Future transport integration with AVs at Sunshine Station

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Autonomous Vehicles in Suburban Melbourne Studio (MUP Studio AV/MArch Studio 39)

Content

Background

The population in Melbourne is growing. It expected the population in Melbourne will be 7.9 million by 2050 (State of Victoria, 2017). The spaces are getting more and more precious. There is already an issue of congestion on the road (State of Victoria, 2017). The urban growth boundary (UGB) was introduced in 2002 by the state government to manage the growth and expansion of Melbourne (Victoria, 2002). Under the pressure of rapid population growth, the UGB was reviewed and expanded, for example, in 2012 the UGB was pushed and included about 6,000 hectares land. Under the current circumstances, more people will own private vehicles, more people will use public transport, and more people will walk and cycle in the future. Victorians is already facing the challenge of overcrowding, and the issue will get more serious if no action is taken.

The climate change has been raised as a global issue in the past years. Several international commitments have already been agreed and issued (e.g. United Nations Framework Convention on Climate Change, 1992, Kyoto Protocol, 1997, Paris Agreement, 2015). Human activities have been the major factor of climate change. Especially with the urbanisation and globalisation process in recent decades, more rapid transport movement and communication have brought more emissions (Ohmae, 1995). Road transport was one of the major contributors of greenhouse gas emission (Chapman, 2007, Berrittella et al., 2007). With the population growth, does it mean more emissions would release to the atmosphere and we could not do anything? The Victoria, the Cycling Strategy: Cycling into the future 2013-23 and Victorian Cycling Action Plan 2013&2014 identified the benefits of cycling (State of Victoria, 2012). It is not only good for the health, but also could reduce the emissions (Maibach et al., 2009).

Over the past several years, autonomous vehicles (AVs) brought many attentions from manufacture firms, governments, and transport departments all over the world (Fagnant and Kockelman, 2015). Many car manufacturers and technology companies are investing the AVs and the availability for the public could be within 10 years or sooner (Childress et al., 2015, Guerra, 2015). The trials of AVs are already in progress. In Australia, many capitals have several trials on the public streets. For example, the RAC Intellibus has been in trial at City of South Perth, Western Australia since 2015. The National Transport Commission has published the Guidelines for Trials of Automated Vehicles in Australia in 2017 (National Transport Commission, 2017). However, it is difficult to find transport planning related documents from the government. Guerra (2015) found that the planning profession failed to prepare transportation plans to accommodate the new technology due to the uncertainty. However, as planners, we should take actions to achieve the most certainty results based on the best possible evidence. This report discusses the potential advantages and disadvantages of AVs. The challenge would be how to balance the usage of AVs and active transport. Using a case study of Sunshine Station, the scenario with AVs integrate with other transport methods is presented. Then the report will analyse the spatial implication of the integration around the station and the policies to support it. Ultimately, this report should be reviewed and updated every 5 year to accommodate the unexpected uncertainty (Infrastructure Victoria, 2016).

Literature review

About AVs

What are Autonomous Vehicles?

The different levels of automatic driving were defined by SAE as showing in Table 1. Full automation vehicles operate on their own system and no human interaction needed while driving. They have the ability to execute steering, acceleration and deceleration, monitor the environment and extreme situation handling all by themselves (SAE International, 2014). In this study, only level 5 autonomous vehicles are been regarded as AVs, because from level 0 to level 4 automation level vehicles all need human interaction more or less, which means they could not operate on the road without human inside the vehicles. For this study, level 5 AVs are capable for all the driving modes, so car parks are not necessary for them, as they could drive back to garage by themselves.

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability (*Driving Modes*)
Human driver **monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
Automated driving system **("system") monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Table 1. Six automation levels of vehicles (SAE International, 2014).

The uncertainties of AVs

After reviewing 25 RTPs (regional transportation plans) and largest metropolitan areas in United States, Guerra (2015) found that no plans incorporated with AVs and only one of them mentioned the technology. However, the planners were familiar with the technologies and concept of AVs during the interviews. The most important factor was the uncertainty. The technology is still constantly changing, when and how they come to the public, and what response will come from the public were all uncertain. Despite how this technology develops, the

travel behaviour, safety, land-use and car ownership would be changed.
Autonomous vehicles have a lot of potentials to influence the current traffic system. The positive side the AVs could be giving people mobility who does not or how to drive and to who cannot drive (patients, elderly, disabilities etc.) (Harper et al., 2016). It could also increase the average traveling speed, reduce traveling time, and last but not least increase capacity of roads (Blumenfeld et al., 2016, Fagnant and Kockelman, 2015). With the vehicle to vehicle coordination technology, the distance between AVs is much shorter when they running on the streets. AVs could also be safer than human drivers (Childress et al., 2015), which means less collisions on the road and road network will be more efficiency. However, the VMT could increase a lot due to AVs development (Harper et al., 2016, Guerra, 2015). Besides, the imperfect technology still need more time to update and give the community more confidence.

Relevant Strategies

According to State Planning Policy Framework, decision making should consider integrated perspectives from different level of government (City of Brimbank, 2018). For the case of Sunshine Station, some relevant strategies from different level of government are introduced.

The state level strategies, Victoria's 30-year infrastructure strategy, encouraged AV to improve accessibility for people with mobility challenge.
Recommendation 10.2.1 and 13.1.2 tend to introduce better transport modelling tools and a transport network price regime which could change the transport network is used by reducing congestion and also could assist the arrival of AVs.
Recommendation 10.6.3 encourages the change of road space in high congestion areas; and long term planning should consider the influence from technology – the AVs.
Recommendation 10.7.3 encourages the change of regulatory to accommodate the future with AVs.

Council Plan 2017-2021
In the Brimbank Council Plan 2017, there is no AV related strategies found. However, the strategy of a liveable community encourages better mobility and accessibility for the community by developing a safer and more assessable transport network, improving access to active transport, and road connections (City of Brimbank, 2017).

Brimbank Planning Scheme
Clause 11.06-3 aims to provide an integrated transport system connecting people to jobs with high quality public transport. It also plan to improve the 20 minute neighbourhoods by walking and cycling.
Clause 18.02-1 encourages walking and cycling with better amenity and facilities (City of Brimbank, 2018).

The Sunshine Town Centre Structure Plan (City of Brimbank, 2014) promotes the connected walking, cycling and public transport network. Strategy 6.4 also aims to give pedestrians and cyclists the priority in the transport modes to encourage more walking and cycling.

Map 1. Existing bike paths and proposed bike paths in Sunshine cluster (Victorian Planning Authority, 2018).

In both Sunshine National Employment and Innovation Cluster Draft Framework Plan and Brimbank Cycling and Walking Strategy Update documents, the walking and cycling network map were showing to existing and proposed bike paths (Map 1). With more walking and cycling paths, people could have healthier transport method that could benefit the physical and mental health. Principle 3 in the draft framework plan stated:

> *"Build stronger transport connections within the cluster and link it to the wider region to provide efficient access to employment, industry and regional infrastructure"*

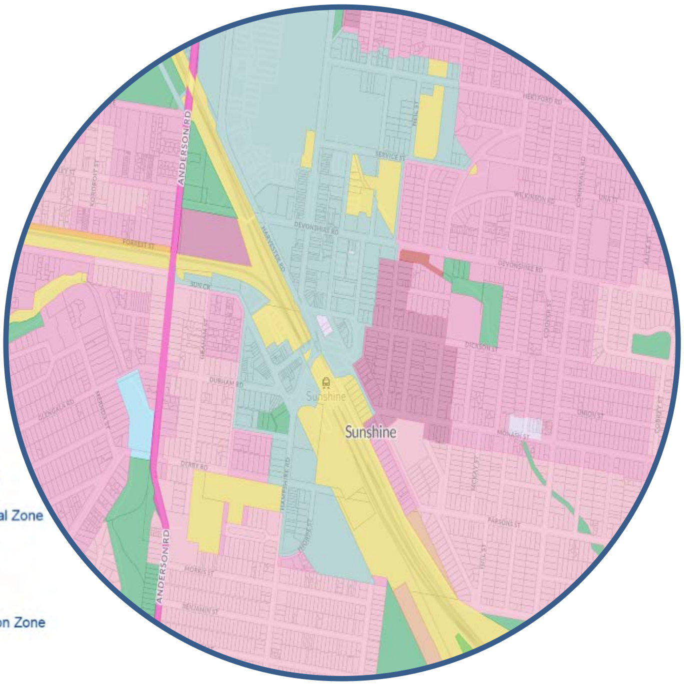
Action 2.1 aims to develop high frequency bus network connecting jobs and residential areas around the cluster. With more efficiency network, people in the Sunshine cluster could have more time to access green infrastructure which could bring both physical and mental health. The second strategic outcome aims to link the key jobs centres and to the workers (Victorian Planning Authority, 2018).

Site Analysis

Sunshine is a suburb in the City of Brimbank. It located about 11 km west of Melbourne CBD. Kororoit Creek, Ballarat Road, and Duke Street defined its shape. In Plan Melbourne, Sunshine was identified as one of the seven National employment and innovation clusters in Melbourne region. It has four Railway stations, two Town Centres, two Tertiary Campuses of Victoria University, Sunshine Hospital and medical research facility, and the potential to attract a broader range of businesses, including office, retail services, entertainment, and residential development (State of Victoria, 2017). Sunshine Metropolitan Activity Centre is one of the key employment centres in the cluster. The area is about 144 hectares (Victorian Planning Authority, 2018). The Western Highway and Western Ring Road are two major roads connecting the west and Melbourne CBD.

Sunshine Station is an important rail hub between CBD, airport, Geelong, Bendigo and Ballarat. The Network Development Plan Metropolitan Rail 2012 proposed that the best route for a Melbourne Airport Rail Link is via the existing Albion East and the Melbourne Metro rail tunnel to link into the Sunshine – Dandenong Line. Trains will operate from Sunbury to Sunshine via the new Melbourne Metro rail tunnel, Melbourne central and Dandenong. The new infrastructure on the Sunshine – Dandenong Line will be constructed with high capacity signalling and allow for the operation of 220 metre long trains (Public Transport Victoria, 2012). This will enable more passengers to be carried from the growth areas in the city's west and south-east.

Sunshine Station is located appropriately centre of Sunshine. The station is within both zone 1 and 2 of PTV's Metropolitan Melbourne zones. There are currently 4 platforms in the station. The majority of the zoning around the station within 400m are activity centre zone, general residential zone, neighbourhood zone, and residential growth zone.



Map 2. 400m Zoning around Sunshine Station

There are 12 bus bays at the bus interchange area of Sunshine Station. The bus interchange area is located north of the station. 14 bus routes are available for passengers come to Sunshine Station from different areas. It takes about 2 mins walk from the bus interchange area to the station. From the observation, during the weekday AM peak, the most popular routes are 410, 420, and 428, and the most popular routes in the PM peak were 400, 427 and 420.

Figure 1. Location of each bus bay.

Bay 1:

Route 216 from Sunshine Station to Brighton Beach

Route 219 to Gardenvale

Bay 2:

Route 408 to Highpoint shopping centre

Bay 3:

Route 903 to Mordialloc

Bay 4:

Route 903 to Altona

Bay 5:

Route 408 to St Albans Station

Bay 6:

Route 219 to Sunshine West

Bay 7:

Route 471 to Williamstown

Bay 8:

Route 220 to Gardenvale

Bay 9:

Route 410 to Footscray

Bay 10:

Route 420 to Watergarden Station

Route 422 to Brimbank Central SC

Bay 11:

Route 426 to Caroline Springs

Route 456 to Melton

Bay 12

Route 427 to Sunshine West

Route 428 to Sunshine West

Route 400 to Laverton Station

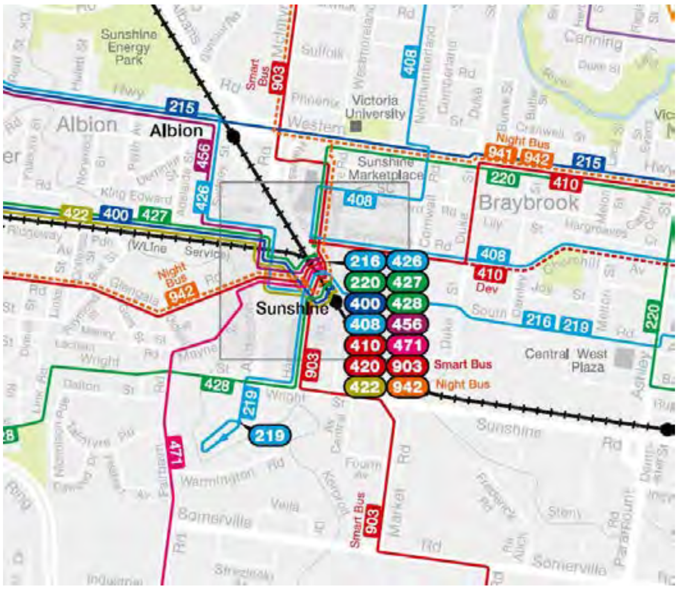


Figure 2. Bus routes and directions from Sunshine Station (Public Transport Victoria, 2018).

There are three formal car park areas around the station which provided by PTV. The number of car parks is 505 (94+108+303). There are 20 racks and 6 lockers available for bicycles storage. The existing kiss&ride kerb length is 30 m (5 spaces) as showing in Photo 1. There are also two dedicated taxi pick-up areas of 60 m kerb space. Within 400 m from the station, the linear metres of restricted on street parking is 1698 m while unrestricted is 895 m.

Photo 1. K&R spaces at Sunshine Station.

Activities

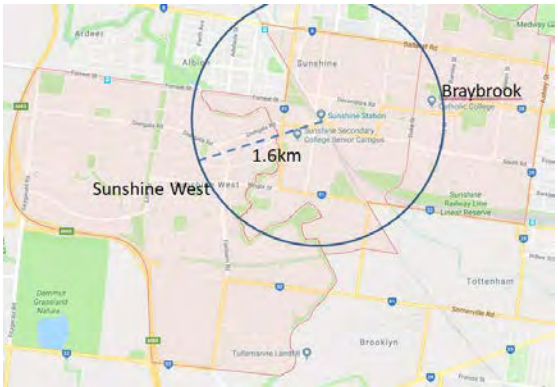
The Sunshine Station could be defined as a transferring hub rather than a destination of its own. Even it is close to shops and activity centre, there are no shops, cafés, or groceries inside the station. From the observation, people went into the station just to catch a train and for those who got off the train; they just walked out of the station without any activities.

Opportunities and challenges

From the zoning map, it observed public land zones near the station, especially south of the station.

Demographic

People lives in Sunshine, Sunshine West and Braybrook would more likely access the Sunshine station. As showing in Map 3, most of Sunshine is inside the radius 1.6 km (20 minutes walking distance) of the station. The circle also covers part of Sunshine West and Braybrook, where do not have station available in within the suburbs.



Map 3. Within 1.6km (20 minutes walking distance) of the station

The 2016 population of Sunshine, Sunshine West and Braybrook are 9772, 18589, and 18232 ((ABS), 2016).

	52%
	53%
	54%

Figure 3. Percentage of people born oversea.

Compare with about 33% of the population in Melbourne were born oversea, the rates around the station are much higher than Greater Melbourne, which means this area has strong culturally diversity.

	Sunshine		Sunshine West		Braybrook	
Male		52.1%		49.9%		50.4%
Female		47.8%		50.1%		49.6%

Figure 4. Percentage of male and female

Compare with Sunshine West and Braybrook, Sunshine has much more male than female in 2016. Also the SEIFA percentile of Sunshine, Sunshine West and Braybrook are 19%, 11%, and 4%. These numbers indicates the socio-economic statuses in these three suburbs are low.

The projection

The weekday entry of Sunshine Station in 2036 is calculated. There are two major factors of weekday entry number, the population growth and the employment growth.

Population

According to profile ID's projection, the population in Sunshine, Sunshine West, and Braybrook will increase 101%, 26% and 34% based on the 2011 level ((ABS), 2011, Profile ID, 2018).

Suburbs	2011	2036	Change	Labour force	Employed	Work outside	Train
Sunshine	8838	17772	101%	58%	89%	69%	20%
Sunshine West	15930	20033	26%	52%	88%	69%	13%
Braybrook	9790	13167	34%	55%	85%	78%	14%

Table 2. Population growth from 2011 to 2036 and the employed workforces method travel to work ((ABS), 2016, Profile ID, 2018).

According to the PTV'S Estimated Station Entries at Metropolitan Stations 2008/09 to 2011/12, the weekday entry of Sunshine Station was 7032. The distribution of timeline in a weekday in 2012 is showing in the table below. About 12.5% of weekday entry passengers will arrive at the station in one hour morning peak (2199/7032/2.5=12.5%).

Pre AM Peak (pre 7:00 am)	AM Peak (7:00 am to 9:29 am)	Interpeak (9:30 am to 2:59 pm)	PM Peak (3:00 pm to 7:00 pm)	PM Late(after 7:00 pm)
6%	31%	35%	24%	4%
432	2,199	2,428	1,717	256

Table 3. Weekday entry by time periods (Public Transport Victoria, 2016).

Two future station patronage calculation methods are introduced below.

The first method: From the calculation of ((The population in 2036)-(the population in 2011)) X Labour force X Employed X Work outside X Train = 952, we can assume about 952 more people from these three suburbs will access the station to go to work in 2036. So 7032+952=7984.

The second method: In 2012, the average weekday entry number was 7032. Compare with the population of Sunshine in 2011, 7032:8838, the ratio is close to 4:5. So if the population in 2036 is 17,772, under business as usual circumstance, the weekday entry should be about 14,140.

The first method has many variables to determine the calculation results. Even it seems more rational and accountable, the problem with it is also very obvious. These variables probably will change between 2011 and 2036. It also does not account for people who come to the station for reasons other than go to work (education, shopping, recreational etc.). Also from the observation on 16th March, 2018 morning peak (7:30 – 8:30 am), the arrival number of bus users was about 500 in one hour. About 60% of the bus users went into the station and the other 40% transferred to another bus or went to shops or work near the station. So it was about 300 people went into the station in one hour on that day. Compare with the PTV data 2012, the number in 2012 plus the patronage growth from 2011 to 2016, 300 is a reasonable number. The weekday entry in 2018 is estimated about 11000 (300/0.22/0.31X2.5=10997). In other words, the first method seems too conservative.

This second method does not count the reality that people from Sunshine West and Braybrook could also access the station in the morning peak. However, the available data from PTV and census does not have information about where the passengers' home and travel purpose other than go to work, so it almost impossible to know the number of passengers come from Sunshine West and Braybrook. However, compare with the first method, the result is closer the expectation (larger number compare to 2018 number). Also based on the projection by PTV, the weekday boardings in 2031 will double the number of 2012. In the case of Sunshine Station, the number will be more than 14,000. So the second method then adopted to calculate patronage from the population growth factor.

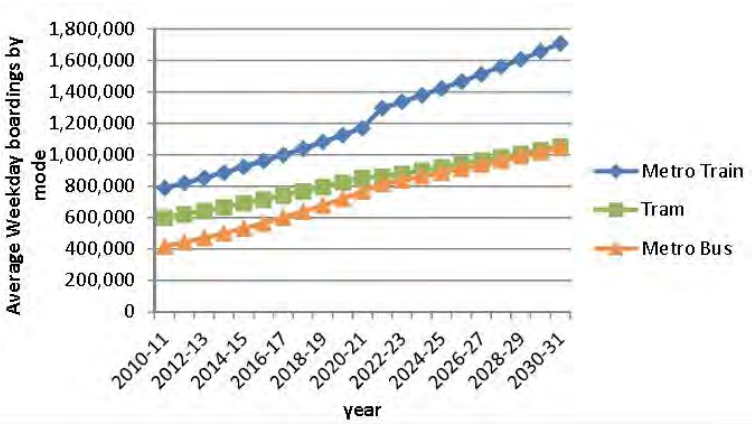


Figure 5. Average week day boardings projection (Public Transport Victoria, 2012).

Weekday		%
Car	2,437	35%
Bus	1,532	22%
Train	278	4%
Active transport	2,785	40%
Total weekday arrival numbers	7,032	100%
Weekday one hour (AM peak)		%
Car	305	35%
Bus	192	22%
Train	35	4%
Active transport	348	40%
Total weekday on hour arrival numbers	880	100%

Table 4. Weekday entry and weekday one hour AM peak entry in 2012.

The employment

Also we mentioned the Sunshine Employment and Innovation Cluster would bring a lot of jobs and workforces to the cluster in the future. The current number of jobs at Sunshine National and Employment Cluster was about 17,000 in 2012. It was projected in 2036, the employment opportunities will increase to about 35,000 as showing in Figure 6 (Victorian Planning Authority, 2018). From the PTV 2012 data, the PM peak entry to Sunshine Station was 1717, the ratio of workers who used the station during PM peak and the total workers in the cluster is about 1717/17000=10.1%. So in 2036, 35000X10.1%=3535. Considering about there are four train stations in the cluster and the other transport methods available for the workers, 10.1% seems reasonable. The change of workers in the cluster who use the station should be 3535-1717=1818. To conclude the projection, the total weekday entry in 2036 is 14140+1818=15958.

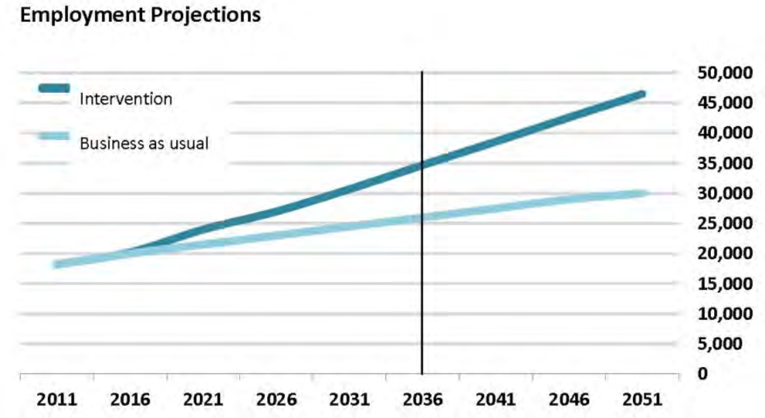


Figure 6. Employment Projection in Sunshine National Employment and Innovation Cluster (Victorian Planning Authority, 2018).

Research question

Primary question: How could AV technology offer opportunities for Sunshine Station as a rail hub in the future?
Secondary: What land use and transport policies should be implemented?

The assumptions

Considering the fact that AV is still has a lot of uncertainties in the future, I have assumed two scenarios.

Scenario one

In scenario 1, the transport methods and the proportion of each method will remain the same, which means based on PTV data in 2012, 692 people will come to the station by private vehicles in one hour.

Weekday		%	Weekday AM peak one hour		%
Car	5,531	34.7%	Car	692	34.7%
Bus	3,477	21.8%	Bus	435	21.8%
Train	631	4.0%	Train	79	4.0%
Active transport	6,320	39.6%	Active transport	791	39.6%
Total weekday arrival	15,960	100%	Total one hour arrival	1,998	100%

Table 5. Business as usual (transport mode share remains the same) in 2036.

The equation to calculate kerb spaces for private drop off: people as drive or as passenger in one hour/average number of people per car X percentage of private cars drop off passenger/30(estimated the average drop off time is 2 min per car)X6(one drop off space linear metres). So if every car has two passengers inside, and 50% of these cars will drop off those passengers and 50% of the cars will park at the car parking. So 692/2X0.5/30X6=34.6. Based on the fact that 5 kiss&ride spaces exist at car park, one more drop off space is needed.

The equation to calculate car parks: people as drive or as passenger on weekday/average number of people per car X percentage of private cars park around the station. So 5531/2*0.5=1,382.75. In addition to the 505 existing formal car parks, 878 new car parks will be needed.

The equation to calculate bus bays: people take bus to the station in one hour/average people per bus/6(bus timetable: average 10 mins per bus). There will be 435 people use the station from taking buses. As discussed before, from the site observation during the morning peak, about 60% of the people get off the buses went into the station, another 40% either transfer to another bus or walk to the activity centre etc., it is expected that more cars, buses, pedestrians and cyclists would be on the streets. So for car users, the number is 1154, 725 bus users and 1319 active transport users. So 725/30/6=4.03, which means 5 bus bays needed. However, the number of average passengers per bus is difficult to estimate. From the observation, the average arrival number in the morning peak was about 20 per bus. There are many factors of people's perception to use buses (Mahmoud and Hine, 2016), including service frequency reliability of the service, safety, comfort, bus fare etc.. So the number could change a lot if some key factors changed.

Scenario 1	Kerb spaces	Car parks	Bus bays
Change needed	+1	+878	-7

Table 6. Scenario one change needed.

From the result of scenario one, more car parks are needed and more congestion probably would occur on the road? It is not a desire result of a liveable and sustainable city. Autonomous Vehicles, however, maybe could help us with the problem of space. There are mainly three types of AVs, private, AV bus, and AV shuttle. As showing in Figure X, private AVs have similar appearance and capacity. This report uses an AV shuttle bus with maximum 15 people capacity, length of 5m (same as private cars) and could operate 45 km/h. The AV buses have capacity of 60 people. It was assumed that in 2036, 50% of the traffic will be LV5 AVs (ARUP 2018).

Photo 2. Private AVs: Renault autonomous vehicle (Source: https://group.renault.com/en/innovation-2/autonomous-vehicle/)

Photo 3. Easymile Shared AV shuttle. (Source: http://www.easymile.com/#Products)

Photo 4. Mercedes semi-autonomous city bus. (Source: https://www.mercedes-benz.com/en/mercedes-benz/next/automation/how-the-city-bus-will-become-autonomous)

Scenario two

In the second scenario, the travel method was assumed with AVs, and the proportion of transport methods will change to as showing in the table below.

Weekday		%	Weekday AM peak one hour		%
Lv0-4 Car	1,596	10.00%	Lv0-4 Car	200	10.00%
Lv5 Private AVs	1,596	10.00%	Lv5 Private AVs	200	10.00%
AV Buses	1,596	10.00%	AV Buses	200	10.00%
AV Mini Van	3,192	20.00%	AV Shuttles	400	20.00%
Train	1,596	10.00%	Train	200	10.00%
Active transport	6,384	40.00%	Active transport	799	40.00%
Total weekday arrival numbers	15,960	100.00%	Total weekday morning peak one hour arrival numbers	1,998	100.00%

Table 7. Estimated 2036 Weekday and AM peak one hour entry.

Private AVs should not need parking spaces as they could navigate itself to any destination the system settled in the second scenario.
The equation to calculate kerb spaces for level 5 private AVs, Level 0-4 cars, and AV shuttle drop off:
Level 0-4 (people as driver or as passenger in one hour/average number of people per car X percentage of private cars drop off passenger/30(estimated the average drop off time is 2 min per car)X6(one drop off space linear metres))+Lv5 (people as passenger in one hour/average number of people per car/60(estimated Lv5 AV average drop off time is 1 min per car)X6)+AV shuttle (people/estimated average passengers per shuttle)/30(estimated Lv5 AV shuttle drop off time is every two minutes). So if private car has average two passengers, AV shuttle has average six passengers, and 50% of lv0-4 cars will drop off those passengers and 50% will park at the car parking. So 200/2X0.5/30X6+200/2/60X6+400/6/30X6=10+10+13.3(m). It would require 2+2+3=7 drop off spaces. Based on the fact that 5 drop off spaces exist at car park, two more drop off spaces are needed. The new drop off spaces will be introduced in the spatial implication section.

The equation to calculate car parks: people as drive or as passenger on weekday/average number of people per car X percentage of private cars park around the station. So 1596/2*0.5=398. The existing two forma car park areas 303+94 should be enough for the parking demand.

The equation to calculate bus bays: people take bus to the station in one hour/average people per bus/6(bus timetable: average 10 mins per bus). There will be 200 people use the station from taking buses in scenario two. 200/0.6=333. 333 people is the estimated number of people come to the bus interchange area. So 333/30/6=1.85, which means 2 bus bays needed.

In this scenario, 7 kerb spaces for level five private AVs, level 0-4 private vehicles and AV shuttles' drop off are required. So only two more drop off spaces other than current five spaces are needed. 398 car parks and drop off is needed and no new development of car parks will be required. In addition, the existing car parks could be integrated and use that space to seek more opportunities.

Scenario 2	Kerb spaces	Car parks	Bus bays
Change needed	+2	-108	-10

Table 8. Scenario 2 change needed.

However, even we could have enough kerb and park spaces for those cars, it is also important to see if the roads around the station will be capable to carry these many of cars? From the observation, Withers Street was congested in the morning which carries both buses and private cars. This section showing in Map 4 is about 100m long and 13.8m width. The road type is defined as UAP2 with “good standard single/dual carriageway road with frontage access and more than two side roads per km” which theoretically means each direction could carry 1900 cars per hour (MRCagney 2018). In scenario two, the numbers of each kind of vehicles in one hour AM peak are: Level 5 private AVs: 100, Level 0-4 private vehicles: 100, AV shuttles: 67, AV buses: 7. So it seems feasible in the second scenario.

Map 4. Selected congested road (Withers Street).

Spatial implication analysis

The extension of the station should be considered under the proposal of updated rail, because the current station platforms do not have the capacity for 220 metres train. Also with the less car parks needed with AVs, the existing car parks could be integrated. One of them could be used as AV drop off and pick up and may have charging facilities for AVs. From the calculation, 10 bus bays could be removed, however, in the short term, the existing fixed routes should be maintained as public should need a period of transition to accept AV buses, and many of whom were estimated transfer to use shared AV shuttles (Mobility as a service (MaaS) approach).

Map 5. Existing car parking areas A, B, C (94+108+303).
Site A could be changed from car parking area to an open space.

Map 6. New changes to the station.

The spatial changes are showing in the Map 6, based on the strategies from state and local government, the connected walking and cycling paths with public transport. As longer platforms – 220 metres were required for updated rail, the new entrance is proposed to let passengers exit the station more efficiently. In addition to rail's update, the future patronage of the station will also more than double the current number, the new entrances are also necessary. 40 car parks at parking area B are removed and repurposed as seven drop off & pick up spaces. Site A is redesigned as an open space where could have more community engagement, social interaction. It also has opportunity to develop a mixed land use area. The potential path from Site B to Derby Road is identified to distribute traffic volume of AVs.

Map 7. Walk paths cycling and public transport integration and on street drop off within 400m.
Walking paths (yellow lines) and cycling paths (green lines) are connected around the station and connecting to Sunshine activity centre. T There are about 150 unrestricted on street parks within 400m. Develop a on street drop off management plan to regulate the on street parking and drop off, then seek the opportunities to proper use the unrestricted spaces.
Better walking and cycling paths should be improved and provided.

Policy implication

With the spatial impact from the patronage growth and AVs, it is important to have policies to support the spatial implication in 2036. First of all, what is the transport mode hierarchy at the station?

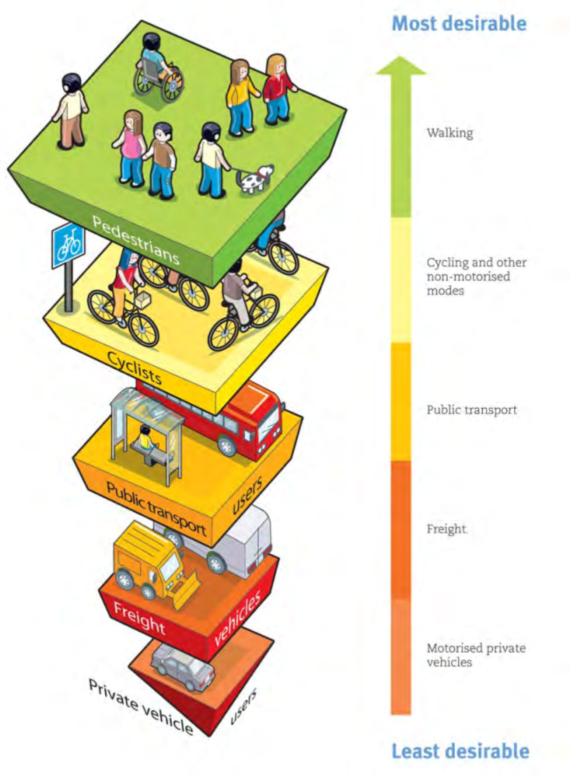


Figure 6. Transport mode hierarchy (Source: https://2016-2017.nclurbandesign.org/2017/01/sustainable-transport-walkable-cities/)

For both health and mitigating climate change impact purposes, prioritise pedestrians and cyclists in the hierarchy is most acceptable.

Policy 1: Walking and Cycling

Develop a transport mode hierarchy to give pedestrians and cyclists priority.

Restrict AVs to give way to pedestrians and cyclists when encounter on the streets or the crossings.

Seek more opportunities of develop new walking and cycling paths especially between different precincts in the cluster.

Build the linkage of walking and cycling path.

Identify missing pedestrian and cyclist way finding signage around the station.

Maintain walking and cycling paths between activity centres and the station with high standard.

Policy 2: AVs

Deliver dedicated AVs drop off and pick up zone.

Restrict private AVs to give way to shared AV shuttles when encounter at the crossings or roundabout.

Policy 3: Spatial change for better accessibility

Introduce the new entrance of the station.

Give priority to walking and cycling paths connecting to the new entrance.

Maintain and encourage community events held on the new open space.

The open space focuses on urban design for pedestrians and cyclists.

Policy 4: Public transport

Provide higher frequency AV buses.

Encourage high capacity use of shared AV shuttle as MaaS service.
Redevelop several current bus bays for more recreational, cultural and engagement communities activities use.
Introduce road pricing and public transport fare adjustment for more public transport usage.

Conclusion

This purpose of this report is to analyse if AVs could solve the problem of over crowd caused by population growth and employment growth at Sunshine Station. The report introduced the background of Melbourne is growing rapidly into a global city in next few decades. With the urgent global issue - climate change, the current transport method is not friendly for the environment. Autonomous vehicle as technology innovation has been discussed by different stakeholders and the communities. Using the case study of Sunshine Station, the report explored the possibilities of transport modes both without AVs and with AVs. The population and employment growth were projected and estimated with different approaches. The result showed that with the intervention of AVs, the outcome is more desirable and feasible than the outcome without AVs. The spatial and policy impact then analysed and discussed. As the technology is still constantly changing and updating, it is important to continue discuss and review the uncertainty future. What is the most desirable future? Everyone has his or her answer. For me, the best urban environment is inclusive and healthy. With the promotion of active transport, the most proportion in the second scenario, healthy and without climate change issue would be the optimal outcome.

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