

Dandenong Line Concept of Operations

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V2.1	24 Aug 2014	-	RS	HM	LW
V2.2	31 Aug 2014	<ul style="list-style-type: none"> • Updated stabling requirements • All rolling stock maintenance constrained to the corridor • 5' minimum signalling headway on Cranbourne line • 234m future train now with ATO • Changes to Appendix E 	RS	HM	LW
V2.3	8 Sep 2014	<ul style="list-style-type: none"> • Inclusion of 'Implementation of extended length High Capacity Trains' as a future project in Table 1 • Correction in Table 2 and Table 7 to include Westall services in shoulder peak as part of current service levels. • Inclusion of rationale for no increase in peak V/Line service numbers in Section 4.3. • Inclusion of Berwick & Lyndhurst freight as termini in Table 5 (Summary of Dandenong Line) • Transfer of requirements to not preclude MIS works into Table 8 (Works recommended) rather than Table 9 (Future proofing). 	RS	HM	LW

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1. Scope of this document

This Concept of Operations (COO) report provides details of the operational concept for the Dandenong Line to 2031.

Within this period the following key projects that directly impact on the Dandenong Line (DL) are assumed to have been implemented to cater for patronage growth and to extend the network into growth areas:

Table 1: Projects included in the scope of this document

NDP Stage	Timing	Projects
2	By 2017	<ul style="list-style-type: none"> Metropolitan Intermodal System (MIS)
2	By 2019	<ul style="list-style-type: none"> Cranbourne Pakenham Rail Corridor Project (CPRCP)
2	By 2020	<ul style="list-style-type: none"> DRL Additional Rolling Stock Project (DARSP)
2	Around 2023	<ul style="list-style-type: none"> Melbourne Rail Link (MRL) Melbourne Airport Rail Link (MARL)
3	Around 2031	<ul style="list-style-type: none"> Rowville Rail Link Implementation of extended length High Capacity Trains
3	Beyond 2031 ¹	<ul style="list-style-type: none"> South Eastern Rail Link (SERL)

Prior to the completion of these projects, the DL P-COO assumes the delivery of several precursor projects including Regional Rail Link (RRL) and the Bayside Rail Improvement Project (BRIP).

The purpose of this document is to outline the following:

- The concept-level network, service and operational plan and the high level outcomes to be delivered by these projects;
- The indicative operational plans for these projects;
- The critical scope items and dependent projects to deliver the outcomes.

The greatest focus in the document will be applied to the passenger rail projects expected to be delivered by 2019 (CPRCP– highlighted in grey in Table 1) as this project has the most immediate need, however the intent is that this will remain a working document with increasing detail provided on the other projects as the need arises.

¹ Timing for SERL is uncertain – principal driver is Port of Hastings development.

2. Background

2.1. Base Case Service levels

Prior to the delivery of the projects discussed in this document, it is assumed a number of other projects will be implemented that improve the capacity and reliability of the rail network, including:

- The July 2014 timetable change which introduced a 10 minute inter-peak service to Dandenong, 20 min inter-peak service to Pakenham and Cranbourne and 2 additional services in each of the AM and PM peak periods;
- Regional Rail Link (RRL), which will provide extra capacity for services on the Ballarat, Bendigo, Geelong, Werribee, Sunbury, Craigieburn, Upfield and Dandenong Lines and alter train consists on the Traralgon line;
- Bayside Rail Improvement Project (BRIP) which will provide improved reliability and travel times on the Frankston Line and lead to a cascade of Xtrapolis trains onto the Cross-City Line and consequential cascading of Siemens trains on the Dandenong Line;

2.1.1. Passenger Service Levels

The July 2014 timetable results in the following peak and off-peak service levels improvements summarised in Table 2.

Table 2: Metropolitan service levels following implementation of July 2014 timetable

Services	Peak Direction Hour ²	Peak Direction 2-hour ²	Daytime off-peak (tph) ³	Other off-peak (tph) ³
Limited express* services to/from Pakenham	7	12	3	3
Limited express* services to/from Cranbourne	4	8	3	-
Cranbourne to/from Dandenong Shuttle	-	-	-	3
Limited express* services to/from Westall	-	3	-	-
Limited express* services to/from Dandenong	4	5	-	-
V/Line express** services to/from beyond Pakenham	2	3	1	1
TOTAL THROUGH CORDON	17	31	7	4

* Express through Malvern, Armadale, Toorak, Hawksburn at most times of the week

** Stopping only Pakenham, Dandenong, Clayton, Caulfield, Richmond (peak only) and Flinders Street. With the exception of Pakenham and Flinders Street, stops are only to dis-embark passengers in the up direction and for passengers to embark in the down direction.

² Number of trains in the inbound direction in the morning and outbound direction in the afternoon in the peak hour and two-hour periods. This is defined as the period in which trains are scheduled to arrive at Richmond between 07:45 – 08:44:59 / 07:15 – 09:14:59 in the morning and depart Richmond between 5:00 to 5:59:59 / 4:30 to 6:29:59 in the afternoon.

³ Both directions

2.1.2. Freight Service Levels

There are currently two types of freight trains that operate on the corridor:

- The 'paper train' which operates seven days a week between the Port of Melbourne and Maryvale (near Morwell) in each direction. It carries containerised paper products to the port and runs empty in the reverse direction. It operates through the Dandenong Line late in the evening. It is up to 1200m long;
- The 'Apex' bulk train which carries crushed rock from the Craigieburn region to Westall and returns empty. It operates 5 days a week (weekdays) late at night to Westall and after the morning peak back to Craigieburn. It is up to 320m long.

There are a range of constraints influencing the scheduling of these freight trains including port and terminal opening times, interaction with V/Line and Metro services and constraints imposed by single line sections. As such, future pathways for these trains will need to be maintained as closely as possible to current timings.

2.2. Patronage Forecasts

Patronage forecasting undertaken by PTV has identified that weekday rail boardings are expected to grow by around 5.5% per annum on the total corridor for the next 10 years with some variations expected across different sections of the corridor. Table 3 shows the specific rates for each corridor section.

Table 3 - Forecast Growth Rate per line section

Line	Sections	Forecast Growth Rate per annum 2011 to 2021 ⁴
Dandenong	Westall to Carnegie	3.6%
Dandenong	Dandenong to Springvale	4.4%
Cranbourne	Cranbourne to Lynbrook	11.1%
Pakenham	Pakenham to Hallam	9.2%
Line Average		5.5%

Growth on the outer portion of the network beyond Dandenong is higher than in the section of the line inbound from Westall. As such, it is important to provide a greater increase in passenger service capacity from Pakenham and Cranbourne, rather than from locations such as Westall or Dandenong.

In order to specifically predict patronage for the key years of operation, patronage modelling using a strategic 4-step model was conducted. As the demographics and base network coding for the model are only available for 2016, 2021, 2031 and 2046, the key years discussed in this document are 2021 and 2031.

⁴ Extracted from the PTV Victorian Integrated Transport Model (VITM). These growth rates are for the entire day in both directions.

3. The role of the Dandenong Line in the network

3.1. Summary of the Network Development Plan

The Network Development Plan (NDP) that has been developed by PTV has identified an optimal sequence of upgrades of the entire Metropolitan rail network to address congestion, meet population growth, improve reliability, enhance accessibility and improve the city's productivity.

Planning for the rail network has hinged on creating a metro-style train system to allow frequent train services day and night so as to meet the needs of an international city of five million people and beyond. Metro rail systems are designed to run higher frequency and higher capacity trains on end to end lines using dedicated tracks. The focus is on simple timetables, frequent services and consistent stopping patterns. The upgrade projects on the Dandenong Line are important steps in achieving this transformation.

The NDP establishes a firm basis for expanding the capacity of Melbourne's rail network over the next 20 years and beyond. The key strategic objectives of the plan are:

- To expand the capacity of the existing network to meet the growing needs of the city;
- To redesign train services to maximise opportunities for seamless coordination with buses and trains; and
- To extend the network to serve new growth areas.

The plan unfolds in four stages over 20 years and beyond and is described in Table 4 below.

Table 4: Key Stages of Network Development Plan with landmark projects

NDP Stage	Intent of NDP Stage	Major Projects
1. Overcome existing network constraints and provide a strong foundation for further expansion of capacity in the future	Addressing current constraints will give passengers more frequent, reliable and convenient services, as well as maximising the use of existing infrastructure and providing the basis for future growth.	<ul style="list-style-type: none"> • Epping to South Morang extension • Upgraded signalling Greensborough to Hurstbridge and new stabling at Eltham • Sunbury electrification • Regional Rail Link (RRL), including Tarneit and Wyndham Vale stations, Southern Cross platforms 15/16 • Bayside Rail Improvement Project (BRIP) • 43 new V/Locity carriages • 53 new Xtrapolis trains • New stations at Grovedale, Ravenhall, Southland and supporting infrastructure • The Metropolitan Intermodal System (MIS)

2. Introduce a metro-style train system for Melbourne	Moving to a metro-style operation will provide more high capacity, high frequency services, allowing passengers to 'turn up and go'.	<ul style="list-style-type: none"> • The Cranbourne Pakenham Rail Capacity Project (CPRCP) • Introduction of High Capacity Metro Trains and High Capacity Signalling • The Melbourne Rail Link (MRL) incorporating the Melbourne Airport Rail Link (MARL) project.
3. Extend the network into growth areas and existing areas without good access to rail services	New lines and the electrification of existing lines will support Melbourne's high growth areas and places currently not served by the rail network.	<ul style="list-style-type: none"> • A new line to Rowville • A new line to Doncaster • Electrification to Melton
4. Prepare for further growth and protect future options	As the city continues to grow and travel needs change, future options for the metropolitan rail network will be investigated, planned and protected.	<ul style="list-style-type: none"> • Electrification to Geelong • Electrification to Wallan • Extension from South Morang to Mernda • South Eastern Rail Link (SERL) • Inner core capacity upgrades and station decongestion

3.2. Network Structure in 2021

Figure 1 below shows the routing of trains on the Dandenong Line in 2021 in the network context.

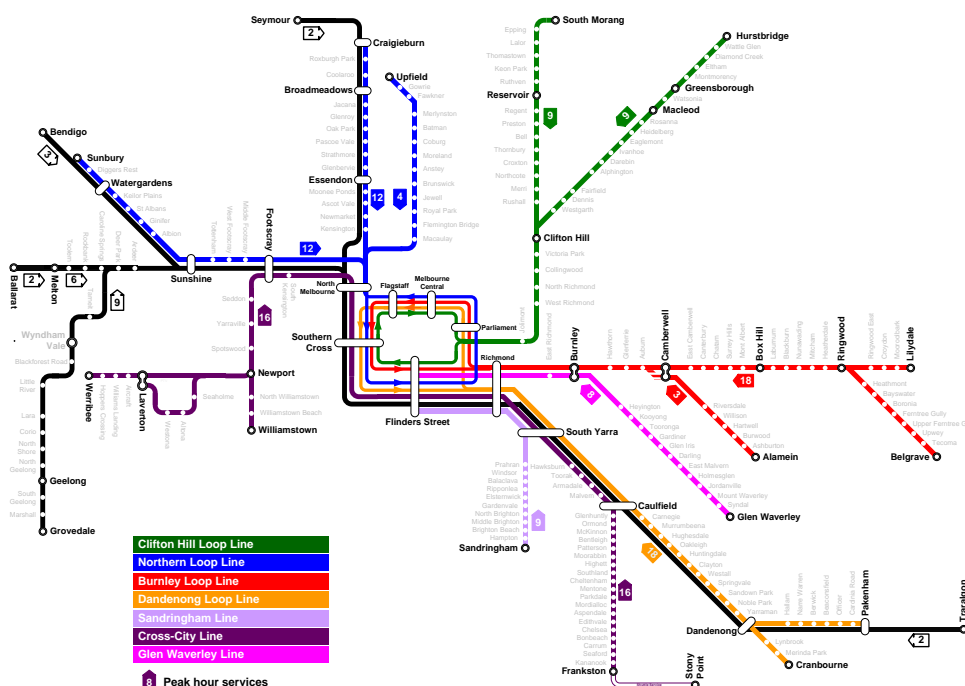


Figure 1: Network structure in 2021

3.2.1. Peak period operations

As can be seen from Figure 1, by 2021 the Dandenong Line will be operationally independent from other groups. All metropolitan services utilising the corridor (Pakenham, Cranbourne, Dandenong and Westall services) will operate independently via the Caulfield Local lines from Caulfield, via the Caulfield Loop and Caulfield Viaduct in a counter-clockwise direction then return to the Dandenong Line via the Caulfield Local lines. The Caulfield Loop will operate counter-clockwise throughout the entire day (AM Peak, PM Peak, inter-peak and all off-peak periods).

During the peak periods V/Line services from beyond Pakenham will also utilise the Caulfield Local lines from Caulfield in, but will run direct to Flinders Street station (turning back on Platform 7).

As in the current operation, it is assumed that freight services will not be scheduled to operate on the Dandenong Line during the peak periods.

3.2.2. Off-peak and inter-peak operations

The routing of trains in the off-peak and inter-peak is largely the same as the peak periods with the exception that the V/Line services will transfer to the Caulfield Through lines at Richmond Junction. They will then join the Cross-City Group through Flinders Street and travel via the Through Suburban lines to Southern Cross station where they will utilise platforms 15 and 16. Freight services to and from the Dandenong Line will also utilise a similar route.

3.3. Network structure in 2031

The projects described below (MRL and MARL, Rowville Rail) will have a direct impact on the Dandenong Rail Line and are planned to be implemented before 2031. As such, they have a number of implications for future-proofing the earlier projects on the corridor (notably CPRCP). The future-proofing implications for these projects are discussed later in Section 4.6.2.

3.3.1. Melbourne Rail Link (MRL) and Melbourne Airport Rail Link (MARL)

The next set of major rail projects that have a direct impact upon the Dandenong Rail Line are the Melbourne Rail Link (MRL) and Melbourne Airport Rail Link (MARL). These projects are planned to be in-place by around 2023 and the structure of the network once this occurs is shown in Figure 2 below.

The implementation of MRL and MARL will lead to a major re-configuration of the Melbourne Metro network and will create six independent lines operating at high levels of reliability and frequency. Each line will operate with a dedicated fleet of trains and will have access to separate stabling and maintenance facilities⁵ as well as separate tracks and platforms.

The key to the delivery of this network will be the establishment of the Frankston-Ringwood Line which will operate trains through a new tunnel from South Yarra to Southern Cross which will connect to the existing Burnley and Caulfield loops and back through to the Ringwood Line.

The implementation of that operation will release tracks from Southern Cross through to South Yarra on the existing network, these will be used to establish a cross-city operation from Melbourne Airport and Sunbury through to Cranbourne and Pakenham via Flinders Street as well as creating the first section of a dedicated freight and V/line railway to the South East and Hastings (between Flinders Street and South Yarra). MRL will result in Dandenong line services

⁵ With the exception of the Glen Waverley Line which will share the Epping maintenance facility with the Clifton Hill Loop Line trains.

no longer operating via the Caulfield Loop and instead will operate as a two-way operation on the Northern and Caulfield viaducts.

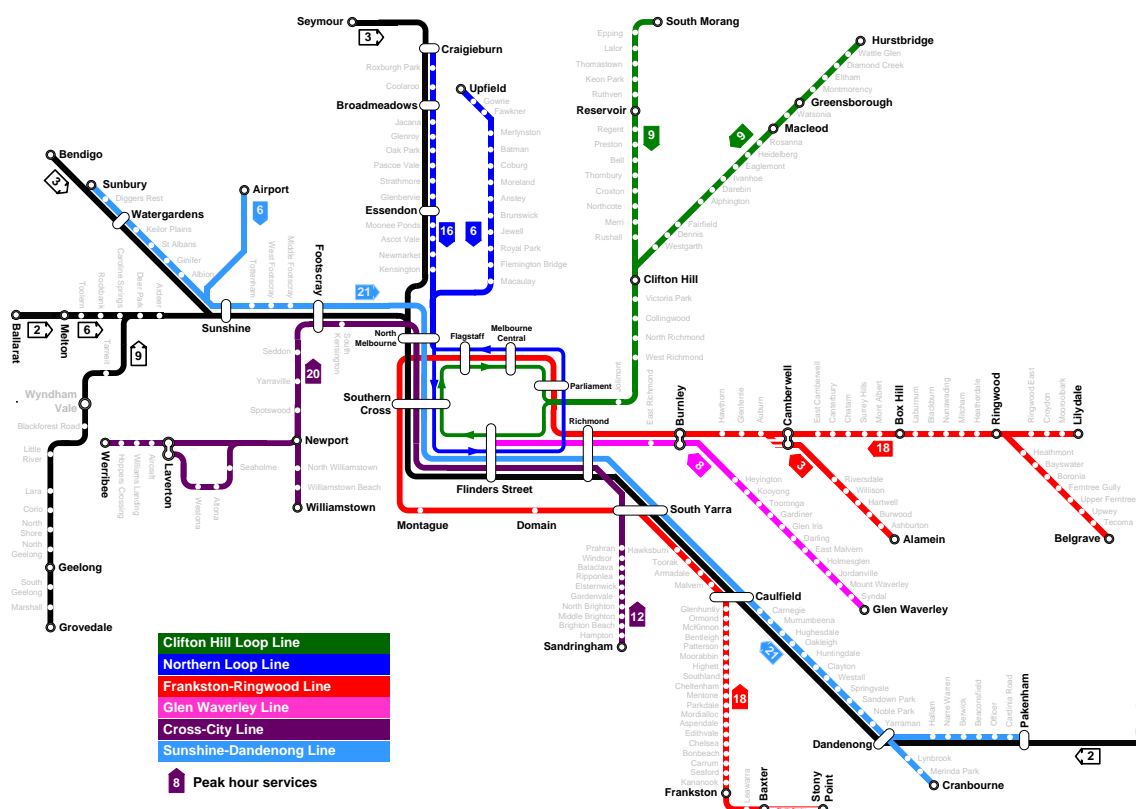


Figure 2 - Network Structure after implementation of Melbourne Rail Link (MRL) and Melbourne Airport Rail Link (MARL) with peak hour train numbers

3.3.2. Rowville Rail Link

The Rowville Rail Link will serve residents in the south eastern suburbs, as well as the large numbers of students accessing Monash University and the surrounding innovation and employment precinct. This new rail link will join the Dandenong Rail Line at Huntingdale via a grade separated junction and will therefore place greater demands upon that line through the injection of more trains and patronage to the corridor. Additional HCMT will be procured to support the inclusion of the Rowville Rail Link, these will be maintained at Pakenham East and stabled at a new facility at Rowville.

3.3.3. Melton Rail Upgrade

The Melton Rail Upgrade will include the provision of two new tracks from Sunshine to Deer Park, a duplication of the line from Deer Park to Melton and an electrification of the entire section between Sunshine and Melton. The project will provide a much needed capacity boost to cater for rapid population growth around the corridor. Upon completion, electrified services from Melton will operate through to Cranbourne, Rowville and Pakenham via the Sunshine-Dandenong trunk section. Additional HCMT will be procured to support the inclusion of the Melton Rail Upgrade, these new trains will be maintained at Pakenham East and stabled on the Melton corridor.

The network structure following implementation of Rowville Rail Link and the Melton Rail Line Upgrade is shown below in Figure 3.

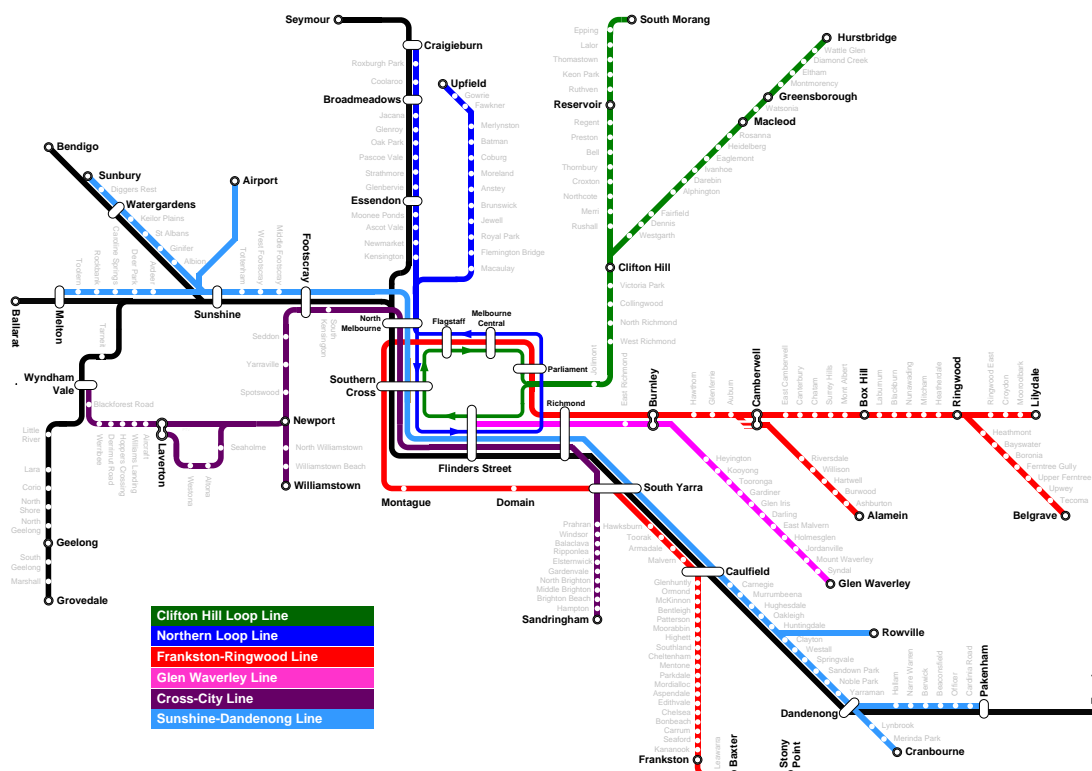


Figure 3 – Planned network structure in 2031 after implementation of Melbourne Rail Link (MRL), Melbourne Airport Rail Link (MARL), Rowville Rail Link and Melton Rail Upgrade

3.4. Network structure post-2031

Beyond 2031, the key planned project that will impact upon the Dandenong Line is the South Eastern Rail Link (SERL) as described below. This project will also have a number of implications for future-proofing earlier projects on the Dandenong Rail Line, also described in Section 4.6.2 below.

3.4.1. South Eastern Rail Link (SERL)

The construction of the South Eastern Rail Link (SERL) is planned for this corridor to accommodate future demand for freight movements on the Dandenong Line related to the development of the Port of Hastings and the South Eastern Intermodal Terminal. SERL would provide a dedicated freight and V/Line corridor in parallel to the existing corridor between Dandenong and the city.

The Freight, Logistics and Marine Division (FLAM) of the Department of Transport, Planning and Local Infrastructure (DTPLI) have developed concept plans for SERL. These plans should not be precluded in the planning, design and delivery of earlier projects. At present the concept plans include the following operational and infrastructure requirements:

- Freight and V/Line services utilising the existing Through Suburbans from Southern Cross to Flinders Street, then the new flyover at Richmond Junction and the dedicated V/Line and Freight lines to South Yarra both delivered by MRL;
- Construction of a new single bi-directional or additional double track along the corridor between South Yarra and Cranbourne Junction;
- Duplicated SERL tracks on the west side of the Cranbourne Line through the existing Greens Rd siding and just prior to the Westernport Freeway will diverge towards Hastings.

Further detail is provided on the proposed SERL alignment on the Cranbourne Line in Appendix D.

Provision should also be made to protect the following possible long term projects:

- An additional two tracks from Southern Cross to Flinders Street alongside the existing Through Suburban viaduct to separate freight and V/Line services from the metropolitan trains operating on the Through Suburban tracks in this area.
- An additional two tracks between Springvale and Cranbourne Junction to separate the Cranbourne from Pakenham services.
- An additional two tracks from Cranbourne Junction to Pakenham on the south side to provide a fully independent freight and V/Line corridor from Pakenham in.

4. The Dandenong Line in 2021

4.1. Passenger demand in 2021

Figure 4 below shows the predicted number of people travelling inbound in the morning peak hour (07:45 – 08:45 at Richmond) and peak two hours (07:15 – 09:15 at Richmond) for 2021 that need to be supported by the Dandenong Rail Line. The following key points should be noted:

- A total of 16,200 passengers are predicted to travel inbound from Richmond in the morning peak hour in 2021;
- However, the peak loading point on the corridor is at Carnegie with 18,900 passengers in the morning peak hour;
- Passengers boarding between Pakenham/Cranbourne and Westall are equal to around 75% of the load at Carnegie.

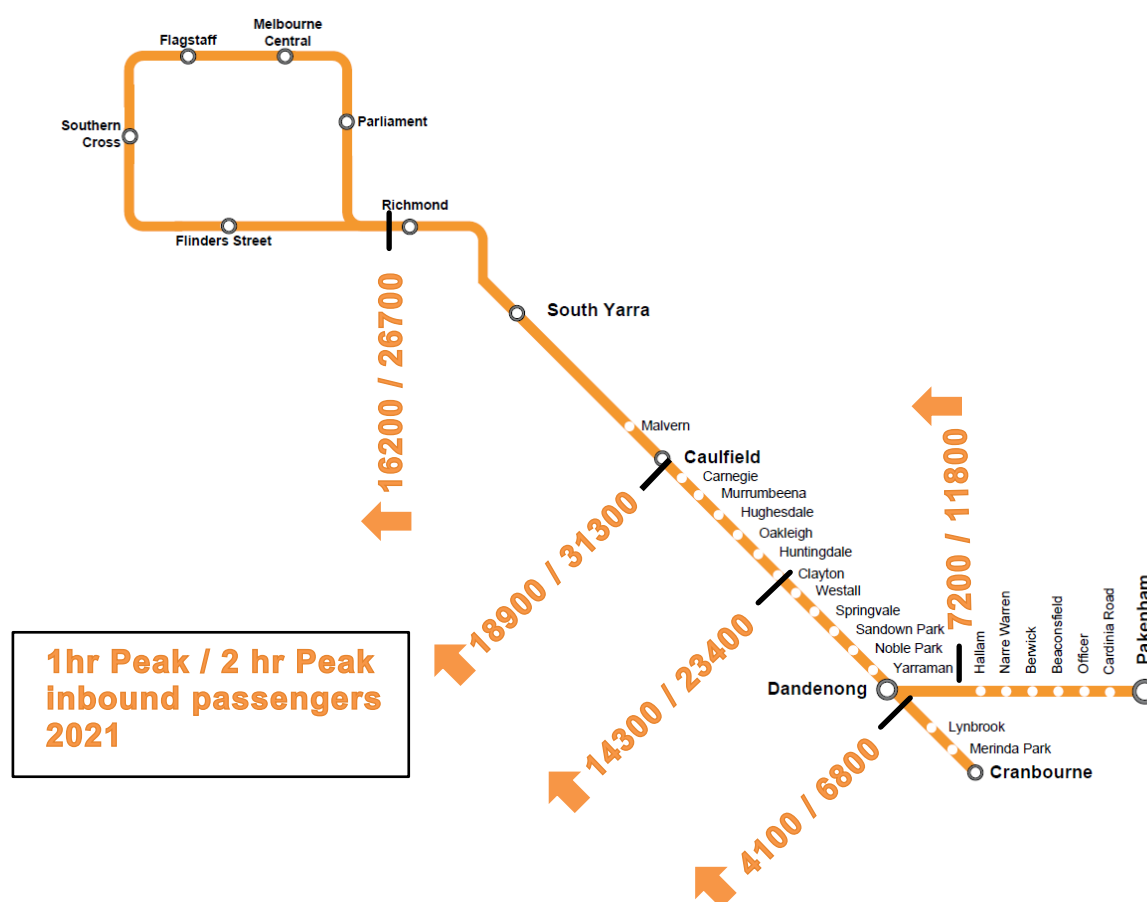


Figure 4 - Dandenong Line predicted AM Peak patronage in 2021

Figure 5 below shows the predicted peak period rolling average loads in 2021 if the July 2014 service numbers and the existing rolling stock were still in place (i.e. with the current load)

standard of 798 passengers per train⁶). It can be seen that these service levels will be insufficient to support predicted demand by 2021.

In summary, the July 2014 service plan with current rolling stock will not be able to support predicted 2021 patronage on the corridor and levels of over-crowding on trains would be unacceptable leading to very poor levels of service performance on all services on the Dandenong line.

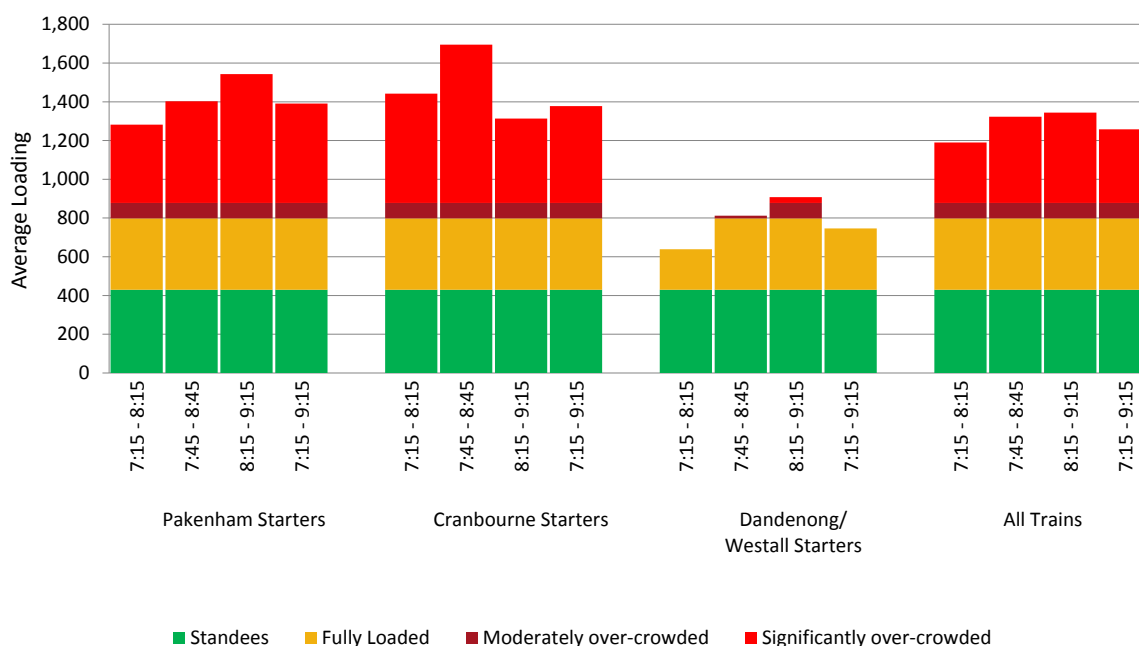


Figure 5 - Forecast average peak loading in 2021 with July 2014 service numbers and existing rolling stock (current load standard)

4.2. Required projects

To support the above passenger demand in 2021 as well the freight needs for the corridor, the following projects will be required prior to 2021:

- The Cranbourne Pakenham Rail Corridor Project (CPRCP). The CPRCP is made up of the following packages:
 - High Capacity Metro Trains (HCMTs);
 - Pakenham East Depot to provide maintenance support to HCMTs;
 - Dandenong Rail Corridor (DRC) modifications, including duplication works on the Cranbourne line;

⁶ The current load standard is based upon the current seating configuration and a standing passenger density of 3.1 pax/m². The future planning load standards for Siemens stock is 900 passengers per train, which assumes a lower number of seats and a higher passenger density of 4.0 pax/m².

- Upgraded signalling capacity along the entire length of the corridor between Cranbourne/Pakenham and the City Loop;
- Power Upgrades to support the operation of higher frequencies and higher capacity trains;
- Grade separation of road-rail level crossings.
- The DL Additional Rolling Stock Project (DARSP). The DARSP would deliver a consistent fleet of HCMT rolling stock on the corridor (rather than a combination of HCMT and Siemens rolling stock) through the procurement of an additional 12 HCMT sets. This initiative will:
 - allow the planning load standards to be achieved by providing greater capacity during the peak periods (reducing over-loading on some services);
 - provide a more consistent higher-quality service offering to passengers;
 - provide an opportunity to optimise junctions, stabling, platform configurations and signalling to the consistent rolling stock;
 - reduce operational complexity, thereby improving the reliability and availability of service; and
 - require additional works (for example stabling siding extensions)
- Metropolitan Intermodal System (MIS) which will provide regular intermodal rail freight operations between key terminals on the rail network including between the Port of Melbourne and Lyndhurst.

4.3. Summary of Dandenong Line Operations in 2021

PTV has developed a preferred peak hour service plan for passenger services on the Dandenong Line, which aims to meet demand up to 2021, is consistent with long term operational requirements for the corridor and provides a customer-focused and cost-effective solution. The preferred solution provides the following peak hour services:

- A 10 minute frequency on the Cranbourne Line (6 metro trains per hour);
- A 5 minute frequency on the Pakenham Line (10 metro trains and 2 V/Lines per hour); and
- An additional 2 trains originating/terminating at Dandenong to maintain sufficient service levels and absorb demand at the inner stations behind the path of an express V/line service ('sweeper services').

This preferred plan schedules a total of 20 trains in the peak hour on the main trunk corridor between Dandenong and Richmond in the peak direction with all but two peak hour services originating from Cranbourne/Pakenham.

Regional patronage growth to 2021 on the Traralgon corridor is expected to be between 3.5% and 5.3% per annum, which is ranked behind the major growth corridors of Geelong and Ballarat. Due to the expected high demand for metropolitan rail travel, it is not proposed to increase the number of current V/Line train paths on the corridor in the peak periods. Increases in peak patronage on the Traralgon corridor will be managed by operating longer trains. The service plan for the regional services on the corridor will be considered further in the Regional Network Development Plan being prepared by PTV in conjunction with V/Line.

Off-peak and inter-peak operations do not vary from the July 2014 timetable, other than for the operation of MIS services between Southern Cross and the proposed MIS terminal at Lyndhurst.

Journey times shall be no longer than existing throughout all periods of the day.

All metropolitan services will operate through the CBD via the Caulfield Loop (Parliament, Melbourne Central, Flagstaff, Southern Cross and Flinders Street stations) operating continually in a counter-clockwise direction throughout the day. To support this service the line will operate with a dedicated fleet of 37 High Capacity Metro Trains (HCMTs) as delivered by a combination of the CPRCP and DARSP projects (see Table 4 below). These HCMTs will be maintained at a new depot at Pakenham East.

In the peak periods, V/Line services will travel directly into platform 7 at Flinders Street from Richmond. In the inter-peak and off-peak periods

PTV intends for the line to function as an operationally independent group (with the exception of V/Line and freight services) with dedicated rolling stock, maintenance, and signalling control.

The following table summarises the key attributes of the Dandenong Line for both the CPRCP only and CPRCP + DARSP cases in 2021:

Table 5: Summary of the Dandenong Line

Feature	CPRCP only	CPRCP + DARSP
Main termini	Cranbourne, Pakenham, Dandenong, Westall, Flinders Street Terminal at Lyndhurst for MIS freight trains	
Additional termini for degraded or special operations	Oakleigh, Caulfield, Berwick (turn-back capability in both directions)	
Inner Area routing	<p>Metropolitan trains:</p> <p>South Yarra - Richmond- Southern Cross-Flinders Street- Richmond-South Yarra via the Caulfield Loop in a counter-clockwise direction</p> <p>V/Line Peak:</p> <p>South Yarra – Richmond – Flinders Street (turn-back) – Richmond – South Yarra</p> <p>V/Line Off-Peak:</p> <p>South Yarra – Richmond – Flinders Street – Southern Cross and vice versa</p> <p>Freight trains (off-peak only):</p> <p>South Yarra – Richmond - Flinders Street – Southern Cross and vice versa</p>	
Stopping patterns	<p>Metro services will operate express between Caulfield and South Yarra (exclusive)</p> <p>V/Line services will stop only at Pakenham, Dandenong, Clayton, Caulfield, Richmond (peak only) and Flinders Street. With the exception of Pakenham and Flinders Street, stops are only to disembark passengers in the Up direction and embark in the Down direction.</p>	
Station dwell times	<p>40 seconds at Dandenong, Caulfield, South Yarra, Richmond and all CBD stations.</p> <p>20 seconds at all other locations on the corridor.</p>	

Feature	CPRCP only	CPRCP + DARSP
Turn-back times	Minimum of 4 minutes for metro services (if relay drivers are not used) and Minimum of 6 minutes for V/Line services. The majority of turn-back times shall be longer than this to support reliable operations.	
Platforms at Flinders St and Southern Cross	Peak Periods: FSS: Metro Pl. 6, V/Line Pl. 7 SXS: Metro Pl.12 Non-peak periods: FSS: Metro Pl. 6, V/Line 8,10 SXS: Metro Pl.12, V/Line Pl. 15,16	
Rolling Stock Fleet overall requirement	25 HCMT (164m maximum length) 12 Siemens (144m length)	37 HCMT (164m maximum length)
Rolling Stock Fleet peak service requirement	24 x HCMT 11 x Siemens (plus 1 spare train of each type not allocated for service during the peaks)	35 HCMT (plus 2 spares not allocated for service during the peaks)
Acceptable Planned Train Capacity⁷	1100 passengers for HCMT rolling stock ⁸ 900 passengers for Siemens rolling stock	
Acceptable number of seats per train	Approx 550 seats for HCMT rolling stock ⁹ 430 seats for Siemens rolling stock	
Acceptable two-hour standing time¹⁰	No more than 10% of passengers standing for greater than 30 minutes	

⁷ Measured as the average for all trains of each type at the maximum load point on the line (Caulfield) over a one-hour or two-hour peak period.

⁸ This standard may be refined once detailed information on the internal configuration of the HCMT rolling stock is available.

⁹ This standard may be refined once detailed information on the internal configuration of the HCMT rolling stock is available.

¹⁰ Measured as the number of inbound people needing to stand for greater than 30 minutes divided by the total number of inbound passengers travelling on the line over the two-hour peak period.

Feature	CPRCP only	CPRCP + DARSP
Maintenance facility	All rolling stock maintenance for metropolitan fleet operating on the corridor will be conducted at facilities on the corridor. Pakenham East will be used for HCMT rolling stock	Pakenham East
Stabling locations	Pakenham East, Pakenham, Cranbourne, Dandenong and Westall	
Number of remaining level crossings	23 road crossings	

4.4. Passenger Service Levels

The number of passenger services operating on the corridor in 2021 is described below. These service levels will be provided if CPRCP only or if CPRCP + DARSP are implemented, as the number of rolling stock available to operate the corridor is the same in either case. However the combination of CPRCP and DARSP will reduce over-crowding on trains, meeting the planning load targets described in Table 5 above. This is due to greater proportion of high-capacity rolling stock operating on the corridor. The relative train loading performance of CPRCP only and CPRCP + DARSP is described in Section 4.7.

In the peak hour, 20tph will operate in the inbound direction in the morning, including 2 V/Line services between Dandenong and Flinders Street. These trains will be scheduled on a 2.5 minute regular headway with four periods in the peak hour where trains are separated by 5 minutes.

Compared to the Base Case (July 2014 timetable) this will provide an increase of three trains in the peak hour for the corridor (+3 Pakenham, +2 Cranbourne, -2 Dandenong). This will effectively add three extra services from beyond Dandenong and extends two of the current Dandenong starters to originate from beyond Dandenong (to support the predicted growth in that region and to provide as many seats as possible for those travelling for journey times longer than 30 minutes). Two Dandenong starters are retained to act as 'sweeper services' behind V/line express trains. In the shoulder peak periods Cranbourne services will continue to operate every 10 mins but fewer Pakenham services will operate than in the peak hour with services mostly operating every 10 mins. In the post peak hour shoulder in the AM rolling stock returning for the city following an early peak run will be used to run a second short service from Westall.

At all times a minimum 20 minute service would operate to and from both Cranbourne and Pakenham. Service patterns and frequencies are shown in Table 6 with changes from the July 2014 timetable highlighted in Table 7.

In the CPRCP only case, Siemens trains will be allocated to Dandenong and Westall services and to a minimum number of Pakenham and Cranbourne services in shoulder peak periods. Peak hour Cranbourne and Pakenham services are predicted to have loads greater than 900 passengers in particular and will therefore need to be operated by HCMT (for example those in the middle of the peak hour or close to the service gaps imposed by the V/Line services).

Table 6 - Passenger service numbers on Dandenong Line in 2021

Service numbers	Peak Direction Hour ¹¹	Peak Direction 2-hour ¹¹	Daytime off-peak (tph) ¹²	Other off-peak (tph) ¹²
Limited express* services to/from Pakenham	10	17	3	3
Limited express* services to/from Cranbourne	6	12	3	-
Cranbourne to/from Dandenong Shuttle	-	-	-	3
Limited express* services to/from Westall	-	3	-	-
Limited express* services to/from Dandenong	2	2	-	-
V/Line express** services to/from beyond Pakenham	2	3	1	1
TOTAL	20	37	7	7

Table 7 - Passenger service improvements on the Dandenong Line in 2021 compared to July 2014 timetable service levels.

Services changes from base case	Peak Direction Hour ¹¹	Peak Direction 2-hour ¹¹	Daytime off-peak (tph) ¹²	Other off-peak (tph) ¹²
Limited express* services to/from Pakenham	+3	+5	-	-
Limited express* services to/from Cranbourne	+2	+4	-	-
Cranbourne to/from Dandenong Shuttle	-	-	-	-
Limited express* services to/from Westall	-	-	-	-
Limited express* services to/from Dandenong	-2	-3	-	-
V/Line express** services to/from beyond Pakenham	-	-	-	-
TOTAL	+3	+6	-	-

* Express through Malvern, Armadale, Toorak, Hawksburn

** Stopping only Pakenham, Dandenong, Clayton, Caulfield, Richmond (peak only) and Flinders Street. With the exception of Pakenham and Flinders Street, stops are only to dis-embark passengers in the Up direction and for passengers to embark in the Down direction.

¹¹ Number of trains in the inbound direction in the morning and outbound direction in the afternoon in the peak hour and two-hour periods. This is defined as the period in which trains are scheduled to arrive at Richmond between 07:45 – 08:44:59 / 07:15 – 09:14:59 in the morning and depart Richmond between 5:00 to 5:59:59 / 4:30 to 6:29:59 in the afternoon.

¹² Both directions

This service pattern has been designed to allow additional services to be easily added when future new rolling stock becomes available and as demand grows. The service pattern allows for an ultimate 24tph to operate on the corridor (post Stage 2 of the NDP) in the following pattern:

- 12tph from Pakenham (including V/line)
- 6 tph from Cranbourne
- 3tph from Westall (diverted to Rowville if/when new line constructed)
- 3tph from Dandenong (diverted to Rowville if/when new line constructed)

This service pattern is also consistent with the service planning undertaken for the MRL and MARL projects as will be discussed later. The connection of the Dandenong Line to the Sunshine Line under MRL and MARL and the consequent through routing of trains from Sunbury and Airport to Cranbourne and Pakenham would necessitate the Dandenong Line to operate on a 10 minute off-peak cycle to allow coordination with Bendigo line pathways between Albion and Sunbury and the operation of the desired consistent 10 minute service from the Airport and Sunbury. The off-peak 10 minute pattern prescribed for the Dandenong Line (increasing to a 2.5 minute pattern in the peaks) is therefore consistent with the longer term corridor plan.

4.5. Freight service levels

Freight service levels are also likely to increase on the corridor by 2021 due to a range of initiatives presented to PTV by FLAM.

4.5.1. The Metropolitan Intermodal System (MIS) Project

The Metropolitan Intermodal System (MIS) has been funded for delivery by 2017. It involves the operation of high-performance short freight trains that are capable of operating amongst metropolitan passenger traffic with minimal disruption. The trains will need to operate with a maximum length of 600m (42 wagons carrying 2 TEU each) powered by two 3000hp locomotives in a push-pull configuration.

The MIS project assumes a total of 1 train per day in each direction between Southern Cross and Lyndhurst initially (2017) then lifting to 3 trains per day on weekdays and 4 trains per day on weekends by 2021 and 7 trains per day on weekdays and 10 trains per day on weekends by 2031. These trains will operate outside peak periods.

A description of the required infrastructure works to support the MIS Project is included in Section 4.6.1, with further detail in Appendix A.

4.5.2. Other Potential Freight Projects on the corridor

Other potential future freight train operational changes on the corridor include:

- the re-instatement of Bairnsdale log train operations;
- trains carrying coal from the Loy Yang region to the Port of Geelong
- an additional train carrying containerised products from the Bairnsdale area; and,
- an anticipated requirement for containerised freight from Morwell to operate to Lyndhurst with facility for train reversal at Dandenong.

These initiatives are still largely speculative and are subject to further investigation, as such the COO only makes passive provision for these initiatives through reserving up to one pathway an hour during off-peak periods subject to demonstration that these service could be operated reliably within those pathways.

4.5.3.Total freight services for 2021

Service planning has assumed, and resultant infrastructure design will need to allow for, the following freight pathways for 2021:

- Existing pathways (with a 20 minute schedule flexibility margin) operated by the Apex and Paper trains;
- 3 return MIS trains per day during the inter-peak and 4 trains per day on weekends operating MIS schedules (schedule for a maximum of 2 tph);
- 2tph after 10pm to cover any other freight movements.

4.6. Scope of works

4.6.1.Works recommended for Dandenong Line for 2021

It is recommended that the following additional infrastructure and systems be provided to support the operation of the Dandenong Line as outlined in this document:

Table 8 Works recommended for Dandenong Line for 2021

Project recommendation	Project Resp.	Key sub-components	Rationale
Cranbourne Line upgrades	CPRCP	<ul style="list-style-type: none"> - New flat junction diamond crossing to enable down Cranbourne line trains to use platform 3 at Dandenong.¹³ - Duplication from new flat junction diamond crossing to just north of the ABB sidings (approx. 860m). - Duplication from Cranbourne to just north (up-side) of Merinda Park (approx. 2820m). - Extension of Lynbrook loop towards Dandenong (approx. 1200m). <p>See Appendix D for detail of the proposed duplication works.</p>	<ul style="list-style-type: none"> -Enables 10 minute frequency to operate on Cranbourne Line in both directions better matching patronage demand. -Enables 5 minute service to operate from Pakenham (incl. V/line) better matching patronage demand. - Service reliability improved through removal of delays associated with single track operations. - Matches the required service pattern for MRL and MARL in the longer term. - Compatible with MIS (see Section 4.5.1) and SERL (see Section 3.4.1) works required on the corridor. In particular to make provision for 2 new dual gauge tracks on Western side of Cranbourne line (for SERL).
Procurement of initial set of high	CPRCP	- Procurement of 25 High Capacity Metro Trains (HCMT)	Initial set of high-capacity trains required to support

¹³ Subject to a final signal design that will support the crossing of Cranbourne with Pakenham trains at this location while meeting the reliability target.

Project recommendation	Project Resp.	Key sub-components	Rationale
capacity rolling stock		to be deployed on the Dandenong Line - Retention of 12 Siemens trains on the corridor	patronage growth and other service initiatives.
Procurement of further set of high capacity rolling stock	DARSP	- Procurement of further 12 High Capacity Metro Trains (HCMT) to be deployed on the Dandenong Line - No Siemens trains remain on the corridor	Further set of high-capacity rolling stock to meet planning load standards.
Cascade of existing rolling stock off the corridor	PTV – other project	Cascade of remaining Siemens trains operating on the line back to the Cross-City Group and with further cascading additional services will be added to the Cross-City, Northern and Clifton Hill groups.	Maximise the utilisation of existing rolling stock
Maintenance facilities	CPRCP +DARSP (CPRCP only)	Pakenham East - Maintenance facility to support fleet of 37(25) HCMT trains for the Dandenong Line. - Maintenance facility to make provision to be expanded to ultimately maintain 80 HCMT with no works precluding extension to 234m length trains (supported by an on-board ATO system). (For CPRCP only: DL Siemens maintenance facility - Maintenance facility on the corridor to support fleet of 12 Dandenong Line (DL) Siemens trains.)	- Provides new maintenance facility for the HCMT - Supports the operation of the entire Dandenong Line fleet - Creates a fully sectorised railway that does not require trains to be moved to other corridors for maintenance purposes
Train Stabling	CPRCP + DARSP (CPRCP only)	Sufficient train stabling roads and maintenance roads shall be provided on the corridor for 37 HCMT (25 HCMT + 12 Siemens) at a minimum, with additional spare maintenance road capacity to ensure the rolling stock utilisation and maintenance requirements are met and with stabling locations	Minimise life-cycle costs for storage and operation of rolling stock. Provision of sufficient stabling to support the entire fleet required for the Dandenong Line (DL) to avoid inefficiency, network congestion and negative impact on the DL corridor performance caused

Project recommendation	Project Resp.	Key sub-components	Rationale
		chosen to minimise both capital expenditure and empty running on the corridor.	by fleet operating outside the corridor.
Signalling & traction power System – Operational frequency in 2021	CPRCP	<p>The signalling and traction power system for the period up to and including 2021 must support a peak operational frequency (trains per hour) for each section of the corridor as follows:</p> <p>Pakenham to Cranbourne Junction – 10 metro + 2 V/Line</p> <p>Cranbourne to Cranbourne Junction – 6 metro</p> <p>Cranbourne Junction to Richmond – 18 metro + 2 V/Line</p> <p>Richmond to Flinders Street (via Loop) – 18 metro</p> <p>Richmond to Flinders Street (Direct) – 2 V/Line</p> <p>Flinders Street to Richmond – 18 metro + 2 V/Line</p> <p>The signalling system must support at least 1.25 X the operational frequency on full clear aspects to ensure the operational frequency can be delivered reliably.</p>	The signalling system must support the planned service plan for 2021
Signalling & Traction power System – minimum separations	CPRCP	<p>The signalling and traction power system for the period up to and including 2021 must support a:</p> <ul style="list-style-type: none"> - 3 minute separation between any two trains between Pakenham and Cranbourne Junction. - 2.5 minute separation between any two trains between Cranbourne Junction and Richmond. - 2.5 minute separation between any two trains between Richmond and Richmond (via the Loop). - 5 minute separation between any two trains between 	<p>Protect the metropolitan network from any minor perturbations arising from long distance regional operations in order to enable a 95% on time to 3 minute to be achieved.</p> <p>The service plan requires trains to be scheduled on 2.5 minute headways.</p> <p>The Cranbourne line may require occasional fleeting or positioning moves in the peak periods.</p>

Project recommendation	Project Resp.	Key sub-components	Rationale
		Cranbourne and Cranbourne Junction.	
Signalling System – freight operations	CPRCP	The signalling system must support the operation of any freight train up to length 1200m between two metropolitan trains separated by 10 minutes.	The signalling system must support the operation of freight trains with a 10 minute off-peak frequency on the corridor
Signalling System – V/Line close-up requirements	CPRCP	<p>The signalling system must also allow:</p> <ul style="list-style-type: none"> - A metro train to depart Pakenham no more than 150s after a V/Line train in the up direction. - A V/Line train to close up to within 150s to a metro train on approach to Pakenham in the down direction. 	The signalling system must maximise the opportunity for express running of V/Line services (minimise the travel time of these services in the metropolitan area).
Signalling System – CBTC (if applicable)	CPRCP	<p>Any CBTC system, if installed on the corridor, must comply with a series of operational requirements.</p> <p>An initial set is described in Appendix E.</p>	As a new technology CBTC would introduce a set of new operational requirements
Inner area rationalisation of the Richmond, Flinders Street and Southern Cross junctions to provide segregation of the Dandenong Line from the remainder of the rail network.	CPRCP	<ul style="list-style-type: none"> - Removal or clipping of sets of points on northern end of Southern Cross station which allow connection from Caulfield loop onto Through Suburban lines. - Removal or clipping of sets of points on western end of Flinders Street which allow connection from Platform 7 to Through Suburbans and other viaducts. - Removal or clipping of existing sets of points East of Flinders Street which allow connection from Caulfield Local lines to Caulfield Throughs, Burnley Locals, Special Lines and Sandringham Lines. Provision of a new set of points to allow connection to Cross City Group as described below. 	<ul style="list-style-type: none"> - Simplification of inner-core of the Melbourne network to support metro-style end to end operations with segregated lines and deliver infrastructure capability to enable a 95% on time to 3 minutes operation.. - Reduction in track and points maintenance costs. - Some connections retained to support MRL operations.

Project recommendation	Project Resp.	Key sub-components	Rationale
Provision of an efficient crossover point between the Dandenong and Cross City Groups at Richmond Junction	CPRCP	<p>Support parallel movement from Up Caulfield Local to Up Caulfield Through and from Down Caulfield Through to Down Caulfield Local simultaneously.</p> <p>Support further connection to/from the Caulfield Through from/to Special Lines.</p> <p>Up and Down Caulfield Through lines must be configured to allow a 600m MIS train to enter the section independent of the Dandenong Line Group or Cross City Group in either direction without an overlap impeding any train moves on the Group it is approaching.</p>	Supports the movement of V/Line and freight services in the off-peak to and from the Cross City group providing access to Flinders Street and Southern Cross.
Provision of a flexible turn-back arrangement at platforms 6 and 7 to support V/Line and degraded operations	CPRCP	<ul style="list-style-type: none"> - Access to either platform 6 or 7 from the Up Caulfield Local and return to the Down Caulfield Local to allow a V/Line or a failed metro train to be sent direct to Flinders Street station (rather than around the loop). - Access to either platform 6 or 7 from the Caulfield Viaduct to by-pass a train held on either platform 6 or 7. 	Provides flexibility to turn back a V/Line or Metro train on either platform 6 or 7
MIS Project Further detail in Appendix A	CPRCP	<p>The proposed MIS works described below are scheduled for construction prior to the CPRCP. As such CPRCP must be designed to not preclude these:</p> <ul style="list-style-type: none"> - construction of an independent track for MIS trains to clear the Cranbourne line prior to entering Lyndhurst terminal configured to allow these movements to occur at 'medium speed' (i.e. 40 km/h). Currently recommended to be from south of Abbotts Road for approximately 1200m on the western side. - provision of a holding track 	Facilitate the operation of freight trains on the corridor operating amongst non-peak passenger services.

Project recommendation	Project Resp.	Key sub-components	Rationale
		for freight shuttles and other freight trains not exceeding 1200 metres in length at Dandenong , clear of passenger traffic, configured to allow these movements to occur at 'medium speed' (i.e. 40 km/h). ¹⁴	
Provision of suitable traction power system.	CPRCP + DARSP (CPRCP only)	Upgrade of existing and installation of new sub-stations, tie-stations and rectifiers as required to support 35 HCMT in service (24 HCMT and 11 Siemens in service).	Support the operation of the service plan as specified in Table 6, particularly HCMTs.
Line Speeds	CPRCP	All works on the corridor will support line speeds no worse than current.	To ensure that the current travel time performance of the corridor is maintained or improved with higher performing rolling stock.
Platform, stabling and siding extensions	CPRCP	Signal and train stop relocations, platform extensions, OHLE modifications and other minor works to support the operation of HCMT trains.	Supports the operation of HCMT rolling stock.
Provision of road / rail grade separations at four locations	CPRCP	Two pairs of grade separations: - Murrumbeena Road and Koornang Road. - Clayton Road and Centre Road.	Reduces the impact on the road network of increased service levels on the corridor.

4.6.2.Future Proofing

The works described as a 'Future Project' and its 'Key sub-components' in Table 9 below are for planned projects that are not part of the scope of the CPRCP or DARSP projects. However the project listed in the Project Resp. column (CPRCP and/or DARSP) must take into account and not preclude future construction of these works where specified:

¹⁴ To be confirmed with further modelling currently being undertaken for the MIS Project

Table 9 Future proofing required for CPRCP and DARSP

Future Project	Project Resp.	Key sub-components	Rationale
Signalling System – beyond 2021	CPRCP	<p>The signalling system beyond 2021 will need to support a peak operational frequency (trains per hour) for each section of the corridor as follows:</p> <p>Pakenham to Cranbourne Junction – 13 metro + 2 V/Line</p> <p>Cranbourne to Cranbourne Junction – 7.5 metro</p> <p>Cranbourne Junction to Richmond – 20.5 metro + 2 V/Line</p> <p>Richmond to Flinders Street (via Loop) – 20.5 metro</p> <p>Richmond to Flinders Street (Direct) – 2 V/Line</p> <p>Flinders Street to Richmond – 20.5 metro + 2 V/Line</p> <p>The signalling system must support at least 1.20 X the operational frequency on a full clear aspect to ensure the operational frequency can be delivered reliably.</p>	The signalling system must support growth beyond 2021.
Signalling System - 2031	CPRCP	<p>The signalling system in 2031 will need to support a peak operational frequency (trains per hour) for each section of the corridor as follows:</p> <p>Pakenham to Cranbourne Junction – 10 metro + 2 V/Line</p> <p>Cranbourne to Cranbourne Junction – 6 metro</p> <p>Cranbourne Junction to Rowville Rail converge – 16 metro + 2 V/Line</p> <p>Rowville Rail spur – 6 metro</p> <p>Rowville Rail converge to Richmond – 22 metro + 2 V/Line</p> <p>Richmond to new MRL flyover diverge – 22 metro + 2 V/Line</p> <p>New MRL flyover diverge to</p>	The signalling system must support the service plan for 2031 and the introduction of Rowville Rail

Future Project	Project Resp.	Key sub-components	Rationale
		<p>Flinders Street Platforms 6 & 7 – 22 metro</p> <p>Flinders Street Platforms 6 & 7 to Spencer Street Platforms 11 & 12 via Caulfield and Northern Viaducts – 22 metro</p> <p>The signalling system must support at least 1.20 X the operational frequency on a full clear aspect to ensure the operational frequency can be delivered reliably.</p>	
Signalling System – other requirements	CPRCP + DARSP	Other signalling requirements specified for 2021, including minimum train separations, assumed dwell times, assumed stopping patterns and V/Line close-up requirements must continue to be maintained post-2021.	Service plans post-2021 have the same requirements
Melbourne Rail Link	CPRCP	Caulfield Junction rationalisation must allow for future cross-overs at Caulfield to/from Caulfield Through lines to/from Caulfield Local lines post-implementation of MRL.	<p>The Frankston Line will operate via the new tunnel through South Melbourne and will connect to the Burnley Group.</p> <p>As such, freight and Stony Point services operating on the Frankston Line will need to exit at Caulfield.</p>
Melbourne Rail Link	CPRCP	<p>The rationalisation works for the Richmond and Caulfield Junctions (and any signalling works) must not preclude:</p> <ul style="list-style-type: none"> - The conversion of the Caulfield Quad lines from South Yarra to Richmond to an Up/Up/Down/Down configuration with the outer two tracks utilised for the Dandenong-Sunbury Line and the inner two tracks utilised for Freight and VLine services. - A future dual-track flyover from the future inner Freight and V/Line tracks to the Sandringham Lines, allowing access to platforms 10 and 13 at Flinders Street. 	The network configuration under MRL will alter the function of many inner area tracks and will result in the need to provide a grade separated path for V/line and Freight to operate from the reconfigured Caulfield Local lines to the Sandringham lines

Future Project	Project Resp.	Key sub-components	Rationale
		- The future inner Freight and VLine tracks (current Up Local and Down Through) supporting unfitted Freight and V/Line services post-MRL.	
Melbourne Rail Link	CPRCP	<p>Inner area rationalisation of the Richmond, Flinders Street and Southern Cross junctions shall allow for dual through running tracks connecting to the Up and Down Caulfield Local Lines post-MRL.</p> <p>In particular, a future interface between the Northern Viaduct and platform 6 at Flinders Street must not be precluded.</p>	<p>The Caulfield and Northern Viaducts will be converted to support the operation of the Sunbury-Dandenong Line (as through running lines in each direction).</p> <p>The Burnley Viaduct will support Northern Group operations.</p>
Melbourne Rail Link	CPRCP	Works on the Caulfield Viaduct shall allow for traffic to operate in the reverse direction (East to West rather than West to East) on this line post-MRL.	The Caulfield Viaduct will operate in an East to West direction only to support the Dandenong Services operating through to Sunbury and the Airport (opposite to the proposed CPRCP operation).
Melbourne Rail Link	CPRCP	Works in the Caulfield Loop must not preclude the operation of the Frankston-Ringwood Group post-MRL, including reversing the direction of traffic	The underground section of the Caulfield Loop will be utilised by the Frankston-Ringwood Group services to carry trains in an eastbound direction between Southern Cross and Richmond
Potential to extend trains to 234m	CPRCP+ DARSP	<p>No works on the corridor shall preclude the operation of 234m long trains.</p> <p>Trains of 234m length would be supported by an on-board ATO system.</p>	<p>The Dandenong Line may require the operation of trains up to 234m trains in the long term.</p> <p>However, trains of 234m length would be supported by ATO to assist with stopping accuracy and control.</p>
Connection of Rowville Line	CPRCP	<p>Works on the corridor must allow for:</p> <ul style="list-style-type: none"> - Connection of proposed Rowville Line with Sunshine-Dandenong Line at Huntingdale station. - Additional stabling on the 	To serve new corridor, including Monash University.

Future Project	Project Resp.	Key sub-components	Rationale
		Rowville Line.	
Implementation of South Eastern Rail Link (SERL)	CPRCP	<p>Works on the corridor must allow for:</p> <ul style="list-style-type: none"> - Construction of an additional track or tracks between Dandenong and Lyndhurst on the western side of the Cranbourne line (through Green's Road siding) to support freight access to Lyndhurst terminal and the Port of Hastings. (See Appendix D) - Construction of additional tracks between Dandenong and South Yarra to be used by V/Line passenger and freight trains. (See Section 3.4.1 for detail.) - Tie in of the above tracks into the inner Freight and VLine tracks at South Yarra as provided in MRL. 	- To accommodate future demand for freight movement in corridor related to development of Port of Hastings and South Eastern Intermodal Terminal.
Signalling System – CBTC (if applicable)	CPRCP	<p>Any CBTC system, if installed on the corridor, must comply with a series of future-proofing operational requirements.</p> <p>An initial set is described in Appendix E.</p>	As a new technology CBTC would introduce a set of new operational requirements

4.7. Train Load Predictions

Passenger loading on trains during the morning peak period for the Dandenong Line were predicted for both the CPRCP only and CPRCP+DARSP cases using patronage forecasts for 2021. The predictions use a demand curve that assume an improvement in peak spreading so that 60% of the two-hour peak patronage travel in the peak hour and 40% in total for the two half-hour shoulders either side of the peak hour.

Both cases require 37 trains in total, of which 35 are utilised to support peak period operations and both cases will support the service plan as described in Section 4.4. However each option delivers different levels of passenger crowding and standing times, by including different numbers of HCMT rolling stock instead of Siemens rolling stock. This is because HCMT rolling stock have a greater overall capacity (1100 passengers vs. 900 passengers at planning load) and a higher number of seats (550 vs. 430) than Siemens rolling stock.

In assessing the performance of each case, two key indicators were used:

- **The % Planned Train Capacity utilisation for each service type.**
This is calculated by firstly determining the maximum load for each train on the line (generally at Caulfield) then averaging these maximum loads over either the one-hour or

two-hour peak period. This calculation is done for each service type (Pakenham, Cranbourne, Dandenong and Westall) and then divided by the weighted average Planned Train Capacity (a combination of 1100 for HCMT¹⁵ and 900 for Siemens stock) for services of that type.

The target for this indicator is no more than 100%.

- **The % of people standing for longer than 30 minutes.**

This is calculated as the number of inbound people predicted to stand for greater than 30 minutes divided by the total number of inbound passengers travelling on the line on trains that arrive at Richmond over the one-hour or two-hour peak period.

The target for this indicator is no more than 10%.

The performance of each case is summarised in Table 10 below.

It can be seen that all of the load and standee standards are met for either the CPRCP only case or the CPRCP+DARSP case, with the exception of the Planned Train Capacity standard for the Pakenham trains, which is slightly above target at 102%. This is largely caused by the over-crowding of Pakenham trains caused by the gaps in service when the two V/Line services travel through the corridor. This breach of this standard is therefore difficult to resolve while these V/Line services share track with the metropolitan services in the peak hour.

The benefits of DARSP are as follows:

- An improvement in % passengers standing >30 mins in the peak hour from 9.6% down to 9.2% and a major improvement in the shoulder peak hour from 9.1% down to 7.7%.
- An improvement in the Planned Train Capacity utilisation for the Pakenham trains in the shoulder hour from 98% to 96%.
- An improvement in the Planned Train Capacity utilisation for the Cranbourne trains in the peak hour from 93% to 91% and a major improvement in the shoulder peak hour from 89% to 81%.

¹⁵This standard may be refined once detailed information on the internal configuration of the HCMT rolling stock is available.

Table 10 Summary of performance of rolling stock options

Option	CPRCP	CPRCP + DARSP
Rolling stock requirement	25 HCMT 12 Siemens	37 HCMT
Comeng trains retired	8	15
Peak period services operated with HCMT	Most services	All services
% passengers standing >30 mins (1 hour peak / 2 hour peak)	9.6% / 9.1%	9.2% / 7.7%
% Planned Train Capacity utilisation (1 hour peak / 2 hour peak)		
Pakenham	102% / 98%	102% / 96%
Cranbourne	93% / 89%	91% / 81%
Dandenong	77% / 77%	63% / 63%
Westall	- / 24%	- / 21%

The graphs (Figure 6 and Figure 7) below show further detail on the predicted loads for each of the above cases in 2021. It can be seen that, except for a minor breach for the Pakenham services, the Planned Train Capacity Utilisation is now met.

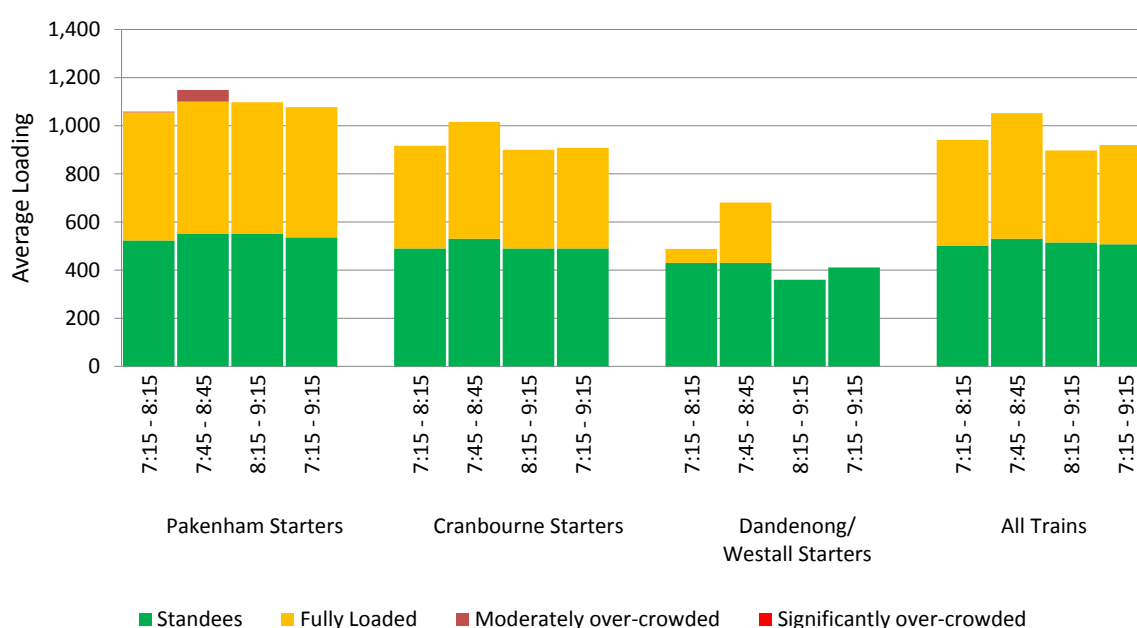


Figure 6 - Forecast average peak loading in 2021 following completion of CPRCP

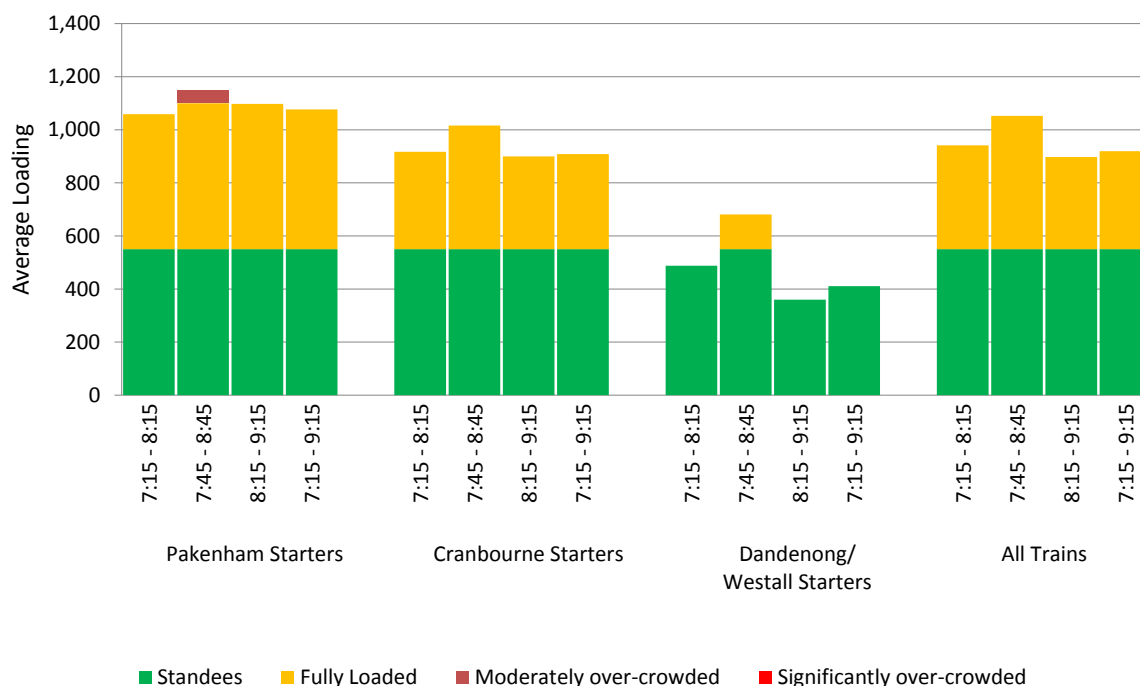


Figure 7 - Forecast average peak loading in 2021 following completion of CPRCP and DARSP

Further detail on the load predictions for 2021 for each of the above cases is included in Appendix B – 2021 Detailed Train Load Predictions.

5. The Dandenong Rail Line in 2031

5.1. Passenger demand in 2031

Patronage forecasting undertaken by PTV has identified that weekday rail boardings are expected to grow by around 5.6% per annum (with Rowville included) on the total corridor between 2021 and 2031. Table 11 shows the specific rates for each corridor section. Growth on the outer sections of the line (from Cranbourne and Pakenham) continues to exceed the inner sections through to 2031.

Table 11 - Forecast Growth Rate per line section

Line	Sections	Forecast Growth Rate per annum 2011 to 2021 ¹⁶	Forecast Growth Rate per annum 2021 to 2031 ¹⁴
Dandenong	Westall to Carnegie	3.6%	3.6%
Dandenong	Dandenong to Springvale	4.4%	3.6%
Cranbourne	Cranbourne to Lynbrook	11.1%	7.9%
Pakenham	Pakenham to Hallam	9.2%	5.1%
Line Average not including Rowville		5.5%	4.5%
Line Average incl. Rowville		-	5.6%

Figure 8 below shows the predicted number of people travelling inbound in the morning peak hour (07:45 – 08:45 at Richmond) and peak two hours (07:15 – 09:15 at Richmond) for 2031 that need to be supported by the Dandenong Rail Line. The following key points should be noted:

- A total of 17,600 passengers are predicted to travel inbound from Richmond in the morning peak hour in 2031;
- However, the peak loading point on the corridor is at Carnegie with 24,700 passengers in the morning peak hour;
- Passengers boarding between Pakenham/Cranbourne and Westall are equal to more than 70% of the load at Carnegie.

¹⁶ Extracted from the PTV Victorian Integrated Transport Model (VITM). These growth rates are for the entire day in both directions.

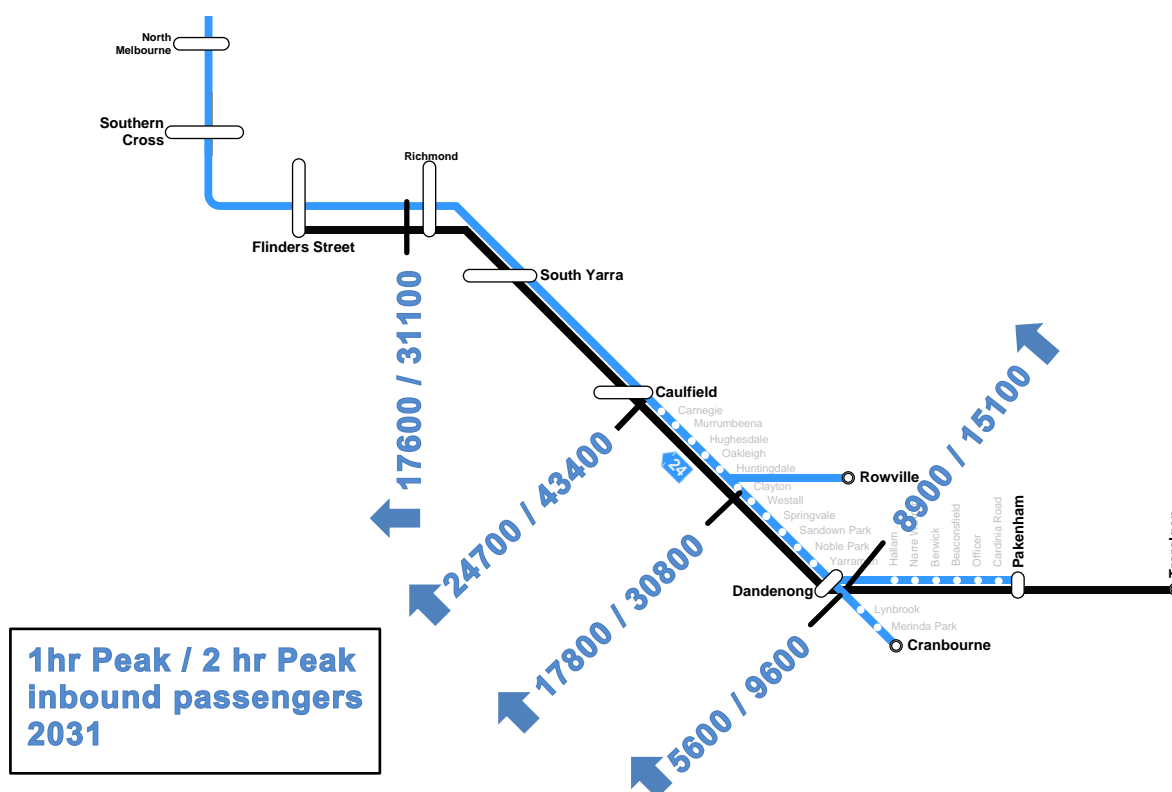


Figure 8 - Dandenong Line predicted AM Peak patronage in 2031

5.2. Required Projects

To support the above passenger demand in 2031 as well the freight needs for the corridor, the following major projects will be required prior to 2031 over and above those required for 2021:

- The Melbourne Rail Link (MRL) and Melbourne Airport Rail Link (MARL) Projects. MRL and MARL will:
 - establish the Frankston-Ringwood Line, by constructing a new tunnel from South Yarra to Southern Cross connected to the existing Burnley and Caulfield loops and through to the Ringwood Line.
 - construct a new rail line to Melbourne Airport, connecting to the existing network at Sunshine.
 - establish a cross-city operation from Melbourne Airport and Sunbury through to Cranbourne and Pakenham via Southern Cross, the existing viaduct and Flinders Street.
 - create the first section of a dedicated freight and V/line railway to the South East and Hastings from Flinders Street to South Yarra.
- The Rowville Rail link, which will be a 12 kilometre rail line between Huntingdale Station and the Stud Park area with the following broad scope:
 - A grade separated junction on the down side of Huntingdale station connecting the Rowville Rail Link to the Dandenong Rail Line.
 - A new rail line following the central median of North Road and Wellington Road from Huntingdale to terminate in the vicinity of Stud Park.
 - Four new stations at Monash University, Mulgrave, Waverley Park and Rowville with a terminus in the vicinity of Stud Park.

- A mix of surface level, below ground and viaduct alignments along the route.
- A stabling facility for trains
- The design would avoid any new level crossings and will preserve the existing road environment.

A range of supporting projects will also be required, including new rolling stock, stabling, traction power and upgraded/additional maintenance facilities.

5.3. Summary of Dandenong Line Operations in 2031

PTV has developed a conceptual peak period service plan for passenger services on the Dandenong Line in 2031. This plan is designed to meet the demand on the corridor in 2031 and provides a customer-focused and cost-effective solution.

The 2031 service plan will differ significantly from the 2021 plan in that the Dandenong line will have been merged with the Sunshine corridor and trains will through-run to Sunbury, Melton and Melbourne Airport in lieu of operating via the Caulfield City Loop. As a result, trains will run direct from Richmond to Flinders Street and then on to Southern Cross and North Melbourne before progressing towards Sunbury and Melbourne Airport.

Figure 9 shows a schematic representation of the planned peak Sunshine-Dandenong line in 2031.

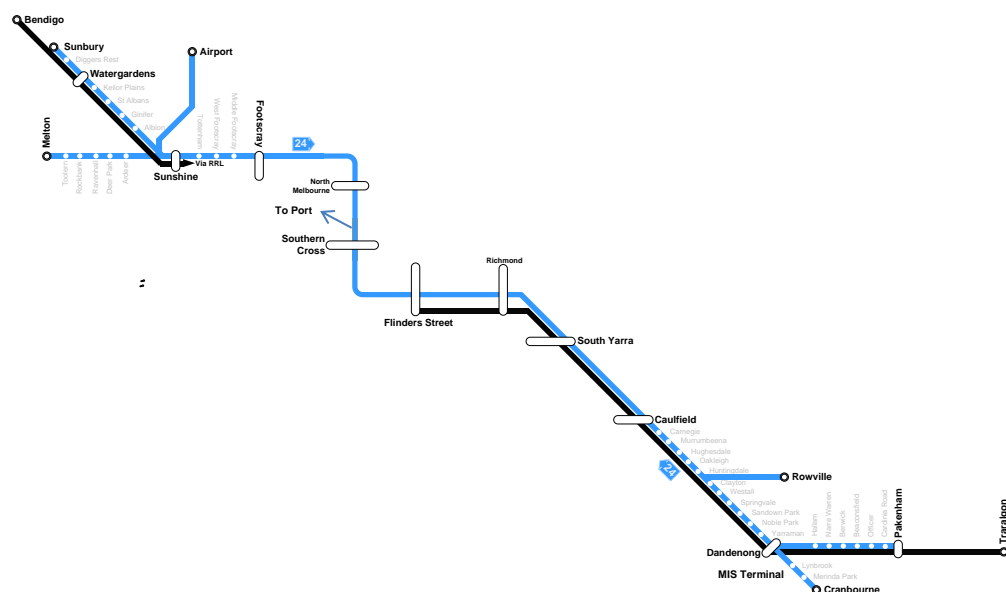


Figure 9: Sunshine-Dandenong line in 2031 (peak hour operation)

From the Dandenong end of the line, the service plan will be similar to 2021 but the trunk section will be augmented to accommodate Rowville services. It is planned that the following peak hour services would be provided:

- A 10 minute frequency from the Cranbourne Line (6 metro per hour);
- A 5 minute frequency on the Pakenham Line (10 metro trains and 2 V/Lines per hour); and
- A 10 minute frequency on the Rowville Line (6 metro per hour).

This preferred plan schedules a total 24tph in the peak hour on the trunk section from Huntingdale but service levels are not adjusted east of Dandenong.

By 2031 it is anticipated that shoulder peak service levels will be equivalent to the peak hour and longer trains will also be in operation on Cranbourne and Pakenham services.

The daytime off-peak services will also differ to enable a 10 minute service to operate to and from the Airport from Dandenong. As a result a total of 13 services per hour will operate, distributed as follows:

- A 20 minute frequency from the Cranbourne Line running through to Melbourne Airport;
- A 20 minute frequency on the Pakenham Line running through to Melbourne Airport;
- A 10 minute frequency on the Rowville Line running through to Melton and Sunbury alternately¹⁷; and,
- One V/line service per hour.

In the other off-peak periods (early morning, evening and weekends) a total of 10 services per hour will operate on the Dandenong Line, distributed as follows:

- A 20 minute frequency from the Cranbourne Line running through to Melbourne Airport;
- A 20 minute frequency on the Pakenham Line running through to Melbourne Airport;
- A 20 minute frequency on the Rowville Line running through to Sunbury¹⁸
- Maximum of one V/Line service
- A 20 minute frequency Melton service would be provided by operating a service between Melton and Flinders Street (turning back at Flinders Street).

The following table summarises the key attributes of the Dandenong Line in 2031:

¹⁷ These services will be 'off-set' from the Cranbourne/Pakenham services (scheduled closer to either a Cranbourne or Pakenham rather than at a 5 minute regular interval) to allow a spare 'slot' for a V/Line or freight train to be scheduled amongst these services.

¹⁸ These services will be 'off-set' from the Cranbourne/Pakenham services (scheduled closer to either a Cranbourne or Pakenham rather than at a 5 minute regular interval) to allow a spare 'slot' for a V/Line or freight train to be scheduled amongst these services.

Table 12: Summary of the Dandenong Line

Feature:	Description:
Termini	Cranbourne, Pakenham, Rowville
Inner Area routing	South Yarra – Richmond - Flinders Street – Southern Cross – North Melbourne and vice versa
Platforms at Flinders St and Southern Cross	FSS: 6 & 7 SXS: 11 & 12
Rolling Stock Fleet	10-car HCMT (234m maximum length)
Rolling Stock Fleet peak service requirement	74x 10-car HCMT for Pakenham/Cranbourne services (234m maximum length) plus 4 spare trains for maintenance
Acceptable Planned Train Capacity¹⁹	1570 passengers for 10-car HCMT rolling stock ¹⁰
Acceptable number of seats per train	785 seats for 10-car HCMT rolling stock ²⁰
Acceptable peak period standing time²¹	No more than 10% of passengers standing for greater than 30 minutes
Maintenance facilities	Pakenham East
Stabling locations	Calder Park, Sydenham, Airport, Melton, Rowville, Dandenong Pakenham East, Pakenham, Cranbourne,
Number of remaining road level crossings	21 road crossings (No level crossings between Caulfield and Huntingdale)

5.4. Passenger Service Levels

The number of passenger services operating on the corridor in 2021 is described below. Compared to the 2021 Dandenong Rail Line operation there will be an additional 4 services operating in-bound in the morning peak hour. In the daytime off-peak/other off-peak there will be an additional 6/3 services per hour in each direction on the corridor caused by the addition of the

¹⁹ Measured as the average for all trains of each type at the maximum load point on the line (Caulfield) over a one-hour or two-hour peak period.

²⁰ This standard may be refined once detailed information on the internal configuration of the HCMT rolling stock is available.

²¹ Measured as the number of inbound people needing to stand for greater than 30 minutes divided by the total number of inbound passengers travelling on the line over the two-hour peak period.

Rowville services. The shuttle service from Dandenong to Cranbourne will also cease to operate and will be replaced by through services to the CBD as discussed in Section 5.3 above.

Table 13 - Passenger service levels on Dandenong Line in 2031

Service numbers	Peak Direction Hour ²²	Peak Direction 2-hour ²⁴	Daytime off-peak (tph) ²³	Other off-peak (tph) ²⁵
Limited express* services to/from Pakenham	10	20	3	3
Limited express* services to/from Cranbourne	6	12	3	3
Limited express* services to/from Rowville	6	12	6	3
V/Line express** services to/from beyond Pakenham	2	4	1	1
TOTAL	24	48	13	10

Table 14 - Passenger service improvements on Dandenong Line in 2031 compared to 2021 service levels.

Services changes from base case	Peak Direction Hour ²⁴	Peak Direction 2-hour ²⁵	Daytime off-peak (tph) ²⁵	Other off-peak (tph) ²⁵
Limited express* services to/from Pakenham	-	+3	-	-
Limited express* services to/from Cranbourne	-	-	-	+3
Limited express* services to/from Rowville	+6	+12	+6	+3
Cranbourne to/from Dandenong Shuttle				-3
Limited express* services to/from Westall		-3		
Limited express* services to/from Dandenong	-2	-2		
V/Line express** services to/from beyond Pakenham	-	+1	-	-
TOTAL	+4	+11	+6	+3

* Express through Malvern, Armadale, Toorak, Hawksburn

** Stopping only Pakenham, Dandenong, Clayton, Caulfield, Richmond (peak only) and Flinders Street. With the exception of Pakenham and Flinders Street, stops are only to dis-embark passengers in the Up direction and for passengers to embark in the Down direction.

²² Number of trains in the inbound direction in the morning and outbound direction in the afternoon in the peak hour and two-hour periods. This is defined as the period in which trains are scheduled to arrive at Richmond between 07:45 – 08:44:59 / 07:15 – 09:14:59 in the morning and depart Richmond between 5:00 to 5:59:59 / 4:30 to 6:29:59 in the afternoon.

²³ Both directions

5.5. Freight Service Levels

Service planning has assumed, and resultant infrastructure design will need to allow for, the following freight pathways for 2031:

- Existing pathways (with a 20 minute schedule flexibility margin) operated by the Apex and Paper trains;
- 7 return MIS trains per day during the inter-peak and 10 trains per day on weekends operating MIS schedules (schedule for a maximum of 2 tph); and
- 2tph after 10pm to cover any other freight movements.

Rowville services will be 'off-set' from the Cranbourne/Pakenham services (scheduled closer to either a Cranbourne or Pakenham rather than at a 5 minute regular interval) to allow a spare 'slot' for a V/Line or freight train to be scheduled amongst these services

5.6. Train Load Prediction

Passenger loading on trains during the morning peak period for the Dandenong Line were predicted for 2031. The predictions use a demand curve that assume an improvement in peak spreading so that 55% of the two-hour peak patronage travel in the peak hour and 45% in total for the two half-hour shoulders either side of the peak hour.

The performance of each case is summarised in Table 15 below.

It can be seen that the service plan with 10-car HCMT rolling stock provides sufficient capacity for the corridor to allow for growth, with both % standee levels and Planned Train Capacity Utilisation falling well within the targets.

Table 15 Summary of performance of Dandenong Rail Line in 2031

Option	DRL 2031
Rolling stock requirement	10-car HCMT
Peak period services operated with HCMT	All services
% passengers standing > 30 mins (1 hour peak / 2 hour peak)	5.1% / 3.1%
% Planned Train Capacity utilisation (1 hour peak / 2 hour peak)	
Pakenham	82% / 72%
Cranbourne	82% / 72%
Rowville	43% / 38%

The graph (Figure 10) below shows further detail on the predicted loads for 2031 during the AM Peak.

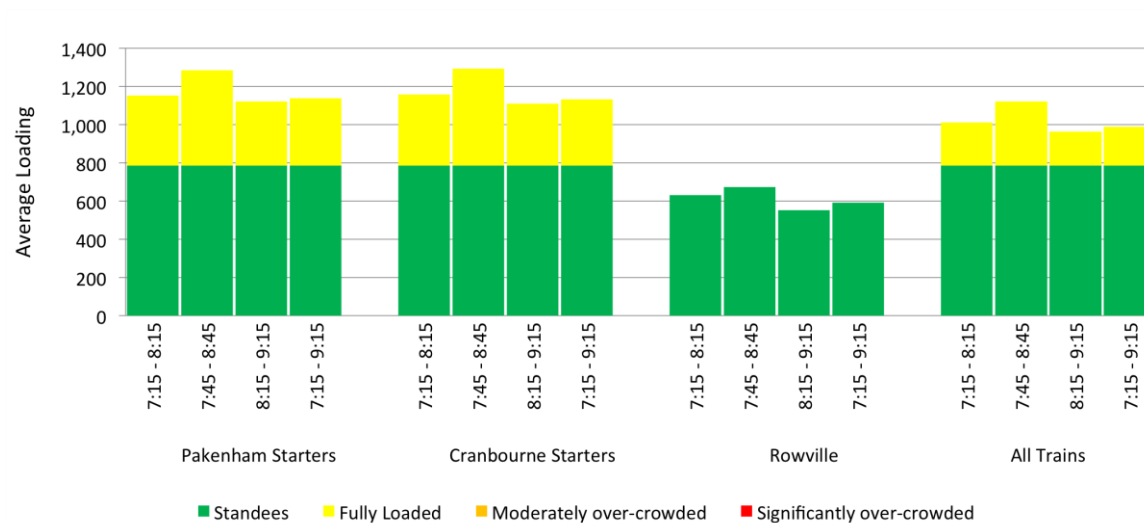


Figure 10: Forecast average peak loading in 2031

Appendix A – Works to support MIS Project

In order to support the MIS operation, provision has been made in the funding for the following works on the Dandenong Line:

- An independent track for MIS trains to stand clear of the Cranbourne line prior to entering Lyndhurst terminal and to accelerate up to line speed prior to merging with passenger trains after leaving the terminal. This is necessary to ensure that freight trains do not delay passenger trains prior to entering the terminal or after exiting the terminal. This independent track is currently proposed to be accessed from a turn-out immediately south of Abbotts Road, then run parallel to the existing Cranbourne line for approximately 1200m on the western side, before diverging into the terminal.
- A holding track for freight shuttles and other freight trains not exceeding 1200m in length at Dandenong. This holding track is assumed to be parallel to the existing platforms and clear of passenger traffic. This holding track is required to allow a freight train to await a path amongst passenger trains before proceeding to Melbourne, Gippsland or Lyndhurst. This holding track must also enable freight trains to reverse direction at Dandenong in order to proceed from Gippsland to Lyndhurst or Lyndhurst to Gippsland, whilst standing clear of passenger traffic. For conventional freight trains, this will necessitate the locomotive(s) being run around to the opposite end of the train using another unoccupied track for this purpose. To support the efficient movement of freight trains arriving into, and departing from the holding track and to do so with minimum impact on passenger services, the signalling and track arrangement should be configured to allow these movements to occur at 'medium speed' (i.e. 40 km/h). It is noted that the holding track facility may not be available for use at times when metropolitan passenger trains are required to enter or leave the Up side stabling sidings.
- In the event that the above independent holding track cannot be provided at Dandenong due to constraints in that area, then the Greens Road sidings (also known as the ABB sidings) may provide a suitable alternative, although far less beneficial. Provision of an independent holding track at either Dandenong or the Greens Road Sidings is to be confirmed with further modelling currently being undertaken for the MIS Project.

These works and how they interact with the required works on the Cranbourne Line are shown in Figure 6 below.

Further detail on the proposed duplication of the Cranbourne Line and how it impacts upon the proposed MIS and SERL alignments is also included in Appendix D.

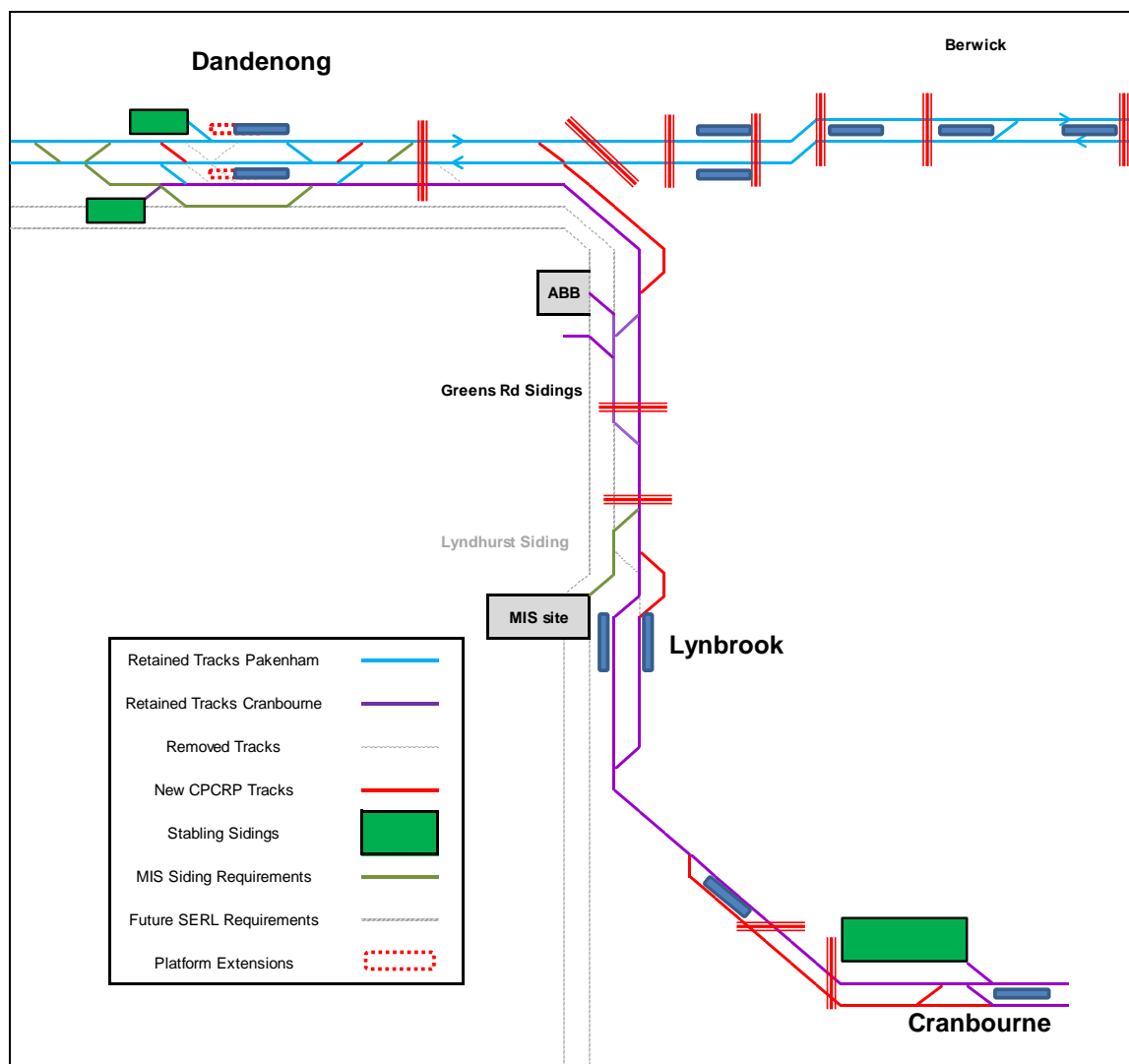


Figure 11 – Proposed works on the Cranbourne Line and Dandenong for CPRCP and MIS Project

Appendix B – 2021 Detailed Train Load Predictions

The following graphs show for both the one-hour and two-hour AM Peak periods:

- > the average number of people travelling on each service type (Pakenham, Cranbourne and Dandenong, Westall).
- > the mix of people standing for greater than 30 minutes, standing for up to and including 30 minutes and not standing at all.

for both the CPRCP only case and the CPRCP + DARSP case in 2021.

One-hour Period - Average number of people travelling on each service type

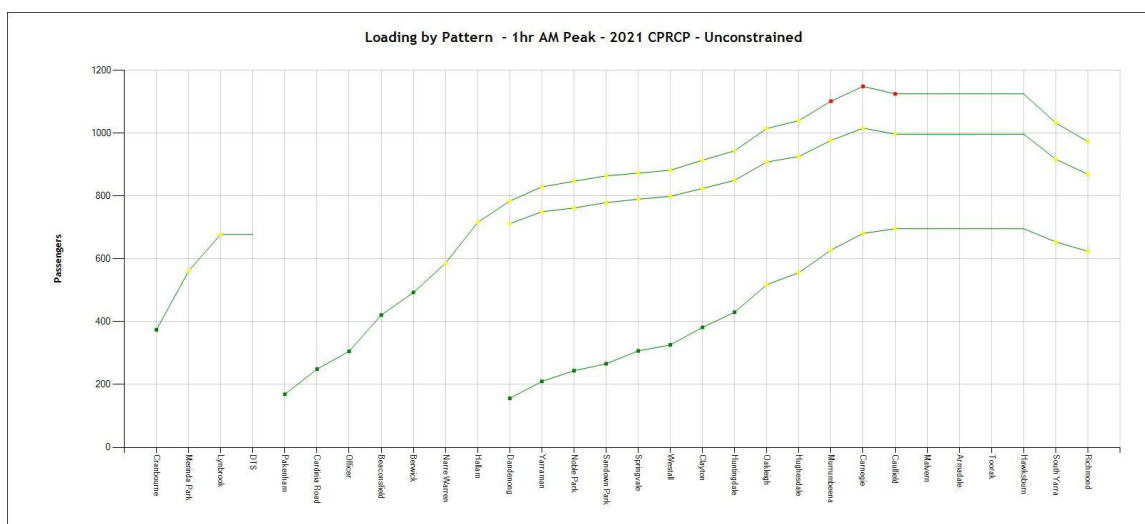


Figure 12 – 2021 AM Peak One-hour - CPRCP case estimate train loads

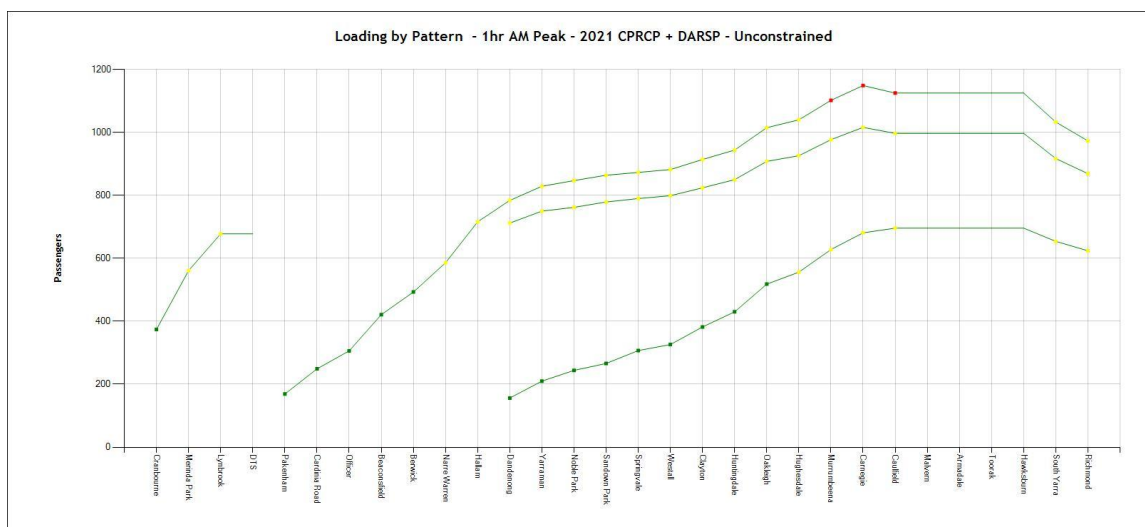


Figure 13 – 2021 AM Peak One-hour – CPRCP+DARSP case estimate train loads

One-hour Period – Number of standees by station of origin

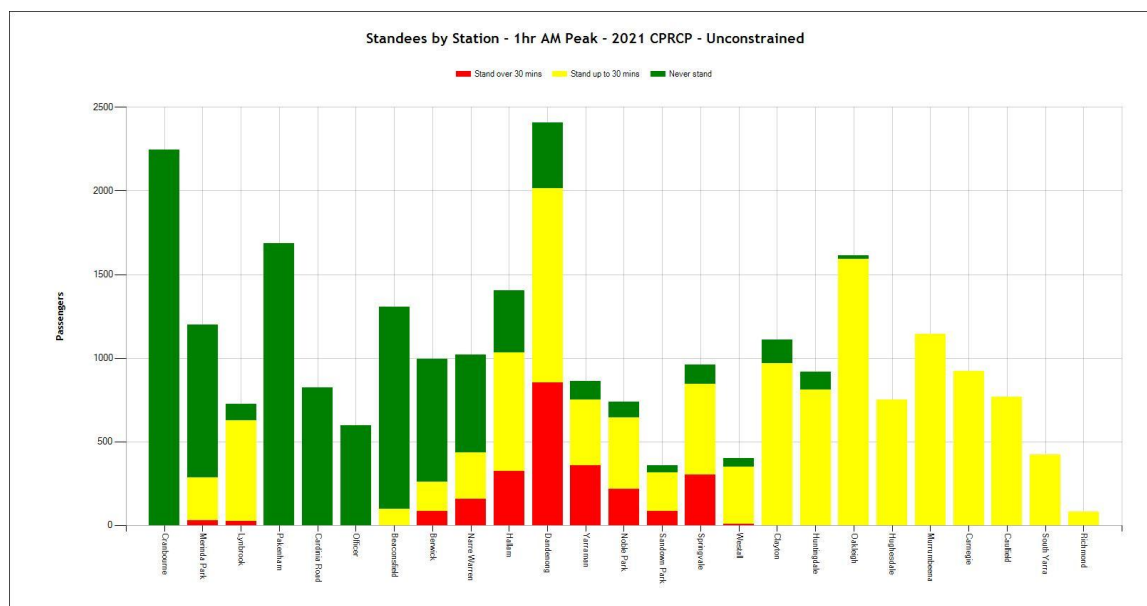


Figure 14 – 2021 AM Peak One-hour - CPRCP case standees by station of origin

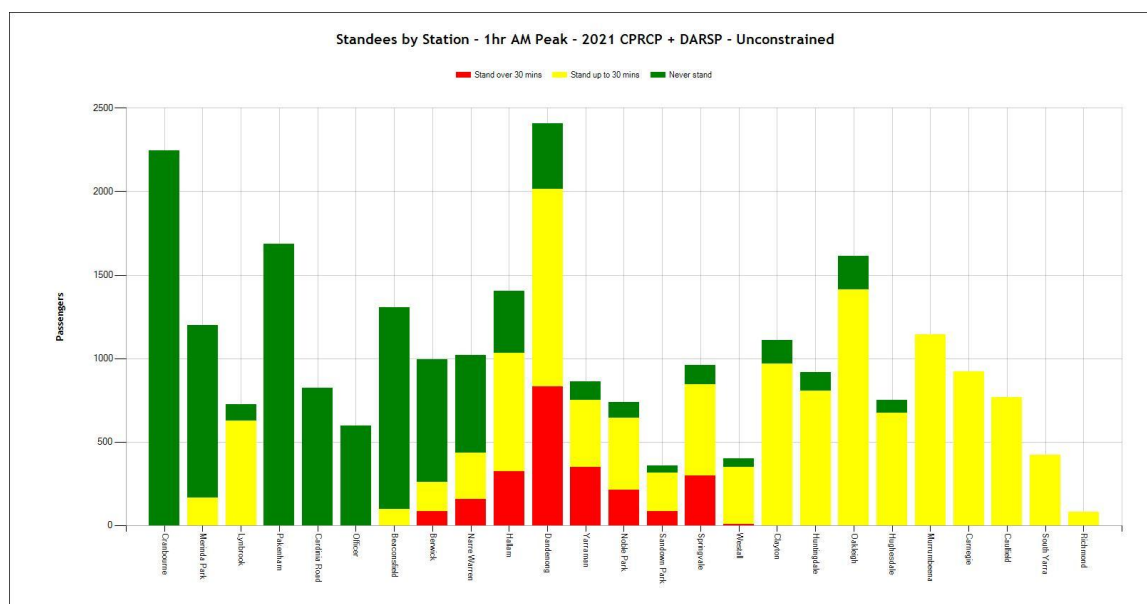


Figure 15 – 2021 AM Peak One-hour – CPRCP+DARSP case standees by station of origin

Two-hour Period - Average number of people travelling on each service type

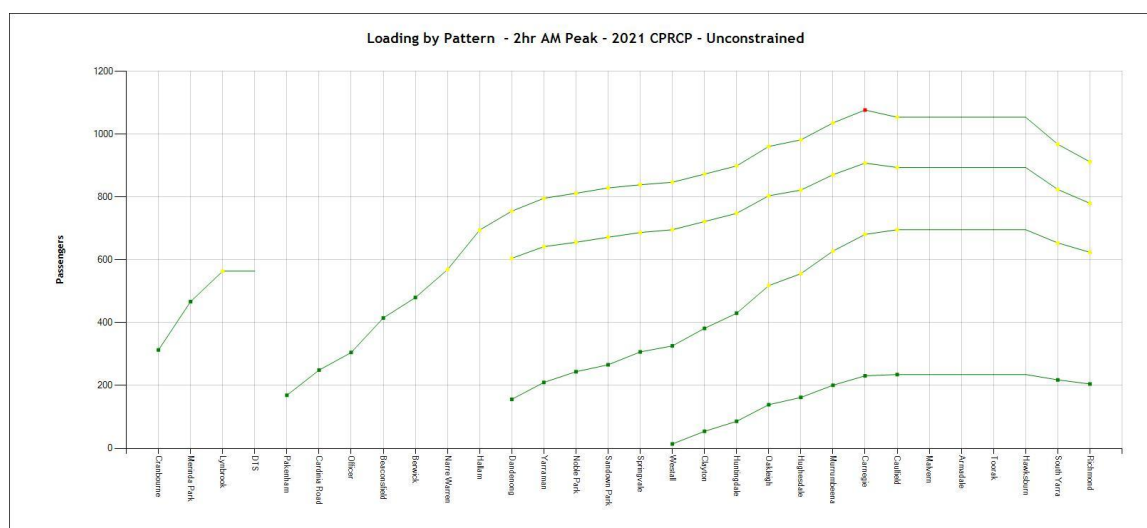


Figure 16 – 2021 AM Peak Two-hour - CPRCP case estimate train loads

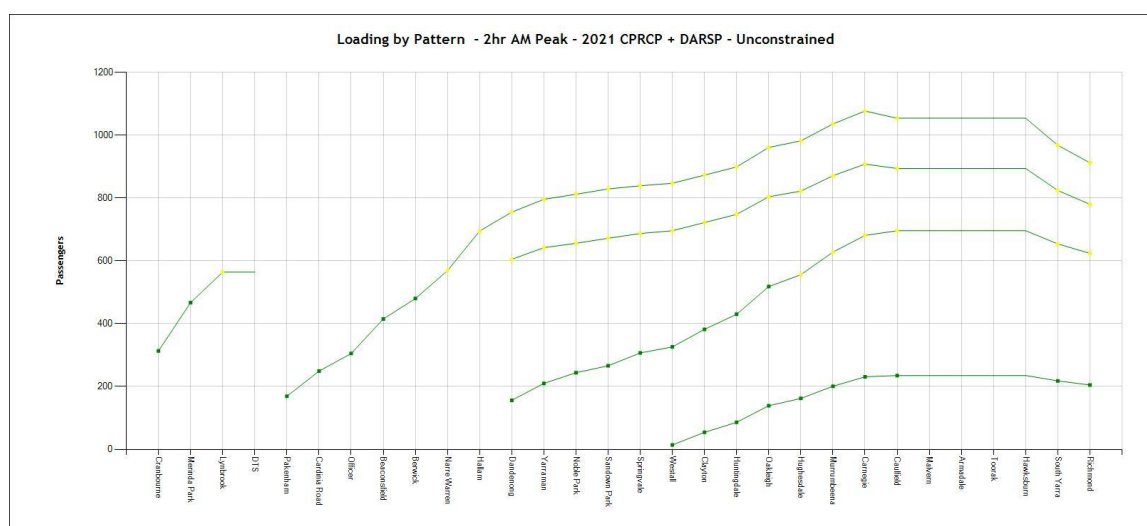


Figure 17 – 2021 AM Peak Two-hour – CPRCP+DARSP case estimate train loads

Two-hour Period – Number of standees by station of origin

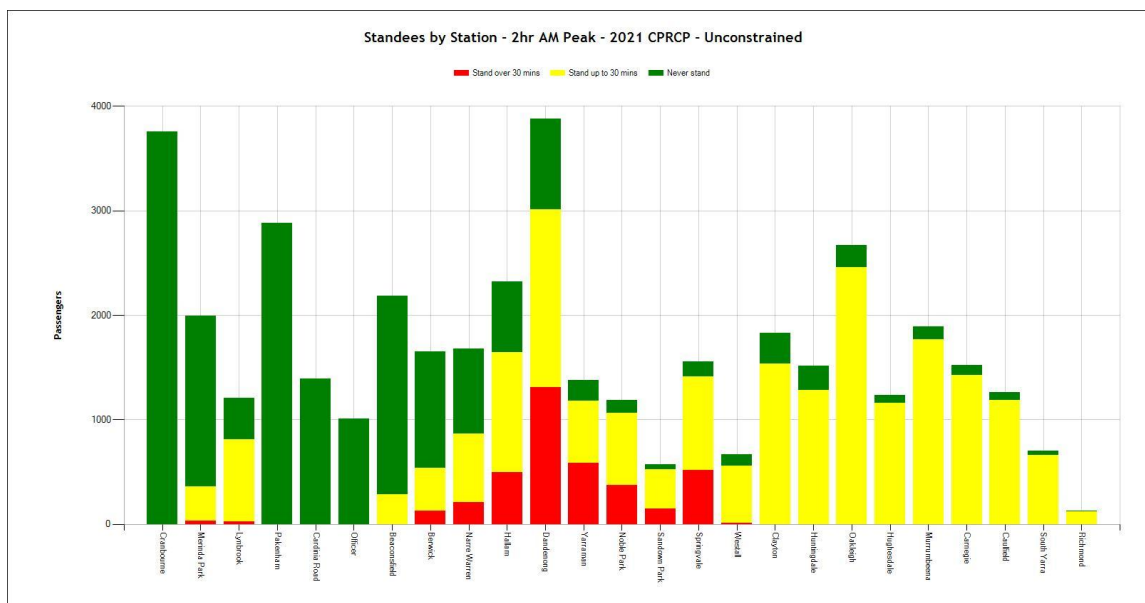


Figure 18 – 2021 AM Peak Two-hour – CPRCP case standees by station of origin

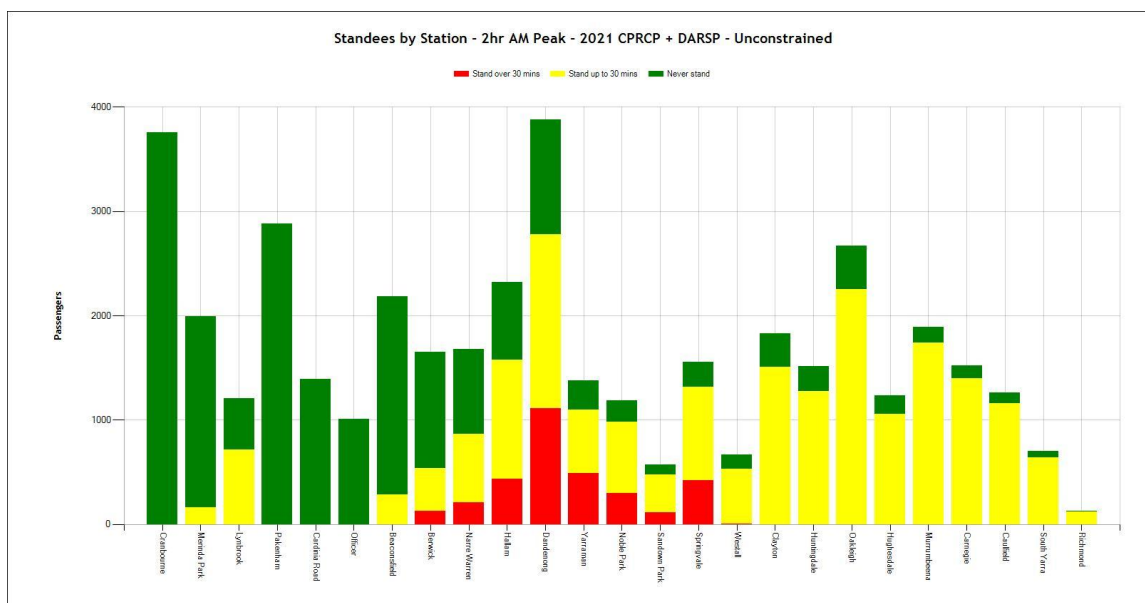


Figure 19 – 2021 AM Peak Two-hour – CPRCP+DARSP case standees by station of origin

Appendix C – 2031 Detailed Train Load Predictions

The following graphs show for both the one-hour and two-hour AM Peak periods:

- > the average number of people travelling on each service type (Pakenham, Cranbourne and Dandenong, Westall).
- > the mix of people standing for greater than 30 minutes, standing for up to and including 30 minutes and not standing at all.

in 2031.

One-hour Period - Average number of people travelling on each service type

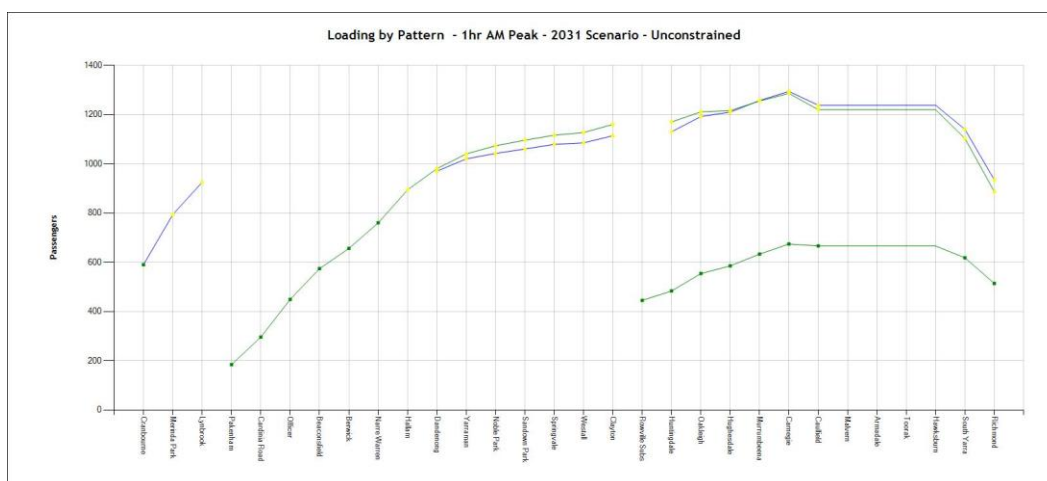


Figure 20 – 2031 AM Peak One-hour - estimate train loads

One-hour Period - Number of standees by station of origin

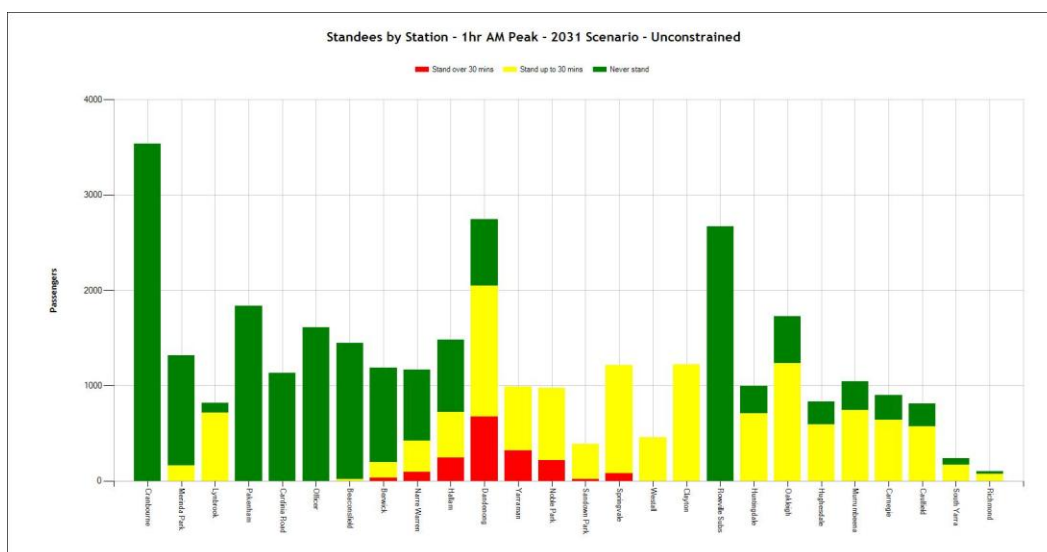


Figure 21 – 2031 AM Peak One-hour - estimate standees

Two-hour Period - Average number of people travelling on each service type

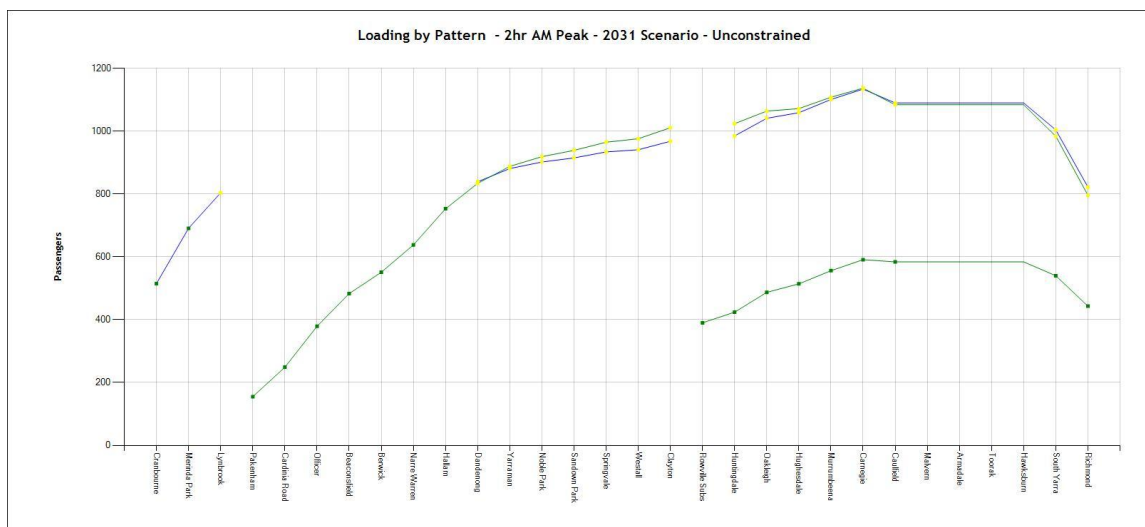


Figure 22 – 2031 AM Peak Two-hour - estimate train loads

Two-hour Period - Number of standees by station of origin

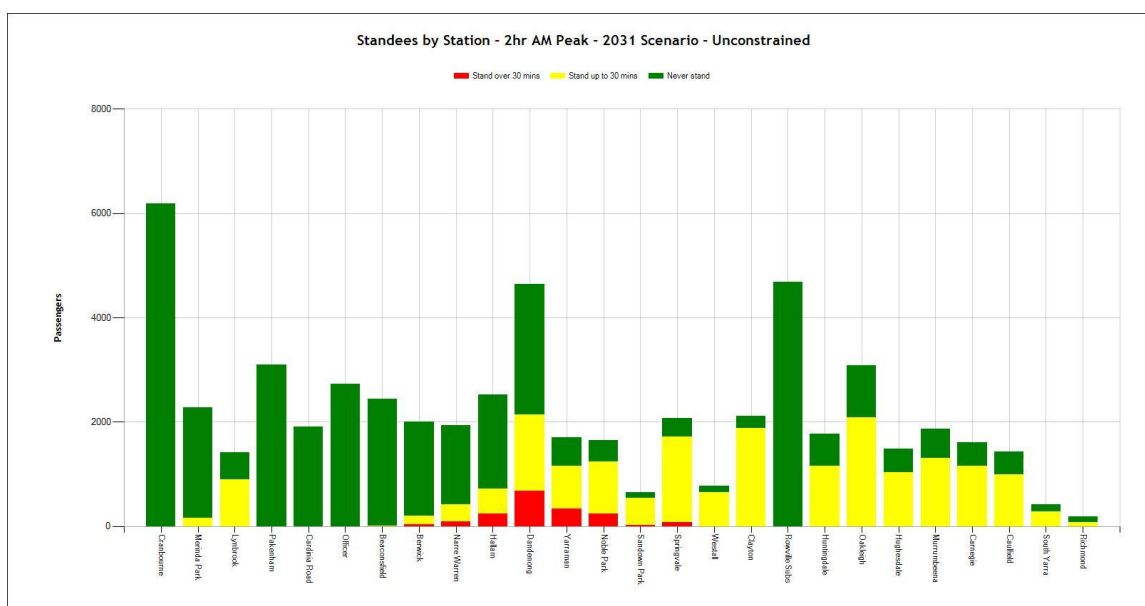
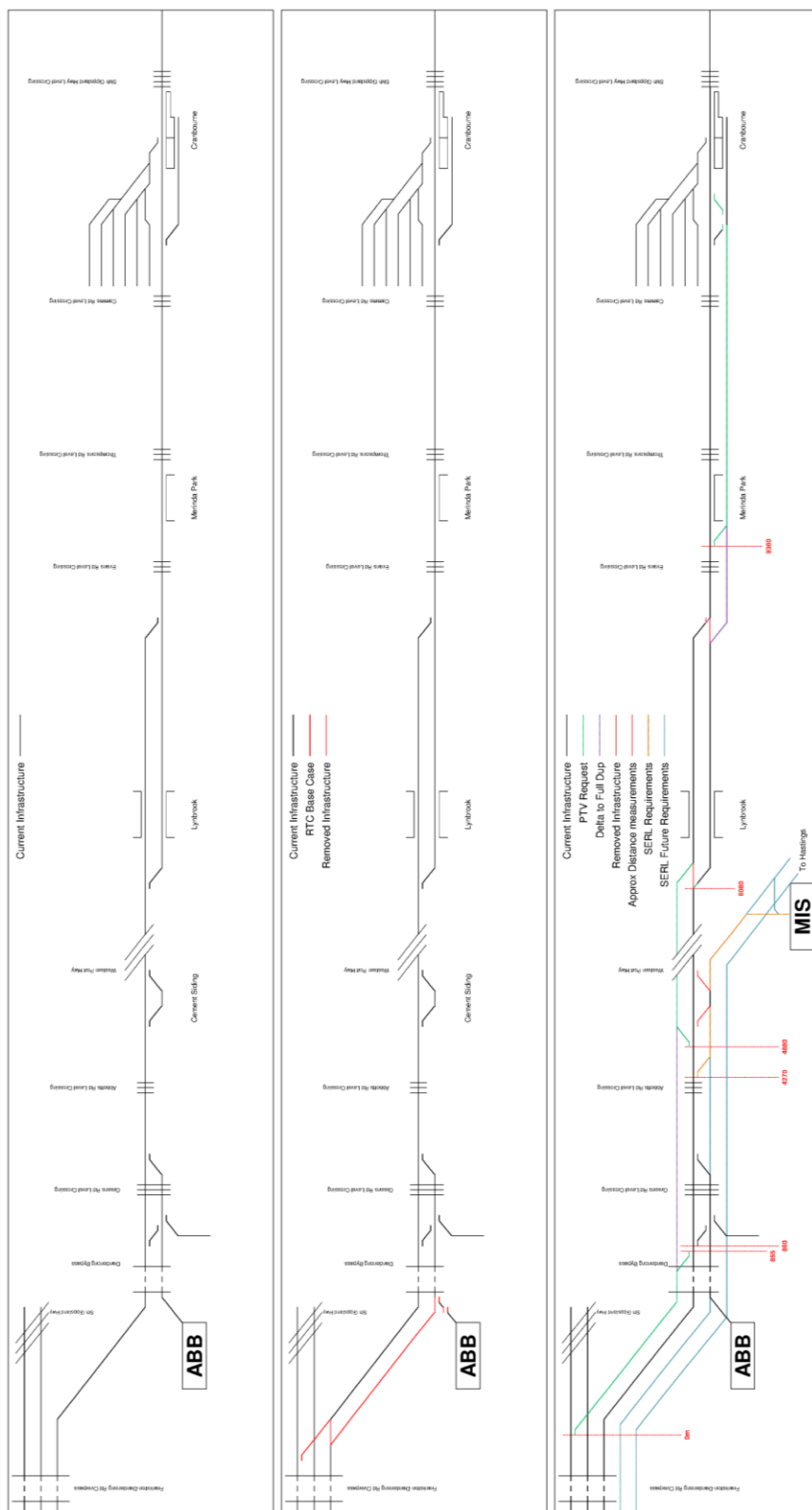


Figure 23 – 2031 AM Peak Two-hour - estimate standees

Appendix D – Proposed Cranbourne line duplication



Appendix E – CBTC Operational requirements

A detailed set of operational requirements will need to be defined for CBTC if such a system is installed on the corridor. An initial set of 2021 requirements and future-proofing requirements are provided as recommendations below:

Table 16 CBTC Operational requirements recommended for Dandenong Line for 2021

Project recommendation	Key sub-components	Rationale
Signalling System – ATP protection in Sidings	ATP must be provided for fitted CBTC trains from start of trip to end of their trip, including the stabling sidings.	Trains are to be fully protected by CBTC in all operational areas – excludes Depots.
Signalling System – ATO operation	The normal mode of operation for CBTC trains shall be under ATO, including from station to station, into/ out of sidings, and onto/ off transfer roads (e.g. at Richmond).	To provide consistent run times/ improve operational reliability
Signalling System – Correct Side and Selective Door Enabling/ Opening	Correct Side Door Enable/ Open must be provided at all Stations. Selective Door Enable/ Open must be possible for those locations where the train length exceeds the platform length.	To ensure only the correct doors can be opened.
Signalling System – Wake Up and Sleep Functions	The signalling system must facilitate manual and automatic Wake Up and Sleep functions at predefined stabling sidings.	To automatically prepare the train for its trip and on completion of its trips to switch off all train functions except the ATC monitoring system.

Table 17 CBTC Future-proofing operational requirements recommended for Dandenong Line

Future Project	Project Resp.	Requirement	Rationale
Signalling System – Platform Screen Doors (PSD) also known as Platform Edge Doors (PED)	CPRCP	The signalling system must allow for the future capability of PSDs being fitted at predefined stations. The signalling system must allow for the passenger train doors to align and open with the PSDs.	PSDs may be installed in the network in the longer term.
Signalling System – Auto Turn-back/ Docking Functions	CPRCP	The signalling system must allow for the future capability of Auto Turn-back/ Docking at predefined Stations without manual intervention from a	To improve operating efficiency where trains can make controlled moves under the protection of GoA4 functionality.

Future Project	Project Resp.	Requirement	Rationale
		driver on board the train.	
Signalling System – Auto Train Wash	CPRCP	The signalling system must allow for the future capability to facilitate the train wash process without manual intervention from a driver on board the train.	To improve operating efficiency where trains can make controlled moves under the protection of GoA4 functionality.