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Superior mobility achieved through an alternative to heavy rail – Melbourne south-east case study

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Abstract

Public Transport Victoria's 2012 Network Development Plan ('NDP') proposes comprehensive expansion of Melbourne's heavy rail infrastructure that relies on expensive investment in central Melbourne to meet capacity growth requirements. This infrastructure, it is argued, is required before transit deficits can be addressed in the Rowville corridor and elsewhere. The potential mobility achieved through this proposal is reported through a 'sketch modelling' exercise. An alternative strategy is also presented to expand access to, and mobility resulting from, rail-based rapid transit in suburban Melbourne. The alternative strategy, based on best-practice international transit planning principles, uses a de-coupled approach, where heavy rail infrastructure is simplified, and complementary medium rail infrastructure introduced.

The two expansion strategies are compared based on the catchment areas of key activity nodes in the southern and eastern suburbs. Significant mobility advantages were observed under the alternative strategy. For example, the research showed that Monash University – Clayton's 30-minute transit catchment area was over three times greater when serviced though a de-coupled transit network, compared to the NDP proposal. These findings support the need for more detailed feasibility studies of the relative benefits of a 'medium rail' option for transit expansion, as well as a decoupled approach to transit planning, in Melbourne.

1. Introduction

This paper examines the influence of alternative infrastructure and network development strategies on transit performance, with particular attention to current transit planning and investment debates in Melbourne.

Heavy rail has a strong legacy in Melbourne; for over a hundred years it has been the backbone of the transit network, and it is envisaged that this will continue. A comprehensive expansion of heavy rail is outlined in Public Transport Victoria's 2012 Network Development Plan ('NDP') which sets out a staged approach for investment in expanding this infrastructure through enhanced primary rail corridors ('trunks') with existing and new secondary lines ('branches'). The NDP argues that expensive capacity-enhancing projects (including a metro rail tunnel project) are required before suburban transit deficits can be addressed through construction of long-promised secondary branches.

This paper investigates whether Melbourne's suburban transit deficits can be better addressed by alternatives to this expensive program of heavy rail construction. It does this through a case study in Melbourne's south and east, where there are significant transit deficits – particularly in Rowville and Clayton. This case study compares improvements in mobility achieved through the NDP and an alternative approach which uses 'medium rail' technology and a decoupled network strategy. This is not intended as a complete transit proposal, but rather as a means to assess the relative mobility merits of the two approaches. Seen in this context, the results of this 'thought experiment' present a strong case to challenge the premise of the NDP, that heavy rail expansion is the best transit option for Melbourne's future.

2. Literature

2.1 Outcomes of transit investment

There is not yet a consensus in the literature on the measurable outcomes of increased transit investment and transit use, however, as Thomopoulos and Grant-Muller (2013) note, for the most part, there is agreement that greater transit use does produce significant economic and social benefit. Transit investments that offer faster travel for more people to key destinations can produce reductions in road congestion costs and other externalities associated with private vehicle dependence (Stanley & Hensher 2009; Tirachini & Hensher 2012).

Road congestion costs are the avoidable losses resulting from high traffic volumes in constrained road networks. These include trip delays, journey inconsistency and variability, business time costs, and additional air pollution (Stanley & Hensher 2009; Tirachini & Hensher 2012). The Australian Bureau of Transport and Regional Economics (2007) estimated Melbourne’s road congestion costs in 2005 at $3.0 billion and forecast to rise to $6.1 billion by 2020. An example of road congestion reductions through transit investment is the Gold Coast Light Rail project, which is anticipated to reduce private vehicle trips by 10% (Department of Infrastructure and Transport 2013), with a present value of $600 million to the local economy (Sunshine Coast Council 2012). Regardless of which measurements are applied, Beed et al. (1983) concluded that the benefits of transit investment should not solely be expressed in monetary terms. Transit also provides other positive externalities, particularly improved social inclusion and enhanced community interaction (Stanley 2010).

2.2 Performance of Melbourne transit network

Transit network performance is a function of pedestrian-friendly street connectivity, and factors such as a network’s coverage, speed and variety of mode and journey path options (Litman & Steele 2014; Waisman, Guivarch & Lecocq 2013). The measurement of such factors has been used to identify areas or “hot-spots” of poor transit network performance in Melbourne.

Delbosc and Currie (2011) conducted a spatial analysis of Melbourne’s transit network, calculating and comparing the proportion of the total employment and population within each of Melbourne’s census districts to their proportion of available transit. Currie’s transit index calculation method (2010) was applied, with distances to public transport stops based on Kittelson (2003). Districts with the lowest proportion of transit, relative to their proportion of population – being two to three standard deviations away from the mean result of this calculation across all districts – were classed as “hot-spots”, being significantly under-supplied by transit. The analysis showed that a number of key employment precincts had deficiencies in their transit supply, particularly within Melbourne’s middle suburbs. Monash University – Clayton, and the business and industrial parks of Rowville, Moorabbin, Mordialloc, Dandenong and Clayton were all identified as “hot-spots” – the potential for improved access to these locations will be tested in this study.

Melbourne’s heavy rail trunks do successfully attract patronage from the urban fringes or from ‘longer-distance commuter suburbs’ (Hale & Eagleson 2013 p.353). However, in Melbourne’s middle suburbs, particularly those serviced by heavy rail branches, rail use is relatively low. It is estimated that only 60% of the middle suburban areas are effectively served by high capacity, mass transit (O’Connell & Roberts 2012).

2.3 Effective transit networks

Creation of effective transit networks through the application of best-practice principles has been clearly shown to influence transport decisions and increase mode shifts from private car to transit (Nielsen et al 2005).

The form that transit networks take – either radial or multi-destination – affects patronage. Radial networks, like Melbourne (Hale & Eagleson 2013), predominantly serve trips between suburbs and the city centre, and what Mees and Dodson (2011) termed "single-seat journeys". This is seen in Melbourne's comparatively low interchange statistics (Hale & Eagleson 2013). Multi-destination transit networks provide for a multiplicity of directions and destinations (Mees & Dodson 2011). Brown and Thompson (2008) compared US multi-destination and radial bus-and-rail networks; their investigation showed a growth of almost 9% in patronage in multi-destination networks between 1984 and 2004, while radial networks fell by 12%. Multi-destination networks cater for a variety of journeys, not just along radial lines (Mees & Dodson 2011). These networks place emphasis on what Bovy and Hoogendoorn-Lanser (2005, p. 341) describe as, 'seamless transfers between the different legs in the chain [trip]'. The relative success of multi-destination networks is linked to commuter behaviour, where overall journey time is more important to commuters than individual trip time (Transport for NSW 2013).

There is a need for conscious decisions, through intelligent planning design, to transform what are now 'stations' in Melbourne into transfer hubs (Hale & Eagleson 2013). One way to ensure that transfers are acceptable to commuters is to provide sufficient frequency of service to ensure a predictable reduction in overall journey times. The Victorian Auditor-General's Report of August 2013 entitled *Developing Transport Infrastructure and Services for Population Growth Areas* argues that frequent transit services are essential to providing an alternative to car travel. Services every 10 minutes is considered the minimum frequency to encourage transit uptake, with 5 minute frequencies considered best practice. A good transit network is also simple, consistent and direct. This allows for fast operating times, while also increasing legibility, an important component of encouraging transit adoption (Nielsen et al 2005).

2.4 Choosing the right mode in a network: a role for medium rail?

As Mees (2010) has noted, network design is the most significant factor in transit planning. Decisions about the appropriate mode for any section of a network are secondary, and should be made on the basis of required capacity and available funding. However, Melbourne's NDP is mode specific, making few references to the rest of Melbourne's transit network; this is despite the relative success of others modes in the transit networks of metropolitan counterparts. Medium rail has been successful in a number of international cities. O'Connell and Roberts (2012) note that this transit mode contains technical advantages to heavy rail (see Table 1). The following technical comparisons are based on successful application of medium rail in Copenhagen, Denmark and Toulouse, France.

Table 1: Technical comparisons between medium and heavy rail

	Medium rail	Melbourne's heavy rail
Average speed (in urban system)	40-45km/h [1] [3]	38km/h [2]
Capacity	400-600 [3]	800-1400 [3]
Horizontal radius	22 meters (Toulouse) [3]	150 meters (ideally 300 metres) [3] [4]
Vertical gradient	12% (Toulouse) [3]	2-2.5% [3] [4]
Tunnelling (twin-track internal diameter)	6.9 meters [3]	10.2 meters [3] [4]
Station size (length)	50–80 meters [3] [4]	160 meters [3] [4]

(1) Greater Vancouver Transportation Authority 2003
(2) Ironmonger & Anderson 2008
(3) O'Connell & Roberts 2012
(4) Alternative Mass Transit Mode Report: Doncaster Rail Study 2012

Medium rail has superior horizontal radius and vertical gradient, meaning routes can be optimised with fewer engineering complexities, and with less impact on existing urban form (O'Connell & Roberts 2012). The *Alternative Mass Transit Mode Report: Doncaster Rail Study* (URS, AECOM, Aurecon, SKM 2012) also notes that tunnelling for medium rail is significantly smaller than heavy rail alternatives. In addition, stations are less than half the size of heavy rail equivalents. Medium rail also requires a significantly narrower rail corridor along roads and freeways, compared to heavy rail. Collectively, this presents significant construction cost savings compared to heavy rail. These technical advantages create a strong case for considering medium rail as part of Melbourne's transit network. In regard to the ongoing operation, medium rail's rolling stock are driverless trains functioning on automated systems, producing a more cost effective solution to heavy rail, with greater reliability, consistency and flexibility of services (O'Connell & Roberts 2012).

Medium rail, like heavy rail, is separated from private vehicles. There may be a degree of criticism regarding the visual aesthetic or intrusion of stations and other infrastructure. This research is confined to mobility, so does not attempt to determine exact alignments, station design, or whether rail should be underground, at grade or elevated. Contemporary best-practice design has been shown across the world to address concerns regarding elevated rail. Seattle's elevated light-rail station Tukwila is a best-practice example of lighting design, with safety, orientation and aesthetic elements featured (Hall 2011). And it is noted that the footprint of medium rail would be significantly less than heavy rail (O'Connell & Roberts 2012). Regardless of mode, it is recognised, as noted in the Rowville Rail Study - Preliminary Rail Design Report (2012), that appropriate design considerations are necessary to avoid detrimental visual impacts. Transfer environment, particularly inter-modal transfers, would need to be a design priority in any realisation of the medium rail concept (Guo & Wilson 2011).

When discussing the options for different rail modes in Melbourne, the term 'component' has been used in this paper. Each mode is considered a distinct component of a single transit network; accordingly, medium and heavy rail are referred to as the 'medium rail component' ('MRC') and the 'heavy rail component' ('HRC'), respectively. The four case study scenarios posed in this research only examine HRC and MRC. The justification for simplifying the transit network in this research is because this paper seeks to critically analyse the transit proposals considered under the NDP (which are only heavy rail), and offers an alternative that fits high capacity, mass transit criteria. The NDP contemplates the large-scale efficient movement of people throughout Melbourne, particularly in the middle and outer suburbs. It is argued that light rail and bus are constrained in their ability to provide for the large-scale efficient movement of people. Light rail has significantly slower average speed (averaging 16km/h, noting this is not exclusively along dedicated reservations) compared to medium and heavy rail (38-45 km/h). While noting its cheaper construction and operating costs, Bus Rapid Transit has a significantly smaller capacity than that offered by these two options. It is also constrained by road capacity unlike medium and heavy rail (O'Connell & Roberts 2012).

3. Methodology

3.1 Mobility metrics

A number of metrics were developed for this analysis. This paper reports primarily on a 'catchment metric', and briefly discusses a 'time to the CBD metric'. The catchment metric refers to the extent to the number of destinations (stations) that can be reached from activity nodes within 30-minutes travel. It provides a measure of the combined effect of the coverage, speed and variety in route options - key indicators of mobility (Waisman, Guivarch & Lecocq 2013). This research provides a comparison of mobility potential under four hypothetical transit networks scenarios as detailed in Section 3.2. It does not draw conclusions about the extent to which an increase in potential mobility will have a causal effect on, for example, commuter behaviour or land use activation: this would require broader, mixed-method design (Zachariadis, Scott & Barrett 2013).

The activity nodes used as centre points for calculation of the catchment metric are Moorabbin, Dandenong, Box Hill and Monash University – Clayton. These centres were selected based on the *State Significant Employment Precincts April 2013* report (Deloitte Economics). The report identifies 14 key employment centres within Melbourne: of these, the above four nodes and Knoxfield (Rowville) are within the investigation area. Rowville was not included, as it would produce similar results to Monash. Clayton and Dandenong have the two highest employment levels of all 14 precincts (CBD was not considered), with estimated workforces in excess of 50,000. Moorabbin is recognised as a specialised industry precinct. Box Hill is an important health and research precinct (Deloitte Access Economics 2013).

To measure and compare mobility through the catchment metric, four scenarios (Section 3.2) have been defined. Under each scenario, timetables were generated for each rail line (heavy rail trunks, heavy rail branches, and MRC lines) based on peak services. It is assumed that no express services are running, and no delays occur. From the four activity nodes the catchment metric is applied every minute, for 30 minutes. As the experiment is based on a hypothetical timetable, the results across the experiment will vary depending on when trains arrive relative to patrons being available to transfer. Median distances are calculated for comparison in the research findings. The walking transfer component is consistently assumed to be two minutes (to change platforms etc.). The waiting transfer component is based on arrival of the next appropriate service. A transfer penalty was not considered in this experiment chiefly because this research is designed to test potential accessibility rather than potential patronage. In addition, the impact on transfers cannot be consistently applied, because the transfer environment will vary between stations and for each scenario. Similarly, any reductions in transfer penalty through an improved transfer environment have not been considered (Guo & Wilson 2011). However, this should be considered in further research.

Although more complex in terms of variables and outcomes, the Spatial Network Analysis for Multimodal Urban Transport Systems (SNAMUTS) model uses similar methods to assess transit mobility and accessibility. Its objective is to measure the impact of changes in network design on the potential accessibility of a transit network. It does so by measuring a network's coverage and speed, but standardises individual journeys by fixing the frequency of services and applying a consistent transfer times (Litman 2003; Scheurer 2009; Curtis 2011; Waisman, Guivarch & Lecocq 2013). In contrast, frequency of service and transfer and wait times are important variables in this research, as they inform potential mobility.

3.2 Four scenarios

The four scenarios are: Scenario 1 ('S1', base scenario) HRC trunk and branch services as in the NDP 2012 Service Plan; Scenario 2 ('S2') replaces some elements of the NDP 2012 Service Plan with MRC; Scenario 3 ('S3') HRC trunk and branch services envisaged under NDP Stage 4 (includes expanded trunk and branch services); Scenario 4 ('S4') replaces some elements of the NDP Stage 4 Service Plan with MRC.

Mobility can be enhanced through a simple, frequent and reliable HRC, complemented by multi-modal feeder networks (Mees 2000; O'Connell & Roberts 2012; Hale & Eagleson 2013). Trunk sections form the backbone of such a network, and, in most cases, have the highest patronage. O'Connell and Roberts (2012) argue that trunk lines should be optimised by converting some branch sections to medium rail. The layout of the MRC additions used in S2 and S4 can be seen in Figure 1. The rationale and the implications for this layout are described below. The Alamein branch was selected for replacement by an MRC in this study, on the basis that the branch currently (and under Stage 4 of the NDP) imposes capacity constraints on the trunk rail line to which it connects. Under the 2012 Service Plan (NDP), the Alamein branch makes up 14.2% of peak services coming east of Camberwell (3 of 21 services an hour). However, in 2012, the Alamein line only accounted for 7.3% of the total patronage coming from east of (and not including) Camberwell (Public Transport Victoria 2013). As noted at Table 1, capacity per vehicle is lower with medium rail, however as stated in the NDP, the demand for services along heavy rail branches is less than on the trunks.

Converting the Alamein branch to MRC allows for the possibility of increased service provision on the Ringwood trunk in S2, and on the Glen Waverley trunk in S4. To maximise network effects, under the case study experiment, the MRC (north-south or Camberwell-Monash line) extends through to an interchange with the Glen Waverley trunk at East Malvern, further south to Chadstone Shopping Centre, and terminating at Monash University – Clayton: two areas identified by Delbosc and Currie (2011) as having poor supply of transit, relative to employment and residential density.

The NDP envisages the planning, construction and operation of four new heavy rail branch lines for Melbourne Airport, Doncaster, Fishermans Bend and Rowville. However, these heavy rail branches absorb much of the services added through capacity enhancing projects. For example, seven hourly services are added during peak on the Dandenong trunk by Stage 4 of the NDP however, six of these are allocated to the Rowville branch, providing minimal benefit to commuters who use trunk Dandenong services past the Rowville branch. The MRC proposed in S2 and S4 includes replacement for the Rowville heavy-rail branch envisaged in the NDP with medium rail infrastructure. This MRC would follow the same easement down North Road (and Wellington Road) as the Rowville branch (Rowville Rail Study - Stage 2 2014). This MRC would connect to the Dandenong trunk at Huntingdale Station, and the MRC (Camberwell-Monash line) at Monash University – Clayton. Given medium rail's cost benefits, and in order to apply best-practice principles to the alternative strategy, the MRC (east-west or Rowville-Gardenvale line) includes an extension further west along North Road connecting to the Dandenong (interchange: Huntingdale), Frankston (interchange: Ormond) and Sandringham (interchange: Gardenvale) trunks. The MRC applied under S2 and S4 is conceptually shown at Figure 1 (not to scale).

Figure 1: The case study, hypothetical MRCs used in Scenarios 2 and 4

The operational focus of S2 and S4 is different to the NDP. The emphasis of the NDP is to create cross-city links; for example Sunshine-Dandenong, and Burnley-Newport. This is useful from an operational perspective, but is not the focus of government policy or supportive of employment behaviour. A greater emphasis of S2 and S4 is on localised journeys. Direction 4.1 of Plan Melbourne (2014, p.114) envisages the creation of 20-minute neighbourhoods that offer access to 'a range of services and facilities including shops, cafés and restaurants, early-years centres, primary and secondary schools, parks and sporting fields... which are well-connected by... local public transport'. Localised work trips are also more significant than longer journeys in the investigation area: for example, over 77% of workers in the City of Monash have their residential location within one of the local municipalities in the investigation area (Census of Population and Housing 2011; City of Monash profile.id). The four scenarios are illustrated at Figures 2 – 5.

Figure 2: Scenario 1 (S1)

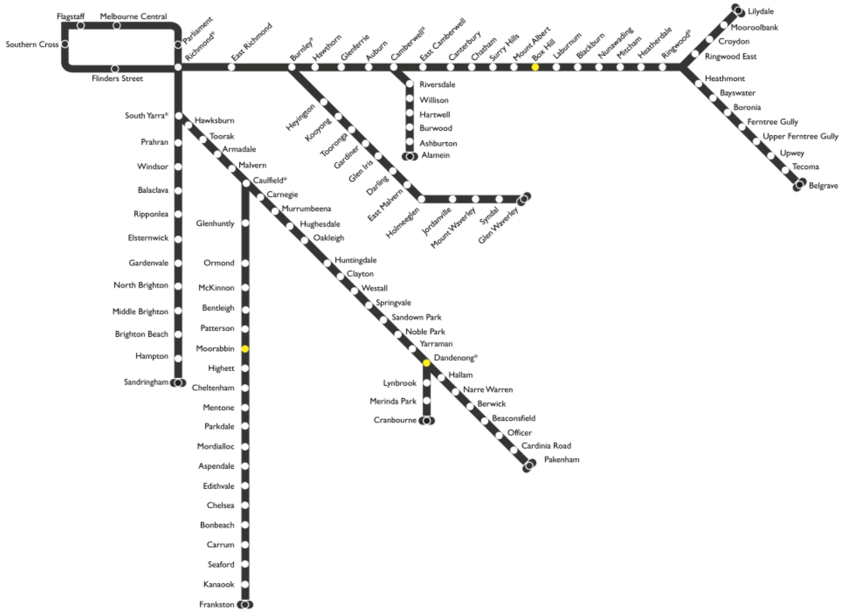


Figure 3: Scenario 2 (S2)

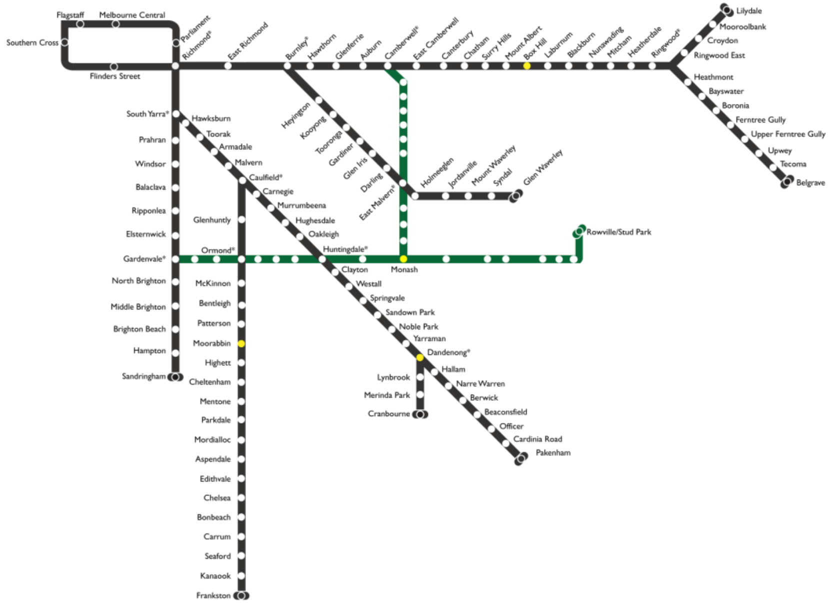
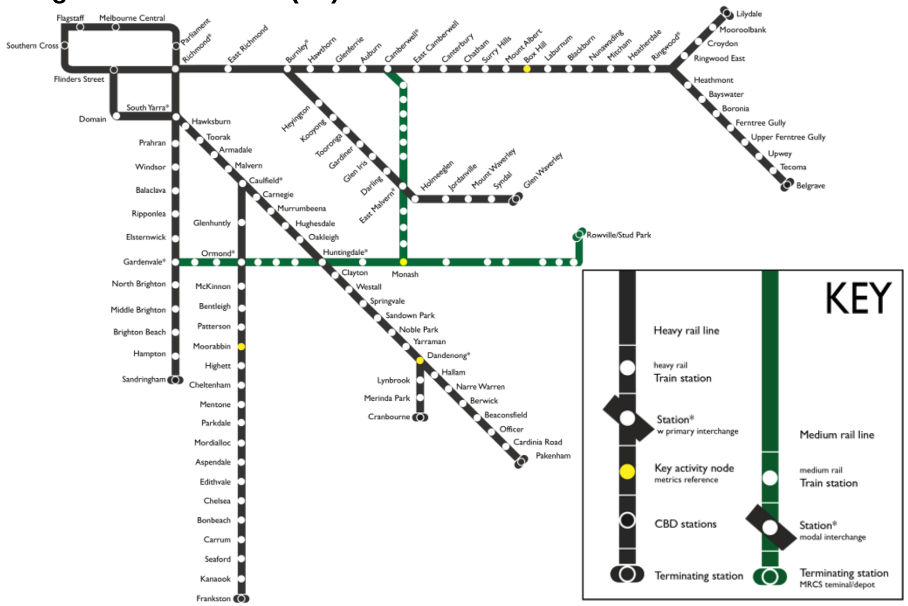


Figure 4: Scenario 3 (S3)

Figure 5: Scenario 4 (S4)



4. Research findings

4.1 Process

S1 (base scenario) applies a simple timetable structure based on the NDP's 2012 Service Plan. S2 incorporates the MRC into the transit network; the Alamein branch is decoupled from the HRC, increasing services on the Ringwood trunk timetable. Both the Camberwell-Monash (north-south) and Rowville-Gardenvale (east-west) MRC lines are operating. S3 applies a revised HRC timetable structure based on the Stage 4 Service Plan contained within the NDP, with increased frequencies to reflect improved capacities on the Sandringham, Frankston, Dandenong and Ringwood trunks. S3 assumes there is no MRC, and that a new branch on the Dandenong trunk services Rowville. The Alamein branch is heavy rail, serviced in accordance with the Stage 4 Service Plan; it is segregated from the Ringwood trunk and incorporated into the Glen Waverley trunk. The final scenario (S4) applies the same Stage 4 Service Plan timetable structure, with the exception that the MRC is again applied. The Alamein and Rowville branches are decoupled and MRC, resulting in increased services to the Dandenong and Glen Waverley trunk timetables compared to S3.

Under S2 and S4, where a branch is de-coupled from a heavy rail trunk, the additional services that have been made available are redistributed onto the respective HRC trunk. Where possible these redistributed services are evenly allocated across other services on the trunk; where not possible services are prioritised to lines with greater geographic coverage.

A single timetable was created for the MRC; as this network is de-coupled from the HRC, the timetable was generated independently; the same timetable is applied under S2 and S4. In accordance with best-practice service frequencies, both the Camberwell-Monash and Rowville-Gardenvale lines have services every five minutes, equating to 12 per hour (Nielsen et al 2005). The Camberwell to Monash West line is a 14.3 kilometre, 12 station route, with eight train units in operation to provide for five minute service frequencies; the hypothetical Stud Park to Gardenvale line has 12 units in operation along its 21.4 kilometre, 17 station route. The average train speed was assumed at approximately 43km/h, between the speed achieved by the Vancouver SkyTrain at 45km/h (Greater Vancouver Transportation Authority 2003) and 40km/h noted by O'Connell and Roberts (2012). For all timetables generated, where possible, trains are spaced evenly; where infrastructure is shared, the timetabling ensures no conflicts are created. This applies to both services on the same trunk line – for example, Belgrave to Parliament and Lilydale to Parliament services – and where services on different trunks use shared infrastructure (e.g. through the City Loop). As required for a real-time timetable, scheduling of these does not conflict across the entire experience.

The catchment metric investigates the coverage of the network that can be reached over 30 minutes from the key activity nodes: Moorabbin, Dandenong, Box Hill and Monash University – Clayton. Under the experiment, a person arrives at the defined station every minute from minute "0" to minute "29". Each person then moves across the network for 30 minutes; the metric is multi-directional; each possible journey is explored with the median stations that can be reached along all possible journeys being identified within the catchment area. The total (median) 'area' that can be reached is used for analysis in this research. Where the median stations reached falls within two stations, a conservative approach is applied and the closer station is recorded as the result. A total of 107 journey paths across the scenarios were considered (S1:14, S2:32, S3:22, S4:38).

The time to the CBD metric was a simple calculation test running for 30 minutes. The calculation measures the average time taken to alight in the city, if a person arrives at the origin station every minute across the course of the 30 minute experiment. The end station of each train line within the case study area was investigated, being: Lilydale, Belgrave, Alamein (noting that in S2 and S4 Alamein is not at the end of a line), Glen Waverley, Cranbourne, Pakenham, Frankston, Sandringham, and Rowville (not applicable under S1).

4.2 Moorabbin metrics

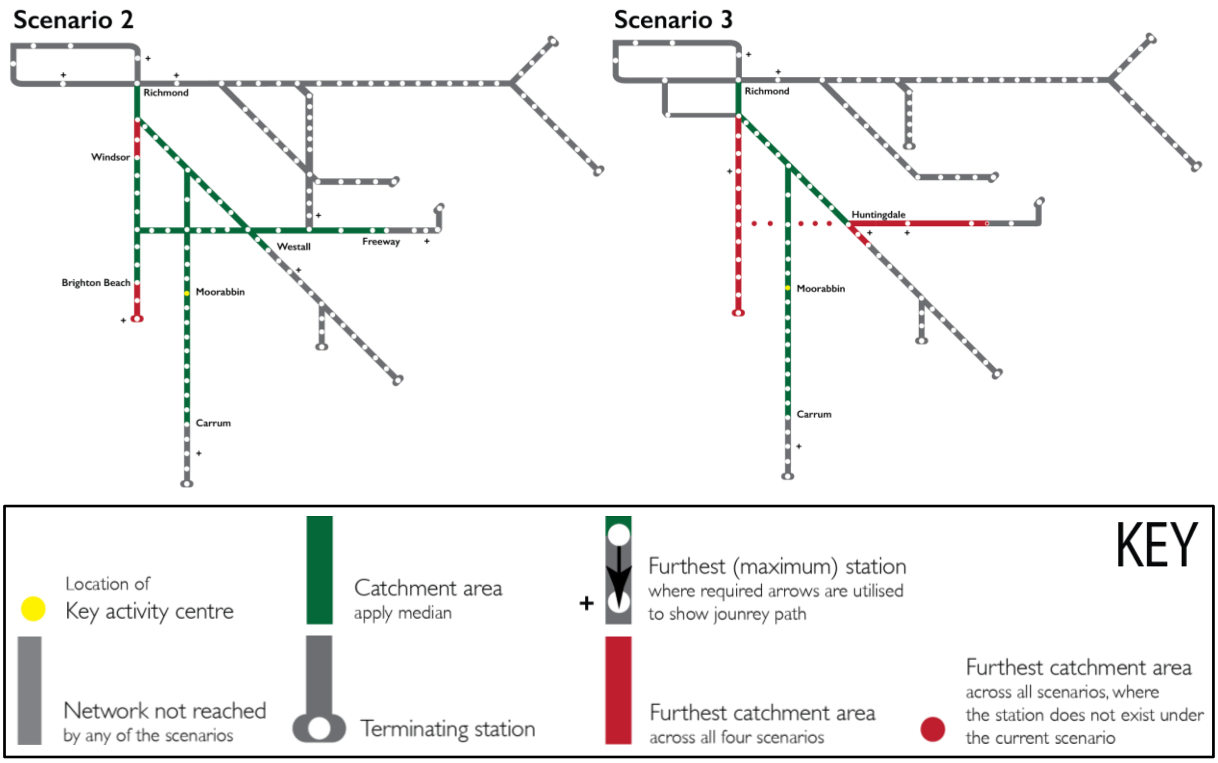
Table 2: Moorabbin catchment area

	S1	S2	S3	S4
Stations reached	27	47	27	51
Increase on base scenario	n/a	+20	0	+24

As shown at Table 2, there is a strong increase in Moorabbin's catchment area through the application of a decoupled strategy. The base scenario of 27 stations increased to 47 (increase of 20) under S2, and 51 (increase of 24) under S4. As the MRC presents greater opportunity for transfers and routes, a total of 11 alternative journey paths were investigated for S2 and S4. For example, all stations on the Sandringham trunk under S4 were within the catchment area, with the median stations being South Yarra (Moorabbin-Ormond-Gardenvale-South Yarra) and Sandringham (Moorabbin-Ormond-Gardenvale-Sandringham). The furthest station reached under S2 and S4 towards Rowville was Waverley Gardens, approximately 8km further along North Road than Huntingdale (the furthest point within the S1 and S3 catchment area).

A sketch model has been produced for all four scenarios. The sketch models below (Figure 6) provide a comparison between the catchments areas under Stage 4 implementation of the NDP (S3) and implementation of MRC without any HRC capacity enhancements (S2). There is no increase in catchment area through the implementation of heavy rail capacity projects (including a metro rail tunnel project). Without the implementation of these projects, but the application of the de-coupled MRC project (S2), the catchment area has increased considerably (from 27 to 47). Implementation of the NDP, complemented by the MRC (S4), provides some further catchment area advantages (four stations greater under S4 than S2).

Figure 6: Moorabbin catchment area, sketch model comparison between S2 and S3



4.3 Dandenong metrics

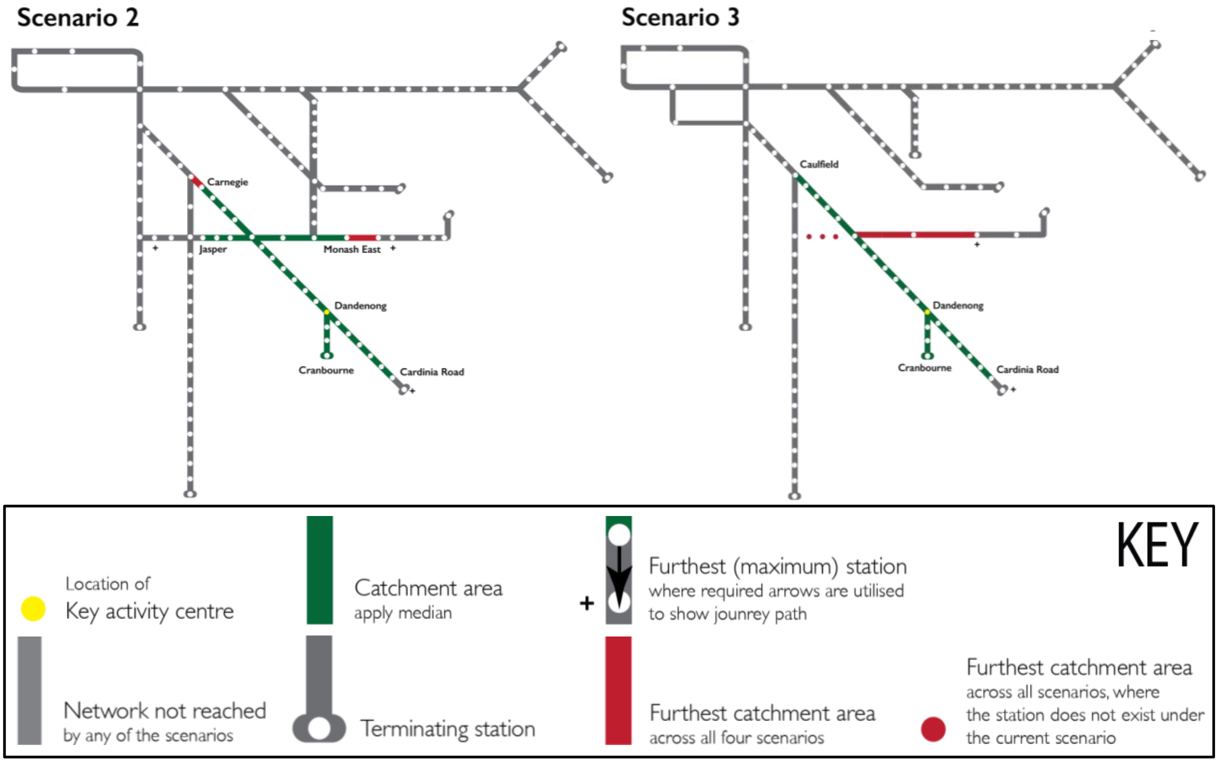
Table 3: Dandenong catchment area

	S1	S2	S3	S4
Stations reached	21	27	22	29
Increase on base scenario	n/a	+6	+1	+8

As shown at Table 3, the S1 (base scenario) catchment area from Dandenong totalled 21 stations. The catchment area under S2 was six stations greater than the base scenario (total: 27), and eight under S4 (total: 29), due to increased mobility through the application of the MRC. Under both scenarios (S2, S4), Jasper was the median station reached to the west (Dandenong-Huntingdale-Gardenvale), with the furthest station being Brighton East. Under S2, Monash East and Freeway were the median and maximum station reached along the Dandenong-Huntingdale-Stud Park route. Freeway remains the furthest station reached under S4, with the median and catchment area increasing to Mulgrave.

The sketch models below (Figure 7) present a strong case for the alternative strategy (S2 over S3). It shows that implementation of the MRC (S2) creates a significant mobility advantage to Stage 4 NDP, despite the introduction of a metro rail tunnel project and the Rowville heavy rail branch. Dandenong is not directly serviced by the Rowville branch or MRC, irrespective, the mobility outcomes between both scenarios are not equal. This conclusion is also supported by the time to the CBD metric; with capacity improvements under S3 and the introduction of the Rowville spur, there is only a 0.5 minute reduction in peak service journey times from Cranbourne to CBD (62.5 minutes). This is due to seven of the six additional peak services servicing Rowville and not the existing Cranbourne and Pakenham branches of the Dandenong trunk. Under S4, the implementation of the heavy rail capacity improvements and de-coupling the Rowville spur to MRC would see a two minute reduction in the average Cranbourne to CBD journey times.

Figure 7: Dandenong catchment area, sketch model comparison between S2 and S3



4.4 Box Hill metrics

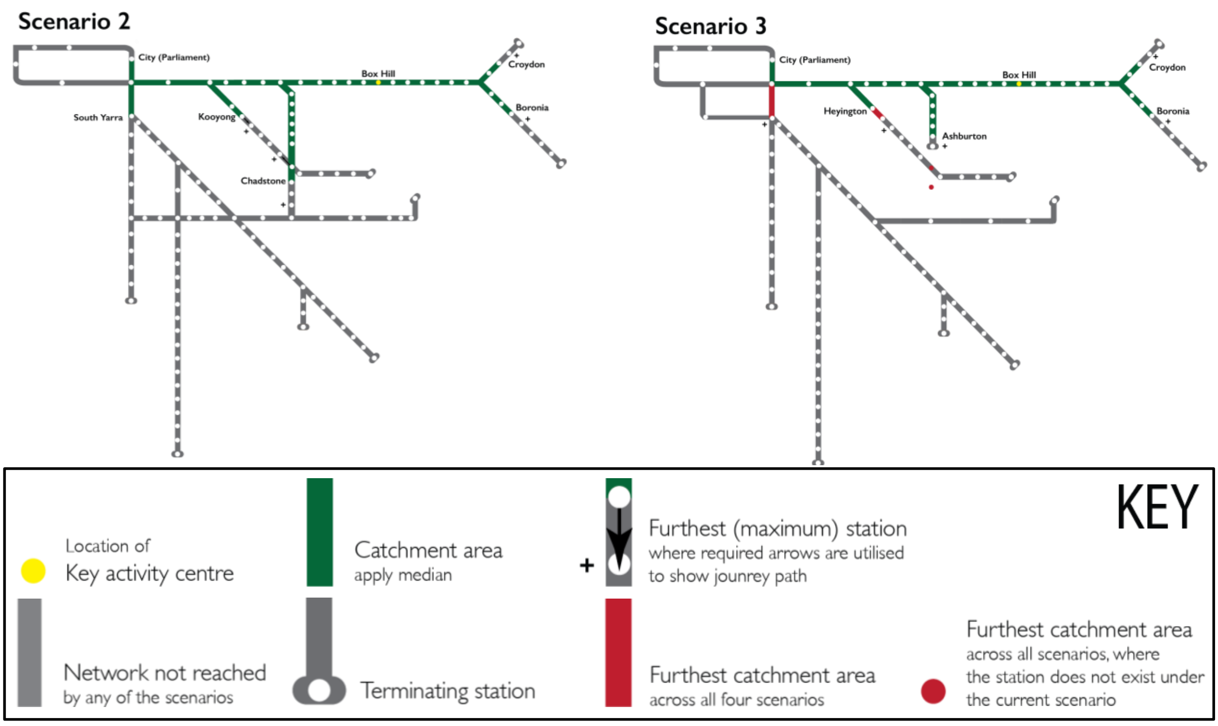
Table 4: Box Hill catchment area

	S1	S2	S3	S4
Stations reached	30	36	31	35
Increase on base scenario	n/a	+6	+2	+5

As shown at Table 4 and Figure 8, the four scenarios shared a number of similarities with regard to the Box Hill catchment, including three median and furthest stations. The de-coupling of the Alamein line under S2 and S4 saw increased service provision on the Ringwood trunk, meaning shorter wait times for trains. For a Box Hill-Burnley-Glen Waverley journey, the catchment area increased by a station from Heyington to Kooyong. The Box Hill catchment was the only nominated centre where S4 did not have the highest catchment area, with one less than S2's 36 stations. Under Stage 4 NDP, Dandenong trunk CBD services do not pass through Richmond. Accordingly, on a Box Hill-Richmond-South Yarra journey, S4 commuters could not use as many services as under S2. There are varied results with respect to Box Hill-Camberwell-Alamein journeys, whether Alamein is a terminating heavy rail station or on the MRC (Camberwell – Monash line). Under S1, the catchment area extends to Burwood (two stations short of Alamein), equating to 30 stations in total. The catchment area under S3 is a single station larger at 31, extending through to Ashburton. The MRC (Camberwell – Monash line) produces a superior catchment area. Under S2 and S4, Chadstone is the median station of this journey, with East Oakleigh being the furthest station reached.

With respect to the time to the CBD metric, the same reduction in journey times can be achieved on the Belgrave (71 minutes) and Lilydale (63.5 minutes) branches by de-coupling the Alamein line as through Stage 4 NDP. From Alamein to CBD journeys under S1, there is a large median and range of journey times, (range: 28 to 47, median: 36). There was only a modest improvement when applying Stage 4 NDP (S3, median: 32, range: 29-35). Under S2 there was a 6.5 and 13 minute reduction in the median (29.5) and maximum (34) journey times respectively, with comparable results under S4 (median: 30, range: 26 – 34).

Figure 8: Box Hill catchment area, sketch model comparison between S2 and S3



4.5 Monash metrics

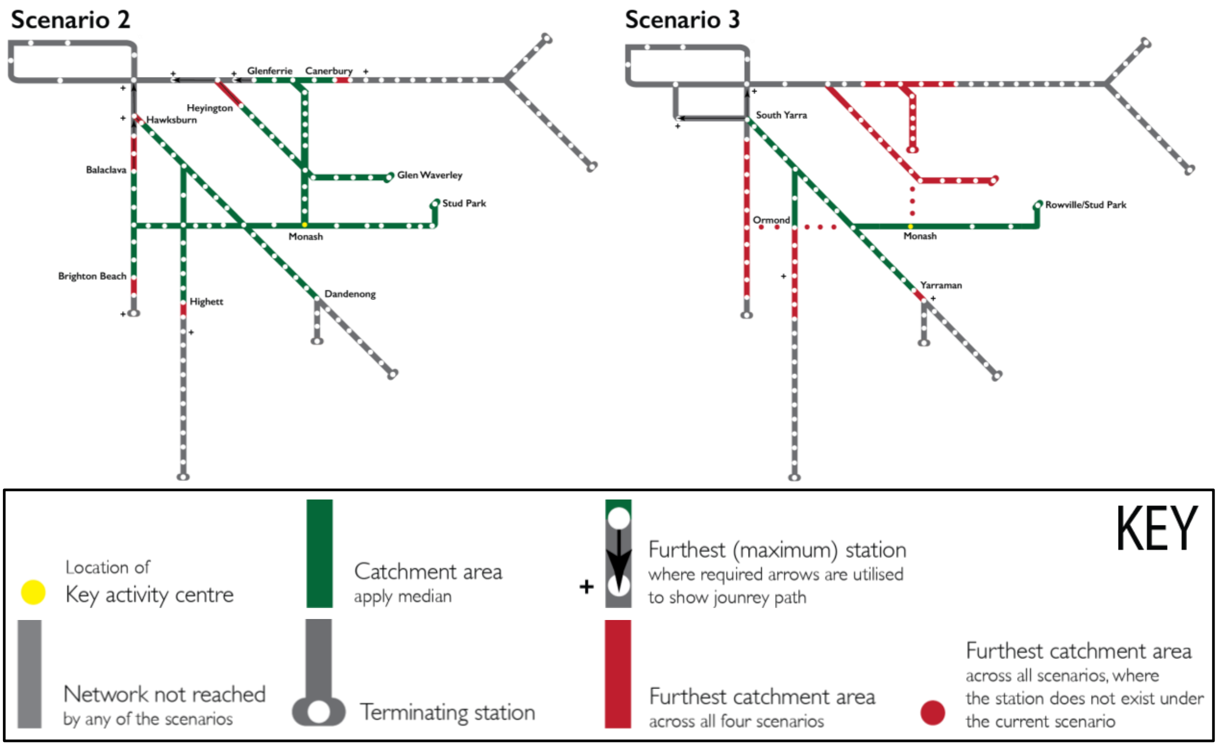
Table 5: Monash University – Clayton catchment area

	S1	S2	S3 (base)	S4
Stations reached	n/a	71	23	78
Increase on base scenario	n/a	+48	n/a	+55

The Monash catchment area showed the greatest variation in results; results are outlined at Table 5, and a sketch model comparing S2 to S3 is provided at Figure 9. S3 was treated as the base scenario in this test, as Monash is not serviced by high capacity, mass transit in S1. Stage 4 of the NDP envisages six services per peak hour to service Monash on the Rowville branch. Under S3, the catchment area reaches Rowville/Stud Park and South Yarra on city bound journeys. Three transfers were also investigated, with the first being Monash-Huntingdale-Dandenong. Yarraman was the median station reached along this route. A transfer at Caulfield, south to Frankston, also extended the catchment area to Ormond (max: Patterson). In total 23 stations were within the S3 (base scenario) catchment area. In contrast, respectively, 71 and 78 stations were within the S2 and S4 catchment areas. Under both S2 and S4, the entirety of the MRC is within the catchment area, with transfers onto HRC realised at Gardenvale, Ormond, Huntingdale, East Malvern and Camberwell. S4 marginally outperformed S2, due to, for the most part, more frequent services on the HRC. For example, Balaclava in S2 and Prahran in S4 are the extent of the Monash-Gardenvale-South Yarra route. The effect of increased services due to the de-coupled strategy is seen on the Monash-Huntingdale-Dandenong route; Rowville being de-coupled from the HRC between S3 and S4. As the Rowville branch's six heavy rail services are redistributed in S4 onto the Dandenong trunk, the catchment area under this scenario is Dandenong, as opposed to Yarraman under S3 (base scenario).

It is also noted that Rowville to CBD commuters would have a 0.5 minute shorter average journey time under S2 and S4 (50 minutes, this includes transfer times at Huntingdale from MRC to HRC) than under S3 (50.5 minutes, direct service).

Figure 9: Monash catchment area, sketch model comparison between S2 and S3



5. Discussion

This research explores whether there is a superior alternative to address Melbourne's transit deficits than extending the city's HRC, and whether capacity projects, such as the metro rail tunnel project, are essential prior to addressing transit deficits.

The case study has shown that an alternative approach to high-capacity transit can produce superior mobility to the NDP – some highlights are discussed below. Locales directly serviced under the MRC would hypothetically experience significant benefit. As discussed at Section 4.4, CBD journey times from Alamein would reduce by 6.5 minutes under S3 compared to 4 minutes through Stage 4 NDP. In addition, while a catchment area investigation was not carried out for Alamein, under S2, Alamein was within the Monash and Box Hill catchments; Alamein was not within any of the four catchments under S3. Furthermore, a transfer onto the Glen Waverley branch is one station away at East Malvern, which also enhances the catchment area for commuters on the Glen Waverley trunk. It is likely that the metrics understate S2's mobility superiority compared to S3. For example, a person leaving Alamein can reach Monash with the MRC in as little as 12 minutes; if a person was to use heavy rail services under S3, in the highly unlikely event that there were no waiting times, it would take 62 minutes for this journey. In terms of current public transport, including other modes, the PTV journey planner at 9am peak recommends three buses taking an estimated 60 minutes (Public Transport Victoria, Journey Planner 2014). A direct route between Alamein and Monash University - Clayton is less than 7km.

With regard to Rowville, only 0.5 minutes separated the CBD journey times between S2 and S3. In addition, the Monash catchment areas under S2 and S3 include Rowville (referring to the terminating station; S2 this refers to Stud Park; S3 this refers to the Rowville/Stud Park station). The results of the two metric, specifically for Rowville, are not conclusive in terms of whether S2 or S3 provides superior mobility. However, other key outputs for analysis were produced through the experiment process. Table 6 outlines the time savings from the four key activity centres to Rowville when applying the MRC (S2), as opposed to Stage 4 NDP (S3); time savings range from 13.7% to 28.3%. From the longest journey (Box Hill) to the shortest (Monash), there are evident time savings under S2 compared to S3. Further, there are only four stations indicated in the Rowville heavy rail branch *Rowville Rail Study - Stage 1 Feasibility Study 2012*. There are considerably more destinations that can be accessed, and more people will be within walking distance of the MRC with its additional stations (Kittelson 2003); this results in improved coverage and mobility under the S2 alternative.

Table 6: Journey times between key activity centres and Rowville

	Moorabbin	Dandenong	Box Hill	Monash
S2 median journey (minutes)	37.5	41	57	16
S3 median journey (minutes)	47	47.5	79.5	19.5
Time savings, S2 over S3	20.2%	13.7%	28.3%	23%

It is noted that S2 and S3 are very different in nature in terms of their proposal and scope, and therefore, cannot be used as direct comparison to answer this question. The NDP is a $30 billion plan that extends across the entirety of Melbourne's HRC, and includes a multiplicity of projects from the electrification of lines to signalling upgrades to increasing heavy rail capacity, particularly to the CBD (Carey 2013; NDP 2012); service frequencies are increased on the Sandringham, Frankston, Dandenong, and Glen Waverley trunks. The transition of Alamein onto the Glen Waverley trunk also increases the capacity of the Ringwood trunk's other services.

Accordingly, the approaches under S2 and S3 should be looked at as shorter-term comparators for addressing transit deficits today. S3 and S4 should be compared as differing longer-term strategic approaches. These scenarios share an equal number of heavy rail services, the difference being that S4 redistributes de-coupled branch services onto trunk lines. There are significantly larger catchment areas under S4, compared to S3; the Moorabbin, Dandenong, Monash and Box Hill catchment areas increase by approximately 89%, 32%, 24% and 13% under S4 compared to S3.

6. Conclusion

Although this research is limited in scope, since transit deficits and transit planning strategies have only been considered from a mobility perspective, and only a portion of Melbourne's transit network has been examined, it has still produced interesting findings.

The de-coupled transit network layout analysed in this research is based on best-practice transit principles. It permits the extension of grid-based services through middle suburbs and the creation of more frequent and simpler heavy rail trunk services. It supports strong connections between key activity nodes and abundant transfer opportunities (Nielsen et al 2005; Delbosc & Currie 2011; Mees & Dodson 2011; Hale & Eagleson 2013). The hypothetical MRC was strategically aligned to improve coverage and transfers with a middle Melbourne focus (where existing transit deficits are prominent). The experiment has shown that there are significant mobility advantages to addressing transit deficits through a MRC. It was also found that mobility on trunk transit lines are compromised when transit deficits are addressed by additional heavy rail branches; at least within the investigation area, the NDP contemplates investments that add capacity to trunk services, while at the same time proposing projects that consume this capacity on new heavy rail branches.

These findings have implications across Melbourne. In addition to Rowville, Melbourne Airport, Doncaster and Fishermans Bend are all to be serviced by future HRC branches under the NDP. It is argued that – provided best-practice transit planning is applied – these transit deficits could be better addressed through application of a de-coupled strategy. In addition, the Monash-Camberwell line detailed in this research could be extended further north through to Kew or south to Moorabbin. And the Rowville-Gardenvale line, has potential extensions through to St Kilda, Port Melbourne and Fishermans Bend (west), and Knox or Belgrave (east/north-east). It is noted that like the Alamein heavy rail branch, the Upfield trunk and Williamstown branch have services constrained under the current HRC, and should be considered transit deficits that may significantly benefit from de-coupling.

Our findings question the foundation of Melbourne's transport planning framework and challenge the primary assumption of the NDP that continuing to add to Melbourne's HRC is the best way to improve mobility and address transit deficits. Naturally, a case study focusing on mobility has its limitations, as it does not consider the transit network in its entirety and only briefly considers other factors of MRC, such as financial and engineering implications. The case study also does not encompass cross-city linkages that are enhanced through the NDP; and while it does consider the importance of linkages between key activity centres, it does not model the relationship between mobility and land use, as for example, SNAMUTS does. However, this research strongly suggests that better transit outcomes can be achieved than those that might be expected from the NDP.

With $30 billion of infrastructure construction included in the NDP, a re-think of its basic assumptions – including trunk and branch HRC structures, and CBD centrality – is urgently required.

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