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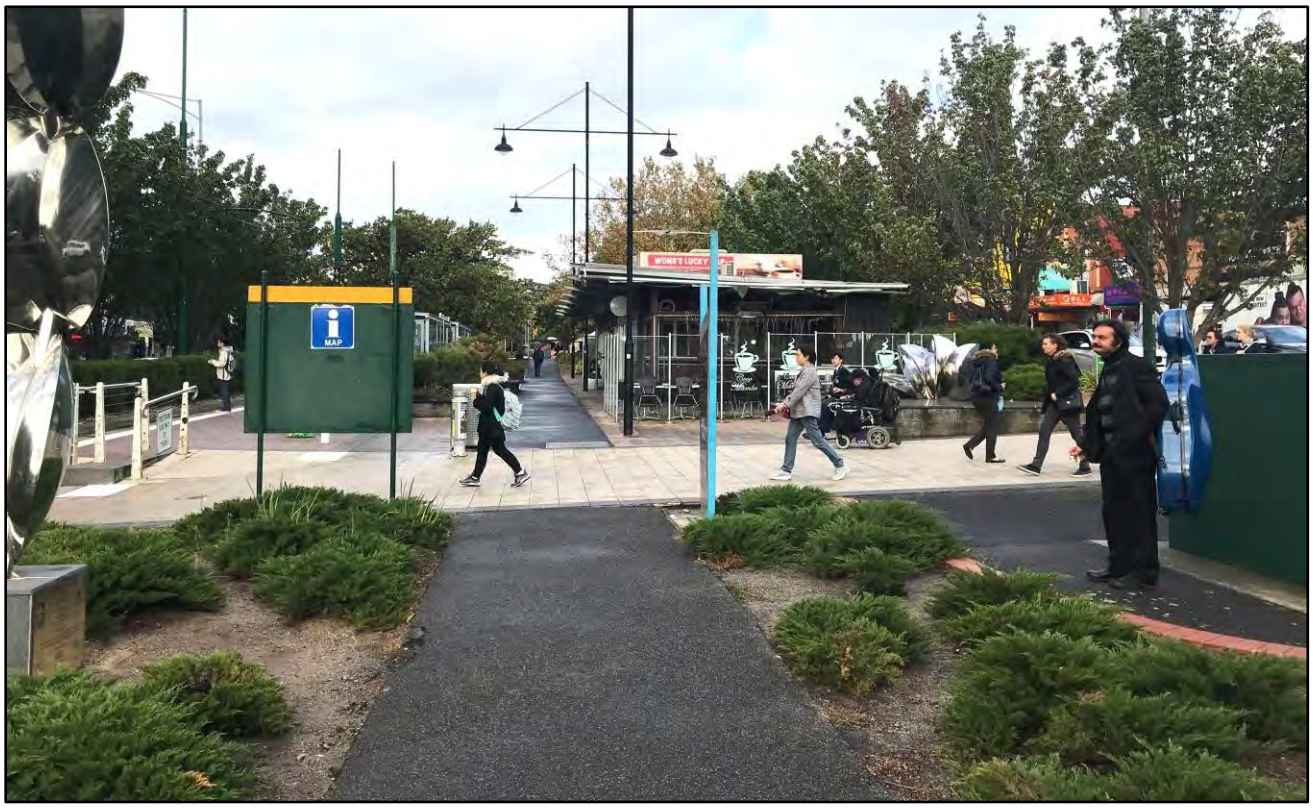
Final Report



Analyzing the Impacts of AV Integration at the Box Hill Activity Centre

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Research Framework & Problem Statement

Box Hill is the most prominent Metropolitan Activity Centre (MAC) and key regional transport interchange in Melbourne's East (VSG, 2017). The anticipated penetration of Autonomous Vehicles (AVs) into the transport sector pose significant potential to bring about various impacts to the accessibility and amenity of the Box Hill Activity Centre (BHAC) in the medium-term (2036).

Thus, this report seeks to explore the question of ***what impacts AV penetration will have on the BHAC by 2036***. However, since the potential impacts of AVs are incredibly vast, a transport framework is adopted in analyzing this question, specifically examining the technical and spatial aspect of AVs. This is further investigated below in terms of changes to the land-use, mode-shares, traffic flows, road capacities, streetscapes and curb space of the study region.

To study the possible range of impacts, we have decided to explore two polarizing AV scenarios (Single Occupancy & Public Transport Integration) to test their *future spatial needs*, the *extent* to which the BHAC is able to accommodate such potential extreme AV futures, their ability to meet current local *planning objectives*, as well as what *policy and physical changes* would need to occur in order for them to be realized.

Research Assumptions

As the topic is complex, forward-thinking and pioneering, the scope of this research has had to be narrowed and clearly defined. In doing so, numerous general assumptions have been made in order to progress with our projections and analyses - namely that:

- The study predominantly researches the BHAC locality, with little-to-no analysis of its regional impacts and relationships with other stations or the rest of metropolitan Melbourne
- All AVs will reach L5 autonomy - fully driverless technology - by 2036 (Rowland, 2018)
- L5 AVs will swiftly achieve full market-share of the motorized vehicle market and thus leave little need to test for a transition period
- The current modal-splits to access the BHAC remain the same into 2036 - and we only vary the proportion of single-occupancy against shared AVs to create test scenarios

- Traffic volume projections are extrapolations of recent traffic data from VicRoads and are not entirely accurate, but can provide some basis for scenario testing
- Idealised average AV occupancy rates for particular mode-shares in our projections
- AV Kiss-&-Ride (K&R) bays would only need to be 6m in length
- AV Park-&-Ride (P&R) bays would only need to be 15sqm
- Only advised minimal-moderate spatial changes or rearrangements to remain realistic

Literature Review

Site History

Box Hill is approximately 14 kilometres East of Melbourne and began as a small agricultural and residential settlement in the mid-19th century, but whilst it developed a train station and basic commercial services (a market, bank, telegraph office, etc.) leading into the 20th century, the township only saw moderate growth - it was only in the post-war period that Box Hill saw more expansive growth. During this time, the Melbourne Metropolitan Board of Works came to recognize the suburb for its development potential because of an abundance of underdeveloped and cheap land in Box Hill South & North. This led to its designation as one of five district centres at the time and the subsequent establishment of a district hospital, TAFE and several office buildings (Victorian Places, 2015).

By the mid-1970s, the Box Hill Interchange Project was approved by the Minister for Transport to trench the existing at-grade station and its level crossing, provide better integration between buses and trains, more commuter parking and allow for land to be redeveloped above the new station. It should be noted that this substantial intervention was exclusive to Box Hill station because of a multitude of opportunities converging at the time. These factors included the established multi-cultural base, the availability of land ready to be developed, a visionary developer, the deregulation of the banking system leading to more money being available for public and private investment, and the governance of a pro-development and innovative council. All this culminated in its unique design of the station, interchange and urban form that still exists today (SGS, 2013).

AV Discourse

A literature review conducted by the Oregon Department of Transportation found that there were twelve general 'elements' of AVs currently mentioned in the discourse, as seen in Figure 1 (2015). Our research seems to briefly touch on some considerations made by studies into AV sustainability, implementation and deployment approach.

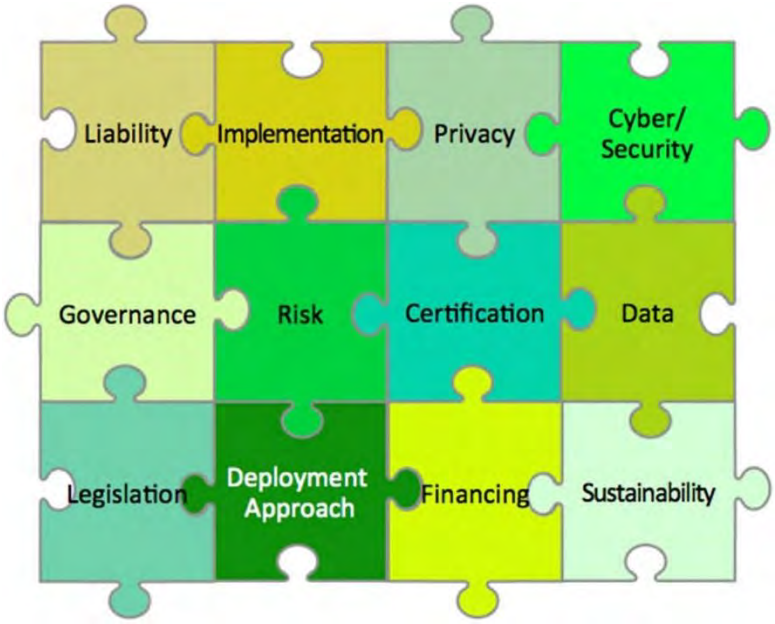

Figure 1: Oregon Department of Transportation, 2016, p. 36

Whilst outside our research scope, a crucial aspect of AVs is *governance*. There is significant attention being paid to the challenges that will arise in the face of changes to pricing, taxation, regulation, networks of actors, powers and resources, the emergence of mobility as a service and the new logics of mobility consumption. Thinking about these aforementioned challenges is critical, as it is very likely that such technological change will outpace the structure of governance and system capacities required to accommodate them if we do not urgently start anticipating possible modes of governance (Docherty et al, 2017).

A business-as-usual approach to AV governance is likely to result in failure to account for their issues and thus risks locking the mobility system along certain transition paths that would exacerbate wider social and environmental problems (Docherty et al, 2017). Thus, it seems that AVs are likely to function as a catalyst for the future of mobility, where their existence can either be instrumental or detrimental to our ability to achieve desired outcomes, depending on whether we have an appropriate model of governance by that time.

Site Context

Existing Site Conditions

Presently, the BHAC is accessible to an established urban catchment and has had the consistent support of investment and pro-growth policies over the past few decades, resulting in it becoming the fastest growing MAC outside the CBD. At the heart of this sits the BHAC, comprising of the retail core and transport interchange which will have important interactions with the introduction of AVs (VSG, 2017b; SGS, 2013) - hence, it was chosen to be our research site.

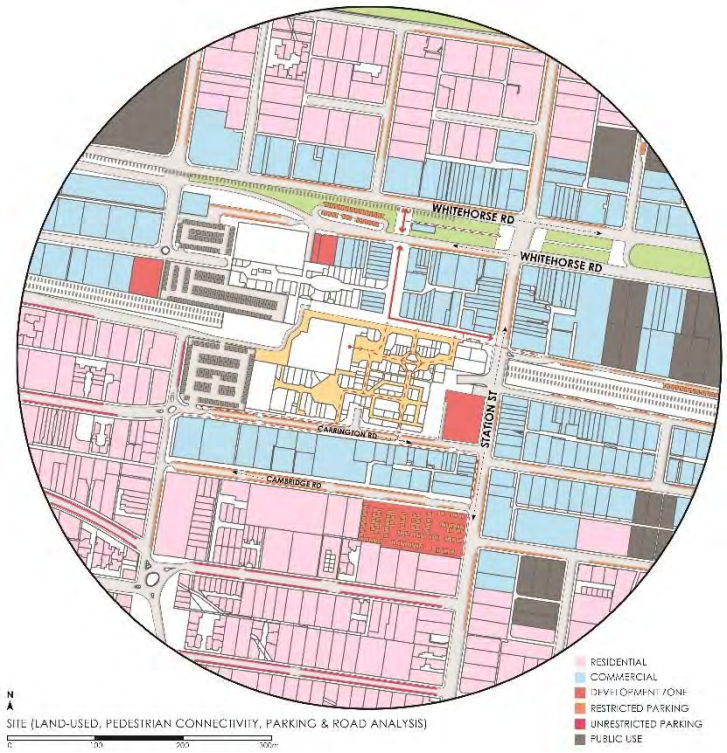

Figure 2: Source, Tang & Yap, 2018

The site contains 2,634 off-street car-parking spaces and provides motorized access via an *arterial* road (Whitehorse Rd), *collector* road (Station St) and two *local* roads (Thurston & Carrington Rds) (GTA, 2014).

Land Use Changes

In the future, the BHAC is set to continue its role as a vital transport, commercial and residential hub. The combined impact of the locality is designed to create a multi-functional metropolitan activity centre in the region, as it develops opportunities to deliver greater employment, recreation, retail, community and accommodation services, alongside a growing health and education precinct (DEDJTR, 2017).

Within a one-kilometre radius of the BHAC, there are currently 33 planning developments. About half (18) are designated North-West of the site - central to the Health and Education precinct - with 4 and 11 more developments West and East of the site respectively (Figure 2). The majority of these developments have recently been approved and the rest are either undergoing construction, planning assessment or sales. In alignment with the existing land use, the new developments are located within either Commercial 1 or Residential Growth Zones.

Land is also being rezoned to make more valuable use of available space within the site. 517 & 519-521 Station St has recently applied for a Whitehorse Planning Scheme (WPS) amendment (C194), that included the rezoning of a carpark and children's service centre from public use to mixed-use zoning. The application underwent a planning panel hearing in late 2017 and has been provided recommendations for the associated planning permit application. The report will be presented to Whitehorse Council in a future meeting and if granted, will facilitate guidance over the development of three mid-high rise, multi-functional buildings on the site (PPV, 2017).

Figure 3: Source - PPV, 2017

Together, these upcoming developments will provide the vicinity with a multitude of mid-to-high rise options for accommodation, as well as opportunities for retail, office and private open space at lower levels. They will also generate additional demand for a safer, more attractive and connected street and bicycle network (particularly between the BHAC and the Health & Education Precinct) as the new residents are likely going to use these mode-shares to access the BHAC.

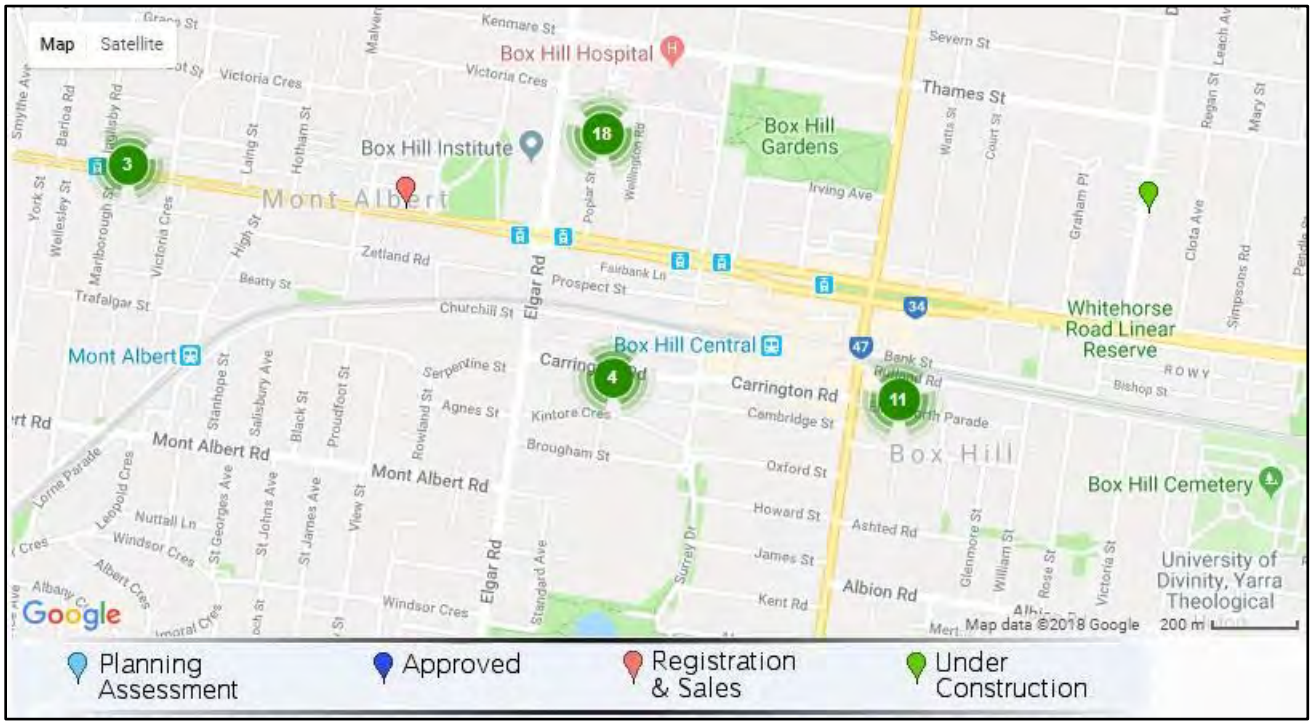

Figure 4: Source - Urban Melbourne, 2018

Data & Methodology

To attempt to understand the BHAC's capacity and changes required to accommodate potential AV futures, we have decided to test and cater to two extreme scenarios, under the assumption that any other futures falling between these extremes will still be manageable. The scenarios are outlined as follows:

Scenario 1: An AV Takeover Future

- The only mode-shares to access BHAC are *rail, active transport,* and *single-occupancy AVs (cars only)*.
- AVs will perform K&R and P&R functions at a 50/50 split.

Scenario 2: An AV & Public Transport Integrated Future

- The only mode-shares to access BHAC are *rail, active transport* and *shared-occupancy AVs* (buses & cars)
- AV cars will perform K&R and P&R functions at a 50/50 split.

Firstly, we noted all current, relevant data to give us an understanding of the existing conditions at the BHAC. This included demographic projections of the BHAC between 2016 and 2036 - this gave us a predicted 94% increase in population (Figure 3). We also looked at PTV data to note the current mode-shares of those accessing Box Hill station (Figure 4).

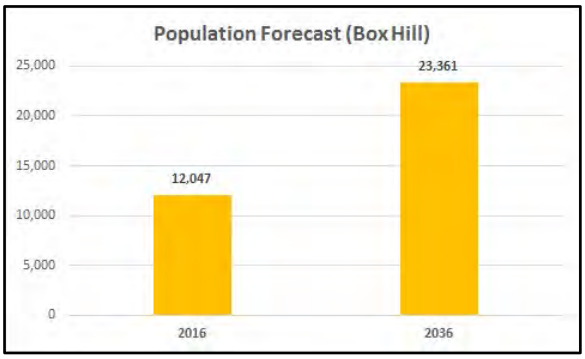

Figure 5: Source, Forecast.id, 2018

We then calculated the proportion of people accessing Box Hill at the busiest peak hour (11.9%/hr). Next, we applied the population increase to current mode-share levels to arrive at our 2036 base-line. We then made assumptions and tweaked the proportion of mode-shares to generate our two scenarios (Appendix 1A-C).

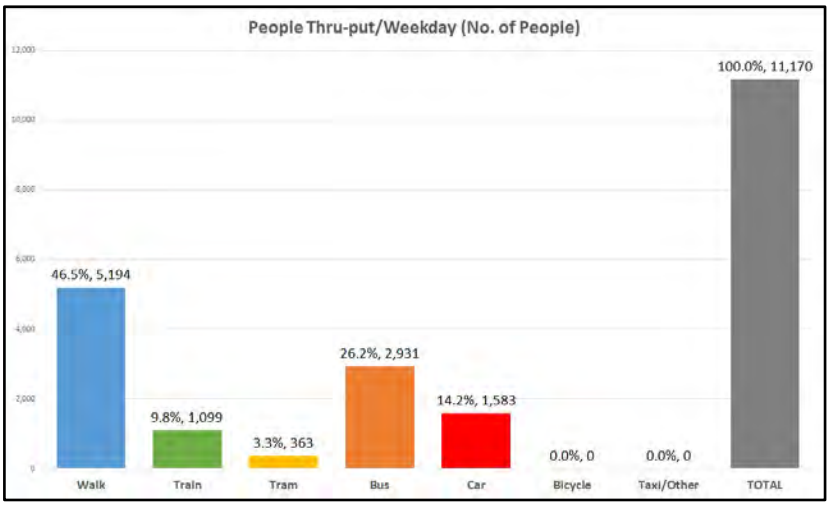

Figure 6: Source, PTV, 2014

From there, we were able to project an estimated number of AV cars and buses that would likely be present at the busiest peak hour in 2036 - giving us an idea of how much kerb and car-parking space would be needed to accommodate them, and if not, where they could possibly be located. As for road space, we used a UK road capacity template as reference to compare against our projected number of cars at peak hour for the roads feeding into the BHAC - Whitehorse Road & Station St (Highways Agency, 1999) (Appendix 2A-C).

Lastly, we compared the results of our projected scenario outcomes against the objectives of the local planning scheme and recommendations of external advisory documents to determine their ability to support the objectives and visions for the BHAC, as seen in tables 1 & 2 (GTA, 2014; Aurecon, 2011; VSG, 2017b; SGS, 2007).

Table 1

Objectives (Whitehorse Planning Scheme)	**Scenario 1** (Single Occupancy AVs)	**Scenario 2** (PT Integrated Shared AVs)
Ensure BHAC creates new, accessible and lively **PUBLIC SPACES**		
Support **WALKING** as the primary means of access in/around BHAC		
Support **CYCLING** as a sustainable & healthy means of access around BHAC		
Support a significant **increase in PT patronage** and **reduced rates of private transport** to access the BHAC		
Carefully manage vehicular traffic in the BHAC to create **transit supportive roads**		

Table 2

Policy Recommendations	**Scenario 1** (Single Occupancy AVs)	**Scenario 2** (PT Integrated Shared AVs)
Favour **shared use of kerb-side space** to generate activity, form a buffer to traffic and contribute to amenity and personal safety		
Modify the **ratio of car-parking** to better reflect the different demand levels in different precinct areas		
The need for provision of **public open space** in BHAC South		
Need for improvement of **interchange opportunities** between transport modes at BHAC (in terms of visual & physical facilitation)		
Pedestrian access between Market St & Carrington Rd via BH Centro currently inconvenient and confusing		

Analysis & Discussion

Our scenarios provide a comparison of ideologies between a forecasting and predict-&-provide (Scenario 1) approach, against one of backcasting and demand-management (Scenario 2). In Scenario 1, although our research suggests that the BHAC contains sufficient existing kerb space and is quite capable of sustaining such levels of AVs for kiss-&-ride functions, the proliferation of single-occupancy AVs means adjacent roads will be operating significantly above capacity during peak hours. Thus, actively hindering several objectives of the WPS (e.g. reducing rates of private transport & supporting cycling/walking), since after accommodating AVs, there are no opportunities for the reclamation of road space for active transport or public space.

Moreover, we assumed half the AVs will perform park-&-ride functions, so there will also be increased demand for car-parking (additional 2242 spaces) that simply do not exist - thus requiring the densification of existing car-parks (at least five more levels) or procurement of more carparks further from the site. This will also have direct impacts to the surroundings as mid-rise car-parking are not conducive to active street frontages and more cars will be incentivized to use local roads in more suburban/conservative zones to access the BHAC as congestion worsens along the main connector roads.

As for Scenario 2, there is a significant reduction in the total number of vehicles on roads during peak hour because of car-sharing and increased public transport patronage. The use of more spatially efficient transport modes allows more opportunities for the repurposing of road space to better facilitate a connected cycling and pedestrian network throughout the BHAC, as well as the shared-use of kerb space. Similarly, the vast majority of upcoming, high density housing is within a 1-kilometre walk/cycling catchment, so this approach is more supportive of the primary mode-share access to BHAC (active transport) and of the local vision.

Furthermore, Scenario 2 suggests that there will be a surplus of about 2146 off-street parking spaces. This means approximately one level of BHAC car-parking at the basement/roof-top can be repurposed to incorporate more retail, office or public open space, increasing the amenity and land-use mix of the site to serve a greater range of people.

We believe an *integrated land use and transport approach* would be critical towards achieving a more prosperous outcome that is also more aligned with the council's vision for the site. With regards to transport, the WPS has adopted a forecasting-inclined approach and a shift towards demand management seems more capable of managing future private car use through improvements in alternative travel modes as opposed to widening roads and providing more carparks. High trip-generating land use should be sited for access to minimize travel distance and be supported by sustainable transport modes outside of walkable catchments. Moreover, transport projects and recommendations must work in line with local and state planning strategies in order to achieve more cohesive and effective outcomes for the BHAC (Curtis, 2017).

In order to guide AVs to support more positive outcomes, planners - especially transport planners - need to play a bigger role in developing productive policies and strategies by anchoring their decisions to the city and council vision (Pruetz, 2018). Whilst there is clarity around Whitehorse Council's *vision*, *goals* and *fact base*, the severe lack of specific *policies*, *implementation* and *measurable objectives* makes it impossible to follow up with *monitoring* and *evaluation* to determine if their policies are working effectively to achieve the strategic goals on time - this lack of mutual reinforcement between planning and implementation generates substantial *internal inconsistency* (Berke & Godschalk, 2009).

Presently, Whitehorse Council should make two major changes to its transport strategy. Whilst keeping in mind the advent of AVs, the first would be to create more concrete, measurable policies in place of the vague and weak ones currently in operation. Second, would be to set out a timeline to ensure that there is commitment to implementing policy actions. These changes would help produce a more effective plan to guide development at the BHAC (Berke & Godschalk, 2009).

An additional element to consider tackling in the BHAC and its surrounds is that parking is very heavily subsidized in our transport system. The local economy, land use patterns and environment are all forced to cater to free, mandatory or under-charged parking. We have explored some potential changes to mitigate this imbalance to provide greater pedestrian and public open space to the people. These spatial changes are reflected in our design of Cambridge and Carrington roads (Tang & Yap, 2018).

Although outside our scope, Whitehorse Council could also consider research to determine what is the appropriate level carparking should be charged at the BHAC (market-rate) and how that can be implemented to further drive sustainable transport use (Manville, 2018).

Limitations

- Only used PTV patronage data and thus not capturing through-put traffic or people accessing the BHAC for reasons other than transport (e.g. work, retail or recreation)
- Traffic volume projections only consider lane traffic and not turning traffic capacities (junctions)
- Research only focuses on AV impacts at the precinct level, with minimal analysis of the wider impacts at the regional scale
- Research scope used a technical and transport framework and thus did not explore the social or environmental aspects of AVs for the study such as - governance, equity, emissions or transport justice

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Appendices

Appendix 1A

Boxhill Current Access Scenario	People Thru-put/Weekday (No. of People)	Mode Share (%)	AM Peak Hour Volume (Max No. of ppl/hour)	Existing Kerb & Parking Space	Existing Parking Space (Sq. Metres)
Walk	5,194	46.5	618	0	0
Train	1,099	9.8	131	0	0
Tram	363	3.3	43	50	0
Bus	2,931	26.2	350	266	0
Car	1,583	14.2	188	240 (K&R) 2,634 (P&R)	39,510
Bicycle	0	0	0	0	0
Taxi/Other	0	0	0	0	0
TOTAL	**11,170 ppl/weekday**	**100%**	**1,330**	**556**	**39,510**

Appendix 1B

Boxhill AV Scenario 1 Single Occupancy AVs (2036)	People Thru-put/weekday (People)	Mode Share (%)	AM Peak Volume (Max No. of ppl/hr)	K&R AM Peak Volume (Max No. of vehicles/hr)	Req. Kerb Space (Linear Metres)	P&R AM Peak Volume (Max No. of vehicles/day)	Req. P&R Space
Walk	9,318	43	1,109	-	-	-	-
Train	2,384	11	284	-	-	-	-
Bicycle	217	1	26	-	-	-	-
AV Car (Single Occupancy)	9,751	45	1,160	581/hr ≈ 10 AVs/Min	If 10 AVs/min, 60m If 50 AVs/min, 300m	581/hr ≈ 4,876/day	73,140 (33,900 Sqm Deficit) (2,242 Parking Space Deficit)
TOTAL	**21,670 ppl/weekday**	**100**	**2,579**	**581**	**AVs: 60m - 300m**	**4,876**	**73,140**

Appendix 1C

Boxhill Access AV Scenario 2 Shared AVs (2036)	People Thru-put/weekday (People)	Mode Share (%)	AM Peak Volume (Max No. of ppl/hr)	K&R AM Peak Volume (Max No. of vehicles/hr)	Req. Kerb Space (Linear Metres)	P&R AM Peak Volume (Max No. of vehicles/hr)	Req. P&R Space (sqm)
Walk	8,668	40	1,031	-	-	-	-
Train	2,384	11	284	-	-	-	-
Bicycle	217	1	26	-	-	-	-
AV Share-Cars (Avg of 4 People)	3,900 (975 Cars)	18	464 (116 Cars)	58 ≈ 1 AVs/Min	If 1 AVs/min, 6m If 10 AVs/min, 60m	58 ≈ 488/day	7,320 (32,190 Surplus) (2,146 Parking Space Surplus)
AV Bus (Avg of 30 People)	6,501 (217 Buses)	30	774	26 ≈ 1 Bus/2mins	Pulse of 1 Bus: 25m Pulse of 10 Buses: 250m	-	-
TOTAL	**21,670 ppl/weekday**	**100**	**2,579**	**142**	**Shared AVs: 6m - 60m AV Buses: 25m - 250m**	**488**	**7,320**

Table A1: Types of urban roads and the features that distinguish them

Feature	ROAD TYPE				
	Urban Motorway	Urban All-Purpose			
	UM	UAP1	UAP2	UAP3	UAP4
General Description	Through route with grade separated junctions, hardshoulders or hardstrips, and motorway restrictions	High standard single/dual carriageway road carrying predominantly through traffic with limited access	Good standard single/dual carriageway road with frontage access and more than two side roads per km	Variable standard road carrying mixed traffic with frontage access, side roads, bus stops and at-grade pedestrian crossing.	Busy high street carrying predominantly local traffic with frontage activity including loading and unloading.
Speed Limit	60mph or less	40 to 60mph for dual, & generally 40mph for single carriageway	Generally 40mph	30 to 40mph	30mph
Side Roads	None	0 to 2 per km	More than 2 per km	More than 2 per km	More than 2 per km
Access to Roadside Development	None. Grade separated for major only	Limited Access	Access to residential properties	Frontage Access	Unlimited access to houses, shops & businesses
Parking and Loading	None	Restricted	Restricted	Unrestricted	Unrestricted
Pedestrian Crossing	Grade separated	Mostly grade separated	Some at-grade	Some at-grade	Frequent at-grade
Bus Stops	None	In lay-bys	At kerbside	At kerbside	At Kerbside

Appendix 2B

Road/Street Name and Section	Traffic Orientation	Theoretical Road Capacities (No. of Lanes, Width, Speed)	2015 Peak Vehicle Flow	Vs. Estimated Vehicle Peak Flow (Scenario 1)	Vs. Estimated Vehicle Peak Flow (Scenario 2)
STATION STREET (Between Eastern Freeway & Whitehorse Rd)	North Bound	UAP3 (2 Lanes, 6.1m, 60km/h) **900/hr**	1,378 Cars/hr	**1,160 AVs/hr Operate at 129%**	**142 AVs + Buses/hr Operate at 16%**
STATION STREET (Between Eastern Freeway & Whitehorse Rd)	South Bound	UAP3 (2 Lanes, 6.1m, 60km/h) **900/hr**	800 Cars/hr	**1,160 AVs/hr Operate at 129%**	**142 AVs + Buses/hr Operate at 16%**
STATION STREET (Between Whitehorse & Carrington Rd)	North Bound	UAP4 (2 Lanes, 6.1m, 40km/h) **750/hr**	1,035 Cars/hr	**1,160 AVs/hr Operate at 155%**	**142 AVs + Buses/hr Operate at 19%**
STATION STREET (Between Whitehorse & Carrington Rd)	South Bound	UAP4 (2 Lanes, 6.1m, 40km/h) **750/hr**	923 Cars/hr	**1,160 AVs/hr Operate at 155%**	**142 AVs + Buses/hr Operate at 19%**
STATION STREET (Between Carrington & Canterbury Rd)	North Bound	UAP2 (2 Lanes, 6.1m, 60km/h) **1,020/hr**	1,054 Cars/hr	**1,160 AVs/hr Operate at 114%**	**142 AVs + Buses/hr Operate at 14%**
STATION STREET (Between Carrington & Canterbury Rd)	South Bound	UAP2 (2 Lanes, 6.1m, 60km/h) **1,020/hr**	1,335 Cars/hr	**1,160 AVs/hr Operate at 114%**	**142 AVs + Buses/hr Operate at 14%**

Appendix 2C

Road/Street Name and Section	Traffic Orientation	Theoretical Road Capacities (No. of Lanes, Width, Speed)	2015 Vehicle Peak Flow	Vs. Estimated Vehicle Peak Flow (Scenario 1)	Vs. Estimated Vehicle Peak Flow (Scenario 2)
WHITEHORSE ROAD (Between Station St & Nelson Rd)	East Bound	UAP2 (3 Lanes, 10m, 60km/h) **1,650/hr**	1,280/hr	**1,160 AVs/hr Operate at 70%**	**142 AVs + Buses/hr Operate at 9%**
WHITEHORSE ROAD (Between Station St & Nelson Rd)	West Bound	UAP3 (2 Lanes, 6.75m, 60km/h) **1,110/hr**	1,156/hr	**1,160 AVs/hr Operate at 105%**	**142 AVs + Buses/hr Operate at 13%**
WHITEHORSE ROAD (Between Station St & Middleborough Rd)	East Bound	UAP2 (3 Lanes, 10m, 60km/h) **1,650/hr**	1,813/hr	**1,160 AVs/hr Operate at 70%**	**142 AVs + Buses/hr Operate at 9%**
WHITEHORSE ROAD (Between Station St & Middleborough Rd)	West Bound	UAP3 (2 Lanes, 6.75m, 60km/h) **1,110/hr**	1,420/hr	**1,160 AVs/hr Operate at 105%**	**142 AVs + Buses/hr Operate at 13%**