Infrastructure constraints or poor service planning? Increasing service to Melbourne's City Loop and Dandenong rail corridor

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1 Introduction

In 1925, Melbourne's Metropolitan Town Planning Commission released its first report, dealing mainly with the question of public transport. The Commission noted that suburban rail patronage had tripled over the previous two decades, reaching a total of 158 million in 1924 without creating capacity problems. Railway authorities attributed the increased system capacity to "automatic signalling, electric traction, longer trains [and] the provision of two double tracks right through from Flinders Street to North Melbourne". As a result, "so far as the Flinders-Street station is concerned, its capacity to handle traffic has by no means been exhausted" (MTPC, 1925, p. 13). The Commission predicted that patronage would continue to increase, to some 370 million in 1964, and consequently recommended the construction of a city underground railway. The Commission did not believe an underground was necessary to deal with congestion of trains at Flinders Street, but rather congestion of passengers.

The projections were wrong, because they didn't foresee the effect of the car. Rail patronage peaked at 201 million in 1950, then declined steadily for three decades. By 1964, the total was only 170 million, and the number of trains entering Flinders Street in the busiest hour of the day had fallen from 116 in 1929 to 108. But the Melbourne Transportation Plan of 1969 (MTC, 1969a) predicted that train numbers would increase to 181 per hour by 1985, and recommended building a city underground rail loop to cope with them. The loop was built, but current patronage is no higher now than in 1964, and the number of suburban trains entering Flinders Street in the busiest hour has fallen to only 90. Although it was probably not needed, the loop should at least ensure that Melbourne has enough rail capacity to absorb any conceivable increase in demand. Its planners designed it to accommodate the predicted 1985 traffic of 181 trains per hour, plus "the capacity for expansion beyond the design year" (MTC, 1969a, p. 34).

Given that the rail system handled more suburban trains in peak hour eight decades ago than it does now, without the added capacity provided by the city loop and modern signalling, observers from outside Melbourne could be forgiven for wondering why this paper is being presented at all. The reason is that there have been repeated claims, from apparently authoritative sources, that the rail system is at capacity in peak period, and could not accommodate more train services without the expenditure of perhaps billions of dollars. The alleged capacity crisis has been widely reported in the media, and offered as a justification for the deteriorating reliability of Melbourne's rail system. In addition to the city loop, the Dandenong rail line, which serves one of Melbourne's designated growth corridors, has been identified as a major capacity bottleneck. The Victorian government's 2006 *Meeting Our Transport Challenges* statement (DOI, 2006) accepted these claims and proposed substantial investment in new capacity on both the city loop and the Dandenong corridor. At no point in this process, however, has anyone publicly released any studies or other evidence to show that there really is a capacity crisis.

This paper seeks to establish that alternative approaches exist which would enable a more efficient use of the track infrastructure on Melbourne's city loop and Dandenong line. These approaches are derived from international 'best practice' in Europe (and to some extent Perth) and from Vukan Vuchic's urban rail planning 'bible' (Vuchic, 2005). To illustrate one possible option for the Dandenong line, a sample of a possible timetable is also produced.

2 How many trains can the City Loop carry?

As Vuchic (2005, chapter 2) notes, the capacity of a rail line is determined by the number of tracks and platforms in the peak direction of travel, at the busiest point in the system. In Melbourne's case, the key point is the city centre, and there are eight in-bound tracks and platforms: five through Richmond station, one through Jolimont and two through North Melbourne (in addition, North Melbourne has a third in-bound track that terminates at Southern Cross/Spencer Street station: the following analysis assumes that track is only used for country services). This should be compared with Sydney's rail system, which carries many more passengers as Melbourne's, but has only six tracks entering the city centre.

Each of the eight tracks can accommodate 24 trains per hour, or a train every 2'30". That this is a modest figure can be seen from a comparison with the Yonge subway line in Toronto, the busiest section of which opened in 1954 and has only one track in each direction. The Yonge line currently carries a train every 2'21" on average in peak period, or 25.5 services per hour (TTC, 2005). Vuchic (2005: 97) notes that sections of the London Underground achieve 38 trains per hour, "while some systems reach only… 24 [trains/hour]" (emphasis added).

So the capacity of the city centre terminal as a whole is 24 times 8, or 192, trains an hour. If each train carried 800 passengers (550 seated, 250 standing), this would enable 153,600 passengers to enter the city centre in the busiest peak hour. This should be compared with the actual 2001 census figure of 118,500 workers using trains per day across Melbourne, of whom fewer than 100,000 entered the city centre at all, let alone in the busiest hour. In fact, the passenger carrying capacity of the city loop is sufficient to permit all 200,000 workers employed in Melbourne's CBD to arrive by train in less than 90 minutes, with none using other transport modes or arriving outside this period!

The main reason the impression has been created of a capacity problem is that the city loop is not currently operated in the way it was designed. While there are eight tracks entering the city centre, there are only four tunnels in the city loop: trains from the four remaining tracks were intended to proceed directly to Flinders Street, and then continue through to the other side of the city. The loop was intended to balance the flow of trains from east and west and to augment the 'direct to Flinders Street' capacity, not to replace it:

> Services would be arranged so that some of the trains on each line would run directly to or from one of the loop lines and the remainder directly to or from… Flinders Street (MTC, 1969a, p. 34).

In contravention of these 'instructions', current rail timetables schedule all, or most, trains through the loop, with few or none on the remaining direct tracks. For example, there are currently two tracks entering the city centre from the Dandenong and Frankston lines, passing through Caulfield station. In the morning peak, one of these tracks corresponds to a loop line, the other to a direct line to Flinders Street. Currently, 19 of the 20 Caulfield trains arriving at Flinders Street between 8:00 and 8:59 run through the loop, utilising around 80% of the capacity of the loop tunnel. If only the capacity of this tunnel is considered, it appears that train numbers can be increased by no more than 25%. But this ignores the fact that little of the capacity of the direct line to Flinders Street is currently being used; the real potential increase in train numbers is closer to 125% than 25%.

A similar situation applies in the case of trains from the Belgrave, Lilydale and Glen Waverley lines. These also share two in-bound tracks, one of which corresponds to the 'Burnley loop', which carries 21 trains arriving at Flinders Street between 8:00 and 8:59 am. The additional direct line to Flinders Street only carries 8 trains, so spare capacity exists for a further 19 trains an hour. The loop line through North Melbourne station sees 19 trains between 8:00 and 8:59 am, but is one of two in-bound lines through that station. The other line is used by only 6 suburban trains in the busiest hour, so again, only half the available capacity is being

utilised. The only loop line without additional 'direct to Flinders Street' capacity is the Clifton Hill loop, which serves a single platform per direction at Jolimont station, but this line only sees 11 trains between 8:00 and 8:59 at present. (The capacity of this Clifton Hill line is limited, in the morning peak only, by the design of the loop tunnel entrance, which requires trains entering the tunnel to cross the path of out-bound trains from Flinders Street station. As with the other lines discussed above, this is only a problem if operators insist on running all city-bound trains through the loop: the simplest solution is to run additional services direct to Flinders Street. The problem does not occur during the evening peak, because the city loop runs in the reverse direction.)

So provided services are timetabled and operated competently, there is no part of the city loop or other central city terminal facilities that is in danger of approaching its train-carrying capacity in the foreseeable future.

3 How many trains can the Dandenong line carry?

The Dandenong rail corridor (which serves suburban trains on the Pakenham and Cranbourne lines, as well as V/Line trains to the LaTrobe Valley) is said to be the other critical choke point on Melbourne's rail system. Both Connex and the Director of Public Transport blame poor reliability on the lack of carrying capacity on this line.

The proposed solution, set out in the *Meeting Our Transport Challenges*, is the addition of a third track between Caulfield and Dandenong (there are already four tracks, shared with Frankston trains, between Caulfield and the city). The proposal is presumably inspired by the third track constructed on the adjacent Frankston line during the 1970s. Given this context, it may be worth noting that daily Frankston line patronage is around 25% lower than it was before the third line was built (see next page). There are only 5 inbound express trains on the Frankston line in the busiest hour of the morning peak in 2007, compared with the 28 projected in 1969 (MTC, 1969, pp. 36-7), suggesting that the third track on this line was probably not needed.

The Dandenong line triplication is predicted to cost up to a billion dollars and take at least a decade to complete. The first stage, between Caulfield and Springvale, is due to commence (not finish) between 2006 and 2011; the second stage, to Dandenong, between 2011 and 2016, and the final stage, a fourth platform at Dandenong, some time after 2021 (DOI, 2006, pp. 40-1). This very long time-frame, to add 19 kilometres of single track, can be contrasted with Perth's new 71-km Southern Railway, which includes a tunnel under the city centre and two underground stations, and will open later this year after a construction period of less than four years (see www.newmetrorail.wa.gov.au).

3.1 Current patronage on the Dandenong line

There is no publicly available data that gives a current, detailed picture of Dandenong line usage. In 2001, daily boardings on the Dandenong line were estimated at 50,327, which made Dandenong the second-busiest corridor after Ringwood (75,891 boardings) (Booz Allen Hamilton, 2002, p. 13). The Frankston line is less busy, with only 44,000 passengers per day: this contrasts with the situation in 1964 (i.e. before the third track was added to the Frankston line), when the Frankston line carried 59,000 per day and Dandenong 50,000 (MTC, 1969b, p. 45). Current daily boardings on the Dandenong line are some 20% higher than in 2001, giving a figure of approximately 60,000 per day.

By international standards, 60,000 daily boardings makes Dandenong a lightly-loaded urban rail corridor. The outer terminal station of Toronto's Yonge subway line (Finch station) handled 91,336 passengers a day in 2006 (TTC, 2006), while the whole line carried around 450,000, with only two tracks and similar trains to Melbourne. Two-track lines on European

metros carry up to a million passengers per day, while Vancouver's Expo light rail line carries around 180,000. Professor Vukan Vuchic's urban transit planning 'bible' cites 60,000 passengers as the hourly single-direction capacity of a well-managed urban rail line (Vuchic, 2005, p. 94).

Meeting Our Transport Challenges states that in the two-hour morning peak, the Dandenong line carries 12,000 passengers (DOI, 2006, p. 27), but this includes passengers travelling against the peak (i.e. away from the City in the morning), so the actual peak period, peak-direction load is less than 11,000. The peak point load is even lower than this, because not all peak-direction passengers travel the whole way into the city (for example, a passenger may board at Dandenong and alight at Clayton, with the seat then used a second time by someone boarding at Clayton for the City). The true peak-point load is likely to be close to 10,000 passengers over the 2-hour period, but the following discussion will use the higher figure of 11,000 to be conservative.

3.2 The current Dandenong timetable already provides enough seats

The current Connex timetable shows 21 Dandenong line suburban trains arriving at Flinders Street between 7:30 and 9:30 am (see Figure 1), so the morning peak load of 11,000 in the peak direction represents an average of 524 passengers per train. A 6-car X-Trapolis train seats 548 passengers, while a Siemens train seats 528, so the current service actually provides enough capacity to give every passenger a seat. Why, then, are there crowding problems?

The first reason is that most mornings less than the full complement of 21 services actually runs, and those trains that do run are often late. Even a train which meets the current standard for on-time running, by being 5 minutes 59 seconds late, may have two train-loads of passengers waiting for it. This is why former Auditor-General Ches Baragwanath recommended in 1998 that the standard for on-time running be raised from 5 minutes (the standard before privatization) to 3 minutes (the current standard in Perth), at least for peak services; instead, the standard was relaxed to 6 minutes.

The second reason is that the current timetable provides very poor utilisation of those 21 services, with the result that even when all scheduled trains run on time, some trains are overcrowded while others have seats to spare. This is a product of the uneven scheduling of services, and the poor arrangement of express and stopping services. Although passenger demand is not spread evenly throughout the two-hour peak, the variations in service level in this period do not correspond to the variations in demand: in fact, as illustrated below, sometimes the worst service is offered at the busiest periods.

To illustrate this point, consider a City-bound passenger travelling from Carnegie in the morning peak. Figure 1 shows that there is:

- a train at 7:02 am, followed by a 20-minute gap then three trains at 4-minute intervals (7:22, 7:26, 7:30)
- then a ten-minute gap followed by three trains at 3-minute intervals (7:40, 7:43, 7:46)
- then gaps of 12, 11, 13, 8 and 12 minutes (7:58, 8:09, 8:22, 8:30, 8:42), followed another group of 3 trains close together (8:42, 8:47, 8:53).

Apart from being confusing, this service pattern actually provides the lowest level of service to Carnegie precisely at the time when most passengers wish to travel from this station (7:50 to 8:40), while ensuring that other trains (e.g. the 7:26, 7:43 and 8:53) have empty seats (at least when the trains preceding then run, and turn up on time).

The justification offered by Connex for this inefficient service pattern is the need to accommodate express suburban services and V/Line services from the LaTrobe Valley. The Director of Public Transport supports this view, arguing that:

> Once you mix these different types of service on the same tracks, you begin to eat away at the capacity of the network: you can't have an express running into the back of a stopper, so you have to separate them out. That means building intervals into the rail timetable which chew up time and limit your ability to run more services (Betts, 2007).

Monday to Friday Pakenham & Cranbourne to City

Station		AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
Pakenham	Dep	6:13	6:26	*	..	..	6:41	6:46	6:53	..	..	7:03	7:11	7:24	..	..	7:29	..	7:44	..	7:49	..	..		8:10	8:25
Officer		6:18	6:31	*	..	..	*	6:51	*	..	..	7:08	*	*	..	..	7:34	..	*	..	7:54	..	..		8:15	*
Beaconsfield		6:22	6:35	*	..	..	*	6:54	*	..	..	7:11	*	*	..	..	7:38	..	*	..	7:58	..	..		8:19	*
Berwick		6:25	6:38	Service	..	..	6:50	6:58	7:02	..	..	7:15	7:20	Service	..	..	7:41	..	Service	..	8:01	..	..		8:22	Service
Narre Warren		6:29	6:42		..	..	6:54	7:02	7:06	..	..	7:19	7:24		..	..	7:45	..		..	8:05	..	..		8:26	
Hallam		6:32	6:45		..	..	6:57	7:05	7:09	..	..	7:22	7:27		..	..	7:48	..		..	8:08	..	..		8:29	
Cranbourne	Dep	..	..	V/Line	6:46	..	..	..	..	..	7:10	..	..	V/Line	..	7:38	..	..	V/Line	7:54	..	..	8:10		..	V/Line
Merinda Park		..	..		6:48	..	..	..	..	..	7:12	..	..		..	7:40	..	..		7:56	..	..	8:12		..	
		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8:22		..	..
Dandenong	Dep	**6:38**	**6:52**	**6:55**	**6:58**	**7:01**	**7:05**	**7:12**	**7:16**	**7:19**	**7:22**	**7:29**	**7:34**	**7:41**	**7:45**	**7:50**	**7:55**	**7:58**	**8:01**	**8:06**	**8:15**	**8:18**	**8:23**		**8:36**	**8:43**
Yarraman		6:41	6:55	*	7:01	7:04	7:08	7:15	7:19	7:22	7:25	7:32	7:37	*	7:48	7:53	7:58	8:01	*	8:09	*	8:21	8:26		8:39	*
Noble Park		6:43	6:57	*	7:03	7:06	7:10	7:17	7:21	7:24	7:27	7:34	7:39	*	7:50	7:55	8:00	8:03	*	8:11	*	8:23	8:28		8:41	*
Sandown Park		6:45	6:59	*	7:05	7:08	7:12	7:19	7:23	7:26	7:29	7:36	7:41	*	7:52	7:57	8:02	8:05	*	8:13	*	8:25	8:30		8:43	*
Springvale		6:47	7:01	*	7:07	7:10	7:14	7:21	7:25	7:28	7:31	7:38	7:43	*	7:54	7:59	8:04	8:07	*	8:15	8:22	8:27	8:32		8:45	*
Westall		6:49	*	*	7:09	7:12	7:16	7:23	7:27	7:30	7:33	7:40	7:45	*	7:56	8:01	8:06	8:09	*	8:17	*	8:29	8:34	8:40	8:47	*
Clayton		6:52	7:04	*	7:12	7:15	7:19	7:26	7:30	7:33	7:36	7:43	7:48	7:52	7:59	8:04	8:09	8:12	8:15	8:20	8:27	8:32	8:37	8:43	8:50	8:53
Huntingdale		6:54	*	*	7:14	7:17	7:21	7:28	7:32	7:35	7:38	7:45	7:50	*	8:01	8:06	8:11	8:14	*	8:22	*	8:34	8:39	8:45	8:52	*
Oakleigh	Dep	6:57	7:08	*	7:17	7:21	7:25	7:31	7:35	7:38	7:41	7:48	7:53	*	8:04	8:09	8:14	8:17	*	8:25	8:30	8:37	8:42	8:48	8:55	*
Hughesdale		6:59	*	*	7:19	7:23	7:27	*	7:37	7:40	7:43	*	7:55	*	8:06	*	*	8:19	*	8:27	*	8:39	8:44	8:50	8:57	*
Murrumbeena		7:00	*	*	7:20	7:24	7:28	*	7:38	7:41	7:44	*	7:56	*	8:07	*	*	8:20	*	8:28	*	8:40	8:45	8:51	8:58	*
Carnegie		7:02	*	*	7:22	7:26	7:30	*	7:40	7:43	7:46	*	7:58	*	8:09	*	*	8:22	*	8:30	*	8:42	8:47	8:53	9:00	*
Caulfield		7:06	7:14	*	7:26	7:30	7:34	7:37	7:44	7:47	7:50	7:54	8:02	8:05	8:13	8:15	8:20	8:26	8:28	8:34	8:36	8:46	8:51	8:56	9:03	9:06
Malvern		7:08	*	*	*	7:32	*	*	7:46	7:49	7:52	*	8:04	*	8:15	*	*	8:28	*	8:36	*	8:48	8:53	*	*	*
Armadale		7:10	*	*	*	7:34	*	*	7:48	7:51	*	*	8:06	*	8:17	*	*	8:30	*	8:38	*	8:50	*	*	*	*
Toorak		7:12	*	*	*	7:36	*	*	7:50	7:53	*	*	8:08	*	8:19	*	*	8:32	*	8:40	*	8:52	*	*	*	*
Hawksburn		7:14	*	*	*	7:38	*	*	7:52	7:55	*	*	8:10	*	8:21	*	*	8:34	*	8:42	*	8:54	*	*	*	*
South Yarra		7:16	7:20	*	7:32	7:40	7:40	7:43	7:54	7:57	7:57	8:00	8:12	*	8:23	8:21	8:26	8:36	*	8:44	8:42	8:56	8:59	9:02	9:09	*
Richmond		7:19	7:23	7:25	7:35	7:43	7:43	7:46	7:57	8:00	8:00	8:03	8:15	8:14	8:26	8:24	8:29	8:39	8:38	8:47	8:45	8:59	9:02	9:05	9:11	9:15
Parliament		7:22	7:26	..	7:38	..	7:46	7:49	8:00	..	8:03	8:06	8:18	..	8:29	8:27	8:32	8:42	..	8:50	8:48	9:02	9:05	9:08	9:14	..
Melbourne Central		7:24	7:28	..	7:40	..	7:48	7:51	8:02	..	8:05	8:08	8:20	..	8:31	8:29	8:34	8:44	..	8:52	8:50	9:04	9:07	9:10	9:16	..
Flagstaff		7:26	:30	..	7:42	..	7:50	7:53	8:04	..	8:07	8:10	8:22	..	8:33	8:31	8:36	8:46	..	8:54	8:51	9:06	9:09	9:12	9:18	..
Spencer Street		7:28	7:32		7:44	..	7:52	7:55	8:06	..	8:09	8:12	8:24		8:35	8:33	8:38	8:48		8:56	8:54	9:08	9:11	9:14	9:20	9:27
Flinders Street	Arr	**7:32**	**7:36**	**7:29**	**7:48**	**7:47**	**7:56**	**7:59**	**8:10**	**8:04**	**8:13**	**8:16**	**8:28**	**8:18**	**8:39**	**8:37**	**8:42**	**8:52**	**8:42**	**9:00**	**8:58**	**9:12**	**9:15**	**9:18**	**9:24**	**9:20**

Figure 1: Dandenong line morning peak timetable 2007

Source: Connex and V/Line printed timetables

This is not the case for the Dandenong line, however: the current patronage and service levels fall so far short of the actual capacity of the line that it is possible to run more express services, more V/Line services and more stopping services than at present, and to spread services more evenly to balance loads and prevent overcrowding. The only proviso is that services are timetabled and operated efficiently.

The third problem is the poor design of Siemens trains used on the Dandenong line. Siemens trains provide only two doors in each carriage which results in an uneven distribution of standing passengers, and ultimately in crowding at the doors. It would be a better idea to redeploy X-Trapolis trains, which have three doors per carriage, to the Dandenong line and to use the Siemens trains on quieter lines.

3.3 How the current timetable wastes line capacity

Let's consider the issue by looking at one of the worst examples of overcrowded trains, the 7:45 am from Dandenong. This train has to carry a lot of passengers because it follows an 11-minute gap in suburban services from Dandenong. Because the train stops all stations, it picks up passengers from the outer and inner sections of the line; by the time passengers close to the city wish to board the train, it is full.

A V/Line train (the 6 am from Traralgon) runs in the 11-minute gap before the 7:45 suburban service, so at first glance this looks like an illustration of the difficulty caused by the need to accommodate different types of service, and therefore a problem that requires a third track to solve it. But this is not the case, as can be seen by comparing the current timetable with the way the same V/Line service was slotted into the suburban network two decades ago (Figure 2).

1985 **2007**

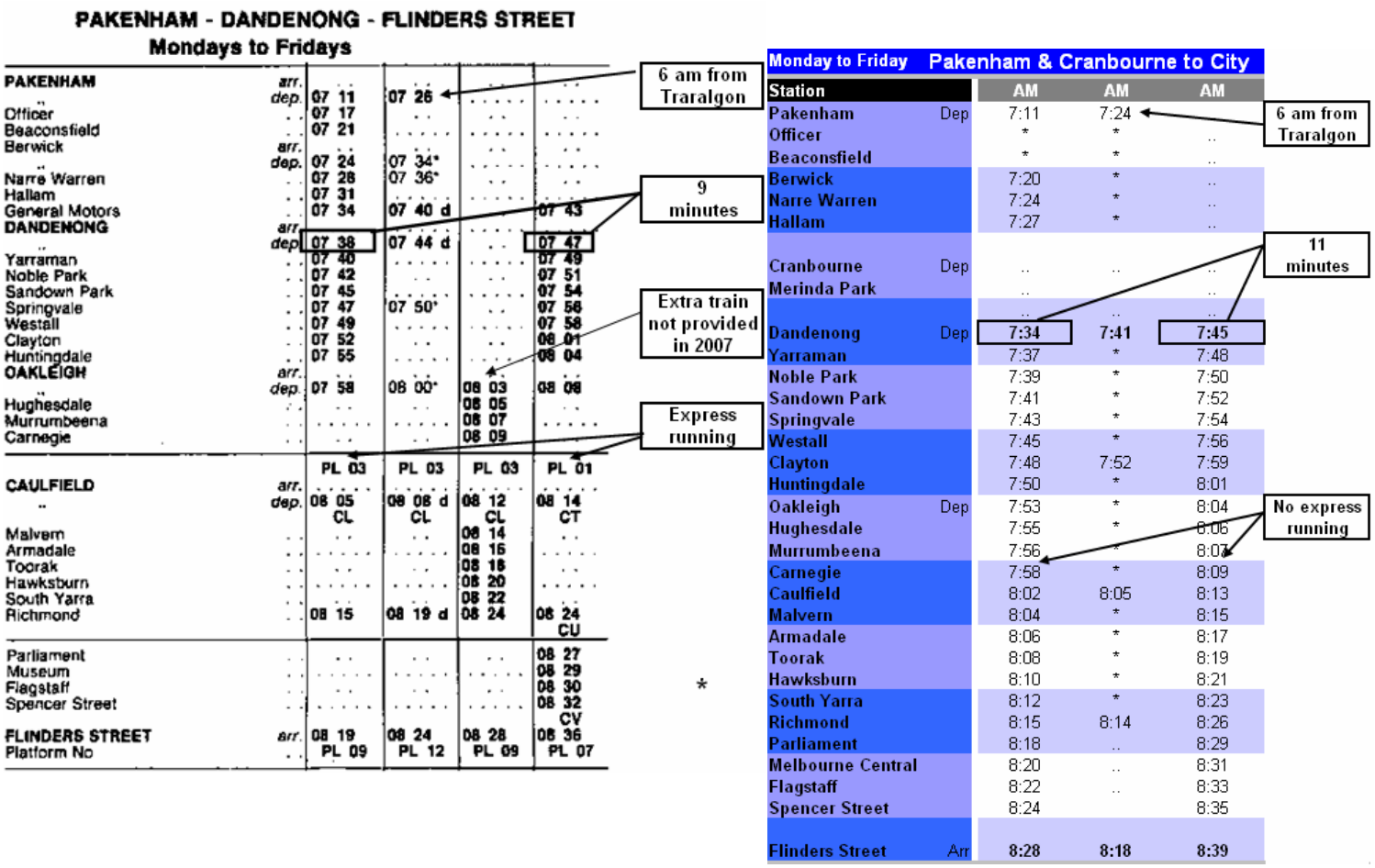

Figure 2: Efficient and inefficient timetabling: The 6 am from Traralgon and suburban trains

(Note: times marked * are 'pass throughs', not stops)
Sources: 1985 working timetable; Figure 1

The 1985 timetable accommodated the V/Line service plus three suburban trains within 9 minutes - two expresses plus a stopping all stations train from Oakleigh - compared to two stopping-all-stations trains within 11 minutes in 2007. The current timetable accommodates the same V/Line train as in 1985, but in an inefficient way that gives suburban passengers

one less train, less express running, longer waits and overcrowding. The basic differences in approach are:

- In 2007, the V/Line service is scheduled to follow a stopping-all-stations service; this creates a big difference in running time between Dandenong and Caulfield, necessitating a long gap between the two trains. In 1985 it was scheduled behind an express (from Oakleigh), enabling a shorter gap between the suburban service and the V/Line train following it.

- The 7:45 suburban service leaves Dandenong 4 minutes after the V/Line train in 2007, compared with a 3 minute gap for the equivalent train in 1985. The combined impact of this with the difference identified above is that the gap between suburban trains at Dandenong is now 11 minutes, compared with 9 minutes in 1985.

- In 2007, a stopping all stations train from Dandenong is the first service scheduled after the V/Line train. In 1985 it was an express; this reduced the delay for city-bound passengers compared with the current pattern.

- In 1985 a third service was provided, leaving Oakleigh station (utilizing the third platform there) shortly after the V/Line service passed through, thus preventing a long wait at stations like Carnegie. In 2007 there are no services originating at Oakleigh, so passengers at stations like Carnegie must wait for the stopping all stations service to come all the way from Dandenong; to add insult to injury this train is overcrowded by the time it reaches them.

Another example of inefficient timetabling is provided by the following V/Line service, the 6:40 from Traralgon, which did not operate in 1985. This train leaves Dandenong at 8:01 am, three minutes behind the 7:58 stopping-all-stations train (see Figure 1), and crawls along behind this train to Caulfield, before finally overtaking it on the extra tracks between Caulfield and Richmond. The slow suburban travel wastes most of the time saved by skipping country stations like Trafalgar. This time, it is V/Line passengers who are disadvantaged by the inefficient timetabling rather than Connex passengers, but the point is the same: the problem has been created by bad planning, not by inadequate infrastructure.

3.4 What infrastructure is available?

The Dandenong line is not simply a two-track line. The section between Caulfield and the city has four tracks, or two per direction, enabling express trains to overtake slower services in both directions at all times of the day. These tracks are shared with Frankston line services, but the Frankston line has lower patronage (see above) and slower projected growth in demand than the Dandenong line, which services a major growth corridor. There are also ‘turnbacks’, or third tracks and platforms, at Oakleigh and Dandenong, enabling services to terminate at both those stations without getting in the way of continuing services.

The third platform at Oakleigh (Figure 3), which was built nearly a century ago, is particularly significant. Until about 15 years ago, it was used to enable trains to originate and terminate at Oakleigh, stopping all stations to the city and allowing most peak services from Dandenong to run express from Oakleigh (see Figure 3). This service pattern, which is also found on the Perth Northern Suburbs line, is called ‘zonal’ operation, and Vuchic points out that it enables services to be speeded up, as well as increasing the efficiency with which rolling stock is utilised (Vuchic, 2005, pp. 128-130). Because Oakleigh is only four stations from the beginning of the four-track section of line at Caulfield, these Oakleigh services can be added to the timetable without significantly limiting the potential to offer express services, which can overtake the Oakleigh services at or after Caulfield.

It is also important to note that the signalling along the Dandenong line is relatively modern, having been upgraded during the 1990s, and that both suburban and V/Line trains have superior speed and acceleration to the 'red rattlers' and 'Harris' trains that were widely used until the late 1980s.

This means that instead of operating a less efficient timetable than that provided in 1985, it should be possible to offer a more efficient service, with shorter intervals between trains and thus more frequent services.

Figure 3: Oakleigh Station, showing 3 platforms
(note grass growing on unused 3rd track at left)

3.5 Trends in demand along the line

Before moving to prepare a new timetable, it would be necessary to obtain accurate and detailed information on patronage levels and trends along the line. Because such information is not publicly available, this task is only dealt with briefly here. The trends in demand along the Dandenong line can be charted using census data (and can then be updated when the 2006 census data becomes available). There has been a clear pattern of change over the last two decades (Lin, 2006, chapter 4):

- Peak-period patronage on the innermost section of line, between Oakleigh and the City, has increased substantially, due to gentrification, which has increased the size of the resident workforce and the share of workers employed in the city centre.

- Peak patronage along the middle section, between Oakleigh and Dandenong, has declined and become more localised (i.e. fewer people travelling all the way to the city), due to population and workforce declines, but also to a trend to increased self-containment (i.e. people working in their local area, rather than the city centre).

- Patronage along the outer section (Dandenong to Pakenham and Cranbourne) has increased due to population growth, but represents a very small share of the total workforce. Self-containment is high in this area, meaning that only a small share of the workforce is employed in the city centre. Very few of those employed elsewhere travel by train.

To illustrate these points, compare the Statistical Local Areas of Caulfield (which includes Carnegie), Dandenong and Cranbourne. While 23% of workers resident in Caulfield were employed in the City of Melbourne at the 2001 census (2006 figures are not yet available), the share for Dandenong workers was 7%, and for Cranbourne workers only 5%. While Dandenong and Cranbourne had 44,000 resident workers between them compared with 36,000 in Caulfield, they produced only 2683 workers travelling to central Melbourne between them, while the smaller Caulfield workforce accounted for 8173, more than three times as many. For both Dandenong and Cranbourne workers, the City of Monash was a much more important destination than the City of Melbourne, attracting 4808 workers in total, nearly twice as many as the City of Melbourne. Few of those workers travelled by train in 2001, but those that did would have alighted at stations between Springvale and Oakleigh.

Significantly, current and recent service planning on the Dandenong corridor has headed in the exact opposite direction to passenger demand. Demand for services between Oakleigh and the city has increased, but these services have been eliminated; the share of workers from beyond Dandenong wishing to travel to the city centre is low and falling, but it is currently proposed that a billion dollars be spent to speed travel for this small minority of patrons, largely ignoring the much bigger number of workers wishing to reach intermediate destinations.

3.6 What an efficient timetable would look like

Best practice in urban rail timetabling is about providing service patterns that:

- are easy to operate reliably,
- make the most efficient use of infrastructure and rolling stock,
- are easy to understand and remember for passengers; and
- simplify the task of providing connecting bus services.

The current Dandenong timetable satisfies none of these criteria; it appears to have evolved through ad-hoc alterations over many years, and consists of different service types arranged apparently at random without any logical pattern. Cranbourne line passengers in particular receive a very poor service, with long waits between trains and little express running, which results in many residents driving to stations along the better served Pakenham line, adding to crowding problems. The 2007 timetable is basically that operated in 2001, with the addition of two extra suburban services and one V/Line service. These services were simply slotted into gaps in the existing timetable, rather than being used as an opportunity to re-think the service provision approach.

The correct approach, as set out in manuals like Vuchic's and applied in 'best-practice' cities like Zurich and Copenhagen, is to adopt a regular service pattern using a recognised model like 'skip-stop' or 'zonal' operation (both types of service are used on the Perth and Copenhagen suburban systems). A regular service pattern is recommended because it is easy for operators and passengers to remember, facilitates the timetabling of connecting bus services, and allows the development of recovery strategies to deal with delays (see discussion below). The following proposal is based on the 'zonal' model, which seems most suited to the pattern of demand along the Dandenong corridor: it should be noted that it is only one example of what is possible.

Three service types would be operated, as illustrated in Figure 4: a stopping all stations service between Oakleigh and the City; alternating suburban services to Pakenham and Cranbourne, all running express between the City and Oakleigh and connecting with stopping services at Oakleigh; and finally, V/Line services (or possibly a mixture of V/Line services and 'super-express' suburban trains) running express between Pakenham and the City (Appendix A shows these services skipping Clayton, but a stop can be added here without disrupting the service pattern). Under such a model, the maximum service provision achievable is 20 trains per hour: four V/Line or super-express services; 8 Pakenham/Cranbourne expresses and 8 Oakleigh stopping services, operating on a regular pattern that repeats every 15 minutes. An illustration of how this model could operate to the City in the busiest hour of the morning peak is provided in the Appendix.

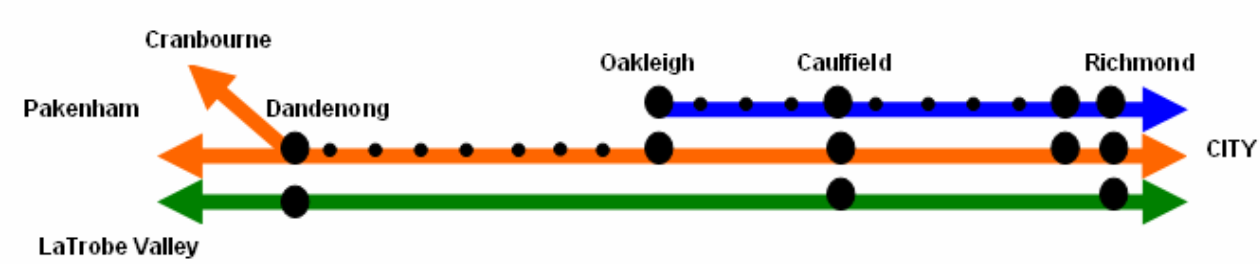

Figure 4: 'Zonal' service pattern

Providing 20 trains per hour on this model across the whole 2-hour morning peak requires 26 suburban train sets (not counting those required to operate the 4 V/Line services per hour), compared with 21 trains for the current service. Allowing for passengers travelling part-way along the line (and therefore some seats being filled twice) and no more than 20% standees, such a pattern would allow 22-25,000 passengers to be transported in the city-bound direction in the two-hour morning peak, compared with 11,000 at present. Running the same pattern on a 10/20 minute service cycle instead of 7.5/15 would only require 20 train sets, but would still give a two-hour capacity of around 17-19,000 passengers.

3.7 Capacity constraints and on-time running

The primary capacity constraint under this model is around Oakleigh station. The strategy for dealing with this is based on the approach adopted for the 1985 timetable. The availability of the third platform is used to allow Oakleigh stopping trains to depart immediately after the V/Line express service has passed the signal half way to Hughesdale, the next station. A V/Line train travelling at 75 km/h will reach this point less than 40 seconds after passing through Oakleigh; once it does so, the following train can depart Oakleigh (Appendix A allows a full minute for this).

Under the high-frequency service model shown in Appendix A, less 'slack' is allowed in the timetable for late-running trains than at present. Rather than unreliability being a consequence of capacity problems, it is actually a cause of them, if it requires unnecessarily large gaps in service to be provided to cater for late-running. The correct approach is to adopt a culture of rigorous on-time adherence, as found in well-run urban rail systems, such as those in Perth and Zurich. Copenhagen's 'S-Tog' suburban rail network provides a particularly apposite example, since it is the most similar to Melbourne's of all European urban rail systems. This is primarily a matter of training, skills and corporate culture – and should be distinguished from the culture of late-running and speeding to catch up formerly

found in Sydney – but it is assisted by the operation of a regular, comprehensible service pattern.

Under such a model, disruptions to service are dealt with through pre-planned recovery strategies, which can be developed because only a limited number of service types are operated. Typical recovery strategies are designed to allow delays to be ironed out within the regular cycle time (15 minutes in Appendix A). An example of such a recovery strategy might be a series of protocols about what to do if a 'stopping' train is late leaving Oakleigh, and might range from skipping stations to sending the next express train through ahead of the stopping service. The idea is to pre-plan recovery strategies to minimise disruption to passengers, rather than doing nothing and allowing delays to be perpetuated throughout the whole of peak period.

4 Recent developments

Since the release of earlier versions of this paper, there have been a number of developments suggesting that those responsible for the Melbourne rail system may be warming to the idea of ursing existing infrastructure more efficiently.

On 28th May 2007, with only a few days' notice, Connex added a service to its morning Dandenong line timetable departing Oakleigh station at 8:00 am, immediately following the 6 am from Traralgon, and stopping all stations to Flinders Street, without traveling through the city loop. This service, which effectively amounts to reinstatement of the 8:03 am from Oakleigh shown in the 1985 timetable in Figure 2, was added some four weeks after an earlier version of this paper was publicly released. Presumably the rail operator and regulator now concede that if one service can be run from Oakleigh, many more can be.

Around the same time, a document appeared on the Connex website purporting to respond to the author's claims, presented in a draft of this paper, about the capacity of the Dandenong line. As no substantiation or referencing was offered for any of the claims in the document, it is difficult to respond. However, the main claim – that the timetable proposed in this paper is not workable because the signaling on the Dandenong line does not permit trains to run closer than 3 minutes apart – is demonstrably false: the 1985 timetable in figure 2 shows trains passing through Oakeligh at 7:58 and 8:00 am. The capacity of the line is determined by the actual configuration of signaling, not by arbitrary assumptions. It may well be that such assumptions have been built into the current timetabling procedures, but all this reveals is that it is those procedures, and not the infrastructure, that are limiting capacity.

In August the *Herald Sun* newspaper reported that Connex is planning a 'major revamp of operations that would result in a major timetable change' in 2008 (Masanauskas, 2007). The central features of the new timetable would be a simpler service pattern and greater use of direct-to-Flinders Street services. The CEO of Connex was quoted as stating that the current service philosophy was 'over-complicating the timetable and causing it to be very fragile on a day-to-day [basis]'.

5 So what is the problem?

If there is ample spare capacity on the Melbourne city loop and the Dandenong line, why is it not being utilised? And why have those responsible for operating and planning the rail system been asserting that a capacity problem exists, when it can easily be shown that there is no problem?

The real deficiency is with 'organisational infrastructure', not physical infrastructure; as Vuchic says:

> With time organisations have a tendency to develop a pattern of operation that is convenient for personnel, rather than for passengers and long-term operating efficiency … This pattern of operations is not easy to change, because in an organization a resistance to change develops that may be designated as "self-defense of incompetence" … The less competent employees are, the more they resist any changes … Management must undertake energetic steps to break the pattern of service deterioration, decreasing economic efficiency, and resistance to innovations. In some cases, to introduce changes, management may need support of political leaders, external advisors, citizen advisory groups, and other bodies to get a better perspective on the conditions of service, needed improvements, and obstacles that should be overcome (Vuchic, 2005, p. 317).

The explanation of this problem in Melbourne lies in the distant and recent history of public transport administration. Mees (2000) recounts how Melbourne's rival rail, tram and bus operators failed to respond to the challenge presented by rising car ownership after World War II. Instead of re-inventing public transport to create a 'go anywhere, anytime' service that could compete with the convenience of the car, operators and planners continued to compete with each other, and gradually fell into the passive position of offering rationalisations for failure. One of the most popular was the claim that there had been insufficient investment in new infrastructure, and this idea can be seen as the origin of proposals like the City Loop and extra tracks on the Dandenong line.

Privatisation in 1999 was supposed to remedy this situation, by bringing the dynamism of private enterprise to bear on the task of reinventing public transport. Incentives to increase patronage were built into the franchise agreements, through provisions tying subsidies to patronage levels. As a result, privatisation was widely praised in the two years between the inauguration of the system and the commencement of its demise. It turned out that the private operators were no more capable of marketing public transport to car travellers than their bureaucratic predecessors, but they proved very successful at marketing themselves to the State government and regulators (Mees, 2005).

The result was a large financial bailout in 2003-4, which has roughly doubled subsidy levels compared with public operation (Auditor-General, 2005, p. 25, fig. 2E). Significantly, not only are subsidy levels much higher than provided for under the 1999 franchise agreements, but they are no longer tied to patronage growth, and so the current operators have little incentive to seek new patrons – especially in peak periods, which are most expensive to serve.

The current privatised arrangements in Melbourne present a classic 'moral hazard' problem. All of the key players – government, regulator, operators – have an incentive to consciously or unconsciously collude against the public interest, by rationalising inaction instead of genuinely improving the effectiveness of public transport (Mees, 2005). In such an environment, the regular assertion of non-existent constraints on rail capacity becomes easy to understand.

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Appendix A

Possible Dandenong line timetable

Monday to Friday Pakenham & Cranbourne to City

Station		AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
Pakenham	Dep	6:46	6:57	..	..	..	7:01	7:12	..	..	..	7:16	7:27	..	..	..	7:31	7:42	..	..	..	7:46	7:57
Officer		6:50	*	..	..	..	7:05	*	..	..	..	7:20	*	..	..	..	7:35	*	..	..	..	7:50	*
Beaconsfield		6:54	*	..	..	..	7:09	*	..	..	..	7:24	*	..	..	..	7:39	*	..	..	..	7:54	*
Berwick		6:58	*	..	..	..	7:13	*	..	..	..	7:28	*	..	..	..	7:43	*	..	..	..	7:58	*
Narre Warren		7:02	*	..	..	..	7:17	*	..	..	..	7:32	*	..	..	..	7:47	*	..	..	..	8:02	*
Hallam		7:05	*	..	..	..	7:20	*	..	..	..	7:35	*	..	..	..	7:50	*	..	..	..	8:05	*
Cranbourne	Dep	..	..	..	7:08	..	..	..	..	7:23	..	..	..	..	7:38	..	..	..	..	7:53	..	..	..
Merinda Park		..	..	..	7:10	..	..	..	..	7:25	..	..	..	..	7:40	..	..	..	..	7:55	..	..	..
Dandenong	Dep	7:12	7:18	..	7:20	..	7:27	7:33	..	7:35	..	7:42	7:48	..	7:50	..	7:57	8:03	..	8:05	..	8:12	8:18
Yarraman		7:15	*	..	7:23	..	7:30	*	..	7:38	..	7:45	*	..	7:53	..	8:00	*	..	8:08	..	8:15	*
Noble Park		7:17	*	..	7:25	..	7:32	*	..	7:40	..	7:47	*	..	7:55	..	8:02	*	..	8:10	..	8:17	*
Sandown Park		7:19	*	..	7:27	..	7:34	*	..	7:42	..	7:49	*	..	7:57	..	8:04	*	..	8:12	..	8:19	*
Springvale		7:21	*	..	7:29	..	7:36	*	..	7:44	..	7:51	*	..	7:59	..	8:06	*	..	8:14	..	8:21	*
Westall		7:23	*	..	7:31	..	7:38	*	..	7:46	..	7:53	*	..	8:01	..	8:08	*	..	8:16	..	8:23	*
Clayton		7:26	*	..	7:34	..	7:41	*	..	7:49	..	7:56	*	..	8:04	..	8:11	*	..	8:19	..	8:26	*
Huntingdale		7:28	*	..	7:36	..	7:43	*	..	7:51	..	7:58	*	..	8:06	..	8:13	*	..	8:21	..	8:28	*
Oakleigh	Dep	7:31	*	7:34	7:39	7:41	7:46	*	7:49	7:54	7:56	8:01	*	8:04	8:09	8:11	8:16	*	8:19	8:24	8:26	8:31	*
Hughesdale		*	*	7:36	*	7:43	*	*	7:51	*	7:58	*	*	8:06	*	8:13	*	*	8:21	*	8:28	*	*
Murrumbeena		*	*	7:37	*	7:44	*	*	7:52	*	7:59	*	*	8:07	*	8:14	*	*	8:22	*	8:29	*	*
Carnegie		*	*	7:39	*	7:46	*	*	7:54	*	8:01	*	*	8:09	*	8:16	*	*	8:24	*	8:31	*	*
Caulfield		7:37	7:39	7:43	7:45	7:50	7:52	7:54	7:58	8:00	8:05	8:07	8:09	8:13	8:15	8:20	8:22	8:24	8:28	8:30	8:35	8:37	8:39
Malvern		*	*	7:45	*	7:52	*	*	8:00	*	8:07	*	*	8:15	*	8:22	*	*	8:30	*	8:37	*	*
Armadale		*	*	7:47	*	7:54	*	*	8:02	*	8:09	*	*	8:17	*	8:24	*	*	8:32	*	8:39	*	*
Toorak		*	*	7:49	*	7:56	*	*	8:04	*	8:11	*	*	8:19	*	8:26	*	*	8:34	*	8:41	*	*
Hawksburn		*	*	7:51	*	7:58	*	*	8:06	*	8:13	*	*	8:21	*	8:28	*	*	8:36	*	8:43	*	*
South Yarra		7:44	*	7:53	7:52	8:00	7:59	*	8:08	8:07	8:15	8:14	*	8:23	8:22	8:30	8:29	*	8:38	8:37	8:45	8:44	*
Richmond		7:47	7:49	7:56	7:55	8:03	8:02	8:04	8:11	8:10	8:18	8:17	8:19	8:26	8:25	8:33	8:32	8:34	8:41	8:40	8:48	8:47	8:49
Parliament		7:50	..	..	7:58	..	8:05	..	..	8:13	..	8:20	..	..	8:28	..	8:35	..	..	8:43	..	8:50	..
Melbourne Central		7:52	..	..	8:00	..	8:07	..	..	8:15	..	8:22	..	..	8:30	..	8:37	..	..	8:45	..	8:52	..
Flagstaff		7:54	..	..	8:02	..	8:09	..	..	8:17	..	8:24	..	..	8:32	..	8:39	..	..	8:47	..	8:54	..
Spencer Street		7:56	..	..	8:04	..	8:11	..	..	8:19	..	8:26	..	..	8:34	..	8:41	..	..	8:49	..	8:56	..
Flinders Street	Arr	8:00	7:53	8:00	8:08	8:07	8:15	8:08	8:15	8:23	8:22	8:30	8:23	8:30	8:38	8:37	8:45	8:38	8:45	8:53	8:52	9:00	8:53

Working timetable (showing pass-through times)

Monday to Friday Pakenham & Cranbourne to City

Station		AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
Pakenham	Dep	6:46	6:57	..	..	..	7:01	7:12	..	..	..	7:16	7:27	..	..	..	7:31	7:42	..	..	..	7:46	7:57
Officer		6:50	(7:00)	..	..	..	7:05	(7:15)	..	..	..	7:20	(7:30)	..	..	..	7:35	(7:45)	..	..	..	7:50	(8:00)
Beaconsfield		6:54	(7:03)	..	..	..	7:09	(7:18)	..	..	..	7:24	(7:33)	..	..	..	7:39	(7:48)	..	..	..	7:54	(8:03)
Berwick		6:58	(7:06)	..	..	..	7:13	(7:21)	..	..	..	7:28	(7:36)	..	..	..	7:43	(7:51)	..	..	..	7:58	(8:06)
Narre Warren		7:02	(7:09)	..	..	..	7:17	(7:24)	..	..	..	7:32	(7:39)	..	..	..	7:47	(7:54)	..	..	..	8:02	(8:09)
Hallam		7:05	(7:11)	..	..	..	7:20	(7:26)	..	..	..	7:35	(7:41)	..	..	..	7:50	(7:56)	..	..	..	8:05	(8:11)
Cranbourne	Dep	..	..	..	7:08	..	..	..	..	7:23	..	..	..	..	7:38	..	..	..	..	7:53	..	..	..
Merinda Park		..	..	..	7:10	..	..	..	..	7:25	..	..	..	..	7:40	..	..	..	..	7:55	..	..	..
Dandenong	Dep	7:12	7:18	..	7:20	..	7:27	7:33	..	7:35	..	7:42	7:48	..	7:50	..	7:57	8:03	..	8:05	..	8:12	8:18
Yarraman		7:15	(7:20)	..	7:23	..	7:30	(7:35)	..	7:38	..	7:45	(7:50)	..	7:53	..	8:00	(8:05)	..	8:08	..	8:15	(8:20)
Noble Park		7:17	(7:21)	..	7:25	..	7:32	(7:36)	..	7:40	..	7:47	(7:51)	..	7:55	..	8:02	(8:06)	..	8:10	..	8:17	(8:21)
Sandown Park		7:19	(7:23)	..	7:27	..	7:34	(7:38)	..	7:42	..	7:49	(7:53)	..	7:57	..	8:04	(8:08)	..	8:12	..	8:19	(8:23)
Springvale		7:21	(7:24)	..	7:29	..	7:36	(7:39)	..	7:44	..	7:51	(7:54)	..	7:59	..	8:06	(8:09)	..	8:14	..	8:21	(8:24)
Westall		7:23	(7:26)	..	7:31	..	7:38	(7:41)	..	7:46	..	7:53	(7:56)	..	8:01	..	8:08	(8:11)	..	8:16	..	8:23	(8:26)
Clayton		7:26	(7:28)	..	7:34	..	7:41	(7:43)	..	7:49	..	7:56	(7:58)	..	8:04	..	8:11	(8:13)	..	8:19	..	8:26	(8:28)
Huntingdale		7:28	(7:30)	..	7:36	..	7:43	(7:45)	..	7:51	..	7:58	(8:00)	..	8:06	..	8:13	(8:15)	..	8:21	..	8:28	(8:30)
Oakleigh	Dep	7:31	(7:33)	7:34	7:39	7:41	7:46	(7:48)	7:49	7:54	7:56	8:01	(8:03)	8:04	8:09	8:11	8:16	(8:18)	8:19	8:24	8:26	8:31	(8:33)
Hughesdale		(7:32)	(7:34)	7:36	(7:40)	7:43	(7:47)	(7:49)	7:51	(7:55)	7:58	(8:02)	(8:04)	8:06	(8:10)	8:13	(8:17)	(8:19)	8:21	(8:25)	8:28	(8:32)	(8:34)
Murrumbeena		(7:33)	(7:35)	7:37	(7:41)	7:44	(7:48)	(7:50)	7:52	(7:56)	7:59	(8:03)	(8:05)	8:07	(8:11)	8:14	(8:18)	(8:20)	8:22	(8:26)	8:29	(8:33)	(8:35)
Carnegie		(7:34)	(7:36)	7:39	(7:42)	7:46	(7:49)	(7:51)	7:54	(7:57)	8:01	(8:04)	(8:06)	8:09	(8:12)	8:16	(8:19)	(8:21)	8:24	(8:27)	8:31	(8:34)	(8:36)
Caulfield		7:37	7:39	7:43	7:45	7:50	7:52	7:54	7:58	8:00	8:05	8:07	8:09	8:13	8:15	8:20	8:22	8:24	8:28	8:30	8:35	8:37	8:39
Malvern		(7:39)	(7:41)	7:45	(7:47)	7:52	(7:54)	(7:56)	8:00	(8:02)	8:07	(8:09)	(8:11)	8:15	(8:17)	8:22	(8:24)	(8:26)	8:30	(8:32)	8:37	(8:39)	(8:41)
Armadale		(7:40)	(7:42)	7:47	(7:48)	7:54	(7:55)	(7:57)	8:02	(8:03)	8:09	(8:10)	(8:12)	8:17	(8:18)	8:24	(8:25)	(8:27)	8:32	(8:33)	8:39	(8:40)	(8:42)
Toorak		(7:41)	(7:43)	7:49	(7:49)	7:56	(7:56)	(7:58)	8:04	(8:04)	8:11	(8:11)	(8:13)	8:19	(8:19)	8:26	(8:26)	(8:28)	8:34	(8:34)	8:41	(8:41)	(8:43)
Hawksburn		(7:42)	(7:44)	7:51	(7:50)	7:58	(7:57)	(7:59)	8:06	(8:05)	8:13	(8:12)	(8:14)	8:21	(8:20)	8:28	(8:27)	(8:29)	8:36	(8:35)	8:43	(8:42)	(8:44)
South Yarra		7:44	(7:46)	7:53	7:52	8:00	7:59	(8:01)	8:08	8:07	8:15	8:14	(8:16)	8:23	8:22	8:30	8:29	(8:31)	8:38	8:37	8:45	8:44	(8:46)
Richmond		7:47	7:49	7:56	7:55	8:03	8:02	8:04	8:11	8:10	8:18	8:17	8:19	8:26	8:25	8:33	8:32	8:34	8:41	8:40	8:48	8:47	8:49
Parliament		7:50	..	..	7:58	..	8:05	..	..	8:13	..	8:20	..	..	8:28	..	8:35	..	..	8:43	..	8:50	..
Melbourne Central		7:52	..	..	8:00	..	8:07	..	..	8:15	..	8:22	..	..	8:30	..	8:37	..	..	8:45	..	8:52	..
Flagstaff		7:54	..	..	8:02	..	8:09	..	..	8:17	..	8:24	..	..	8:32	..	8:39	..	..	8:47	..	8:54	..
Spencer Street		7:56	..	..	8:04	..	8:11	..	..	8:19	..	8:26	..	..	8:34	..	8:41	..	..	8:49	..	8:56	..
Flinders Street	Arr	8:00	7:53	8:00	8:08	8:07	8:15	8:08	8:15	8:23	8:22	8:30	8:23	8:30	8:38	8:37	8:45	8:38	8:45	8:53	8:52	9:00	8:53