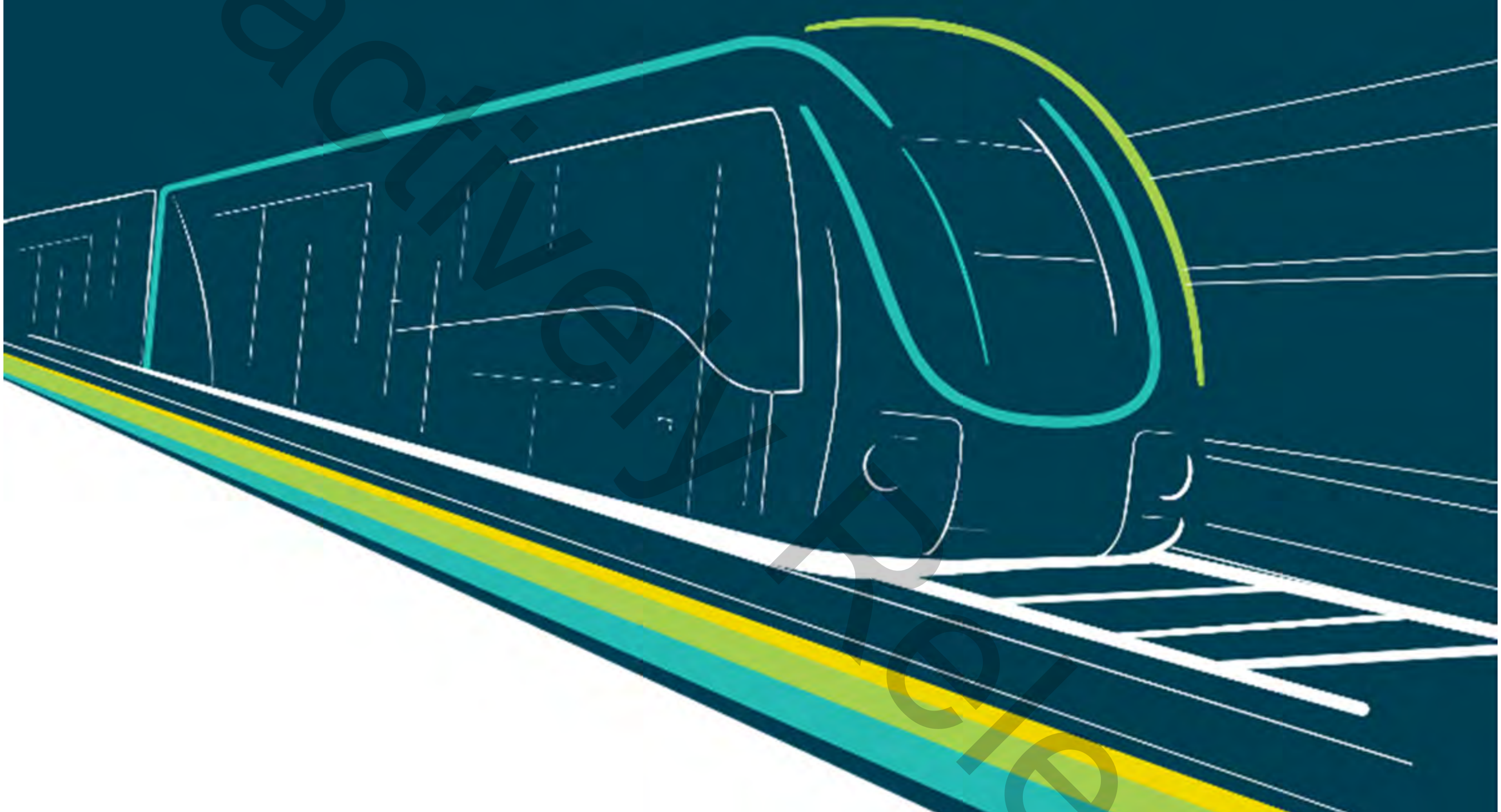
LNIRIM

Lower North Island
Rail Integrated Mobility



Proven innovation towards a decarbonised regional passenger rail solution for the lower north island and beyond

LNIRIM
1.0
1st November 2021

metlink

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EXECUTIVE SUMMARY

Project at a glance

The project need has been firmly established through problem definition and development of agreed investment objectives

The overall problem:
a growing inability of the existing rail service to deliver critical regional passenger commuter transport services necessary to enable the validated growth in population and network demand forecast for the Wairarapa and Manawatū lines.

1. The current fleets have reached the end of useful life and do not align with modern standards
2. The existing regional rail services are unattractive to commuters
3. The current regional passenger services do not maximize the opportunity to meet the government's objectives on decarbonisation
4. The existing regional train operations are inflexible and inefficient

In response to the problem, what are the **INVESTMENT OBJECTIVES**?

1. **Improve connectivity and access to opportunities** through safe and reliable transport options on the Manawatū and Wairarapa corridors.
2. **Improve corridor capacity** by providing for forecast demand for longer distance travel within the growth areas of the Manawatū and Wairarapa corridors.
3. **Improve attractiveness** of land public transport within the corridors.
4. **Reduce carbon emissions** related to commuter travel within the corridors.
5. **Enhance value for money** through increased network productivity and efficiency of operation of transport services.

The preferred solution will provide **double** the peak services per week on the Wairarapa line and **quadruple** the peak services on the Manawatū line

The preferred solution includes the provision of new rollingstock and associated infrastructure

Rollingstock

- A new fleet of 22 four-car tri-mode units
- Tri-mode operations feature 1600V DC + combustion ignition generator + battery

Maintenance services

- New maintenance depot to be built at Masterton
- Maintenance and presentation (cleaning) services for the rollingstock fleet

Simulator

- Delivery of a fixed simulator (location to be determined) to support crew training

Stabling facilities

- Interpeak daytime stabling is within the Wellington yard region (development of the site required)
- Overnight stabling required at Masterton (16 units) and Palmerston North (6 units)

Station upgrades

- Basic platform and stations upgrade on the eight stations north of Upper Hutt
- Additional platform and pedestrian access at Maymorn station
- Upgrade of the four Manawatū stations north of Waikanae

Track and other infrastructure

- Allowance included for the equivalent of two non-electrified passing loops extensions north of Waikanae to ease the interface with freight service and de-risk the proposed increased service
- Selective Door Operation and automatic changeover track balises across both lines

An investment of **$587.3 million** (2021 real terms, P50 cont.) will be needed to deliver the preferred solution

On a present value **whole of life** basis, the net cost of the preferred solution is only **$182 million greater than the do-minimum** case but provides **significant service uplift**

The preferred solution investment ranks **very high** in its alignment with **GPS2021** priorities

The preferred solution is expected to deliver a range of benefits for the region

Provide a critical community link, the only commuter alternative to road, to enable inclusive access to economic, social and health opportunities

Promote mode shift by enhancing the attractiveness of public transport

It will **divert 23.8 million trips** from the roads, resulting in 0.6 to 1.6 million tonnes of avoided carbon emissions

Improve the overall transport corridor resilience and capacity with improved frequency, less crowding and better reliability.

Reduce greenhouse gas emissions with a potential for full decarbonisation as battery technology improves

A new tri-mode train will emit **8x** less carbon than current diesel locomotives hauled trains.

Improve public transport attractiveness and mode choice with new amenities

It will provide more comfortable, clean and modern trains with good ventilation

Improve safety by reducing road congestion with safe and accessible rollingstock

It will **prevent over 100 crashes** resulting in serious injuries or death

Enable value for money with reduced operating risk and increased operating efficiency

New services **will cost almost 50% less** per service, compared to the do-minimum case

Support economic growth by enabling regional land use plans with transport infrastructure

Provide **benefits that outweigh costs** with a benefit cost ratio of **1.83**

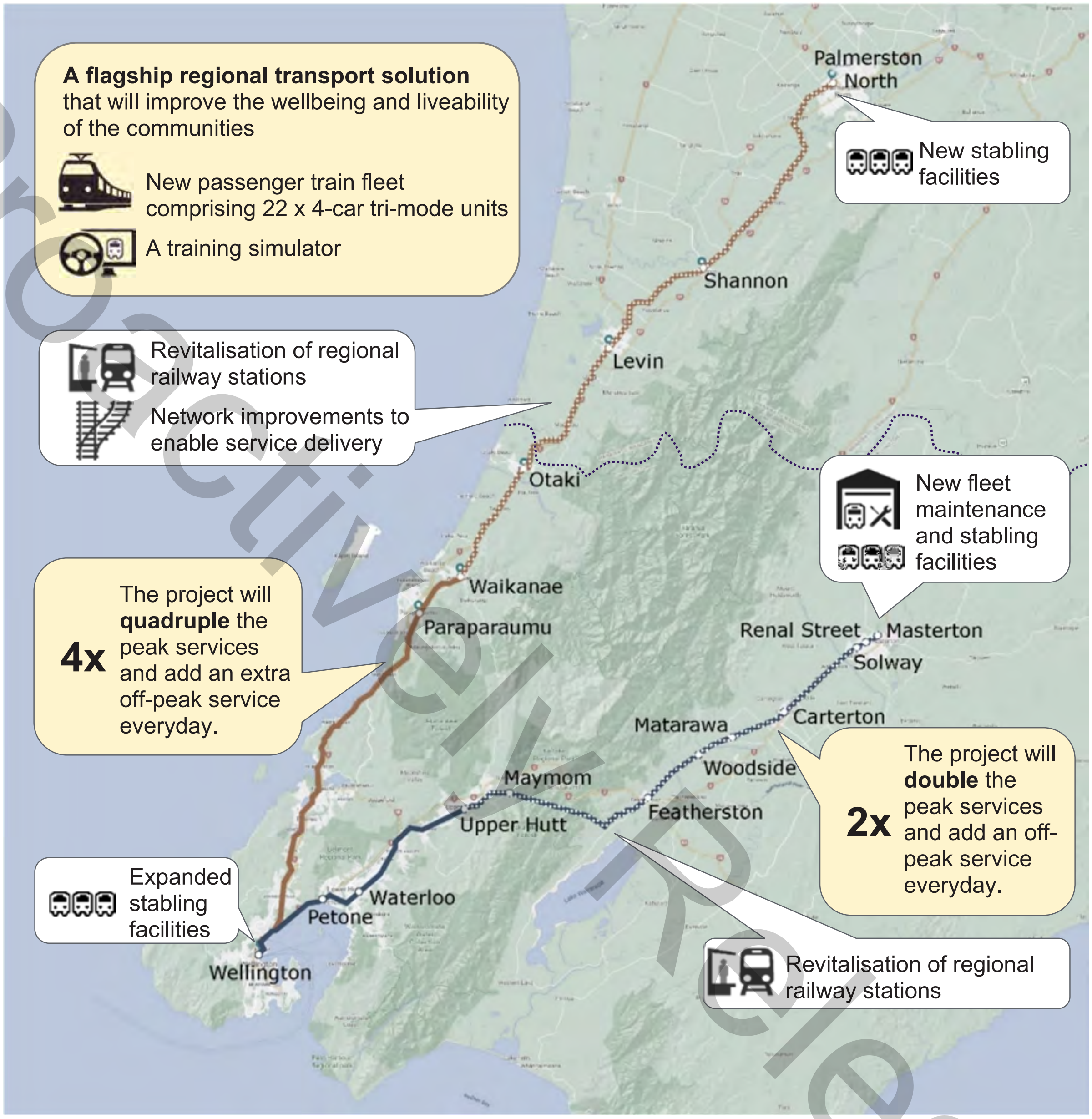
It will deliver **$481 million in benefits***, including:

- $186m – rail user benefits
- $146m – road user benefits
- $68m – environmental benefits
- $81m – community benefits

The region will also benefit from rollingstock safety, accessibility, active transport benefits, resilience benefits and wider economic benefits from improved connectivity

** In present value over 40 years*

Wairarapa (blue) and Manawatū (amber) regional passenger rail services[1]



Key features of the preferred solution include:

- Using existing overhead lines plus **battery technology**, topped up by an onboard low-emission generator outside of stations and tunnels.
- The tri-mode is a solution that is **highly reliable** and provides **dependable connectivity.**
- It maximises the regeneration of braking energy to achieve minimal emissions and does not require long and expensive electrification works.
- The new trains will provide amenities and services tailored to **customers' needs**, and lift NZ regional passenger rolling stock to international **safety** standards.

[1] Notes: The shaded areas of the lines represent non-electrified parts of the network. The regional boundary is indicative only.

1. Introduction and overview

- The regional Wairarapa and Manawatū commuter rail services are a critical part of the broader regional transport network, providing a commuter alternative to road travel. These services provide regional commuters with a critical and affordable access to key economic, social and health opportunities.
- The limited service levels that can be provided by the existing carriage fleets are a significant barrier to achieving the objectives for transport set out in the Government Policy Statement and the strategic outcomes required by the Regional Land Transport Plans and Regional Public Transport Plans.

With a timely investment, the government has a unique opportunity to enable mode shift, provide a safe and resilient transport option, reduce carbon footprint, and enable economic development along the Wairarapa and Manawatū transport corridors.

- Promoting and enabling public transport as the preferred mode for connecting regions with Wellington's CBD and surroundings will be essential to achieving these objectives.
- Without modern, safe and reliable rolling stock, the strategic objectives of providing attractive public transport to encourage mode shift away from private vehicles and the resulting decarbonisation benefits would not be realised.
- The Wairarapa and Manawatū lines' rolling stock fleets are refurbished and modified 1970's ex-British Rail Mark 2 carriages that have reached the end of service life.
- The life of the current fleet is being extended with further minor refurbishments, posing risks of unknown defects and the inability to meet modern crashworthiness, emission, fire, safety, accessibility, ride quality, and customer amenity standards. Operation and maintenance of these carriages currently involves complex contractual arrangements with multiple parties and is complicated by the use of diesel locomotives.
- Despite poor service frequency, reliability and punctuality, the Wairarapa Line's peak patronage is forecast to exceed the current seating and standing capacity by 2025, while the Manawatū Line's current seating capacity is forecast to be exceeded by 2030, which indicates significant untapped latent demand.
- Given the long lead time to plan for and deliver new rollingstock, forward planning is critical to manage the capacity demands. Without sufficient rolling stock capacity, the services would be significantly degraded and would potentially lead commuters to use an alternative road mode of transport, which will likely lead to further congestion and safety issues.
- The Wairarapa and Manawatū public transport commuter services are critical to realise the government's aspirations of enabling future land use and economic growth while improving commuter safety, facilitating mode shift, contributing to decarbonisation and improving freight connection. Strongly aligned with the government national and regional priorities, a timely investment in LNIRIM will improve the overall resilience of the transport network and enable economic development along the Wairarapa and Manawatū transport corridors.
- Without a timely intervention, the regions face an increasing risk of ceasing operating services due to inability to meet minimum safety requirements, resulting in inability to connect regions with social and economic opportunities. With an investment in LNIRIM, the government has a unique opportunity to positively influence the future of the regions and their communities.

2. Recommendations

It is recommended that local and central governments endorse this detailed business case and note:

- Investing in a new fleet and associated infrastructure for the Wairarapa and Manawatū commuter rail services will fulfill investment objectives of improving connectivity and access to opportunities in the region, improving corridor capacity, improving the attractiveness of public transport, reducing carbon emissions relating to commuter travel and enhancing value for money through increased network productivity and efficiency of operations.
- Failure to intervene exposes an increasing risk of ceasing operating services on the corridors due to an inability to meet minimum safety requirements.
- The scope of the preferred solution includes a new fleet of 22 four-car tri-mode (electric, combustion ignition and battery) trains, a simulator to support crew training, a maintenance depot located at Masterton, stabling facilities located at Wellington, Masterton and Palmerston North, station upgrades north of Upper Hutt and Waikanae and allowance for additional passing loops and other track infrastructure.
- Delivery of the preferred solution will enable a significant uplift in rail services to meet forecast demand.
- Other benefits generated from the delivery of the preferred solution include inclusive access and improved mobility, increased transport network resilience, safety and reliability, improved operational efficiency, improved attractiveness of the public transport network resulting in increased mode shift and positive environmental outcomes through reduced carbon emissions.
- The positive economic merit of the preferred solution, which has a benefit cost ratio of 1.83 and an economic NPV of $218 million.
- The preferred solution will be delivered by GWRC as three separate works packages:
  - The Rollingstock and depot package (Package 1) is to be delivered under a Design, Build, Maintain and [Operate] (DBM +[O]) contract. The commercial arrangements for operators will need to be managed and transitioned separately from the DBM due to commercial risks associated with terminating the existing operational and maintenance agreement.
  - The Station upgrades package (Package 2) is to be delivered via a Managing Contractor arrangement.
  - The stabling and track facilities package (Package 3) is to be procured and delivered via the Rail Network owner (KiwiRail), with access to bulit assets provided to GWRC by amendment to the Network Agreement.
- Total whole of life cost for the preferred solution is $999 million without the committed funding, or $1.18 billion with committed funding (NPV, P95), which is only an incremental increase of $182 million over the do-minimum case despite more than doubling the total number of services provided to commuters.
- The delivery phase funding requirement is $762 million (non-committed, nominal, P95) delivered over a period of 8 years from FY22 to FY29, with funding to be shared between Central Government and Regional Councils (GWRC and Horizon).
- The key risks of the project, to be further mitigated in subsequent phases, include:
  - risks of delay in delivery of the project due to late funding commitment or exceptional international supply chain disruption
  - risks of technical incompatibility between modern trains and the local rail network
  - risks related to foreign exchange volatility between the estimate date and the supply agreement.
- Ōtaki and Levin railway stations, currently listed on the Treaty Settlement land bank, will only be upgraded to the benefits of relevant Māori groups and the wider community insofar as an agreement with relevant parties, including Te Arawhiti, can progress to be endorsed by Ministerial decision or Cabinet approval.
- The full new fleet is forecast to be in revenue service by Q4 2028.

- Mitigation measures are planned to address the gap between existing fleet retirement and new fleet in service, as well as other key risks and opportunities.
- Members of the governance steering group set up to deliver the project will include The Ministry of Transport, Waka Kotahi, KiwiRail, Horizons Regional Council and Greater Wellington Regional Council, ensuring a concerted approach to maximise benefit delivery.
- The preliminary implementation schedule defines the critical path to the implementations of LNIRIM as the delivery of Package 1 - Rollingstock and depot. It currently includes commencing the procurement of Rolling Stock expression of interest (EOI) stage in Q3 2022 and the request for proposal (RFP) stage in Q1 2023.
- Achieving the timing of activities and milestones proposed by the current schedule will be critical to the delivery of the benefits sought by the proposed investment. It will be essential to secure agreement with all levels of government regarding funding. The procurement phase should not commence unless this occurs to provide certainty of process and funding to the market.

3. Strategic case

3.1. Overview and strategic context

- The Lower North Island Rail Integrated Mobility (LNIRIM) project explores options to deliver critical passenger transport services as the aged locomotive-hauled trains of the Wairarapa and Manawatū Lines reach the end of their service lives.
- Building on the Initial Business Case (IBC) work, this Detailed Business Case (DBC) expands the analysis and aims to recommend a preferred option that meets the service needs for accessing social and economic opportunities and maximises value for money, while also providing a safe and environmentally friendly transportation mode.
- This DBC aligns with the newly issued strategic priorities and policies, including the Government Policy Statement on land transport 2021-2031, and the Waka Kotahi New Zealand Transport Agency (Waka Kotahi) guidelines. It has been developed collaboratively and in consultation with key stakeholders including Greater Wellington Regional Council (GWRC), Waka Kotahi and Horizons Regional Council (Horizons) as well as members and Ministry of Transport, KiwiRail and Transdev as advisors.

LNIRIM aims to improve the resilience of the transport network in the lower North Island now and into the future.

- The LNIRIM project achieves a **very high** alignment with GPS2021 priorities. LNIRIM will provide a modern, reliable and safe commuter public transport option and also, through mode shift, reduces congestion, carbon emissions and improves safety on roads. LNIRIM will provide access to opportunities, enable transport choice and improve the overall resilience of the transport corridors. LNIRIM also contributes to the strategic direction of the national and regional transport priorities.

Relevant national and regional strategic frameworks

National strategy/policy/plan	Regional strategy/policy/plan
• Government Policy Statement on land transport	• Wellington Regional Land Transport Plan
• New Zealand Rail Plan	• Wellington Regional Public Transport Plan
• National Land Transport Plan	• Wellington Regional Rail Plan
• Rail Network Investment Programme	• Horizons Regional Land Transport Plan
• Climate Change Commission Advice for Consultation	• Horizons Regional Public Transport Plan
• New Zealand Upgrade Programme – Transport	• Wellington Regional Mode Shift Plan
• Road to Zero: New Zealand's Road Safety Strategy	• Let's Get Wellington Moving
• Keeping Cities Moving: A Plan for Mode Shift	

- The two regions' forecast population growth, an increased focus on carbon neutral objectives and required mode shift to public transport, coupled with future economic and employment growth opportunities underpins an increasing need for public transport services on the Wairarapa and Manawatū Lines.
- The Wellington Growth Framework Report 2021 recognises that the region's population could grow by 200,000, or by about 37%, with an additional 100,000 jobs in the next 30 years. Similarly, the Horizons region's population will grow by approximately 12% by 2028 and 28% by 2053. The highest population growth is estimated to be in Porirua, Kāpiti Coast, the Wairarapa and Palmerston North.
- Growing urban population is expected to shift further from the capital to Wairarapa and North of Waikanae, because these areas have relatively cheap greenfield development potential and are within commuting distance to Wellington City.
- Of the 88% housing development growth from areas identified in the Wellington Growth Framework:
  - one-quarter is expected to be in Wellington City
  - nearly one-third is expected to be in the eastern corridor from Lower Hutt to Masterton
  - the remainder (just over 40%) is expected to be in the western corridor from Tawa to Levin.
- The regions are expected to have higher density development in the vicinity of rail and bus services to facilitate mode shift.
- The National Policy Statement on Urban Development is driving the intensification around rail, which then in turn supports mode shift and the wider transport outcomes, such as the current GPS priority of climate change.
- Catering for future transport infrastructure and services can support a shift to more sustainable modes of transport, while also supporting economic growth and shaping desired land use.

3.2. Need for investment

- The Wairarapa and Manawatū lines serve as an essential regional public transport commuter alternative to highly utilised parallel roads connecting the regions to the economic centre of Wellington CBD and inner city. Without these services, increased private car use is likely to lead to significant infrastructure costs and restrict economic activity, while also increasing congestion, which can in turn reduce road safety, increase carbon emissions, and impact freight and commercial movements.
- The need for investment has been considered in the context of current and future service needs. These needs are driven by projected population growth in the vicinity of the Wairarapa and Manawatū lines and desired future land uses, which are anticipated to have higher density development and include improved access to bus and rail services to enable the economic growth.
- The overall problem requiring intervention is a growing inability to deliver critical regional passenger commuter transport services with the existing fleet and enable the validated growth in network demand on the Wairarapa and Manawatū Lines. This overarching problem can be categorised into four sub-problems:

#	Problem	Causes	Effects
1	The current fleets are approaching the end of useful life and do not align with modern standards (crashworthiness, emission, fire, safety, accessibility, customer)	• Most of the rollingstock has approached 50 years in age • Retrofit to meet modern standards is uneconomical and technically challenging	• Increased risk of inability to connect regions with social and economic opportunities once the rollingstock can no longer be considered safe to operate • Increased maintenance costs • Increased rollingstock safety risks • Limited accessibility • Service frequency constraints due to emissions in tunnels

#	Problem	Causes	Effects
2	The existing regional rail services are unattractive to commuters	• Services are close to capacity and do not allow for a full potential of mode shift • Limited frequency makes the public transport option unattractive	• Decreased transport network resilience due to congestion pressures on parallel roads • Longer travel time • Reduced safety • Higher emissions from road transport • Increased crowding and untapped latent demand • Reduced economic development and limited potential to release affordable housing
3	The current regional passenger services insufficiently contribute to achieving the government's objectives on decarbonisation	• Higher emissions from road transport • Emissions from 1970's diesel locomotives	• Higher emissions for longer
4	The existing regional train operations are inflexible and inefficient	• Fleets' incompatibility • Separate operations • Complex operational and maintenance arrangements • Limited locomotive performance capability and fleet incompatibility	• Reduced reliability and punctuality • Reduced interoperability, higher maintenance and operational costs • Service frequency constraints due to operational requirements

- With a timely investment in LNIRIM, the government has an opportunity to contribute to achieving GPS 2021 and strengthen the overall long-term transport resilience within the Wairarapa and Manawatū corridors by reducing the car dependency and associated congestion while catering for the future transport demand.

4. Economic case

4.1. Options assessment

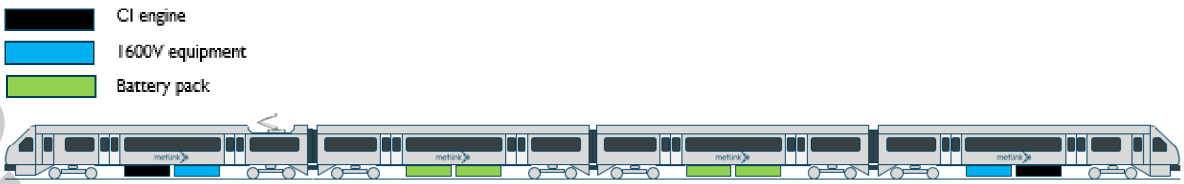
- The options assessment process developed for this DBC is consistent with the Waka Kotahi guidelines, intervention hierarchy and optioneering process, which encourages the identification and consideration of options beyond construction of a new asset.
- As a benchmark to compare and assess potential options, a 'do-minimum' base case option was identified. The 'do-minimum' base case assumes that the existing service levels on both Wairarapa and Manawatū lines are maintained, initially using the existing fleet until it reaches the end of its service life in FY2028 and subsequently through a purchased and reasonably refurbished second-hand fleet of carriages and locomotives. The 'do-minimum' base case also includes related infrastructure upgrades with committed funding.
- The long list of options considered broader options presented in the IBC, including a mix of integrated planning, demand, supply and productivity related responses, variations in mode and fleet type, and variations in service levels.
- Several non-asset options were considered in the analysis, however it was determined that investment in a new infrastructure solution is needed to address a growing inability of the existing commuter rail service to best achieve the service objectives.
- The analysis also considered contemporary rollingstock propulsion solutions, such as hydrogen and alternative fuels.

- Hydrogen fuel options were not shortlisted due to the low maturity of hydrogen industry in New Zealand and the associated issues, including:
  - the timescales involved in providing supporting infrastructure
  - the maturity of green hydrogen production in New Zealand
  - the immaturity of the technology on trains
  - the lack of competition in the market.
- A range of rollingstock options were shortlisted for a more detailed analysis via a MCA process, including a mix of electric, compression-ignition (CI) and battery propulsion systems. Shortlisted options were:
  - Option 1: EMU (1600V DC) + 1600V DC partial electrification + buses beyond Featherston and Ōtaki + increased services
  - Option 2: B-DMU + increased services
  - Option 3-1: B-EMU (1600 V DC + extra battery) + no further electrification + increased services
  - Option 3-2: B-EMU (dual voltage + battery) + 25 kV AC partial electrification + increased services
  - Option 3-3: B-EMU (1600 V DC + battery) + 1600 V DC partial electrification + increased services
  - Option 4-1: Tri-mode (1600 V DC + battery + CI) multiple units + no further electrification + increased services
  - Option 4-2: Tri-mode (1600 V DC + battery + CI + 25 kV AC provision) multiple units + no further electrification + increased services
  - Option 5: EMU (dual voltage) + 25 kV AC electrification over full current non electrified route sections + increased services
- Alternative fuels could be used if the rolling stock relies on a CI engine, which can help reduce the emissions and include the following:
  - gas to liquid (GTL) fuel is a diesel substitute derived from natural gas and can be used with existing diesel infrastructure with no modification, while infrastructure can be returned to diesel use if required with no modification
  - a dual-fuel modification to diesel multiple units involves the installation of additional fuel tanks and control technology, which enables the engine to be fuelled both with diesel and natural gas. And determine the fuel mix for greatest economy and lowest emissions
  - hydro-treated vegetable oil (HVO) is a more recent development in alternative fuels that can be a viable alternative to diesel, which involves the hydro-treatment of vegetable oils or animal fats.

4.2. Preferred option

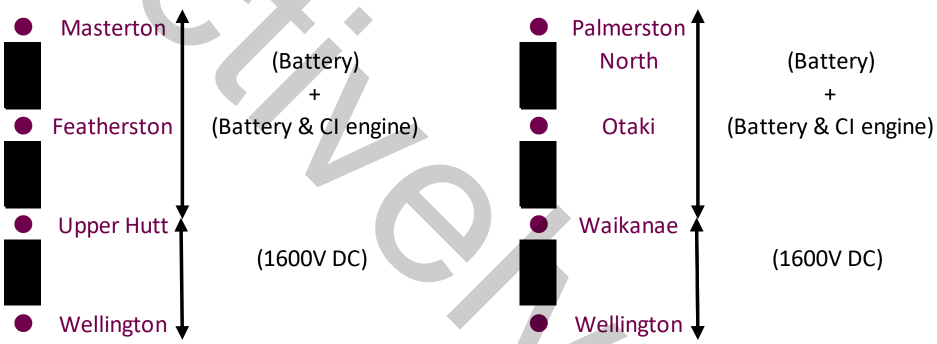
- The preferred rollingstock option selected from detailed analysis is a tri-mode (1600V DC + CI + battery) multiple unit (TMU). This option assumes utilisation of the existing 1600 V DC network in place on the Wellington commuter network and a CI engine as well battery on the non-electrified parts on the lines. The battery technology is expected to advance with the passage of time, allowing the battery range to be further extended in the later lifecycle of the trains, while reducing reliability on any form of fuel over time.

Preferred option train architecture



- On a TMU, the CI engine has no mechanical drive and is connected to a generator. When in electric mode, the power is sourced from the overhead line for both traction and to recharge the battery. Energy from regenerative braking is used to charge the battery until the battery is fully charged when the energy is returned to the overhead line. In self-power mode, traction power is sourced from the battery or a combination of the battery and the CI engine. Energy from regenerative braking is used to recharge the battery. Additionally, the CI engine can be used to charge the battery.

Preferred option propulsion modes

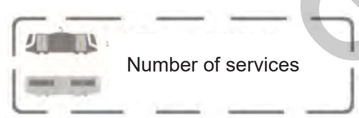


- The preferred service level option selected from detailed analysis will see regional commuters benefit from 49 extra train services every week from January 2029, which include more frequent peak and off-peak services. This includes double the current peak services on the Wairarapa line and quadruple the current peak services on the Manawatū line. Additionally, the project will boost the transport capacity for off peak and weekend travel.

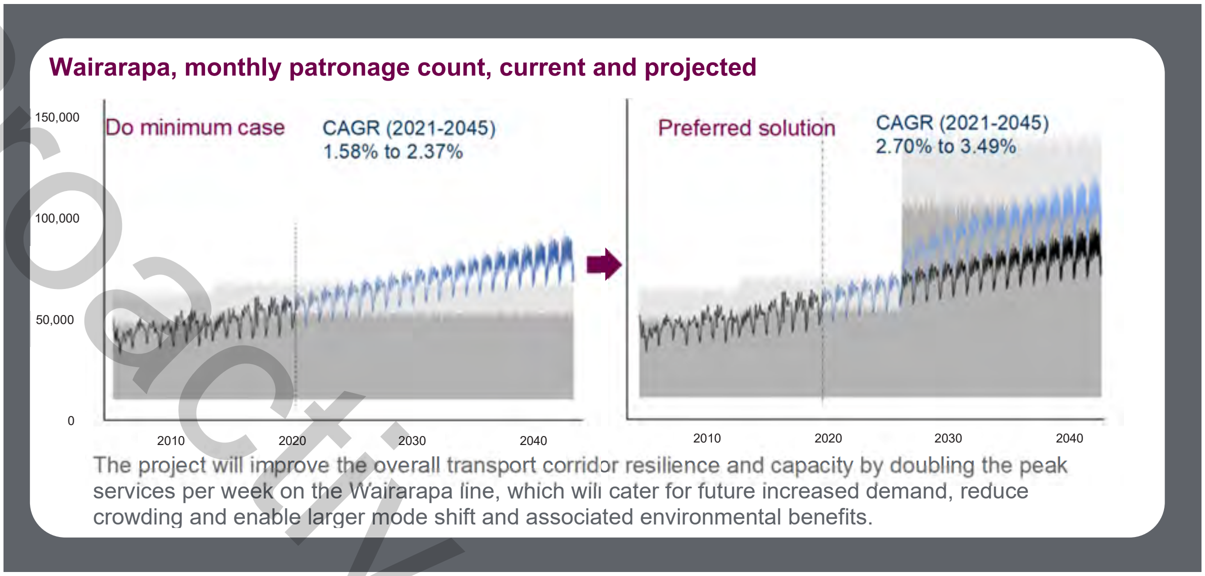
Services in each direction

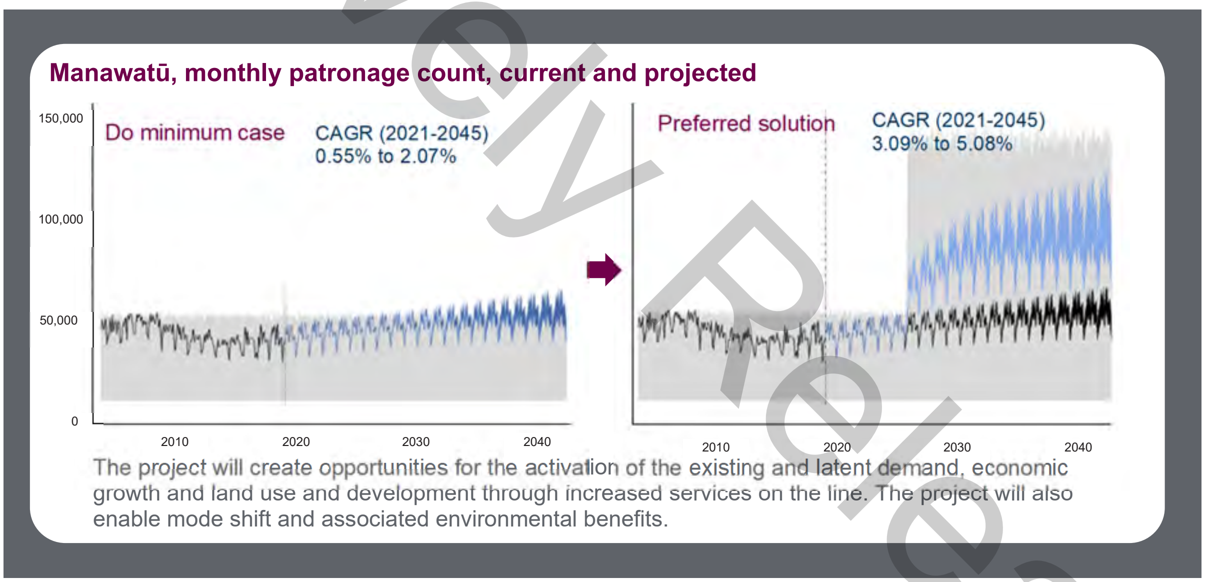
	Current		Proposed	
	Peak	Off-peak/weekend	Peak	Off-peak/weekend
Wairarapa				
Manawatū				

Note: The Wairarapa line has an additional Friday night off-peak service



- The increase in services is projected to translate into higher patronage numbers than what would be observed under the do minimum case. This reflects the more attractive and frequent services, along with increases in patronage from regional population growth, mode shift and activation of latent demand.





Note: CAGR = the compound annual growth rate

4.3. Preferred solution - scope

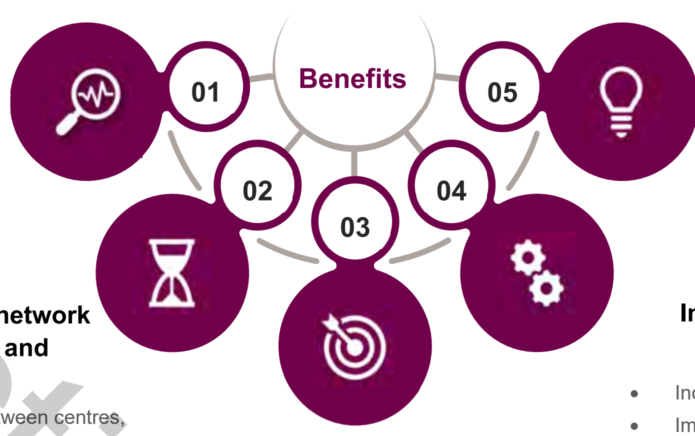
- The scope of the preferred solution includes the following components:

Scope element	Key assumptions
Rollingstock	• A fleet of 22 four-car tri-mode units (1600V DC & CI generator & battery)
Simulators	• One simulator (the location is flexible)
Depot	• One depot at Masterton (station area) located at a brownfield site, currently owned by KiwiRail, which will require KiwiRail's consent to build a new depot building for the new fleet.
Stabling facilities	• Three stabling facilities: – interpeak daytime stabling is within the Wellington yard region, currently owned by KiwiRail – overnight stabling would be required at Masterton (16 units) and Palmerston North (6 units) • The stabling facilities are located at a brownfield site, currently owned by KiwiRail, which will require KiwiRail to deliver their design and construction.
Track and other upgrades	• An allowance for the equivalent of two non-electrified passing loops extensions north of Waikanae to ease the interface with freight service and de-risk the proposed increased service, to be delivered through future KiwiRail NIMT capacity improvements. • Station Door Opening (SDO) and automatic changeover track balises across both lines.
Stations	• Basic platform and stations upgrade on the eight Wairarapa line stations north of Upper Hutt. • One additional platform and pedestrian access at Maymorn station. • Upgrade of the four Manawatū stations north of Waikanae, including allowances for purchase and refurbishment of Ōtaki and Levin station buildings and lease of station land.

4.4. Benefits of the preferred solution

- With a timely investment, the preferred solution provides a unique, significant and compelling opportunity to:
  - meet the **service needs** for **accessing** social and economic opportunities
  - maximise value for money and operational efficiency
  - provide a **safe** and **reliable** transportation mode
  - reduce the **carbon emissions** through mode shift and new purpose-built fleet.
- The preferred solution's increased services over the 40-year period will:
  - provide a critical public transport commuter alternative to road to access social, economic and health opportunities
  - cater for current and future transport demand projections to reduce crowding
  - enable future land use opportunities consistent with regional land use plans
  - improve attractiveness of the public transport alternative to roads (with higher frequencies and improved amenities)
  - activate mode shift opportunities (divert 23.8 million trips from the roads), resulting in 0.6 to 1.6 million tonnes of avoided carbon emissions
  - deliver better outcomes for the environment (about 8 times less carbon per service train)
  - prevent over 100 road crashes resulting in serious injuries or death.

Preferred solution benefits



Inclusive access and improved mobility

- reduced risk of discontinuing public transport services
- improved access of regional communities to economic, health and social opportunities

Positive climate outcomes

- Reduced carbon emissions from mode shift and fleet

Increased transport network resilience, safety and reliability

- Increased connectivity between centres, across towns
- Increased urban planning and land use benefits
- Improved commuter safety

Increased mode choice

- Increased service frequency
- Improved public transport attractiveness

Improved operational efficiency and economic outcomes

- Reduced operating risk and costs
- Improved punctuality
- Improved interface with increasing freight

4.5. Economic analysis

- The benefits of the project significantly exceed its cost. A full economic appraisal, including cost benefit analysis (CBA) and sensitivity testing, estimates that the present value (PV) benefits of the project will exceed the PV costs over 40 years of operation.
- The detailed CBA estimates that the preferred solution has a BCR of 1.83 and NPV of $218 million.

Category	Preferred solution	% Total
Capital costs (P50)	$501m	
Operating and maintenance costs (P50)	$565m	
Avoided costs (P50)	-$803m	
Total costs (PV)	**$263m**	
Rail user benefits	$186m	39%
Road user benefits	$146m	30%
Environmental benefits	$68m	14%
Community benefits	$81m	17%
Total benefits (PV)	**$481m**	**100%**
BCR	**1.83**	
NPV	**$218m**	

- A BCR greater than 1 indicates that the project is economically viable.
- Additional benefits were identified but were not able to be quantified in the economic appraisal. However, they should be also considered by decision-makers in assessing the project's expected value for money. These include the increased safety of a new rollingstock fleet, resilience benefits, active transport benefits and wider economic benefits, such as productivity uplifts associated with agglomeration, increases in labour supply due to increased availability in public transport, land use and renewal benefits, increased knowledge sharing of workers along the corridor and social benefits around access to health and education.

5. Financial case

5.1. Risk and opportunity

- The risks identified are typical of risks found in rail/ rollingstock projects. However, some risks were avoided as the preferred solution:
  - does not require land acquisition or urban planning management to deliver planned benefits
  - does not rely on unproven technologies or supply chains to function as planned
  - does not require track electrification work to provide reliable service.
- The key risks of the project, to be further mitigated in subsequent phases, include:
  - risks of delay in delivery of the project due to late funding commitment or exceptional international supply chain disruption
  - risks of technical incompatibility between modern trains and the local rail network.
  - risks related to foreign exchange volatility between the estimate date and the supply agreement.
- A key opportunity related to the LNIRIM project is to exploit synergies between the Connector, Te Huia and LNIRIM by designing the LNIRIM fleet as a national platform for Passenger Rail and leveraging more advantageous supply conditions from train manufacturers by increasing the potential size of the order.

5.2. Financial analysis

- A whole of life financial appraisal has been undertaken at a P95 level of confidence, including construction and maintenance of the new train fleet and the associated infrastructure as detailed in the preferred solution scope.
- The financial analysis shows the financial impacts of the preferred solution compared to the do-minimum case. Overall, the preferred solution demonstrates better value-for-money than the base case.

Net Whole of Life Cost Breakdown in nominal terms

Item ($NZD Millions)	Real			Nominal			Present Value		
	Preferred Solution	Do Min Case	Diff	Preferred Solution	Do Min Case	Diff	Preferred Solution	Do Min Case	Diff
Delivery phase costs	690	174	517	763	191	573	611	155	456
Operating phase costs	1,293	1,536	(243)	2,179	2,611	(432)	859	1,014	(155)
Total Costs	**1,983**	**1,710**	**274**	**2,942**	**2,801**	**141**	**1,469**	**1,169**	**301**
Less Revenue	(709)	(529)	(181)	(1,204)	(896)	(307)	(468)	(349)	(119)
Net Whole of Life Cost	**1,274**	**1,181**	**93**	**1,739**	**1,905**	**(166)**	**1,001**	**819**	**182**

- Additionally, both the preferred solution and the do minimum case assume committed funding for renewal and refurbishment of the existing fleet and NZUP track upgrades, summarised in the table below. As this committed funding applies to both cases, it has been excluded from the analysis summarised in the table above.

Committed funding

Item ($NZD Millions)	Real	Nominal	Present Value
Committed funding	194	203	181

Net incremental risk adjusted annual cashflows in nominal terms

- While the initial delivery phase costs of the preferred solution are greater than the do-minimum case (by $573 million in nominal terms), the total whole of life cost of the preferred solution is smaller than the net whole of life cost for the base case by $166 million. This is explained by:
  - the do minimum case's higher operating phase costs due to refurbishment and maintenance of the second-hand fleet
  - the do minimum case's lower farebox revenue as current service frequencies are maintained compared to the preferred solution assuming increased service frequencies.
- The table below illustrates that:
  - the preferred solution provides for about 151,000 more services over the operations period compared to the do minimum case
  - the net cost per service is lower for the preferred solution by about ~$3,800 (PV) per service.

- In addition to increased services enabling increased mode shift, the communities would benefit from safety and environmental benefits associated with an investment in a modern brand-new fleet that would utilise electrified parts of the Manawatū and Wairarapa rail lines while also leveraging the opportunities for carbon reduction through battery propulsion on the non-electrified parts of the network.

Service frequencies for base case and preferred solution over the 30-year operations period, compared to net Whole of Life Cost in nominal PV terms

Service	Wairarapa Number of services	Manawatū Number of services	Total Number of services	Net WOL PV cost NZD Millions	$ PV cost per service
Do Minimum Case	90,304	15,252	105,556	819.3	7,762
Preferred Solution	158,334	83,282	256,868	1,001.1	3,897
Difference	68,030	68,030	151,312	181.8	(3,864)
% Difference	**75.3%**	**446.0%**	**143.3%**	**22.2%**	**(50.0%)**

5.3. Affordability analysis

- The affordability analysis shows the funding required for the preferred solution. The analysis shows that over the 38 years (3 years of pre-delivery, 4.5 years of delivery and 30.5 years of operations), a total investment is estimated at $1.7 billion in nominal terms over the whole life of the asset.
- The delivery phase funding requirement is $763.5 million, delivered over a period of 8 years as shown in the figure below.

Pre-delivery and delivery phase investment profile

- The analysis indicates that:
  - the Central Government's (Waka Kotahi and Crown) funding contribution of $699.0 million will be needed for the pre-delivery and delivery phase costs, with the balance of $64.3 million to be provided by the Regional Councils (GWRC and Horizon)
  - while all the operational costs of $975.2 million in nominal terms are assumed to be funded at the current prevailing funding rate of 49% from the Regional Councils and 51% from Waka Kotahi.
- An investment of $699.0 million by Central Government to deliver the project directly aligns with GPS2021 and other strategies and presents a compelling opportunity to:
  - ensure regional communities have a reliable public transport option, currently the only alternative to road, to access social, health and economic opportunities
  - improve the corridors' capacity, safety and efficiency
  - contribute to carbon reduction through mode shift and new fleet
  - deliver a better value for money with increased services and improved public transport attractiveness.

6. Commercial case

6.1. Delivery strategy

- The recommended delivery strategy is that GWRC will procure and deliver the preferred solution in three packages of work:
  1. Rollingstock and depot
  2. Station upgrades, and
  3. Stabling facilities and track upgrades.

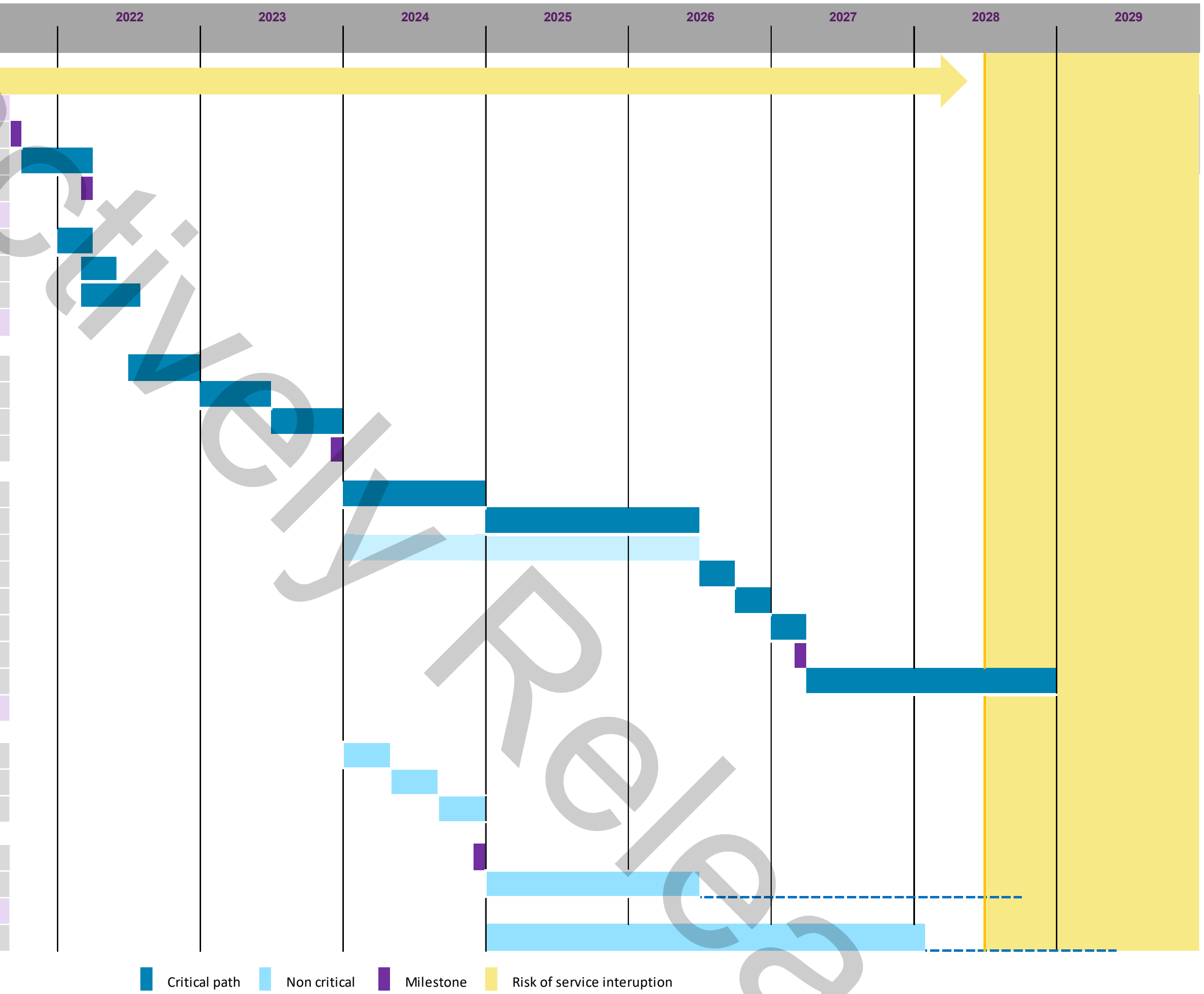
- The Rollingstock and depot package (Package 1) is to be delivered under a Design, Build, Maintain and [Operate] (DBM +[O]) contract, and the Station upgrades package (Package 2) is to be delivered via a Managing Contractor arrangement.
- For Package 1, the option to include operations within the DBM (i.e., a DBOM) was initially discussed with GWRC but subsequently discounted and excluded from the delivery model options assessment. The decision to exclude was premised on mitigating the commercial risks associated with terminating the existing operational and maintenance agreement early for convenience to implement these outcomes. The existing GWRC operating, and maintenance agreement is due to expire in March 2025 but, by way of a performance incentive, includes a right for the existing operator to extend until March 2031 if it meets specified punctuality, reliability, and performance outcomes. It is understood that, to date, these outcomes are being met. Based on the above, the commercial arrangements for operators will need to be managed and transitioned separately from the DBM, hence the operations have been bracketed [O] from the DBM delivery approach.
- The Stabling facilities and track upgrades works (Package 3), included in the preferred solution and its costs, relate to the development of stabling and track facilities currently owned by KiwiRail. Package 3 will therefore be delivered via KiwiRail. GWRC will instruct, monitor and provide support for procurement and delivery of the works. GWRC will also manage the interface risks for Package 1 and 2 with Kiwi Rail's delivery of the stabling facilities and track upgrade works.
- Further refinement of the approach to packaging and delivery for GWRC-led packages will need to be undertaken prior to any packages being taken to market.
  - Package 1 (Rollingstock and depot) – further work will be required to explore the interface between the preferred DBM+[O] Delivery Model and the existing operating arrangements to determine how best to mitigate interface issues.
  - Package 2 (Station upgrades) – refinement of the delivery model assessment will be required once the scope and key risks associated with that scope are better understood.
- This will involve further market sounding and further detailed work on package definition, delivery model option development, potentially alternative approaches to Project funding/financing, and procurement planning and scheduling.

6.2. Delivery program

- Based on the proposed delivery strategy, a high-level procurement program has been developed for Packages 1 and 2, which accommodates the full new fleet in revenue service by Q4 2028. Following completion of the DBC, a detailed procurement program will be developed in line with the development of a comprehensive procurement plan for the Project.
- Conservative but realistic timeframe assumptions, informed by the delivery timeframe of current international transactions of similar nature, and confirmed by market sounding, indicate that the full new fleet included in this preferred solution may not be in service before the end of 2028.
- An indicative project delivery schedule is provided on the next page.
- The preferred solution's critical path follows the procurement and delivery of rolling stock. Time constraints related to infrastructure and station upgrades are of secondary importance and can fit within the rolling stock procurement timeframe.
- The figure on the next page indicates a potential 6 month gap between the retirement of the existing fleet and the commencement of operations for the new fleet. Activities planned to be carried out in the market readiness phase will include the validation of an accelerated programme including:
  - An early mobilisation of the procurement team, saving up to 2 months on the critical path,
  - A shorter EOI process capitalising on the market sounding conducted in 2021, saving up to 3 months on the critical path,
  - A subsequent RFP process reduced to 12 months, saving another 3 months on the critical path.
  - A potential staged introduction of the new fleet from early 2027.

Indicative timetable

Indicative Delivery Programme	Months
Current Fleet - End of life	
Approvals Process	
DBC submission	M
Investment approval	6
Funding commitment	M
Market Readiness Phase	
Governance transition	3
Strategy and Models validation	3
Project esatablishment	5
Package 1 - Rolling Stock and Depot	
Procurement Phase	
Mobilise procurement team, prepare and issue EOI	6
EOI in the market and select shortlist	6
Issue RFP and appoint preferred tenderer	9
Supply agreement	M
Delivery Phase	
Design of the rollingstock	12
Manufacture of the rollingstock (first unit)	18
Design and Delivery of Maintenance depot	30
Testing at manufacturing facility	3
Shipping time	3
Commissioning and testing in NZ	3
First Unit in revenue service	M
All Units produced commissioned and accepted	21
Package 2 - Stations upgrades	
Procurement Phase	
EOI	4
RFP	4
Evaluation, negotiation & documentation for Award	4
Delivery Phase	
Managing Contractor agreement	M
Design and Delivery of upgrades	18
Package 3 - Infrastructure upgrades	
By KiwiRail	24



7. Management case

- A governance structure for the delivery of the LNIRIM Project has been developed from an analysis of institutional capabilities and recommends modifying the existing LNIRIM Phase 1 Governance Group and establishing appropriate Governance Working Groups to lead the implementation of discrete packages of work and initiatives.
- The Project Governance Group will be led by GWRC. GWRC will have overarching responsibility for all activities of the three packages. GWRC, as rolling stock and service owner, will lead the delivery of Package 1 and 2 with its own teams and instruct KiwiRail, as network owner, to deliver Package 3 with its specialist teams, under the leadership of the Governance Group Steering Group.
- The preliminary implementation schedule includes commencing the procurement of Rolling Stock expression of interest (EOI) stage in Q3 2022 and the request for proposal (RFP) stage in Q1 2023. The timing of certain activities will be refined in a detailed procurement strategy during the market readiness phase preceding the procurement phase. This will allow opportunities to accelerate the programme if it can advantageously mitigate the risks related to delayed service start.
- Achieving the timing of activities and milestones proposed by the current schedule will be critical to the delivery of the benefits sought by the proposed investment. It will be essential to secure agreement with all levels of government regarding funding. The procurement phase should not commence unless this occurs to provide certainty of process and funding to the market.
- The current LNIRIM Governance Group will have to complete significant tasks during the market readiness phase. These will include:
  - validating of the preferred ownership and operation models,
  - validating the implementation plan,
  - securing funding commitments,
  - securing land lease agreements with relevant stakeholders,
  - confirming financial models with all stakeholders,
  - developing a detailed procurement and packaging plan (including technical specifications and further consideration of interface risks)
  - initiating the value engineering processes,
- A preliminary benefits management plan has been developed in accordance with Waka Kotahi's Benefits Management Framework, including Indicative key performance indicators. This plan articulates the key steps in defining, planning, and reviewing project benefits throughout the project development lifecycle. This will be further developed during the procurement, delivery, and operation phases, with a focus on implementing opportunities to enhance the level of benefit derived from the project.
- GWRC will require appropriate resources to implement the LNIRIM Project. Initial budgets and resource requirements have been developed across each of the three packages. This initial budget will be subject to review and refinement as the LNIRIM Project progresses. However, for this business case, the current budget is considered to be appropriate and sufficient (within the bounds of reasonableness) for the tasks and activities identified for the implementation plan.

1 CHAPTER 1 – INTRODUCTION AND BACKGROUND

CHAPTER SUMMARY AND CONCLUSIONS:

- The Lower North Island Rail Integrated Mobility (LNIRIM) project explores options to deliver critical passenger transport services as the aged locomotive-hauled trains of the Wairarapa and Manawatū Lines reach the end of their service lives.
- Building on the Initial Business Case (IBC) work, this Detailed Business Case (DBC) expands the analysis and aims to recommend a preferred option that meets the service needs for accessing social and economic opportunities and maximises value for money, while also providing a safe and environmentally friendly transportation mode.
- This DBC aligns with the newly issued strategic priorities and policies, including the Government Policy Statement on land transport 2021-2031, and the Waka Kotahi New Zealand Transport Agency (Waka Kotahi) guidelines. It is developed collaboratively and in consultation with key stakeholders represented in the Steering Committee, the main governance body for the DBC development, comprising Greater Wellington Regional Council (GWRC), Waka Kotahi and Horizons Regional Council (Horizons) as members and Ministry of Transport, KiwiRail and Transdev as advisors.

1.1 Purpose and overview of the chapter

This chapter provides an overview of the project and the purpose of the Detailed Business Case (DBC). It outlines the project background, the process and outcomes of the previous work, organisational focus, and identifies partners and key stakeholders. This chapter also highlights any constraints, dependencies and key assumptions.

1.2 Purpose of this Detailed Business Case

Greater Wellington Regional Council (GWRC) and Horizons Regional Council (Horizons) are exploring options to deliver critical public transport services through the **Lower North Island Rail Integrated Mobility** project[2] (LNIRIM) as the aged locomotive-hauled trains of the Wairarapa and Manawatū Lines in New Zealand's lower North Island reach the end of their service lives.

GWRC and Horizons aim to use the replacement fleet to improve regional rail service levels to make them more attractive to commuters, meet modern crashworthiness and accessibility standards, improve operational efficiencies and affordability of service delivery, while also meeting the policy expectations on decarbonisation. LNIRIM aims to improve the resilience of the transport network in the lower North Island to ensure that the Wairarapa and Manawatū Lines continue playing their critical roles and:

- provide regional connectivity to a growing population of residents by enabling access to employment, education and other social and economic opportunities
- strengthen the regional corridor capacity by providing a safe, convenient and reliable transport mode alternative to the road network
- maintain a transport system that improves livability while also contributing to meeting the Government commitments on developing a low carbon transport system and reducing emissions.

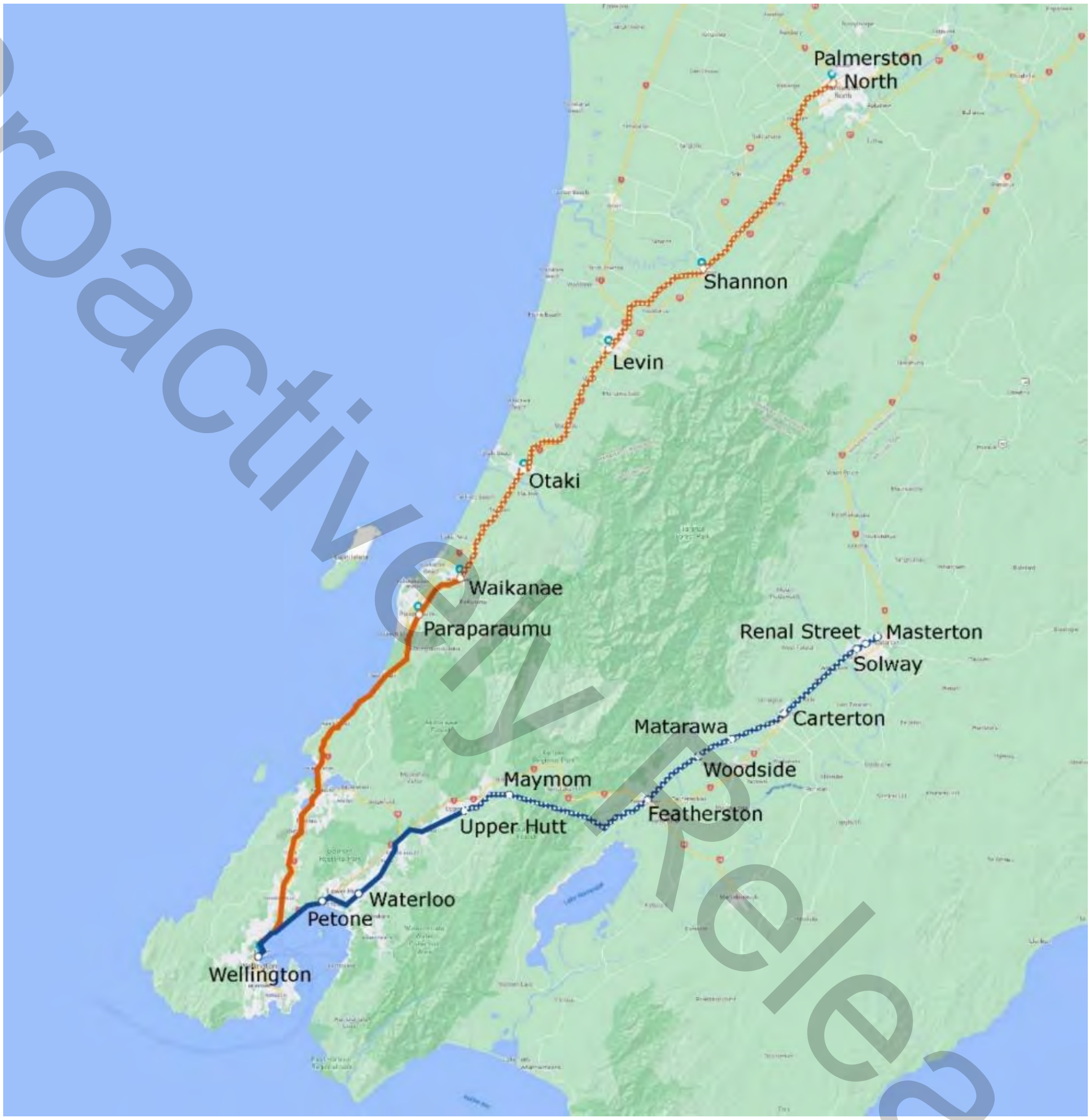
> LNIRIM aims to improve the resilience of the transport network in the lower North Island now and into the future.

The Wairarapa and Manawatū Lines have been providing regional rail services between Wellington and Masterton and Palmerston North, respectively, since their completion in

[2] The project was formerly known as Lower North Island Longer-distance Rolling Stock.

the 1880s[3]. Both partially electrified rail lines are used for passenger rail and freight transportation and are shown in Figure 1-1.

Figure 1-1 Wairarapa (blue) and Manawatū (amber) regional passenger rail services[4]



The purpose of this DBC is to recommend a preferred option that meets the service needs on two regional commuter routes of Wairarapa and Manawatū Lines and maximises value for money, while providing access to social and economic opportunities and a safe and environmentally friendly transportation mode. This DBC aligns with the contemporary policy strategies and the Waka Kotahi New Zealand Transport Agency (Waka Kotahi) guidelines. It is developed collaboratively and in consultation with key stakeholders represented in the Steering Committee, the main governance body for the DBC development, comprising Greater Wellington Regional Council (GWRC), Waka Kotahi and Horizons Regional Council (Horizons) as members and Ministry of Transport, KiwiRail and Transdev as advisors.

[3] Source: Lower North Island Longer-distance Rolling Stock Business Case. Stantec. 2 December 2019

[4] Note: the shaded areas of the lines represent non-electrified parts of the network

The previous business case 'Lower North Island Longer-distance Rolling Stock Business Case', which was issued in December 2019, took a form of a single-stage business case and is referred to in this DBC as the Initial Business Case (IBC). The key outcomes of the IBC included a short list of six options, with option 5 being assessed as the primary preferred option based on the defined investment objectives:

- Option 1: maintain the existing Wairarapa Line fleet and services and allow Manawatū Line services to cease operating (the IBC do-minimum option)
- Option 2: improve the Wairarapa Line fleet and service levels by purchasing additional used rolling stock and maintain the existing Manawatū Line fleet and service levels (the enhanced status quo option)
- Option 3: electrify to Featherston and Ōtaki, extend Electric Multiple Unit (EMU) operations to those points and improve service levels, with bus connections from outer points
- Option 4: replace existing fleets with a Diesel Multiple Unit (DMU) fleet at the earliest opportunity and improve service levels
- Option 5: (the primary preferred option): replace existing fleets with a bi-mode multiple unit (BMU) fleet at the earliest opportunity and improve service levels
- Option 6 (the alternative preferred option): electrify to Masterton and Palmerston North, extend EMU operations to those points at earliest opportunity and improve service levels.

This DBC builds on the IBC completed in December 2019 to make relevant improvements and includes the following **key changes**.

- This DBC:
  - revises and confirms the strategic assessment, including service needs and investment objectives and a review of Investment Logic mapping
  - further develops the economic and financial analysis, including
    - demand modelling for Wairarapa and Manawatū services over the period 2020 to 2040
    - a more detailed analysis of whole of life fleet ownership costs
    - options for fleet capital funding and operational costs
  - reiterates the options development process and how the preferred option was selected by further assessment of technical options, including
    - further discussion of the long list of options
    - analysis of viable secondary propulsion and auxiliary energy modes
    - options for the maintenance facilities to support a new fleet
    - potential additional network improvements required to support fleet introduction
  - provides detailed planning for project implementation, including future commercial and delivery considerations such as:
    - an international rolling stock market sounding exercise
    - vehicle requirements specification
    - procurement risk assessment with practical options for risk mitigation and management
    - contracting options for the supply of the rolling stock and depot facilities, and for the future operation and maintenance
    - contracting options for the supply of the rolling stock and depot facilities, and for the future operation and maintenance of the fleet and depot.

This DBC aligns with the contemporary policy strategies that were issued after the IBC completion and also considers other relevant programmes and reports, described in detail in Chapter 2 - Strategic context.

One of the key changes related to the planning and funding of the rail network. Following the development of the IBC, the New Zealand Rail Plan was released as draft in late 2019 and final in 2021. The document focused on a multi-modal approach for the national transport system and outlined structural changes for rail planning and financing. Subsequently, the Land Transport (Rail) Legislation Act 2020 came into effect on 1

July 2020. The act amended LTMA and the Land Transport Act 1998 to implement a new long-term planning and funding system for the heavy rail track network owned by KiwiRail[5]. The bill enabled an integrated planning and the establishment of a statutory Rail Network Investment Programme (RNIP) that allowed the rail network to be funded from NLTF on the same basis as other land transport modes. KiwiRail prepared the first RNIP to take effect from 1 July 2021. The RNIP will be funded from the Rail Network activity class, Public Transport Infrastructure activity class, and the Crown[6]. Meanwhile, the $3 billion Provincial Growth Fund set up in February 2018 to invest in regional economic development has been almost fully allocated[7].

1.3 Organisational overview and DBC governance

The delivery of passenger rail transport services on the Wairarapa and Manawatū Lines involves multiple stakeholders. Figure 1-2 provides a schematic overview of the key parties, including multi-party funding arrangements and potential contributing parties, transport network planning parties, above and below rail service providers and beneficiaries.

Figure 1-2 Key passenger rail stakeholders on the Wairarapa and Manawatū Lines

The roles of key passenger rail stakeholders:

- Transport funding
  - The Ministry of Transport is the Government's system lead on New Zealand's transport covering air, sea and land. Through the Government Policy Statement on land transport 2021-2031 it outlines land transport investment sources to deliver the strategic priorities.

[5] Source: The Land Transport (Rail) Legislation Act 2020 https://www.legislation.govt.nz/act/public/2020/0033/latest/whole.html

[6] Source: The Government Policy Statement on land transport 2021-2031

[7] Source: Provincial Development Unit. Accessed on 15 May 2021 on: https://www.growregions.govt.nz/contact-us/submit-an-application/

- Waka Kotahi is responsible for a long-term planning for the integrated land transport system, which includes considering rail alongside state highway investment to deliver on the government's priorities. Waka Kotahi prepares the National Land Transport Plan and advises the Ministry of Transport on the Rail Network Investment Programme. Waka Kotahi acts as a funder in land transport, including road, rail and public transport.

The funding options include a combination of investment from:

- the National Land Transport Fund (NLTF) through Waka Kotahi
- councils (Local Share) through GWRC and Horizons
- funding appropriated by Parliament outside of the Fund (Crown appropriations), which is spent by Waka Kotahi or KiwiRail acting as the Crown's delivery agent to progress specific transport projects[8].

- Transport planning
  - GWRC through its brand Metlink provides the transport network planning and funding services, including a public bus, rail and ferry transport network in the wider Wellington region[9]. GWRC is responsible for procuring the operator of passenger services.
  - Horizons is responsible for planning and funding public transport in the Manawatū-Whanganui Region (a relevant section of the Manawatū rail line).
- Above rail operation and maintenance
  - On the Wairarapa rail line, GWRC / GWRL owns the passenger rolling stock and related infrastructure required to support passenger operations, such as station buildings and maintenance depots[10]. KiwiRail owns diesel-powered locomotives and provides them and the locomotive crew on a hook and tow arrangement. Transdev Wellington operates the trains, and its partner Hyundai Rotem maintains the rolling stock using the KiwiRail-owned Wellington Carriage Depot through an access agreement as the location for this maintenance[11].
  - On the Manawatū rail line, KiwiRail operates the Capital Connection, a weekday commuter train. KiwiRail owns and maintains the passenger rolling stock, station building and maintenance depot outside of the Metlink network. It also owns locomotives and provides them with locomotive crews through an intra-company hook and tow arrangement.
- Below rail
  - KiwiRail owns the railway infrastructure network and provides infrastructure access and maintenance services.
  - New Zealand Railway Corporation owns land beneath the railway network on behalf of the Crown and provides a long-term lease of it to KiwiRail[12].
- Beneficiaries
  - The main beneficiary of the commuter passenger rail service on both lines is the general public, which receives a safe and reliable access to economic and social opportunities in the region that are not available locally. Other beneficiaries are the road users, as available commuter rail transport reduces congestion through mode shift and improves road users' travel times.

The Capital Connection operates as a stand-alone service with a its own fare structure and some funding support from GWRC, Horizons and Waka Kotahi and is exempt from the need to operate under contract to Metlink. Its exempt service status is subject to change in accordance with regional transport planning prioritisation by GWRC, Horizons, KiwiRail, Waka Kotahi and regional transport partners[13].

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[8] Source: The Government Policy Statement on land transport 2021-2031
[9] Source: Metlink's official website. Accessed on 3 March 2021 on: https://www.metlink.org.nz/about/about-us/
[10] Source: New Zealand Rail Plan https://www.transport.govt.nz/assets/Uploads/Report/The-New-Zealand-Rail-Plan.pdf
[11] Source: Lower North Island Longer-distance Rolling Stock Business Case. Stantec. 2 December 2019
[12] Source: New Zealand Government, New Zealand Railways Corporation. Accessed on 5 March 2021 on: https://www.govt.nz/organisations/new-zealand-railways-corporation/
[13] Source: Draft Wellington Regional Public Transport Plan 2021-2031. Accessed on 8 March 2021 on: https://haveyoursay.gw.govt.nz/public-transport-plan-2021

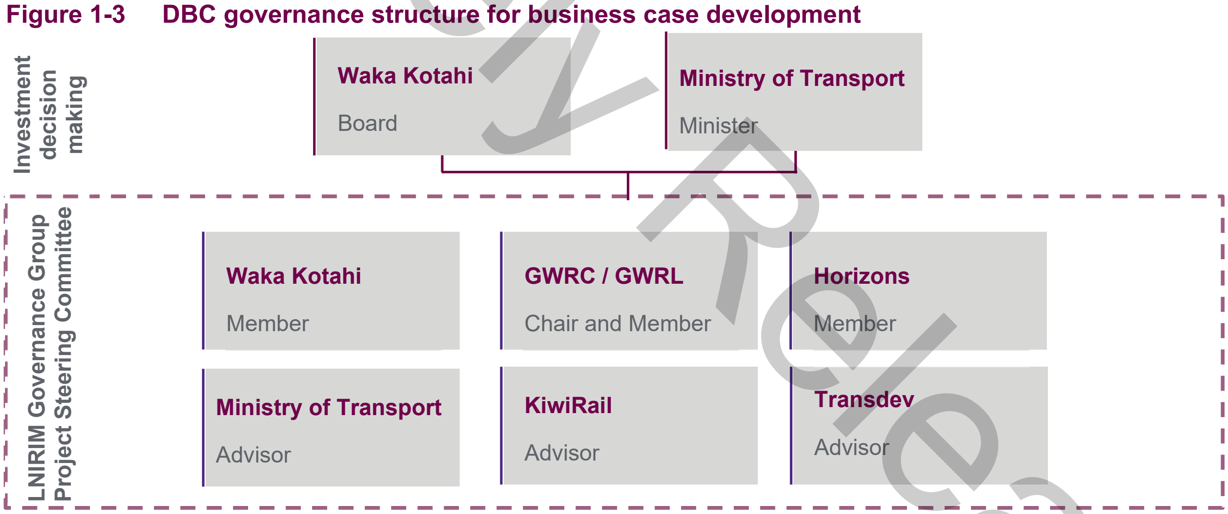
In January 2020 the government announced a $12 billion infrastructure package, $211 million of which related to four major rail projects. They include improvements to the Wellington, Wairarapa and Palmerston North rail network and beyond, upgraded tracks for the Wairarapa and Capital Connection lines, safety connections and refurbishment of Capital Connection carriages[14].

This DBC has been developed collaboratively by key stakeholders. The governance plan was developed by GWRC as part of the LNIRIM Detailed Project Implementation Plan, which was endorsed by the senior management on 28 October 2020. Each key stakeholder involved in the Project has its own decision-making governance processes, such as boards and councils. To ensure the views and positions of each key stakeholder are fully considered, a dedicated multi-stakeholder Project Steering Committee (PSC), or LNIRIM Governance Group, was established to provide oversight of, and leadership for, delivering this DBC. The PSC is the key review, consultation and support body. Figure 1-3 outlines the governance arrangements for the Project. Key roles and responsibilities of each governance group participant include:

- The Chair, responsible for overseeing the DBC and procurement strategy development and managing PSC meetings and outcomes.
- Members, responsible for making informed decisions and providing appropriate advice in relation to the project and its objectives in PSC meetings while representing their respective organisations and acting as an escalation mechanism of key documents/ issues to superior governance groups, such as boards and councils.
- Advisors have a similar role to that of PSC members but do not participate in any decision-making and participate as observers.

Key project controls include monthly reporting to PSC on the project status and risks from March 2021 onwards, regular updates of the issue and risk registers and established change control processes with delegated authorities. To assure quality, peer review of the DBC was performed by specialist advisors commissioned by GWRC.

Figure 1-3 DBC governance structure for business case development



1.4 Overview of DBC structure

The LNIRIM DBC structure is outlined in Figure 1-4. The DBC structure has been developed to comply with the Waka Kotahi guidelines, with appropriate modification to suit project specific circumstances and requirements.

[14] Source: Beehive.govt.nz the official website of the New Zealand Government. Accessed on 5 March 2021 on: https://www.beehive.govt.nz/release/future-proofing-new-zealand%E2%80%99s-rail

Figure 1-4 LNIRIM DBC outline summary

Executive Summary:
This chapter provides a summary of the key aspects of the business case for decision makers in a concise format. Will be structured to follow the five-case model – strategic, economic, financial, commercial, management.

Ch 1 – Introduction and background:
This chapter provides an overview of the project and the purpose of the DBC. The chapter also includes discussion around the organisational focus, identifies partners and key stakeholders and highlights any constraints, dependencies and key assumptions.

Ch 2 – Strategic Context:
This chapter maps out the strategic alignment with government objectives and provide strategic context in terms of relationship with other key government projects.

Ch 3 – Need for Investment:
This chapter clearly identifies and articulates the problems to be addressed by the project, the benefits sought, and investment objectives. Project urgency is also addressed within the summary case for change.

Ch 4 – Options Assessment:
This chapter outlines the do-minimum case used for comparative purposes in the options assessment. The chapter also reviews the options assessment findings from the IBC and reinterrogates the shortlisted options with a revised set of criteria that recognise some key changes to objectives and priorities post IBC. At the conclusion of this chapter, a preferred solution will be identified for further detailed analysis through the remainder of the DBC.

Ch 5 – Preferred Option:
This chapter defines project scope by presenting a detailed overview of the key technical features of the proposed solution, including rollingstock and associated facilities and infrastructure upgrades.

Ch 6 – Economic Analysis:
This chapter outlines the economic impacts of the project, including sensitivity testing and consideration of risks in the economic evaluation outcomes. The chapter also reconfirms the investment prioritisation method profile in line with guidance material.

Ch 7 – Risk Analysis:
This chapter identifies and assesses the risks that may adversely impact delivery of the project and its intended outcomes.

Ch 8 – Financial Analysis:
This chapter outlines the financial impact of the proposed solution. The financial analysis incorporates high-level revenue and costs associated with delivery and operation of the Project over the evaluation period.

Ch 9 – Affordability Analysis:
This chapter considers alternative funding sources available to the project prior to making an assessment of overall project affordability through cash flow analysis.

Ch 10 – Delivery Options:
This chapter identifies, defines and assesses the options available for project delivery. This includes an assessment of how the various elements of project scope will be packaged for procurement and delivery, and the delivery model for each package of work that will best drive achievement of the project's objectives and value for money. Market sounding outcomes are a key input to the delivery options assessment.

Ch 11 – Commercial Considerations:
This chapter outlines the proposed procurement arrangements for the preferred option, based on the selected delivery model. This chapter includes consideration of approvals, property requirements, procurement timeframes and risk allocation.

Ch 12 – Management Considerations:
This chapter presents an implementation plan from a project management perspective. The chapter focuses on the management framework, governance arrangements for delivery, management structure and reporting requirements, stakeholder engagement and implementation timeframes.

Next Steps / Recommendations:
This chapter presents a list of recommendations for approval and describes next steps towards implementation.

Legend:
- Strategic Case
- Economic Case
- Financial Case
- Commercial Case
- Management Case

1.5 Project background

The **Wairarapa** Line links Masterton and Wellington

- **Overview.** The Wairarapa Line serves communities travelling between Masterton and Wellington and stretches over 91 km in the eastern part of the Greater Wellington Region. It connects multiple territorial authority areas, including Masterton, Carterton, South Wairarapa, Upper Hutt, Lower Hutt and Wellington City. The Wairarapa Line runs on the Wellington electrified commuter network for the first stage of the journey from Wellington to Upper Hutt (32 km) beyond which it runs on a non-electrified section from Upper Hutt to Masterton (59 km). However, the services currently use diesel locomotives throughout the whole route. The line provides five weekday services (three peak and two off-peak weekday services) in each direction, an additional service in each direction on Friday nights, and two weekend services in each direction[15]. The end-to-end travel time of each service is between 1 hour and 40 minutes and 1 hour and 50 minutes, offering a comfortable, accessible and competitive alternative to car travel.
- **Importance.** The line provides Wairarapa residents with a critical connection and access to many employment, educational and other opportunities and services in the Hutt Valley and Wellington areas, which are not available locally. The Wairarapa Line services carried about 637,000 peak passengers and 147,000 off-peak passengers in 2019. The line serves the Masterton, Carterton and South Wairarapa Districts, which is mostly a rural area. Its population of 48,900[16] in 2020 is experiencing significant ongoing growth, which is forecast to continue in the future, up to 60,600 people in 2048[17].
- **Alternatives.** The Wairarapa Line plays an important role as one of only two transport links between the Wairarapa and the rest of the Wellington region. The rail line enables mode shift from private cars to public transport. The line also provides the only public transport services to the Maymorn area of Upper Hutt. It also provides the Hutt Valley and Wellington city with environmental and liveability benefits, such as reduced congestion and lower need for parking spaces. Its direct route under the Remutaka Range via the 8.8 km Remutaka Tunnel provides a safer, more reliable and resilient alternative to parallel State Highway 2. The Highway crosses the range via a steep, winding and narrow route over a 555-metre summit[18]. This road has high traffic volumes at peak times and has a high crash risk[19], low average speed[20] and susceptibility to weather-related closure[21]. According to the Wellington Regional Land Transport Plan 2021, there were 186 deaths and serious injuries on the region's roads in 2019, with a five-year rolling average of 208. It led to creating the national reduction target of 40 per cent by 2030 that aligns with the Road to Zero safety strategy.
- **Operation.** The Wairarapa Line passenger services are operated as part of the Metlink public transport network by Transdev, contracted by GWRC. Transdev uses a mixed fleet of GWRC-owned carriages, which are hauled by KiwiRail's 1970s diesel locomotives (Figure 1-5). Hyundai Rotem is subcontracted by Transdev to maintain the Carriages and uses the KiwiRail-owned Wellington Carriage Depot through an access agreement[22]. Modern diesel emissions standards are significantly lower than those of the existing fleet, which pre-date any standards. The Euro Stage V emissions standards become mandatory this year (2021): any new rolling stock will need to utilise compliant engines.

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[15] Source: Metlink' official website. Accessed on 2 March 2021 on https://www.metlink.org.nz/service/WRL

[16] Source: NZ.Stat. 2020 estimates. Accessed on: https://www.stats.govt.nz/topics/population

[17] Based on a "high" scenario, or 52,800 based on "medium" scenario. Source: NZ.Stat. 2018-2048 sub-national projections. Accessed on: https://www.stats.govt.nz/topics/population

[18] Source: Lower North Island Longer-distance Rolling Stock Business Case. Stantec. 2 December 2019

[19] New Zealand Road Assessment Programme (KiwiRAP) collective and personal risk scores for this section of road varied between Medium High and High. Both are at the high end of the five-point risk scale. Source: KiwiRAP Taranaki, Manawatū-Whanganui and Wellington Regional results 2012. Accessed on 5 March 2021 on http://www.kiwirap.org.nz/pdf/Taranaki%20brochure.pdf

[20] This section of State Highway 2, which had a nominal 100 km/h speed limit, had an average speed of 58 km/h. Source: The 2016 NZ Transport Agency SH2 Te Marua to Masterton Programme Business Case. Page 14. Accessed on 5 March 2021 on https://www.nzta.govt.nz/assets/About-us/docs/oia-2017/SH2-Te-Marua-to-Masterton-programme-business-case.pdf

[21] State Highway 2 had 19 closures due to unplanned natural events (snow/ice, wind, slip). Each had an average duration of 36 hours, equating to an average of 5.7 days a year due to weather related events. Source: The 2016 NZ Transport Agency SH2 Te Marua to Masterton Programme Business Case. Page 19. Accessed on 5 March 2021 on https://www.nzta.govt.nz/assets/About-us/docs/oia-2017/SH2-Te-Marua-to-Masterton-programme-business-case.pdf

[22] Source: Lower North Island Longer-distance Rolling Stock Business Case. Stantec. 2 December 2019

Figure 1-5 KiwiRail's 1970s DFB EMD Locomotive

Source: Wairarapa Times - Age. 2020.

- **Rolling stock.** The existing carriage fleet utilised is owned by Greater Wellington Rail Limited (GWRL), a 100% owned subsidiary and Council Controlled Organisation (CCO) of GWRC. The carriage fleet is reaching peak capacity and is approaching the end of the service life in the next 6-8 years[23]. The existing SW and SE type carriages are refurbished and modified 1970s ex-British Rail Mark 2 carriages that entered New Zealand service in 2007 and 2009, respectively. The passenger safety of these vehicles cannot be assessed against any modern standard. Additionally, the fleet includes a single AG type luggage / generator van, dated from the late 1970s, that is used to supplement or replace the SWG or SEG carriages when required. Table 1-1 lists the rolling stock fleet in use on the Wairarapa Line. Trains usually operate with between five and nine carriages, providing a seated capacity of between 266 and 599 passengers per train. Each consist requires a SWS/SES and SWG/SEG, with the balance of SW/SE types. Two SWs, one SWS and one SWG are typically held as spares to facilitate maintenance[24].

Table 1-1 The Wairarapa Line's rolling stock fleet

Fleet type	Number of carriages	Description
SW	12	carriages have 64 seats and a single toilet
SWS	3	carriages have 37 seats, a servery (unused), a wheelchair hoist on each side, an audio induction loop system and an accessible toilet
SWG	3	carriages have 37 seats, a luggage compartment and a diesel generator to power the carriages.
SE	4	carriages have 69 seats and a single toilet
SES	1	a carriage has 44 seats, a wheelchair hoist on each side, an audio induction loop system and an accessible toilet
SEG	1	carriage has 40 seats, a luggage compartment and a diesel generator to power the carriages
AG van	1	a single AG type luggage / generator van with no seated capacity

GWRC commenced early 2020 a light refurbishment of the SW and SE fleets, which is expected to be completed by January 2023 and extend the carriages' service life to the mid-2020s[25].

[23] Source: GWRC. Draft Asset Management Plan. February 2021.

[24] Source: Lower North Island Longer-distance Rolling Stock Business Case. Stantec. 2 December 2019

[25] Source: GWRC. Draft Asset Management Plan. February 2021.

Figure 1-6 SW carriages

Source: GWRC. Draft Asset Management Plan. February 2021.

Figure 1-7 SE carriages

Source: GWRC. Draft Asset Management Plan. February 2021.

The **Manawatū** Line links Palmerston North and Wellington

- **Overview.** The Manawatū Line extends over 136 km in the western side of the Greater Wellington and Manawatū-Whanganui regions, connecting Palmerston North and Wellington. It covers the territorial authority areas of Manawatū, Palmerston North, Horowhenua, Kapiti Coast and Wellington City. The Manawatū Line runs on the Wellington electrified commuter network for the first stage of the journey from Wellington to Waikanae (55 km) at 1,600 V DC before running on a non-electrified section from Waikanae to Palmerston North (81 km). However, similar to the Wairarapa line, the services currently use diesel locomotives throughout the whole route. The line runs a single peak direction service in each weekday peak. Each end-to-end service takes 2 hours and 5 minutes, which is competitive with the car alternative during peak travel times. The line carried about 136,000 passengers in 2019.
- **Importance**. The Manawatū Line is the only commuter rail passenger service on this corridor north of Waikanae[26]. The link is important to residents, since it provides access to many employment, educational and other opportunities and services that are not available locally. Additionally, the services provide necessary extra capacity to supplement the electrified metro rail services south of Waikanae.
- **Alternatives.** The Manawatū Line parallels State Highway 57 north of Levin and State Highway 1 south of that point. State Highway 1 passes large traffic volumes south of Levin, while its geographical constraints limit it to a single lane making it exposed to high congestion[27].
- **Operation.** The Manawatū Line is served by the Capital Connection, a weekday commuter train operated and maintained by KiwiRail. KiwiRail also provides locomotives (Figure 1-5) and locomotive crews through an intra-company hook and tow arrangement. Similar to the Wairarapa line, the existing locomotives pre-date any modern emissions standards. The introduction of the mandatory Euro Stage V emissions standards this year (2021) means that any new rolling stock will need to utilise compliant engines.
- **Rolling stock.** KiwiRail's conventional locomotive-hauled rolling stock fleet utilised to deliver its Capital Connection service is reaching peak capacity and is nearing the end of its service life. Like the Wairarapa Line's rolling stock, the Capital Connection's S type fleet was rebuilt from ex-British Rail Mark 2 early 1970s carriages prior to entering New Zealand service in 1999, although differently from the SW and SE cars, which they are not compatible with[28]. The passenger safety of these vehicles cannot be assessed against any modern standard. Table 1-2 outlines the Manawatū Line's existing rolling stock.

Figure 1-8 S carriages

Source: The Great Journeys of New Zealand official website.

The train currently operates in an eight-car configuration between Friday afternoon and Tuesday morning, with six standard cars, the servery car, and luggage / generator van, to provide a seated

[26] Noting that the three-times-a-week tourism-focused Northern Explorer also uses the line, which is not considered as commuter rail passenger service.

[27] Source: Lower North Island Longer-distance Rolling Stock Business Case. Stantec. 2 December 2019

[28] Source: Lower North Island Longer-distance Rolling Stock Business Case. Stantec. 2 December 2019

capacity of 388. It operates with one less standard car at other times to allow for maintenance, providing a seated capacity of 328. One standard car is inoperable due to significant structural issues. No spares are held, so the train operates at reduced capacity when additional maintenance is required. In January 2020, the government announced capital funding for the refurbishment of Capital Connection S fleet carriages[29] (for detail refer to Rail Network Investment Programme in Section 2.3.1).

Table 1-2 The Manawatū Line's rolling stock fleet

Fleet type	Number of carriages	Description
S	7	standard S class carriages have 60 seats and a single toilet
S servery	1	a servery carriage has 28 seats and a toilet
AG van	1	a single AG type luggage / generator van, equipped with a wheelchair hoist, with no seated capacity

In January 2020 the government announced an infrastructure investment package through its New Zealand Upgrade Program. They include improvements to the Wellington, Wairarapa and Palmerston North rail network and beyond, upgraded tracks for the Wairarapa and Capital Connection lines, safety connections and refurbishment of Capital Connection carriages, which would extend their service life to FY2027-FY2028. NZUP funds rail network infrastructure improvements, which were identified in the IBC, to provide capacity for growth in passenger and freight services and support increased frequency of the Wairarapa and Manawatū line services. Without investment in the rolling stock the benefits of this investment will not be fully realised.

1.6 Key constraints, dependencies and assumptions

The LNIRIM project is influenced by a range of broader considerations: constraints, dependencies and assumptions. These considerations are addressed in each subsequent chapter throughout the DBC. The financial, economic and demand modelling assumptions are descried in detail in Chapter 4, 5 and 8.

Table 1-3 summarises key constraints, dependencies and assumptions.

Table 1-3 Key constraints, dependencies and assumptions

	Constraints	Notes
C1	Service life of the existing fleet	To ensure continuation of services, a solution need to be in place before the existing fleet can no longer be safely operated
C2	Procurement and delivery timeframes associated with the rolling stock	Rolling stock is typically associated with long procurement and delivery timeframes (5-7 years)
	Dependencies	**Notes & Management strategies**
D1	Funding availability	Ongoing stakeholder engagement and further investigation of value capture and other opportunities to improve affordability
D2	Timely decision making from the PSC	Ongoing engagement and monthly steering
D3	Approvals and consents	Develop stakeholder engagement strategy to assist with facilitating required approvals and consents
	Assumptions	**Notes & Management strategies**
A1	The existing fleet for the Wairarapa Fleet and the Capital Connection reaches the end of its service life between FY2027 and FY2028	Consideration in the delivery schedule
A2	Base case assumes there would be suitable rollingstock available even though in practice that may not be the case	Consultation with key stakeholders, such as Waka Kotahi, GWRC and Horizons, and agreement on the definition of the do minimum base case
A3	The market sounding outcomes represent the industry sentiment, particularly in relation to procurement and delivery timeframes and technical feasibility of the preferred solution	Further market engagement in the next phases of the project

[29] Source: Beehive.govt.nz the official website of the New Zealand Government. Accessed on 5 March 2021 on: https://www.beehive.govt.nz/release/future-proofing-new-zealand%E2%80%99s-rail

2 CHAPTER 2 – STRATEGIC CONTEXT

CHAPTER SUMMARY AND CONCLUSIONS:

- The LNIRIM project aligns with and contributes to the strategic direction of the national and regional transport priorities, reflected in critical government plans and policies, including the Government Policy Statement on land transport 2021-2031. The LNIRIM project aims to support the government facilitate mode shift, safety, decarbonisation, access and enable future economic opportunities.
- The two region's forecast population growth, an increased focus on carbon neutral objectives and needed mode shift to public transport, coupled with future economic and employment growth opportunities, underpins an increasing need for public transport services on the Wairarapa and Manawatū Lines.
- The Wellington Regional Growth Framework Report 2021 recognises that the region's population could grow by 200,000, or by about 37%, with an additional 100,000 jobs in the next 30 years, compared to 2020. Similarly, the Manawatū-Whanganui region's population will grow by approximately 12% by 2028 and 28% by 2053. The highest population growth is estimated to be in Porirua, Kāpiti Coast, the Wairarapa and Palmerston North.
- Growing urban population is expected to shift further from the capital to Wairarapa and North of Waikanae, because these areas have relatively cheap greenfield development potential and are within commuting distance to Wellington City.
- Of the 88% housing development growth from areas identified in the Wellington Regional Growth Framework:
  - One-quarter is expected to be in Wellington City
  - Nearly one-third is expected to be in the eastern corridor from Lower Hutt to Masterton
  - The remainder (just over 40%) is expected to be in the western corridor from Tawa to Levin.
- The regions are expected to have higher density development in the vicinity of rail and bus services to facilitate mode shift.
- The National Policy Statement on Urban Development is driving the intensification around rail, which then in turn supports mode shift and the wider transport outcomes, such as the current GPS priority of climate change.
- With the introduction of the Rail Network Investment Programme, LNIRIM shares interdependencies with key other projects, including KiwiRail's network upgrades and feasibility study on track electrification, the outcomes of which will influence LNIRIM's future opportunities.
- Catering for future transport infrastructure and services can support a shift to more sustainable modes of transport, while also supporting economic growth and shaping desired land use.

2.1 Purpose and overview of chapter

The purpose of this chapter is to outline the strategic context to the LNIRIM project and its strategic alignment with government objectives, policies, plans and relationships with other key government projects. This chapter also describes the underpinning drivers, such as transport and urban development demands that will impact current and future service needs for the Wairarapa and Manawatū Lines' transport corridors.

While an understanding of the future growth and demand assists with setting the scene for the problem definition in Chapter 3, the strategic context assists with ensuring that the multi criteria analysis leads to selecting a preferred solution that is aligned to critical government plans and policies.

This chapter details:

- strategic context, including forecast demographics and land use
- the background and approach to service need development
- relevant national and regional strategic policies
- related projects.

2.2 Strategic context: service need drivers

The need for investment has been considered in the context of current and future service needs. These needs are driven by high projected population growth in the vicinity of the Wairarapa and Manawatū lines and desired future land use areas, which are anticipated to have higher density development and include improved access to bus and rail services to enable the economic growth.

The Wellington Region is the third largest region in New Zealand by population, which amount to about 542,000 people based on the 2020 estimates[30]. The region experienced a higher than predicted population growth over the past 20 years[31].

The region is made up of an interdependent network of cities, towns and rural areas, distributed across the region in a Y-shaped pattern (as shown in Figure 1-1 in Chapter 0). The steep terrain of the Tararua and Remutaka Ranges restricts urban development and transport networks to two linear corridors running north south, either side of the ranges, which come together in the south of the region. The region's topography limits opportunities for east-west connections between these two corridors and has encouraged a dispersed and mostly low-density development pattern across the region[32].

The National Policy Statement on Urban Development (NPS-UD)[33]:

- Requires councils to enable greater supply and ensure that planning is responsive to changes in demand, plan well for growth and ensure a well-functioning urban environment for all people, communities and future generations.
- Aims to improve accessibility for all people between housing, jobs, opportunities for social interaction, services and public open spaces, including by way of public and active transport.
- The Wellington Region (excluding Wairarapa) is considered a tier 1 urban environment, required to enable greater intensification in areas of high demand, remove minimum parking requirements and prepare a future development strategy. Additionally, for Tier 1 councils the NPS-UD requires intensification of six stories around rapid transit stops.
- The Wellington Regional Growth Framework is a part of the region's response to these requirements. The transport aspects of the Wellington Regional Growth Framework will be implemented through current and future Regional Land Transport Plans (RLTPs).

The draft Wellington Regional Growth Framework is a spatial plan that will set out the approach to urban development across the region over the next 30 years. The framework is a collaboration between the region's councils (plus Horowhenua District Council), central government and iwi. The framework recognises that the region's population could grow by 200,000, with an additional 100,000 jobs. It has identified three growth corridors – western, eastern and Let's Get Wellington Moving – and two potential west-east corridors. Transport is integral to achieving the region's growth potential and needs to be integrated with urban planning. The framework calls for urban intensification supported by integrated transport networks[34].

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[30] Source: NZ.Stat. Subnational population estimates: on 30 June 2020. Published on 22 October 2020. Accessed on 11 March 2021 on http://nzdotstat.stats.govt.nz/wbos/Index.aspx

[31] Source: Draft Wellington Regional Public Transport Plan 2021-2031

[32] Source: Regional Transport Committee 8 June 2021. Order paper - Approval of the Wellington Regional Land Transport Plan 2021

[33] Source: Regional Transport Committee 8 June 2021. Order paper - Approval of the Wellington Regional Land Transport Plan 2021

[34] Source: Regional Transport Committee 8 June 2021. Order paper - Approval of the Wellington Regional Land Transport Plan 2021

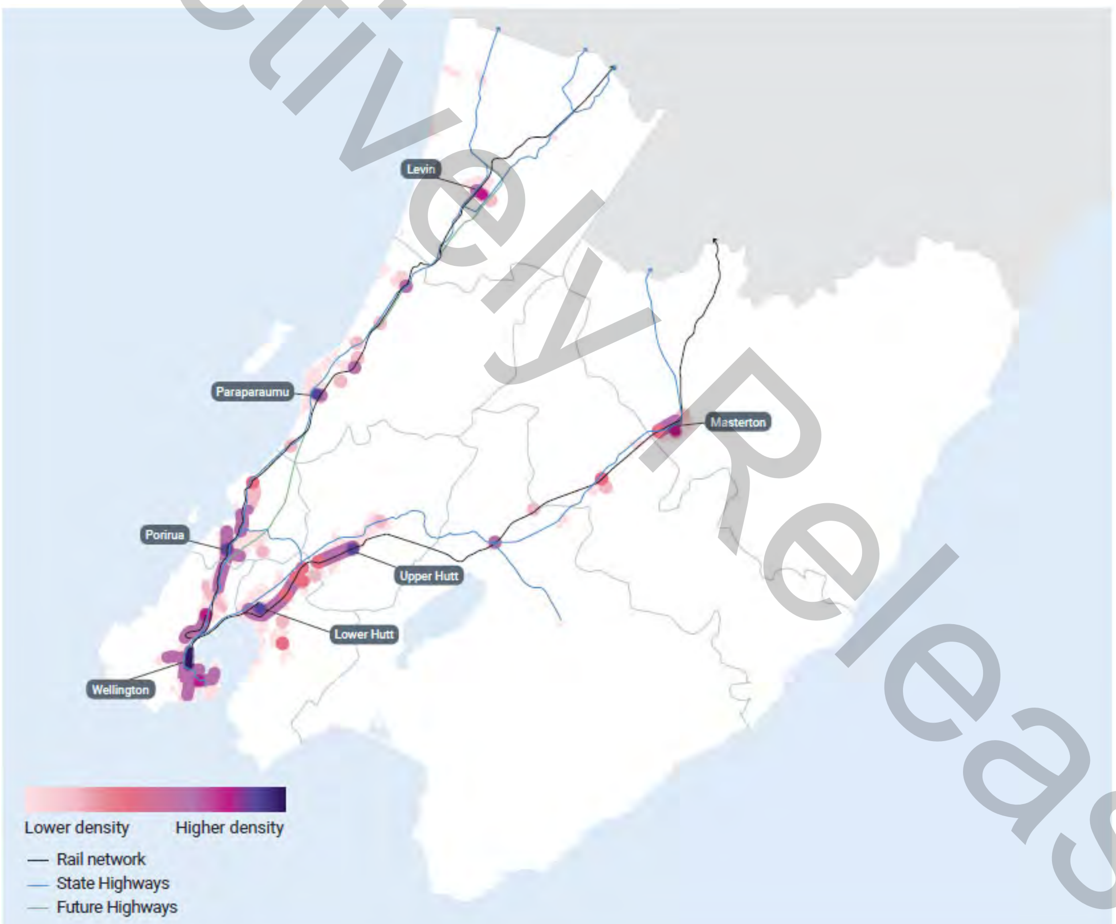
The highest population growth is estimated to be in Porirua, Kāpiti Coast and the Wairarapa. The increased residential growth is expected in Wairarapa and North of Waikanae because these areas have relatively cheap greenfield development potential and are within commuting distance to Wellington City. This increased residential growth will bring economic opportunities and place increasing demands on regional transport.

The Wellington Regional Growth Framework Report 2021 outlines proposed changes to the region's urban form, which are a mix of development in both Urban Renewal Areas[35] and Future Urban Areas[36]. Both areas are anticipated to have higher density development and include improved access to bus and rail services. These transport services are expected to increase in frequency, capacity and reach over time. Of the 88% housing development growth from areas identified in the Framework:

- One-quarter is expected to be in Wellington City, including the Let's Get Wellington Moving corridor
- Nearly one-third is expected to be in the eastern corridor from Lower Hutt to Masterton.
- The remainder (just over 40%) is expected to be in the western corridor from Tawa to Levin[37].

Figure 2-1 and Figure 2-2 show the existing and future residential development areas are mostly in the vicinity of the Wairarapa and Manawatū Lines' transport corridors.

Figure 2-1 Conceptual illustration of residential density and development



Source: Wellington Regional Growth Framework: Draft Framework Report 2021

[35] Urban Renewal Areas are brownfield developments, including high-density developments in all seven major centres in the region and medium-density developments at nodes

[36] Future Urban Areas are greenfield developments, generally more than 1000 new dwellings

[37] Source: Wellington Regional Growth Framework: Draft Framework Report 2021. Accessed on 8 March 2021 on: https://wrgf.co.nz/wp-content/uploads/2021/03/Draft-Framework-Report.pdf

Similarly, the Manawatū-Whanganui's population increased from 247,500[38] people in 2018 to 254,300 people in June 2020, 35.7% (88,300) of which reside in the Palmerston North City boundary. The regional population grew by 7.2% in the 5-year period from 2013 to 2018[39]. The Manawatū-Whanganui region is projected to grow by approximately 12% by 2048, compared to 2018, with Palmerston North city and Horowhenua district growing by 16% each over the same period[40].

The Manawatū-Whanganui region was identified as one of 'surge regions'[41] and its Growth Strategy Accelerate 25 (Accelerate 25) is attracting investment to unlock its economic potential. The coalition government identified 'surge regions' as the areas requiring a higher level of investment to unlock their full economic potential, including investment from the Provincial Growth Fund that was launched in February 2018. Accelerate 25 is supported by the Accessing Central New Zealand (ACNZ) Governance Group, a sub-group of the Regional Transport Committee, to ensure a connected, safe, resilient and cohesive transport network to, from and within the Manawatū-Whanganui region[42]. Taking advantage of its centralised geographic location, the Accelerate 25 Economic Action Plan identified Palmerston North as a major intersection requiring further investment in streamlined rail and road networks. Additionally, Palmerston North is well established as the major distribution hub for the lower North Island, and also hosts the national distribution centres for Toyota, EziBuy and Steelfort. With its convergence of roads, large rail goods yard and easy access to air transport, the city has undergone rapid recent growth in the warehousing, logistics, and distribution sectors[43], providing growing employment opportunities. Supporting the passenger services on the Manawatū line will further support Accelerate 25 and the economic development of the region.

[38] Source: Statistics NZ, Population Estimates for 2018, based on 2018 Census - Final June 2018 and June 2020 estimate (published September and October 2020)

[39] Source: Statistics NZ, based on 2018 census data.

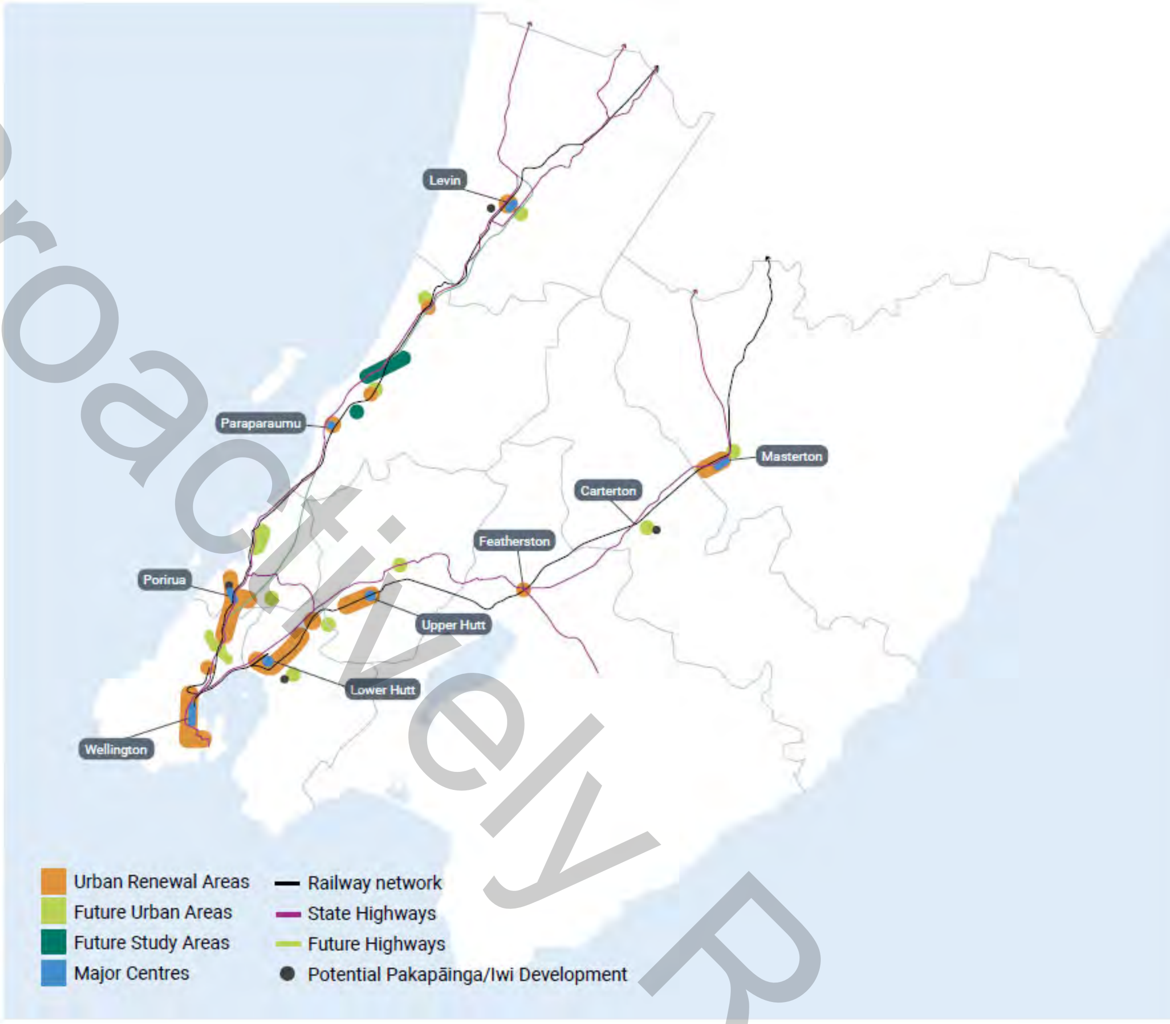
[40] Under a "medium" growth scenario. Source: NZ.Stat. 2018-2048 sub-national projections. Accessed on: https://www.stats.govt.nz/topics/population

[41] Source: Beehive.govt.nz the official website of the New Zealand Government. Provincial Growth Fund. Accessed on 12 March 2021 on: https://www.beehive.govt.nz/sites/default/files/2018-02/PGF%20overview_1.pdf

[42] Source: Accelerate 25 Manawatū-Whanganui. Distribution and Transport. Accessed on 12 March 2021 on: https://www.accelerate25.co.nz/distribution-and-transport.html

[43] Source: Colliers. Huge distribution centre with land bank in high-growth Palmerston North. Accessed on 6 August 2021 on: https://www.colliers.co.nz/en-nz/news/huge-distribution-centre-with-land-bank-in-high-growth-palmerston-north

Figure 2-2 Future Urban Development Areas

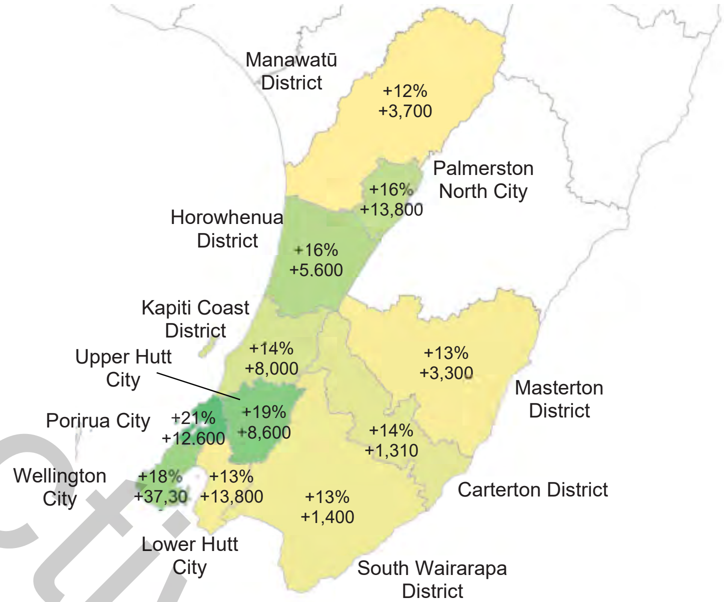


Source: Wellington Regional Growth Framework: Draft Framework Report 2021

Figure 2-3 shows that all areas in the vicinity on the Wairarapa and Manawatū lines are projected to have a double-digit growth rate by 2048, compared to 2018. The growing population is aligned with the future land use with higher density development. Proposed changes to the region's urban form include improved access to bus and rail services, which will be expected to increase in frequency, capacity and reach over time[44]. Future service needs are also shaped by an increased national and regional focus on carbon neutral objectives, safe and accessible transport and associated need for mode shift. The transport network will need to meet the needs not only of existing commuters but also support population and economic growth over the next 10-15 years and beyond.

[44] Source: Wellington Regional Growth Framework: Draft Framework Report 2021. Accessed on 8 March 2021 on: https://wrgf.co.nz/wp-content/uploads/2021/03/Draft-Framework-Report.pdf

Figure 2-3 Total projected population change by district, 2048 to 2018, % and number of people



Source (underlying data): Stats.NZ. *https://www.stats.govt.nz/information-releases/subnational-population-projections-2018base2048*

Additionally, Sense Partners released revised population projections for the Wellington Region in April 2021. The projections were developed collaboratively between the various territorial authorities in the region, with a methodology that uses predictable and structural composition characteristics of populations and economies to extract future trends. The forecasts are based on four component models: people, work, household and housing. Sense Partners projections show that:

- Population growth is expected to be high by historical standards, driven by high rates of migration particularly for the first 10 years. Longer run, growth is expected to moderate with lower birth rates and lower rates of immigration, however population growth over the next 30 years is forecast to be significantly higher than over the last 30 years.
- The projections show a 50 per cent probability of annual population growth rates between 1.4 per cent and 1.9 per cent (25th to 75th percentile range) over the next 10 years, with a 50 per cent probability of annual population growth rates between 0.8 per cent and 1.7 per cent over the next 30 years.

Improved passenger rail will contribute to the broader transport system, complementing other significant transport investments in the Greater Wellington and Manawatū-Whanganui regions. Catering for future transport infrastructure and services can support a shift to more sustainable modes of transport, while also supporting economic growth and shaping desired land use.

2.3 Strategic policy frameworks

The legal framework that guides the strategy, management, and funding of land transport activities include the Land Transport Management Act 2003 (LTMA), the Local Government Act 2002 and the Resource Management Act 1991[45]. Other relevant legislations include the Railways Act 2005, the Climate Change Response Act 2002 and the Land Transport Act 1998.

Following the development of the IBC, both national and local governments issued a range of new strategic policies and frameworks to guide the long-term direction of the transport sector. Figure 2-4 outlines main current government strategies, policies and plans relevant for the Wairarapa and Manawatū Lines. The long-term transport strategies that impact Greater Wellington and Horizon's public transport systems focus on multi-modal transportation options. The strategies focus on improving the overall resilience of the transport corridors by improving the rail network and enabling mode shift to make the overall land transport system safer.

In addition to NPS-UD, the Wellington Regional Growth Framework Report 2021 and Accelerate 25 discussed in Section 2.2, the LNIRIM project aligns with and contributes to the strategic direction of the future transport priorities, reflected in critical government plans and policies, including the Government Policy Statement. The LNIRIM project aims to support the government facilitate mode shift, safety, decarbonisation, access and enable future economic opportunities.

Figure 2-4 Relevant national and local government strategic frameworks

National strategy/policy/plan

- Government Policy Statement on land transport
- New Zealand Rail Plan
- National Land Transport Plan
- Rail Network Investment Programme
- Climate Change Commission Advice for Consultation
- New Zealand Upgrade Programme – Transport
- Road to Zero: New Zealand's Road Safety Strategy
- Keeping Cities Moving: A Plan for Mode Shift
- Arataki Version 2

Local government strategy/policy/plan

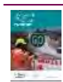
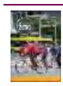
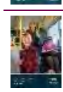
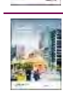
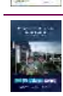
- Wellington Regional Land Transport Plan
- Wellington Regional Public Transport Plan
- Wellington Regional Rail Plan
- Horizons Regional Land Transport Plan
- Horizons Regional Public Transport Plan
- Wellington Regional Mode Shift Plan
- Let's Get Wellington Moving

This section provides summaries of the key relevant national and local government strategic frameworks, policies and plans. Table 2-1 on page 39 also outlines LNIRIM's alignment with these documents.

[45] Source: Waka Kotahi official website. Accessed on 8 March 2021 on: https://www.nzta.govt.nz/planning-and-investment/planning/our-role-in-planning/the-role-of-local-government/our-guiding-legislation/

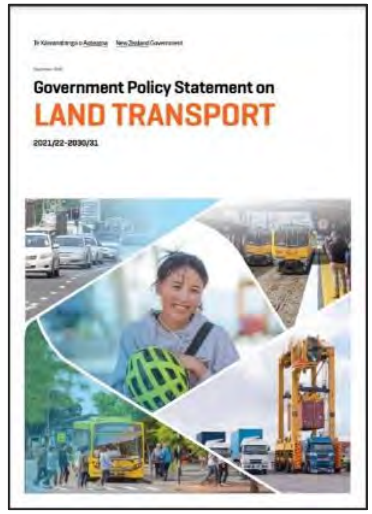
A summary below outlines the alignment the LNIRIM project with key strategies, policies and plans.

Table 2-1 A summary of key strategic frameworks and LNIRIM's alignment

		Strategy/policy/plan	LNIRIM's alignment
National		Government Policy Statement on land transport 2021-2031	LNIRIM contributes to all four strategic objectives of GPS 2021: safety, better travel options, climate change, and improving freight connections.
		New Zealand Rail Plan	LNIRIM aligns with the strategic direction outlined in the Plan, specifically by supporting growth in New Zealand largest cities.
		Rail Network Investment Programme	LNIRIM aligns with RNIP and aligns with works on future capacity improvements to cater for increasing passenger demand. LNIRIM contributes to the integrated view of the transport network in the Wairarapa and Manawatū Lines' transport corridors.
		National Land Transport Plan 2021–2024	The new NLTP is currently being developed. LNIRIM aligns with the NLTP's investment signals, which are guided by GPS 2021.
		Climate Change Commission 2021 Advice for Consultation	LNIRIM contributes with the Government's objectives to reduce emissions by providing commuters with a transport option alternative to road and enabling mode shift. Additionally, LNIRIM will consider options' propulsion modes, including options with potentially lower environmental impact.
		New Zealand Upgrade Programme – Transport	LNIRIM aligns with and complements the objectives of the programme to increase the Wairarapa and Manawatū Lines' capacity and safety. NZUP's $211 million investment in rail network improvements north of Wellington aims to provide capacity for growth in passenger and freight services and support increased frequency of Metlink and Capital Connection services. LNIRIM strongly aligns with NZUP and supports the realisation of its benefits.
		Road to Zero: New Zealand's Road Safety Strategy 2020 – 2030	LNIRIM enables mode shift for commuters from road to rail and improves the safety through reduced traffic volumes on roads.
		Keeping Cities Moving: A Plan for Mode Shift	LNIRIM aligns to the strategy as it aims to provide current and future commuters with access to social and economic opportunities through accessible, safe, and sustainable public transport services.
		Arataki Version 2	LNIRIM directly supports Arataki Version 2 because it aligns with the future land use, enables mode shift and supports access to social, health and employment opportunities that are not available locally.
Local government		Wellington Regional Land Transport Plan 2021-2031	LNIRIM aligns with all Wellington RLTP's investment priorities and will contribute to meeting RLTP's targets.
		Wellington Regional Public Transport Plan 2021-2031	LNIRIM aligns with the RPTP's strategic priorities and investments in the Wairarapa and Manawatū lines are specifically mentioned in RPTP.
		Wellington Regional Rail Strategic Direction 2020	LNIRIM contributes to achieving the new RRP's desired outcomes, specifically, by improving access, capacity and frequency of services and enabling mode shift that will assist with improving safety and reducing emissions.
		Horizons Regional Land Transport Plan 2021-2031	LNIRIM directly contributes to all five Horizons RLTP's investment objectives of connectivity and access, safety, better travel options, environment and resilience. Additionally, Horizons RLTP specifically outlines a significant local investment as part of RLTP to enable the continuation of the Manawatū Line services
		Horizons Regional Public Transport Plan 2015-2025	The new Horizons RPTP is currently being developed. LNIRIM aligns with the 2015-2025 RPTP and will need to consider the details of the new Horizons RPTP and its strategic priorities.
		Wellington Regional Mode Shift Plan 2020	LNIRIM aligns with Wellington Regional Mode Shift Plan and contributes to all three of its key levers of shaping urban form, making shared and active modes more attractive, and influencing travel demand and transport choice.
		Let's Get Wellington Moving	LNIRIM is aligned to and contributes to LGWM's objectives by enabling mode shift by providing safe and reliable access to social and economic opportunities to a growing population.

2.3.1 National strategies, policies, and plans

Government Policy Statement on land transport 2021-2031



This Government Policy Statement on land transport 2021-2031 (GPS 2021) outlines the government's strategy to guide land transport investment over the next 10 years (2021/22-2030/31). It is consistent with the purpose of the LTMA 2003 'to contribute to an effective, efficient, and safe land transport system in the public interest'[46]. It is released every three years and informs the subsequent development of the National Land Transport Plan (NLTP). The latest GPS was released in September 2020.

Through GPS2021 the Government identified four strategic priorities for land transport investment, which LNIRIM closely aligns with. The strategic priorities are:

- Safety - developing a transport system where no-one is killed or seriously injured
- Better travel options - providing people with better transport options to access social and economic opportunities
- Climate change - developing a low carbon transport system
- Improving freight connections - improving freight connections for economic development[47].

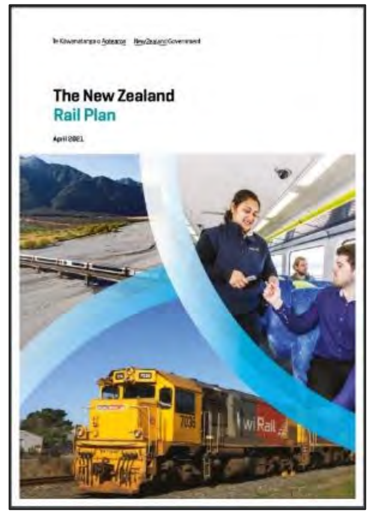
Specific relevance for this DBC:

- *LNIRIM will contribute to all four priorities:*
  - *Safety – LNIRIM aims to enable mode shift from road to rail through making commuter rail travel more available and attractive for commuters. With the increasing numbers of fatal and serious road accidents since 2013, LNIRIM will help deliver an improvement in overall safety by reducing the number of cars on roads and making the overall travel safer for New Zealanders.*
  - *Better travel options - LNIRIM aims to provide faster, more frequent, and more reliable travel options for people commuting on the Wairarapa and Manawatū lines, which will make these services more attractive to commuters and enable mode shift from road to rail. The reduction in road use will reduce congestion and improve journey times for those that need to use private motor vehicles. LNIRIM will also improve the resilience of regional transport network by providing a more diverse land transport network. These enhanced travel options will improve the liveability of communities not only in Horowhenua, Manawatū, and Palmerston North but also in the Wellington, Hutt and Porirua cities.*
  - *Improving freight connections - LNIRIM will enable mode shift that will reduce private motor vehicle volumes on regional corridors and on major arterial routes, which will shorten travel times for road freight operators.*
  - *Climate change - LNIRIM will contribute to decarbonisation of regional transport networks by achieving mode shift from road to rail and by investigating potential low carbon service options.*

[46] Source: Land Transport Management Act 2003. Accessed on 12 March on: https://www.legislation.govt.nz/act/public/2003/0118/77.0/DLM226236.html

[47] Source: Government Policy Statement on land transport 2021-2031. Accessed on 12 March on https://www.transport.govt.nz/assets/Uploads/Paper/GPS2021.pdf

New Zealand Rail Plan



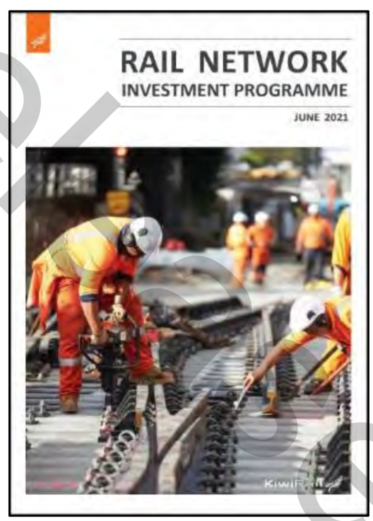
The first New Zealand Rail Plan was developed by the Ministry of Transport and KiwiRail following the Future Rail review. It was released for public feedback as draft in December 2019 and focused on enabling alternative transport options and a multi-modal transport system. The rail plan included the Future of Rail review's recommendations and informed GPS 2021. It outlines the Government's long-term vision and priorities for rail[48]:

- Establishing a new long-term planning and funding framework under LTMA
- Investment priorities for a reliable and resilient rail network
  - Investing in the national rail network to restore rail freight and provide a platform for future investments for growth
  - Investing in metropolitan rail to support growth and productivity in our largest cities.

Specific relevance for this DBC:

- *LNIRIM strongly aligns with the strategic direction outlined in the Plan, specifically by supporting growth in New Zealand largest cities. New Zealand Rail Plan refers to more extensive network and rolling stock upgrades to enable increased levels of service and support growth opportunities and regional initiatives. Specifically, the plan lists a replacement of Wairarapa and Capital Connection trains and station upgrades to provide for metro growth as one of its investment priorities for the Wellington region[49].*
- *The report indicates future opportunities for further investments that support meeting the emission reduction targets, including further electrification of the track and locomotives on high volume routes, such as the North Island Main Trunk (NIMT) between Auckland and Wellington.*
- *The plan, however, does not provide a definitive list of investments or commit to any projects in the plan. KiwiRail is currently developing the Rail Network Investment Programme (described below) and is investigating the feasibility of completing the electrification of the NIMT (described in Section 2.4 on page 50). The outcomes of the proposed network improvements and feasibility study will influence the next generation of North Island locomotives.*

Rail Network Investment Programme



The Draft New Zealand Rail Plan led to the Land Transport (Rail) Legislation Act 2020 that came into effect on 1 July 2020 to amend LTMA. It introduced a requirement to develop Rail Network Investment Programme (RNIP) every three years, alongside the National Land Transport Programme, and allowed the rail network to be funded from NLTF on the same basis as other land transport modes. Guided by GPS 2021, the RNIP will be funded from the Rail Network activity class, Public Transport Infrastructure activity class, and the Crown[20]. It facilitates integrated planning and investment across the transport network. The RNIP includes significant rail activities for the next six years, and a 10-year financial forecast. The Minister of Transport, in consultation with KiwiRail Shareholding Ministers, approves the RNIP[50]. Waka Kotahi advises on the RNIP's alignment with broader land transport investment programmes and report annually to the Minister of Transport on the

[48] Source: New Zealand Rail Plan https://www.transport.govt.nz/assets/Uploads/Report/The-New-Zealand-Rail-Plan.pdf

[49] Source: New Zealand Rail Plan, page 37. https://www.transport.govt.nz/assets/Uploads/Report/The-New-Zealand-Rail-Plan.pdf

[50] Source: Ministry of Transport. Future of rail. The work to date, 7 July 2020. Land Transport (Rail) Legislation Act comes into effect. Accessed on 15 March on: https://www.transport.govt.nz/area-of-interest/infrastructure-and-investment/future-of-rail/.

RNIP's activities and outcomes. KiwiRail has prepared and published the first RNIP to take effect from 1 July 2021[51].

The New Zealand Budget Policy Statement issued on 9 February 2021 indicated the $969.4 million Government's infrastructure investment programme. It included Future of Rail investments ($821.2 million capital and $148.2 million operating) to replace ageing locomotives and upgrade KiwiRail's mechanical maintenance facilities, replace the ageing Interisland ferry assets, and fund ongoing maintenance and renewal of the rail network via the National Land Transport Fund[52].

The NZ Rail Plan investment priorities for regional commuter rail are to support the Capital Connection service between Palmerston North and Wellington. The RNIP states that the Transitional Rail activity class has contributed $3.5m to maintain rolling stock for the Capital Connection service, with NZUP funding contributing an additional $15m for a substantial rolling stock upgrade. Refurbished carriages will be used to support the continuation of this service, until GWRC is able to purchase new long-distance rolling stock, which will come into service in around five years (subject to funding).

The key improvement project for the Wellington metro region is the detailed business case phase of the Network Re-signalling and Train Protection programme (WMUP V) project. KiwiRail will seek business case and design funding for this project, over the next three years from the PTI activity class. The NZUP – Wairarapa and Wellington rail projects are delivering capacity improvements to support the regional rolling stock business case. Further business case funding has been included to address any network issues arising from GWRC's choice of a new commuter fleet. This includes determining the cost and staging for further northwards extension of electrification on the NIMT, potential partial electrification on the Wairarapa line and the interaction between the new fleet and longer freight trains associated with larger ferries at the freight yard entry.

Specific relevance for this DBC:

LNIRIM contributes to the integrated view of the transport network in the Wairarapa and Manawatū Lines' transport corridors. The RNIP's potential improvement projects include re-signalling and capacity improvements, which directly align to LNIRIM.

National Land Transport Plan 2021–2024

A new 2021-2024 National Land Transport Plan (NLTP) is currently being developed, which is expected to be published in late August to early September 2021[53]. The NLTP will set out activities that will receive funding from NLTF. Its investment signals align with GPS 2021 and include safety, better travel options, climate change and improving freight connections[54].

Specific relevance for this DBC:

LNIRIM aligns with the NLTP's investment signals, which are guided by GPS 2021.

[51] Source: Land Transport (Rail) Legislation Bill. Accessed on 15 March on: https://www.legislation.govt.nz/bill/government/2019/0191/9.0/d5873116e2.html

[52] Source: New Zealand Budget 2021. Budget Policy Statement. 9 February 2021. ISBN: 978-1-99-004501-1 (online). Page 13. Accessed on: https://www.treasury.govt.nz/sites/default/files/2021-02/bps21.pdf

[53] Source: Waka Kotahi. Development timeline for RLTPS and NLTP. Accessed on 12 March on: https://www.nzta.govt.nz/assets/planning-and-investment/docs/2021-24-nltp-high-level-timeline.pdf

[54] Source: Waka Kotahi. 2021–24 NLTP investment signals – November 2020. Accessed on 15 March on: https://www.nzta.govt.nz/assets/planning-and-investment/docs/NLTP-investment-signals-202011.pdf

Climate Change Commission 2021 Advice for Consultation

With the rising importance to prepare for a resilient climate future, the Climate Change Response (Zero Carbon) Amendment Act 2019 came into effect on 14 November 2019 and led to a creation of an independent Climate Change Commission on 17 December 2019[55]. A Draft Advice for Consultation that was issued by the Commission on 31 January 2021. It highlights an increased focus on carbon neutral objectives and outlines pathways for achieving net zero emissions by 2050.

The Advice emphasises a critical role of transport sector decarbonisation to achieve this target with a shift towards active, public and shared transport modes, moving of freight by rail and shipping and utilising existing technologies, such as an electric or low emissions transport fleet[56]. The advice states that New Zealand can almost completely decarbonise land transport to meet the 2050 targets[57].

Specific relevance for this DBC:

LNIRIM contributes to the Government's objectives to reduce emissions by providing commuters with a transport option alternative to road with lower emissions levels. Additionally, LNIRIM will consider options' propulsion modes, including options with potentially lower environmental impact. Safe and reliable passenger rail services on the Wairarapa and Manawatū Lines will help reduce a climate-related risk to the transport network's resilience by presenting an alternative option for the road network if the latter gets damaged by weather-related events.

New Zealand Upgrade Programme – Transport

In January 2020, the Ministry of Transport and Waka Kotahi issued the New Zealand Upgrade Programme for the transport sector with $6.8 billion being invested across road, rail, public transport and walking and cycling infrastructure[58]. The programme focused on the transport infrastructure in six main growth areas, which included Wellington. The Wellington package of $1.35 billion included SH58 safety improvements, Melling interchange, Ōtaki to north of Levin (Ō2NL) and the Wellington rail package.

Specific relevance for this DBC:

- *The programme's Wellington rail package of $211 million aims to provide capacity for growth in passenger and freight services.*
- *Infrastructure upgrades to increase line capacity and support increased frequency of Metlink and Capital Connection services include[59]:*
  - *new passing infrastructure at Carterton and Maymorn (the Wairarapa Line)*
  - *a second platform at Featherston to enable two passenger trains to pass (the Wairarapa Line)*
  - *safety improvements: installation of a new signalling system, reduction in or upgrade of level crossings*

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[55] Source: Ministry for Environment. Accessed on 15 March 2021 on: https://www.mfe.govt.nz/climate-change/climate-change-and-government/establishing-climate-change-commission

[56] Source: Climate Change Commission. 2021 Draft Advice for Consultation https://www.climatecommission.govt.nz/get-involved/consultation/

[57] Source: Climate Change Commission. Accessed on 5 March 2021 on: https://www.climatecommission.govt.nz/

[58] Source: Waka Kotahi. New Zealand Upgrade Programme – Transport. Accessed on 15 March 2021 on: https://www.nzta.govt.nz/assets/Roads-and-Rail/20-011/NZ-Upgrade-Programme-Transport.pdf

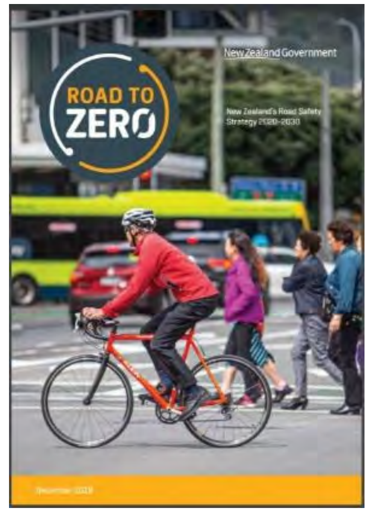
[59] Source: Waka Kotahi. New Zealand Upgrade Programme – Transport. Page 36. Accessed on 15 March 2021 on: https://www.nzta.govt.nz/assets/Roads-and-Rail/20-011/NZ-Upgrade-Programme-Transport.pdf

– *building of three new storage facilities for train carriages in Masterton, Levin and Wellington for extra peak capacity and maintenance*

– *refurbishment of platforms and the Capital Connection rolling stock until new rolling stock is bought.*

LNIRIM closely links with NZUP, which delivers some of the required infrastructure for LNIRIM reflecting the need identified through the IBC, and supports the realisation of its benefits. NZUP's $211 million investment in rail network improvements north of Wellington aims to provide capacity for growth in passenger and freight services and support increased frequency of Metlink and Capital Connection services.

Road to Zero: New Zealand's Road Safety Strategy 2020 – 2030



The Ministry of Transport published the Road to Zero strategy and plan in December 2019 targeting a reduction in the number of people being killed or seriously injured on roads. Road to Zero outlines an approach to improve road safety over a 10-year period to 2030 and the initial 3-year action plan.

Building on the previous Safer Journeys strategy 2010-2020, Road to Zero focuses on infrastructure improvements, speed management, vehicle safety, work-related road safety, road user choices and system management[60]. It introduces a target of a 40% reduction in death and serious injuries (from 2018 levels) by 2030.

Specific relevance for this DBC:

LNIRIM seeks to enable increased levels of mode shift for commuters. Mode shift towards an increased use of passenger rail aligns with the Road to Zero strategy because it leads to safer transport options through reduced traffic volumes on roads.

Keeping Cities Moving: A Plan for Mode Shift

Waka Kotahi published Keeping Cities Moving: A Plan for Mode Shift in September 2019 to address the causes of car dependency and balance the transport system. New Zealand's private vehicle usage has been increasing, with 83 per cent of total trip legs made by a car[61].

This plan's objective is to increase the wellbeing of New Zealand's cities by growing the share of travel by public transport, walking and cycling through three main ways[62]:

- Shaping urban form - encouraging good quality, compact, mixed-use urban development.
- Making shared and active modes more attractive - improving the quality, quantity and performance of public transport facilities and services, and walking and cycling facilities.
- Influencing travel demand and transport choices - changing behaviour through a mix of incentives and disincentives.

Specific relevance for this DBC:

LNIRIM aligns to the Keeping Cities Moving strategy as it aims to provide current and future commuters with access to social and economic opportunities through accessible, safe and sustainable public transport services.

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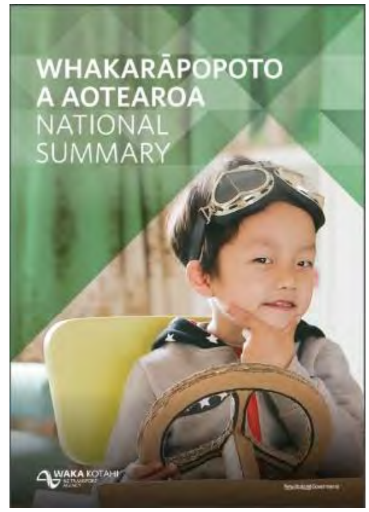
[60]Source: The Ministry of Transport. Road to Zero. Accessed on 15 March 2021 on: https://www.transport.govt.nz/area-of-interest/safety/road-to-zero/

[61] Source: Waka Kotahi. Keeping Cities Moving: A Plan for Mode Shift. Accessed on 15 March 2021 on: https://www.nzta.govt.nz/assets/resources/keeping-cities-moving/Keeping-cities-moving.pdf

[62] Source: Waka Kotahi. Keeping Cities Moving: A Plan for Mode Shift. Accessed on 15 March 2021 on: https://www.nzta.govt.nz/assets/resources/keeping-cities-moving/Keeping-cities-moving.pdf

Arataki Version 2



Arataki is Waka Kotahi's 10-year view of what is needed to deliver on the government's current priorities and long-term objectives for the land transport system. The national summary identifies the types of activities at a national 'system-wide' level and the step changes. Arataki V2 reflects initial findings on the impact of COVID-19 on the land transport system.

National responses:

- improve urban form – aligning and integrating transport and land use planning
- transform urban mobility – addressing the causes of car dependency and growing the share of travel by public transport, walking and cycling
- significantly reduce harms – no death or serious injury while travelling on the land transport system is acceptable
- tackle climate change – considering adaptation and mitigation of climate change impacts
- support regional development – supporting positive socio-economic outcomes

Specific relevance for this DBC:

LNIRIM directly supports Arataki Version 2 because it:

- *aligns with the future land use (intensification of developments around the Manawatū and Wairarapa rail corridors*
- *aims to enable mode shift by providing commuters with safe and convenient public transport alternatives to road travel, which will also enable a reduction in carbon emissions*
- *supports access to social, health and employment opportunities that are not available locally.*

2.3.2 Local government strategies, policies and plans

Wellington Regional Land Transport Plan 2021-2031

The Regional Land Transport Plan (RLTP) was developed as a collaboration between all councils in the Wellington Region, Waka Kotahi and KiwiRail. Published in February 2021, the RLTP sets the direction for the Wellington Region's transport network for the next 10-30 years. Its investment priority areas include:

- Public transport capacity - build capacity and reliability into the rail and public transport network to accommodate future demand.
- Travel choice - make walking, cycling and public transport a safe and attractive option.
- Strategic access - improve access to key regional destinations for people and freight.
- Safety - improve safety
- Resilience - build resilience into the region's transport network[63].

The RLTP aims to achieve three targets within the next 10 years:

- Carbon emission - 35 per cent reduction in transport-generated emissions.
- Safety - 40 per cent reduction in deaths and serious injuries on roads.
- Mode share - 40 per cent increase in active travel and public transport mode share.

Specific relevance for this DBC:

RLTP directly refers to the Manawatū and Wairarapa line fleet renewal and service increase. LNIRIM aligns with all Wellington RLTP's investment priorities and will contribute to meeting RLTP's targets. It aims to improve public transport capacity. LNIRIM aims to encourage mode shift to public transport by making it more attractive, which will support a reduction in carbon emissions, help reduce road congestion and improve associated safety.

Wellington Regional Public Transport Plan 2021-2031

GWRC through Metlink issued a new Wellington Regional Public Transport Plan (RPTP) in February 2021. RPTP provides a strategic direction for the planning and delivery of public transport in the Wellington region over a 10-year period from 2021 to 2031, with a particular focus on the first three years.

- Three strategic priorities[64]:
  - Mode shift – contribute to the RLTP's target on mode share by
    - providing a high quality, high capacity, high frequency core network
    - improving access to public transport
    - promoting behaviour change.
  - Decarbonisation – reduce emissions of the public transport fleet by

[63] Source: Wellington Regional Land Transport Plan 2021-2031. Accessed on 15 March 2021 on: https://haveyoursay.gw.govt.nz/rltp-2021

[64] Source: Wellington Regional Public Transport Plan 2021-2031. Accessed on 15 March 2021 on: https://haveyoursay.gw.govt.nz/public-transport-plan-2021

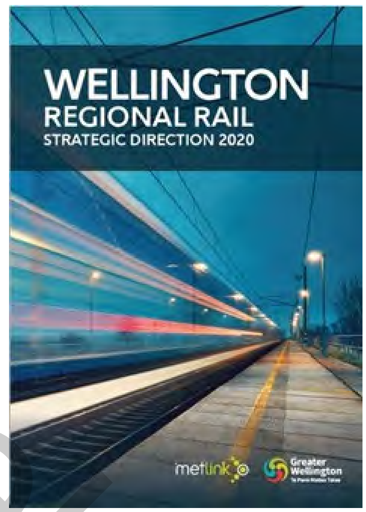
- pursuing environmentally and cost sustainable opportunities of lower carbon technologies
    - decarbonising the Metlink bus fleet by 2030
    - exploring ways to further decarbonise the Metlink rail and ferry fleet.
  - Improving customer experience by.
    - providing greater flexibility for journey planning and payment
    - improving the accessibility of public transport for all
    - improving information; improving shelter.

Specific relevance for this DBC:

LNIRIM aligns with the current RPTP's investment objectives and is expected to align with those of the new RPTP. LNIRIM aligns with the new RPTP's strategic priorities. Specifically, RPTP provides examples of future investments that include new rolling stock on the Wairarapa and Manawatū lines and other safety, resilience and access upgrades.

Wellington Regional Rail Strategic Direction 2020

The previous Wellington Regional Rail Plan was issued in 2009 and provided a long-term strategic direction for Wellington's regional rail network over a period from 2010 to 2035[65].



The new Regional Rail Plan's (RRP) 2020-2050 vision for a rail system is to provide "safe, customer-focused and efficient rail passenger and freight services and supporting infrastructure to drive the region's economic development and social wellbeing in an environmentally and socially sustainable and resilient manner"[66]. The outcomes that the new RRP aims to achieve are to:

- make accessing the rail network easier
- improve the waiting experience
- reduce carbon footprint
- allow bigger and more frequent trains
- improves safety of the network
- reduce the number of rail closures and improve ability to recover when closures occur.

Specific relevance for this DBC:

LNIRIM contributes to achieving the new RRP's desired outcomes, specifically, by improving access, capacity and frequency of services and enabling mode shift that will assist with improving safety and reducing emissions. The new RRP is the overarching programme that LNIRIM sits within, which is included in the RRP Strategic Direction document.

[65] Source: Wellington Regional Rail Plan 2010-2035. Accessed on 15 March 2021 on: http://www.gw.govt.nz/assets/council-reports/Report_PDFs/2014.56a1.pdf

[66] Source: Wellington Regional Rail Strategic Direction 2020. Page 8.

Horizons Regional Land Transport Plan 2021-2031

Horizons issued its new RLTP in February 2021 outlining its long-term vision and transport investment priorities. Its 30-year vision is to connect central New Zealand and support safe, accessible, and sustainable transport options. Horizons transport investment priorities for the next 10 years are[67]:

- Connectivity and access - enable efficient and safe movement of people and freight and improved access to opportunities
- Safety - improve the transport network to create a safe transport system for all users
- Better travel options - make active and public transport, and alternative freight modes safe, attractive and viable options
- Environment - reduce environmental impacts and carbon emissions from the transport system
- Resilience - build resilience into the transport network by strengthening priority transport lifelines.

Specific relevance for this DBC:

LNIRIM directly contributes to all five Horizons RLTP's investment objectives. Horizons RLTP recognises the importance of the Manawatū Line as an integral part of the transport network on the Palmerston North to Wellington corridor. The plan specifically outlines a significant local investment as part of RLTP to enable the continuation of the Manawatū Line services, including fleet replacement and increased service frequency[68]. This investment aims to improve access and transport choice for the communities between Wellington and Palmerston North.

Horizons Regional Public Transport Plan 2015-2025

Horizons RPTP sets out the public transport system that Horizons Regional Council, in partnership with local councils, proposes to fund and operate. The Horizons RPTP was last updated in 2015 when it set out a public transport strategy for a 10-year period from 2015 to 2025. Its investment objectives include[69]:

- a reliable, integrated, accessible and sustainable public transport
- an effective procurement system to deliver desired public transport services
- a safe and accessible network of supporting infrastructure
- increasing patronage.

A new 2021-2031 plan is currently being developed, following the release of the new Horizons RLTP[70].

Specific relevance for this DBC:

LNIRIM aligns with the current RPTP's investment objectives and is expected to align with those of the new RPTP.

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[67] Source: Horizons Regional Land Transport Plan 2021-2031. Accessed on 17 March 2021 on: https://www.horizons.govt.nz/HRC/media/Media/Draft-Regional-Land-Transport-Plan.pdf

[68] Source: Horizons Regional Land Transport Plan 2021-2031. Page 19. Accessed on 17 March 2021 on: https://www.horizons.govt.nz/HRC/media/Media/Draft-Regional-Land-Transport-Plan.pdf

[69] Source: Horizons Regional Public Transport Plan 2015 – 2025. Accessed on 15 March 2021 on: https://www.horizons.govt.nz/HRC/media/Media/Bus-Route-Timetable/REGIONAL-PUBLIC-TRANSPORT-PLAN.pdf

[70] Source: Horizons Regional Land Transport Plan 2021-2031. Accessed on 17 March 2021 on: https://www.horizons.govt.nz/HRC/media/Media/Draft-Regional-Land-Transport-Plan.pdf

Wellington Regional Mode Shift Plan 2020

Waka Kotahi published Wellington Regional Mode Shift Plan 2020 in September 2020, which it developed collaboratively with councils across the region and with KiwiRail. It supports the national mode shift plan Keeping Cities Moving developed by Waka Kotahi [71].

The plan outlines three key levers the region can use to increase the share of travel by public transport, walking and cycling:

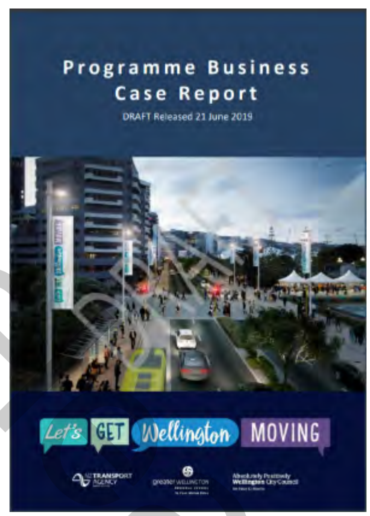
- shaping urban form
- making shared and active modes more attractive
- influencing travel demand and transport choice

These levers aim to integrate transport policies with land use change to achieve greater benefits from mode shift and emission reduction.

Specific relevance for this DBC:

- *The Mode Shift Plan's focus areas, relevant for this DBC, include:*
  - *increasing development density near rail stations*
  - *improving rail safety, capacity and resilience by upgrading rolling stock, infrastructure and services, and purchasing additional trains to address overcrowding, provide for future growth and enable higher service frequencies*
  - *promoting mode shift to public transport and active modes.*
- *LNIRIM aligns with Wellington Regional Mode Shift Plan and contributes to all three of its key levers.*

Let's Get Wellington Moving



LGWM is a program that provides a strategic direction through the Programme Business Case[72] and aims at improving and better integrating Wellington's transport networks. It is a joint initiative between Wellington City Council, GWRC and Waka Kotahi [73].

GPS 2021 makes explicit reference to supporting LGWM projects as a government commitment that has specific investment expectations. Mode shift is central to LGWM, targeting more people walking, cycling and using public transport. The programme objectives include liveability, access, reduced car reliance, safety and resilience.

Specific relevance for this DBC:

LNIRIM is consistent with and contributes to LGWM's objectives by enabling mode shift by providing safe and reliable access to social and economic opportunities to a growing population. While LGWM does not directly relate to the corridors in scope, the two projects are complimentary, as congestion charging and parking minimums will effect ridership growth on the wairarapa and Manawatū lines

[71] Source: Wellington Regional Mode Shift Plan 2020. Accessed on 17 March 2021 on: https://www.nzta.govt.nz/assets/resources/keeping-cities-moving/Wellington-regional-mode-shift-plans.pdf

[72] Source: Programme Business Case Report. DRAFT. 21 June 2019. Accessed on 17 March 2021 on: https://lgwm.nz/assets/Documents/Programme-Business-Case/LGWM-PBC-Report-21-June-2019-Draft.pdf

[73] Source: Australia & New Zealand Infrastructure Pipeline. Let's Get Wellington Moving programme. Accessed on 17 March 2021 on: https://infrastructurepipeline.org/project/lets-get-wellington-moving-programme/

2.4 Related projects

This section lists key other current or proposed projects that may impact on or share interdependencies with the LNIRIM project.

KiwiRail feasibility study of track electrification

Currently, both Wairarapa and Manawatū lines include parts of the Wellington electrified commuter network at 1,600V DC for the first stage of the journey:

- from Wellington to Upper Hutt (32 km) on the Wairarapa line, and
- from Wellington to Waikanae (55 km) on the Manawatū line.

Meanwhile, the sections beyond those points are currently not electrified.

The Manawatū and Kapiti lines operate over a portion of what is known as the NIMT between Wellington and Auckland. Several hundred km of the NIMT is electrified with 25kV AC north of Palmerston North.

KiwiRail is currently investigating the feasibility of completing the electrification of the North Island Main Trunk (NIMT) from Auckland to Wellington[74] (although with which system is unclear), outcomes of which can be a key dependency or constraint for LNIRIM. The benefits for electrification for freight and passenger rail need to be considered as a whole, particularly considering the national and global climate change objectives.

Specific relevance for this DBC:

LNIRIM's preferred solution will need to consider future electrification and possible options for flexibility in the propulsion systems to accommodate potential future outcomes.

KiwiRail freight Hub

On 2 July 2020 Regional Economic Development Minister announced the preferred site of the Regional Freight Hub near Palmerstone North[75]. KiwiRail is proposing to develop a new intermodal regional freight hub near Bunnythorpe and lodged a Notice of Requirement to designate land for its construction and operation, which will create additional jobs for the region[76].

Freight is an important pillar needed to unlock future economic opportunities as it is expected to increase by 55 per cent by 2042[77]. To achieve improved speed connectivity, capacity, and to reduce double handling[78], KiwiRail is proposing to grow the logistics industry in Manawatū and develop a new intermodal regional freight hub near Bunnythorpe in the proximity of Palmerston North and has lodged a Notice of Requirement to designate land for its construction and operation[79]. In addition to an increased capacity and reduces wear and tear of roads, freight carried by rail reduces carbon emissions by 66 per cent[80], which supports the government's priority to developing a low carbon transport system.

Specific relevance for this DBC:

In addition to the passenger rail transport, the Wairarapa and Manawatū Lines share rail track infrastructure with freight carried by KiwiRail. The LNIRIM options assessment process needs to consider impacts on freight efficiency. Further considerations may be required regarding a coordinated timetable for freight and passenger transportation.

The Horowhenua Business Park and other industrial and distribution centres

In September 2020 New Zealand government confirmed a $2.9 million investment in Horowhenua Business Park Infrastructure[81] near Levin. Connected to big cities, transport links, and a skilled labour pool, the

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[74] Source: GWRC. October 2020. Detailed Project Implementation Plan Lower North Island Rail Integrated Mobility

[75] Source: KiwiRail. Regional Freight Hub. Accessed on 12 March 2021 on: https://www.kiwirail.co.nz/what-we-do/projects/regional-freight-hub/

[76] Source: KiwiRail. Regional Freight Hub. Accessed on 14 March 2021 on: https://www.kiwirail.co.nz/what-we-do/projects/regional-freight-hub/

[77] Source: New Zealand Upgrade Programme – Transport. January 2020 | 20-011

[78] Source: KiwiRail. Intermodal Freight Hub Master Plan Summary. Accesses on 5 March 2021 on: https://www.kiwirail.co.nz/assets/Uploads/documents/Intermodal-Freight-Hub-Master-Plan-summary-WEB.pdf

[79] Source: KiwiRail. Regional Freight Hub. Accesses on 5 March 2021 on: https://www.kiwirail.co.nz/what-we-do/projects/regional-freight-hub/

[80] Source: New Zealand Upgrade Programme – Transport. January 2020 | 20-011

[81] Source: RNZ. 17 September 2020. Accessed on: https://www.rnz.co.nz/news/political/426279/labour-releases-list-of-5bn-in-lower-north-island-infrastructure-projects

Horowhenua Business Park aims to stimulate the local economy and become a facility of a national significance. The Horowhenua Business Park is spread over a 4.6-hectare site with the 10,000 square meter facility that will be protected by specialised lighting, temperature and humidity. It is anticipated to have security and protection from risks such as water damage, fire, earthquakes and pests. It is expected to generate jobs during the construction scheduled for completion in 2025 and in the long term with the creation of high-value jobs across IT and logistics.[82]

Additionally, Palmerston North's North-East Industrial zone growth and Marton Rail hub present future growth opportunities for the region.

Specific relevance for this DBC:

The business park and other industrial centres will likely present additional transport needs for both businesses and people in the area, making a more resilient transport network critical for benefit realisation and attraction of workforce.

The National Ticketing Solution

The National Ticketing Programme, known as Project NEXT from 2018, was first established in 2016 to facilitate with a coordinated approach to regional payment solutions for public transport services[83]. Benefits of the project include the ability of public transport customers to pay for their public transport using their mobile phone, credit or debit card, cash or a single nationally issued transit card. By making payment easier, the government aims to increase public transport usage and, therefore, reduce congestion and emissions from private motor vehicles[84].

Specific relevance for this DBC:

The timing of the roll out, transition and any benefit realisation in terms of additional public passengers' take up will influence the Greater Wellington's public transport. The National Ticketing Solution is expected to introduce full multi-modal public transport ticketing integration within the Wellington region and between Wellington and Horizons, which is expected to make public transport more attractive as an option, notably by making bus customers in Wellington and Manawatū connect easily with the LNIRIM services via bus and other PT options.

Regional road investments

In January 2020 the NZ Upgrade Programme announced a $1.35 billion investment in projects across the greater Wellington region[85], including:

- Ōtaki to North of Levin highway - a programme of works to improve the safety and resilience of the transport corridor[86], and
- SH58 safety improvements[87]

Additionally, major road investment projects including Transmission Gully[88] and Ōtaki to Peka[89] are nearing completion, with expected completion in late 2021. The Manawatū-Whanganui region is looking to progress the Palmerston North Integrated Transport Improvements project to assist in building the region's resilience and provide a safer, more effective connection between some of the region's key industrial areas and improve access and safety for pedestrians and cyclists.

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[82] Source: Horowhenua Developments Limited. Media Release. 11 December 2020. Accessed on: https://www.electra.co.nz/assets/Latest-News/HDL-BP-media-release.pdf

[83] Source: Waka Kotahi. Project Next – Ticketing Solutions Programme, 2019. Accessed on 22 March 2021 on: https://www.nzta.govt.nz/assets/About-us/docs/project-next-frequently-asked-questions-october-2019.pdf

[84] Source: Waka Kotahi. Project Next – Ticketing Solutions Programme, 2019. Accessed on 22 March 2021 on: https://www.nzta.govt.nz/assets/About-us/docs/project-next-frequently-asked-questions-october-2019.pdf

[85] Source: Waka Kotahi. Planning and investment. Accessed on 22 March 2021 on: https://www.nzta.govt.nz/planning-and-investment/national-land-transport-programme/2018-21-nltp/regional-summaries/wellington/wellington-2020-update/

[86] Source: Waka Kotahi. Ōtaki to North of Levin highway. Accessed on 22 March 2021 on: https://nzta.govt.nz/projects/wellington-northern-corridor/otaki-to-north-of-levin

[87] Source: Waka Kotahi. SH58 safety improvements. Accessed on 22 March 2021 on: https://www.nzta.govt.nz/projects/sh58-safety-improvements/

[88] Source: Waka Kotahi. Transmission Gully motorway. Accessed on 31 March 2021 on: https://www.nzta.govt.nz/projects/wellington-northern-corridor/transmission-gully-motorway/

[89] Source: Waka Kotahi. Peka to Ōtaki Expressway. Accessed on 31 March 2021 on: https://www.nzta.govt.nz/projects/wellington-northern-corridor/peka-peka-to-otaki-expressway/

Specific relevance for this DBC:

Similar to LNIRIM, the regional highway road upgrades and improvements aim to strengthen the transport corridor resilience. The benefit realisation of these projects relies on future assumptions on the road and rail usage. The demand projections for the LNIRIM project consider the decreases in potential demand resulting from currently funded road upgrade projects upon their completion. However, in the medium to long term the demand could increase, since Wellington is likely to remain a key destination for many trips and congestion could remain an issue on the Wellington motorway network.

2.5 The impacts of COVID-19

The coronavirus 2019 (COVID-19) pandemic has had wide-ranging impacts on New Zealand. In terms of the impact of the COVID-19 pandemic on population projections, population in the region is expected to grow almost 9 percent in the next 10 years, with an increasingly diverse and aged demographic. The region's population is expected to experience slowed growth in the near term (2021–23) due to the impacts of COVID-19, including reduced migration flows and economic activity in the region. Population growth will then likely recover to levels similar to those experienced in the region in recent years. Compared to 2020, the region's population is expected to grow approximately 9 percent by 2030 and 20 percent by 2043[90]. Population growth will not be evenly distributed across the region, with higher growth rates expected in Porirua, the Kāpiti Coast and Wairarapa. Hutt City and Wellington City will remain the largest residential centres in the region. It is likely that there will be an increased aged demographic across the region, particularly in the Kāpiti Coast and Wairarapa. Younger populations will continue to be centred in the cities, particularly in Porirua, Lower Hutt and Wellington City[91].

In terms of the impact on the transport sector, COVID-19 impacted the safety recommendations for taking the public transport, where passengers are recommended to maintain physical distancing from other passengers at terminals, stations and, where possible, on board of public transport[92]. The public transport patronage significantly decreased due to COVID-19 in the short term[93]. However, the analysis of the COVID-19 impacts on land transport in the Wellington region published by Waka Kotahi[94] indicates that given the relative resilience of the Wellington economy, no significant changes are expected in the nature, scale and location of transport demand over the medium to long-term. The ten-year outlook for transport demand remains largely unchanged[95]. It is explained by the prevalence of public sector employees and the Government's stimulus package likely requiring additional public and private sector administrative support, which places the Wellington regional economy comparatively well to recover. Additionally, an ongoing need for transport services will be driven by the need to improve access to employment and essential services for vulnerable communities to support COVID recovery[96]. It is important to note that there is an inherent level of uncertainty regarding any set of projections, which increases the further from the present day that the projection extends. Additionally, COVID-19 has raised the level of uncertainty surrounding our near-term projections. These figures should be considered an indicative guide for planning, rather than a specific outcome.

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90 Source: Regional Transport Committee 8 June 2021. Order paper - Approval of the Wellington Regional Land Transport Plan 2021

91 Source: Regional Transport Committee 8 June 2021. Order paper - Approval of the Wellington Regional Land Transport Plan 2021

92 Source: Waka Kotahi. Waka Kotahi services. Accessed on 31 March 2021 on: https://www.nzta.govt.nz/about-us/coronavirus-disease-covid-19-services-update/waka-kotahi-services/

93 Source: Australia Railway Association. Member briefing: the impact of COVID-19 on passenger rail in Australia & New Zealand. Accessed on 31 March 2021 on: https://ara.net.au/wp-content/uploads/ARA-member-briefing-The-impact-of-COVID-19-on-passenger-rail-in-Australia-and-New-Zealand-1.pdf

94 Source: Waka Kotahi. COVID-19 – implications for land transport in Wellington. Accessed on 31 March 2021 on: https://www.nzta.govt.nz/assets/planning-and-investment/arataki/docs/regional-summary-9-wellington-potential-impacts-of-covid-19.pdf

95 Source: Waka Kotahi. COVID-19 – implications for land transport in Wellington. Page 27. Accessed on 31 March 2021 on: https://www.nzta.govt.nz/assets/planning-and-investment/arataki/docs/regional-summary-9-wellington-potential-impacts-of-covid-19.pdf

96 Source: Waka Kotahi. COVID-19 – implications for land transport in Wellington. Page 27. Accessed on 31 March 2021 on: https://www.nzta.govt.nz/assets/planning-and-investment/arataki/docs/regional-summary-9-wellington-potential-impacts-of-covid-19.pdf

3 CHAPTER 3 – NEED FOR INVESTMENT

CHAPTER SUMMARY AND CONCLUSIONS:

- The Wairarapa and Manawatū lines serve as an essential and only regional public transport commuter alternative to highly utilised parallel roads connecting the regions to the economic centre of Wellington CBD and inner city. Without these services, increased private car use is likely to lead to significant infrastructure costs and restrict economic activity, while also increasing congestion, which can in turn reduce road safety, increase carbon emissions, and impact freight and commercial movements.
- The need for investment has been considered in the context of current and future service needs. These needs are driven by high projected population growth in the vicinity of the Wairarapa and Manawatū lines and desired future land use areas, which are anticipated to have higher density development and include improved access to bus and rail services to enable the economic growth.
- The overall problem requiring intervention is a growing inability to deliver critical regional passenger commuter transport services with the existing fleet and enable the validated growth in network demand on the Wairarapa and Manawatū Lines. This overarching problem is sub-divided into four problems:
  - The current fleet's age and condition
  - Unattractiveness of the public transport network for regional commuters
  - Inability to adequately contribute to decarbonisation goals
  - Operational inefficiency and lack of flexibility
- With a timely investment in LNIRIM, the government has an opportunity to contribute to achieving GPS 2021 and strengthen the overall long-term transport resilience within the Wairarapa and Manawatū corridors by reducing the car dependency and associated congestion while catering for the future transport demand.
- LNIRIM will deliver a range of benefits and outcomes directly contributing to national and regional plans. These benefits include inclusive access and improved mobility to unlock associated economic benefits; increased transport network resilience, safety and reliability; increased levels of mode shift to public transport and associated decongestion of the road network; and optimised operations and costs.

3.1 Purpose and overview of chapter

Developing a sound understanding of the service need involves studying the extent, scale, cause and effect of problems and opportunities confronting GWRC and Horizons within the subject areas. This analysis is critical to form a basis for assessing options to meet the service need and determine a preferred solution to address a defined problem.

The purpose of this chapter is to clearly identify and articulate the problems to be addressed by LNIRIM including supporting evidence, the benefits sought, and investment objectives. This chapter demonstrates the need for investment in the Wairarapa and Manawatū Lines and project urgency within the summary case for change.

This chapter builds on the IBC and its Investment Logic Map (ILM). This chapter reviews, confirms and captures changes that have occurred since the IBC, including the changes in strategic context, a higher emphasis on climate change mitigation and adaptation strategies, service need drivers (Chapter 2) and outcomes of the workshop held with GWRC in March 2021. Chapter 12 – Management considerations provides specific measurable KPIs and benefit realisation plan.

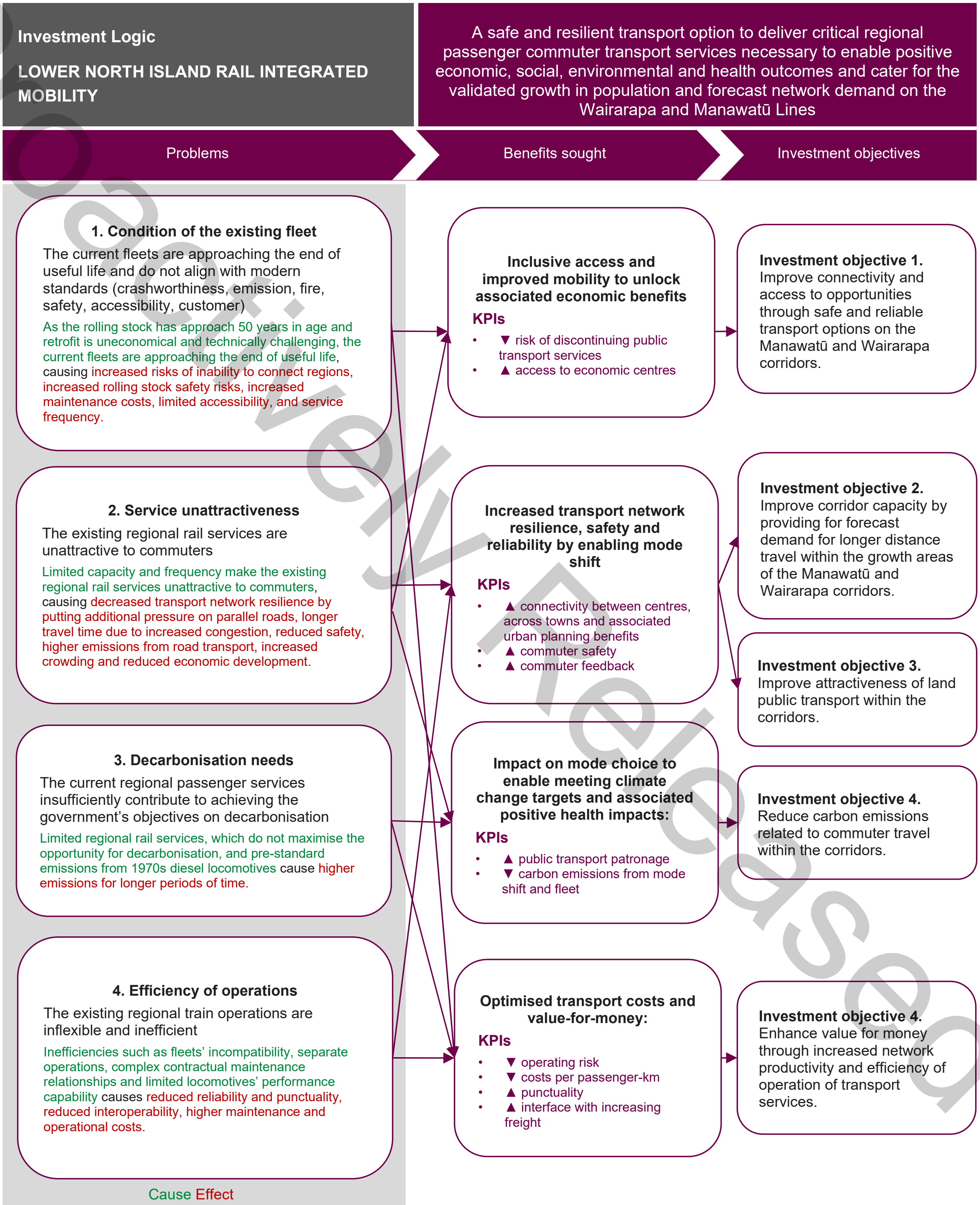
This chapter outlines:

- existing and future problems or constraints that would impede implementation of the strategic objectives
- investment objectives
- benefits sought from the project.

3.2 Investment logic

The investment logic mapped in Figure 3-1 resulted from stakeholder workshops carried out in March 2021.

Figure 3-1 LNIRIM investment logic



3.3 The case for change

The regional Wairarapa and Manawatū commuter rail services are a critical part of the broader regional transport network, providing a single commuter alternative to road travel. These services provide regional commuters with a critical and affordable access to key economic, social and health opportunities. The limited current service levels that can be provided by the existing carriage fleets are a significant barrier to achieving the objectives for transport set out in the Government Policy Statement and the strategic outcomes required by the Regional Land Transport Plans and Regional Public Transport Plans. Promoting and enabling public transport as the preferred mode for connecting regions with Wellington's CBD and surroundings, especially during peak hours, as well as connecting between centres and Palmerston North, will be essential to achieving these objectives. Additionally, they serve as an essential connecting link in case of any major weather and environmental events impacting the alternative roads. Without modern, safe and reliable rolling stock, the strategic objectives of mode shift, attractive public transport and decarbonisation would not be realised.

> With a timely investment, the government has a unique opportunity to enable mode shift to provide safe and resilient transport option and reduce carbon footprint while enabling economic development along the Wairarapa and Manawatū transport corridors

The Wairarapa and Manawatū lines' SE, SW and S type fleet are refurbished and modified 1970s ex-British Rail Mark 2 carriages that have reached the end of service life, which is being extended with further minor refurbishments, posing risks of unknown defects, inability to modern meet modern crashworthiness, emission, fire, safety, accessibility, ride quality, customer amenity standards and may result in inability to continue to provide services with the existing rolling stock. Operation and maintenance of these carriages currently involved complex contractual arrangements with multiple parties and is complicated by the use of diesel locomotives. Despite poor service frequency, poor reliability and punctuality, the Wairarapa Line's peak patronage is forecast to exceed the current seating and standing capacity by 2025, while the Manawatū Line's current seating capacity of the services by 2030, which indicates of significant untapped latent demand. Additionally, without an intervention, Manawatū line's low frequency, service reliability, and travel time will likely shift people off the train in the shorter term especially once Peka to Ōtaki Expressway and Transmission Gully are completed. Commuters are expected to shift to alternate modes when their individual experience approaches capacity, which is likely to be sooner that 2025 and 2030. Given the long lead time to plan for and deliver new rolling stock, forward planning is critical to manage the capacity demands. Without sufficient rolling stock capacity, the services would be significantly degraded and would potentially lead commuters to use an alternative road mode of transport, which will likely lead to further congestion and safety issues.

The Wairarapa and Manawatū public transport commuter services are critical to realise the government's aspirations of enabling future land use and economic growth while improving commuter safety, facilitating mode shift, contributing to decarbonisation, and improving freight connection. Strongly aligned with the government national and local government priorities, a timely investment in LNIRIM will improve the overall resilience of the transport network and enable economic development along the Wairarapa and Manawatū transport corridors. Without a timely intervention, the regions face an increasing risk of ceasing operating services due to inability to meet minimum safety requirements, resulting in inability to connect regions with social and economic opportunities. With an investment in LNIRIM, the government has a unique opportunity to positively influence the future of the regions and their communities.

3.4 Problem definition

The **overall problem** that GWRC and Horizons are aiming to solve though LNIRIM is a growing inability of the existing rail service to deliver critical regional passenger commuter transport services necessary to enable the validated growth in population and network demand forecast for the Wairarapa and Manawatū Lines.

The overarching problem can be further defined and articulated as follows:

#	Problem	Causes	Effects
1	The current fleets are approaching the end of useful life and do not align with modern standards (crashworthiness, emission, fire, safety, accessibility, customer)	• Most of the rolling stock has approached 50 years in age • Retrofit to meet modern standards is uneconomical and technically challenging	• Increased risk of inability to connect regions with social and economic opportunities once the rolling stock can no longer be considered safe to operate • Increased maintenance costs • Increased rolling stock safety risks • Limited accessibility • Service frequency constraints due to emissions in tunnels
2	The existing regional rail services are unattractive to commuters	• Services are close to capacity • Limited frequency makes the public transport option unattractive	• Decreased transport network resilience due to congestion pressures on parallel roads • Longer travel time • Reduced safety • Higher emissions from road transport • Increased crowding, limited potential for mode shift and untapped latent demand • Reduced economic development and limited potential to release affordable housing
3	The current regional passenger services insufficiently contribute to achieving the government's objectives on decarbonisation	• Higher emissions from road transport • Emissions from 1970s diesel locomotives	• Higher emissions for longer
4	The existing regional train operations are inflexible and inefficient	• Fleets' incompatibility • Separate operations • Complex operational and maintenance arrangements • Limited locomotive performance capability and fleet incompatibility	• Reduced reliability and punctuality • Reduced interoperability, higher maintenance and operational costs

The sections below further outline the primary causes and effects underpinning these problems and provide supporting evidence based on Asset Management Plans, technical reports, demand modelling, the previous IBC and other relevant sources.

3.4.1 Condition of the existing fleet

Problem: The current fleets are approaching the end of useful life and do not align with modern standards (crashworthiness, emission, fire, safety, accessibility, customer)

As the rolling stock has approach 50 years in age and retrofit is uneconomical and technically challenging, the current fleets are approaching the end of useful life, causing increased risks of inability to connect regions, increased rolling stock safety risks, increased maintenance costs, limited accessibility and service frequency.

This problem is driven by the following causes:

- **Most of the rolling stock has approached 50 years in age.** The Wairarapa Line's rolling stock fleet of SW and SE type carriages and the Manawatū Line's S type fleet are refurbished and modified 1970s ex-British Rail Mark 2 carriages that entered New Zealand service in 2008, 2010 and 1999, respectively, and have reached the end of service life, which is currently being extended through minor refurbishments.
  - The SW carriages were re-manufactured in 2007-2008, with a design life of 20 years. The SW carriages are showing its age: the exterior finish has degraded and bodysides show signs of corrosion, especially near window areas. The window double glazing and soft furnishings require replacement[97]. Minor refurbishment of the SWs to address these issues began in early 2020 and is scheduled to finish in January 2023 to enable them to remain operational until 2027-2028[98].
  - The SE carriages were re-furbished to enter New Zealand service in 2010, following which further work was carried out in 2013 to allow them to supplement the SWs. Minor refurbishment of the SE carriages began in mid-2020 and is expected to be completed in January 2023. This work will extend their service life to 2027-2028[99].
  - The S type carriages have been in continuous post-rebuild service in New Zealand for over 20 years since they were rebuilt in 1999. To temporarily enable Manawatū Line services continuation, the NZ Upgrade Programme includes $15 million to refurbish the line's S type carriages until new rolling stock is procured[100]. This places some urgency on an investment decision and subsequent implementation of the preferred option.
  - Both lines' fleet includes a single AG type luggage / generator van, dated from the late 1970s, that is used when required.
- **Retrofit to meet modern standards (crashworthiness, emission, fire, safety, accessibility, customer) is uneconomical and technically challenging**. It is uneconomical and technically impossible to retrofit the existing 50-year-old rolling stock with modern features, which are becoming expected in a rail carriage such as crashworthiness and accessibility standards.

  The retrofit is not technically feasible because it would likely require a complete rebuild of the car body structure making it more economical to build brand new carriages. The modern standards and expectations for passenger rail services have evolved over the past decades. A SE and SW rolling stock valuation performed in 2019 calculated an Optimised Replacement Cost (ORC)[101]. Then ORC was reduced by depreciation to calculate an Optimised Depreciated Replacement Costs (ODRC)[102] [103]. The estimates for SE and SW carriages resulted in $41.2 million for ORC and $7.7 million for ODRC as

[97] Source: GWRC. Draft Asset Management Plan. 2021

[98] Source: GWRC. Draft Asset Management Plan. 2021

[99] Source: GWRC. Draft Asset Management Plan. 2021

[100] Source: Waka Kotahi. New Zealand Upgrade Programme – Transport. Page 36. Accessed on 15 March 2021 on: https://www.nzta.govt.nz/assets/Roads-and-Rail/20-011/NZ-Upgrade-Programme-Transport.pdf

[101] Note: ORC is defined as the minimum cost of replacing or replicating the service potential embodies in an asset with its modern equivalent asset

[102] Note: ODRC recognises the value of assets considering current effective age, current and future utilisation, estimated total overall and remaining useful life, current condition, technical obsolescence, depreciation method and estimated residual value at the end of the asset's economic life

[103] Source : GWRC Rail Assets Division. Rolling Stock Asset Valuation for Financial Reporting Purposes. Prepared by Bayleys Valuations Limited 30 June 2019.

of 30 June 2019, meaning over 80% loss in value of existing SE and SW rolling stock, which reflects a high level of obsolescence and a high level of investment requirement. A similar situation is observed for S rolling stock. Therefore, the life of these carriages is not recommended to be extended beyond 2027-2028[104].

The effects of these problems include:

- **Increased risk of inability to connect regions with social and economic opportunities** once the rolling stock can no longer be considered safe to operate.

  An independent rolling stock asset valuation[105] prepared for GWRC for the period ending 30 June 2019 recorded the remaining useful life of three years for each of the SE and SW type carriages (in the period ending 30 June 2021). Even with continued rolling stock maintenance, the further ageing of the 50-year-old rolling stock means that fault events can become less predictable to a degree that it may not be possible to continue providing services with the existing rolling stock. Additionally, the aged rolling stock poses a risk of unknown structural defects due to potential initial manufacture or rebuild/refurbishment error or degradation in structural materials[106]. If the Wairarapa and Manawatū commuter services can no longer be provided, the only existing alternative would be travelling on parallel roads, which would cause further congestion on already highly utilised routes. Additionally, it will limit socially disadvantaged people who do not own a motor vehicle and rely on public transport to access critical social services and employment. Without a timely intervention, the region faces an increasing risk of ceasing operating services due to inability to meet minimum safety requirements, resulting in inability to connect regions and its people with social and economic opportunities.

  If the Wairarapa and Manawatū commuter rail services can no longer be provided, the access to key social and economic opportunities by the only road alternative may become unavailable in case of natural disasters and weather events. On the routes connecting Palmerston North and Wellington or Masterton and Wellington, some bridges and road sections will have high, significant or medium impacts, meaning reduced access by road. Meanwhile, rail transport is more resilient to land slips and weather events. For example, the Wairarapa line's direct route under the Remutaka Range via the 8.8 km Remutaka Tunnel provides a safer, more reliable and resilient alternative to parallel State Highway 2. The Highway crosses the range via a steep, winding and narrow route over a 555-metre summit[107]. This road has high traffic volumes at peak times and has a high crash risk[108], low average speed[109] and susceptibility to weather-related closure[110]. Therefore, the Wairarapa and Manawatū commuter services are essential for providing alternative access to key economic and social opportunities

- **Increased maintenance costs to counter decreased reliability.** The Minimum Vehicle Operating Standard (MVOS) details the extent of defects allowed and the duration these defects can remain unrepaired. If the vehicle does not meet this, it should be removed from service for repair. The ageing rolling stock requires increased maintenance to prevent and remedy faults. On the Manawatū line, during the Christmas period in late December 2020 structural issues discovered on S carriages were more significant than expected and led to unplanned maintenance for an emergency structural remediation work and reduction in services.

- **Increased rolling stock safety risks.** Although the rolling stock fleets have been rebuilt to varying degrees, as the rolling stock continues to age and the passenger safety of these vehicles are becoming

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104 Source: GWRC. Draft Asset Management Plan. 2021

105 Source: GWRC Rail Assets Division. Rolling Stock Asset Valuation for Financial Reporting Purposes. Prepared by Bayleys Valuations Limited 30 June 2019.

106 Source: GWRC. Draft Asset Management Plan. 2021

107 Source: Lower North Island Longer-distance Rolling Stock Business Case. Stantec. 2 December 2019

108 New Zealand Road Assessment Programme (KiwiRAP) collective and personal risk scores for this section of road varied between Medium High and High. Both are at the high end of the five-point risk scale. Source: KiwiRAP Taranaki, Manawatū-Whanganui and Wellington Regional results 2012. Accessed on 5 March 2021 on http://www.kiwirap.org.nz/pdf/Taranaki%20brochure.pdf

109 This section of State Highway 2, which had a nominal 100 km/h speed limit, had an average speed of 58 km/h. Source: The 2016 NZ Transport Agency SH2 Te Marua to Masterton Programme Business Case. Page 14. Accessed on 5 March 2021 on https://www.nzta.govt.nz/assets/About-us/docs/oia-2017/SH2-Te-Marua-to-Masterton-programme-business-case.pdf

110 State Highway 2 had 19 closures due to unplanned natural events (snow/ice, wind, slip). Each had an average duration of 36 hours, equating to an average of 5.7 days a year due to weather related events. Source: The 2016 NZ Transport Agency SH2 Te Marua to Masterton Programme Business Case. Page 19. Accessed on 5 March 2021 on https://www.nzta.govt.nz/assets/About-us/docs/oia-2017/SH2-Te-Marua-to-Masterton-programme-business-case.pdf

harder to assess against any modern safety standard. Crashworthiness design standards have improved significantly since the carriages were designed. While condition is maintained, the fleet will not perform as well as new rolling stock in an accident. The current carriages do not have modern crashworthiness features such as energy absorption crumple zones and anti-climb protection, meaning that currently in case of a crash one carriage can climb up and severely damage the other carriage. Additionally, a current diesel locomotive-hauled propulsion poses extra risks. A diesel operated train passing in the 8km long tunnel poses an increased risk of fire.

- **Limited accessibility**. Passenger accessibility on most of the fleet does not align with modern expectations for inclusive access. There are only four accessible carriages in Wairarapa line's fleet, with three being used every peak. On Manawatū line, currently the wheelchair ramp is only in the AG type luggage / generator van. Additionally, the height of the carriages and the platform interface make the services difficult to use not only for commuters travelling with wheelchairs, but also to the ones with low vision or even travelling with bicycles if they combine publish transport with active mode.
- **Service frequency constraints due to emissions in tunnels and air quality in carriages**. Currently, a change in regulations of acceptable levels of gases in tunnels requires 1 hour between freight and passenger train. However, a modern passenger rolling stock that is better sealed, or a new zero emission rail passenger service, would allow for a shorter time gap and increase the train passage capacity on the rail corridors. Considering the expected increase in freight and the government's strategic objective to facilitate mode shift to public transport, discussed in Chapter 2, it is important to consider the interface between passenger services and freight on shared tracks of the Manawatū and Wairarapa lines.

3.4.2 Service unattractiveness

Problem: The existing regional rail services are unattractive to commuters

Limited capacity and frequency make the existing regional rail services unattractive to commuters, causing decreased transport network resilience by putting additional pressure on parallel roads, longer travel time due to increased congestion, reduced safety, higher emissions from road transport, increased crowding and reduced economic development.

This problem is driven by the following causes:

- **Services are close to capacity**

  Despite a relatively unattractive service with low frequency, poor reliability and punctuality, services are expected to experience capacity issues in the coming years, indicating a significant level of untapped commuter demand. Such untapped demand can be addressed if a more attractive and reliable service with sufficient frequency and capacity is provided.

  Driven by sub-regional population projections and future land use patterns discussed in Chapter 2, the services of the popular with commuters Wairarapa and Manawatū lines are expected to soon reach their capacity. The Wairarapa Line's peak patronage is projected to exceed the current seating and standing capacity by 2025, while the Manawatū Line's current seating capacity of the services by 2030. Commuters are expected to shift to alternate modes when their individual experience approaches capacity, which is likely to be sooner that 2025 and 2030. Given the long lead time to plan for and deliver new rolling stock of about five-six years, forward planning is critical to manage the capacity demands.

  The historical data on patronage demand shows that:

  - Patronage on the Wairarapa Line has grown substantially over the last decade from circa 660,000 passengers in 2009 to circa 780,000 in 2019, an increase of 18% over that period, with a more significant peak period patronage growth, which increased from circa 485,000 to circa 637,000 by 32% over the same period.

– The Manawatū Line's historical patronage experienced turbulence from 2011 to 2015 likely caused by the extension of services and subsequent Capital Connection fare increases[111]. From 2016 to 2019, the patronage grew by an average of 3.3% per year. Utilisation of the Manawatū lines does not consider unsatisfied or latent demand, which would have been attracted by greater service availability.

- Modelling for the projected patronage demand[112] shows that:
  - The Wairarapa Line's projected patronage demand will experience an average annual growth rate of around 1.8-2.5% a year for the lower and upper bound scenarios of peak demand growth for the 2021-2040 period. The growth is projected to exceed the current seating and standing capacity of the peak services by 2025.
  - The Manawatū Line's projected patronage demand will grow by around 0.9-2.2% on average per year for the lower and upper bound scenarios from 2021 to 2040. The growth is expected to meet and then plateau at the current seating capacity of the services by 2030 with people expected to shift to alternate modes when their individual experience approaches capacity, which is likely to be sooner.

  The modelling deals with the expectations of patronage demand assuming no significant service changes or amendments to rolling stock type, while considering funded improvements to alternatives such as highway upgrades.
- **Limited frequency makes the public transport option unattractive.** Even though the Wairarapa and Manawatū services have been popular with commuters, given the limited frequency of services, especially on Manawatū line that runs a single peak weekday service each way, the existing patronage does not include latent customers who would have used public transport if it was available more frequently. Service frequency is a core determinant in travel behaviour and influences the land use and mode shift.

The effects of these problems include:

- **Decreased transport network resilience and additional pressure on parallel roads.** Current limited availability and attractiveness of the Wairarapa and Manawatū services impedes a mode shift to rail and reduces the overall transport network resilience. That, in turn, will lead to the following effects:
  - **Longer travel time due to increased congestion** of already busy State Highway 1, State Highway 2 and State Highway 57. Figure 3-2 shows the One Network Road Classification, which divides New Zealand's roads into categories based on how busy they are, whether they connect to important destinations, or are the only route available. Figure 3-3 shows the location of each individual recorded crash by severity level (serious injury and fatal). State Highway 1 is classified as national high-volume road, meaning it makes the largest contribution to the social and economic wellbeing by connecting major population centres and have high volumes of heavy commercial vehicles or general traffic[113]. The increased congestion will lead to longer travel time, including by road public transport options, for people and goods, limiting economic opportunities.
  - **Reduced safety.** As Figure 3-3 shows, State Highway 1 has experienced a large number of fatal and serious crashes. A similar situation is apparent on State Highway 2 and State Highway 57. The GWRC and Manawatū-Whanganui regions recorded 947 fatal and 6,221 serious crashes from 2000 to 2020[114]. While road upgrades are planned or underway, mode shift to public transport is needed to meet the government Road to Zero safety strategy. Therefore, unattractiveness of the current regional rail services will put more pressure on the whole transport system potentially leading to an increase in the number of fatal and serious crashes.

[111] Source: Radio New Zealand's official website. Train fare increase. Published on 15 April 2013. Accessed on 31 March 2021 on: https://www.rnz.co.nz/news/national/132835/train-fare-increase

[112] The modelling is based on autoregressive integrated moving average (ARIMA) that projects future monthly patronage based on historical seasonality and overall trends.

[113] Source: Waka Kotahi. The One Network Road Classification (ONRC). Accessed on 9 April 2021 on: https://www.nzta.govt.nz/assets/Road-Efficiency-Group/docs/onrc-right-road-right-value-right-time-combined-poster.pdf

[114] Source: Waka Kotahi. Crash Analysis (CAS) data. Accessed on 9 April 2021 on: https://opendata-nzta.opendata.arcgis.com/datasets/crash-analysis-system-cas-data-1?geometry=-172.524%2C-60.014%2C161.988%2C-13.825

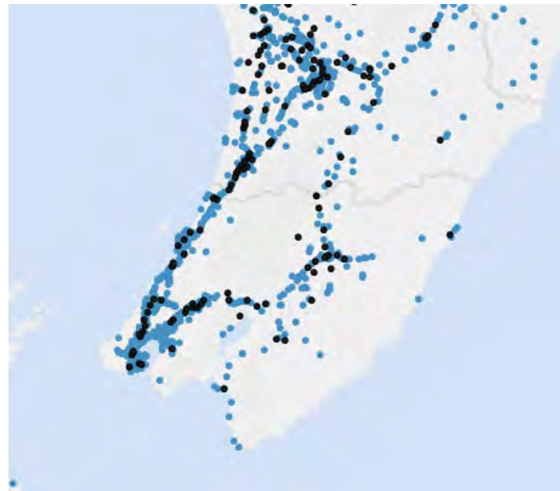
– **Higher emissions from road transport.** Limited commuter public transport frequency and attractiveness and resulting limitations on mode shift will hinder the government's objectives on decarbonisation of the transport sector discussed in Section 3.4.3.

Figure 3-2 Road classification

Legend (State Highway One Network Road Classification):
- high volume
- national
- regional
- primary collector
- arterial
- unknown

Source: Waka Kotahi. One Network Road Classification. Accessed on 8 April 2021 on https://nzta.maps.arcgis.com/

Figure 3-3 Crash Analysis System map



Legend:
- fatal crash
- serious crash

Source: Waka Kotahi. Arataki CAS Heat Map Experience. Accessed on 8 April 2021 on https://nzta.maps.arcgis.com/

- **Increased crowding, limited potential for mode shift and untapped latent demand**. As fleets reach their capacity with the growing population, services will increasingly experience crowding. Given the regional nature of the line and the single peak period daily service on Manawatū line and a significant projected demand growth for the Wairarapa line's peak services, customers are likely to be more sensitive to crowding and the maximum seating capacity of the services. Once crowding exceeds commuters' comfort levels, they will likely shift to alternative modes. However, as the road congestion and resulting travel time increases to a point of discomfort, some commuters will reach a point of switching to rail services, causing additional crowding. Addressing existing negative perceptions of public transport, such as limited frequency of services and overcrowding, will assist with the realisation of the national and local government goals set out in Chapter 2, including 40 per cent increase in active travel and public transport mode share, and will also help addressing latent demand. Horizons recent consultation on rail within the RLTP highlighted the greatest demand was for increased frequency and service both north and south bound[115].
- **Reduced economic development and limited potential to release affordable housing**. As outlined in Chapter 2, GWRC and Horizons consider combined land use and transport planning essential to foster the economic growth of the regions. The growth in population and multi-story development intensification are expected to be in the vicinity of the Manawatū and Wairarapa rail corridors. The success of these plans is predicated by available, reliable, safe and attractive rail transport. A lack of such passenger rail transport services on the Wairarapa and Manawatū transport corridors is likely to limit the potential for achieving the planned land use and release of affordable housing. A timely response to the immediate priority of shaping integrated land use-transport outcomes is critical to realise the region's future economic potential.

[115] Source: provided by Horizons

3.4.3 Decarbonisation needs

Problem: The current regional passenger services insufficiently contribute to achieving the government's objectives on decarbonisation

Limited regional rail services, which do not maximise the opportunity for decarbonisation, and pre-standard emissions from 1970s diesel locomotives cause higher emissions for longer periods of time.

This problem is driven by the following causes:

- **Car travel to work records the highest mode share, contributing to higher greenhouse gas emissions.**

  Overall, transport represents circa 21.1% of total New Zealand greenhouse gas emissions and is the second largest contributor to the total emissions[116].

  Car travel to work as a driver or a passenger represents the highest mode share percentage overall in New Zealand (94%) as well as in the Wellington (90%) and Manawatū-Wanganui (96%) regions, as shown in Table 3-1.

Table 3-1 Household Travel Survey: regional results (3-year moving average)[117]

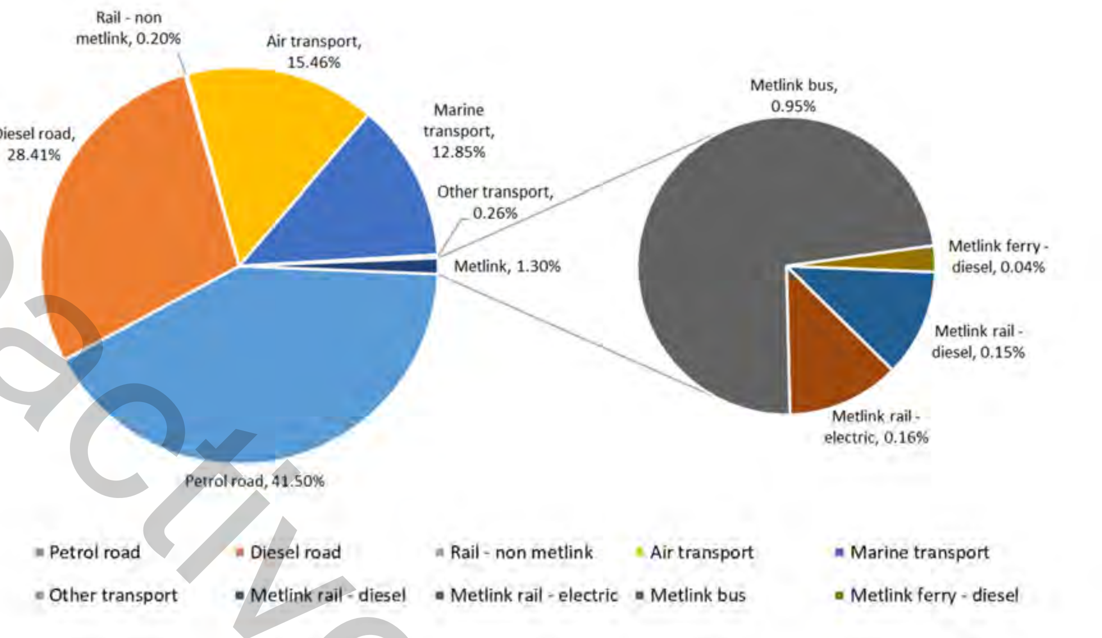
Measure / Mode of travel	New Zealand			Wellington			Manawatū-Wanganui		
	Mode's share of total km (%)	Mode's share of total hours (%)	Mode's share of trip legs (%)	Mode's share of total km (%)	Mode's share of total hours (%)	Mode's share of trip legs (%)	Mode's share of total km (%)	Mode's share of total hours (%)	Mode's share of trip legs (%)
Car/van driver	60	52	53	57	46	48	64	56	57
Car/van passenger	34	27	26	33	24	23	32	27	27
Pedestrian	2	13	17	2	16	23	1	11	13
Public transport (bus/train/ferry)	3	4	3	7	7	4	1	2	2
Cyclist	1	2	1	1	2	1	1	2	1
Motorcyclist	0	0	0	0	0	0	0	0	0
Other household travel	..	2	1	..	3	1	..	1	1
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Figure 3-4 shows that 70% of transport greenhouse gas emissions in the Greater Wellington region are generated by road transport. Mode shift to public transport is needed to contribute to achieving the government's commitment of net zero emissions by 2050 and transport sector decarbonisation. LNIRIM aims to contribute to decarbonisation of regional transport networks by achieving mode shift from road to rail and by investigating potential low carbon service options.

[116] Source: New Zealand's Greenhouse Gas Inventory 1990-2018, published April 2020

[117] Source: Stats.NZ. Dataset: New Zealand Household Travel Survey: Regional results (3-year moving average) for the period July 2011 - June 2014 http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE7432

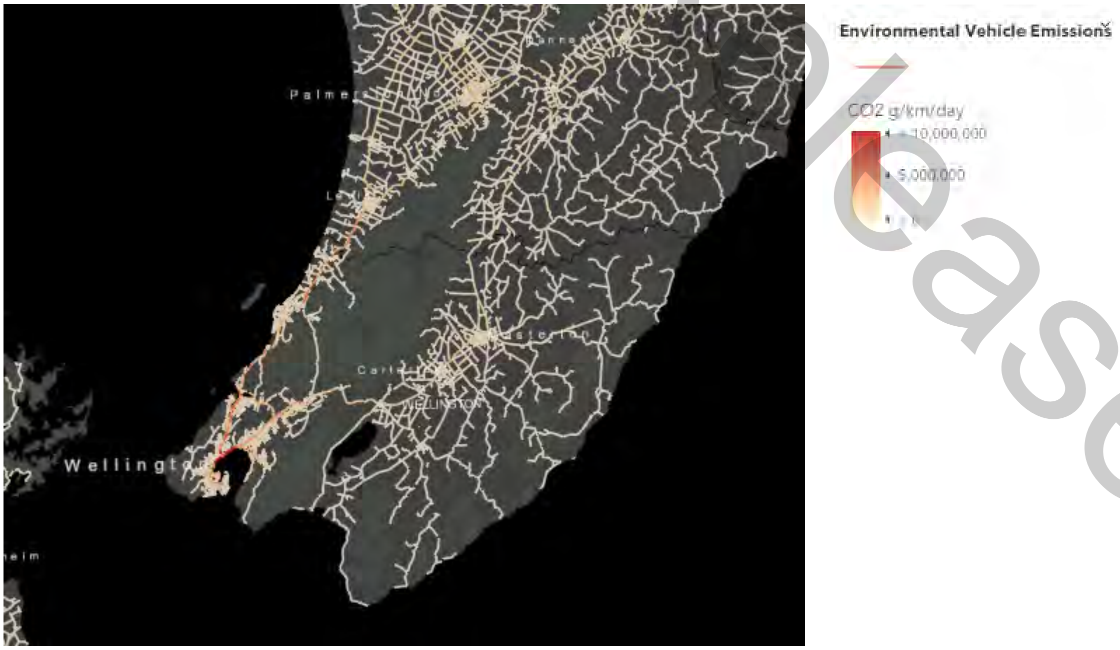
Figure 3-4 Greater Wellington transport greenhouse gas emissions



Source: AECOM. 2020. Wellington Region Greenhouse Gas Inventory

Figure 3-5 shows CO_2 vehicle emissions in the Greater Wellington and Manawatū-Whanganui regions in total grams per kilometre per day, with higher emissions on Highway 1, 2 and 57, which are highly utilised alternative roads to the Wairarapa and Manawatū rail lines. As discussed in 3.4.2, public transport unattractiveness on the Wairarapa and Manawatū transport corridors is likely to increase mode share of private vehicles, which is likely to lead to further increased CO2 emissions. In contrast, an attractive and reliable public transport alternative on these corridors is a critical enabler to realise the government's commitments on climate change.

Figure 3-5 CO_2 vehicle emissions total grams per kilometre per day



Source: Waka Kotahi. CO_2 vehicle emissions. Accessed on 15 April 2021 on https://nzta.maps.arcgis.com/

- **Emissions from 1970s diesel locomotives**. As discussed in Chapter 1, to haul the carriages on Wairarapa and Manawatū lines, KiwiRail provides 1970s DFB EMD diesel locomotives on a hook and tow arrangement. The existing diesel locomotives used throughout the entire partially electrified routes on the Wairarapa and Manawatū rail lines pre-date any modern emissions standards.

  Given the rising concern for environmental sustainability, some manufacturers have removed diesel engine vehicles from their portfolios. Additionally, the introduction of the mandatory Euro Stage V emissions standards this year (2021) means that any new rolling stock will need to utilise compliant engines. Respondents to the public consultation on the draft Wellington Regional Public Transport Plan also expressed general support for the vision to decarbonise the Metlink fleet. Those who agreed with the strategic priority frequently wanted to see this initiative happen sooner than the 2030 deadline[118]. Therefore, the government is presented with a timely opportunity to replace the solely locomotive-hauled fleet on both lines with new and sustainable rolling stock, which can utilise the existing overhead line and then continue off-wire for the remainder of the journey.

The effects of these problems include:

- **Higher emissions for longer**. Currently, the Manawatū and Wairarapa lines provide the only commuter public transport alternative to road travel. The services' limited projected capacity, unattractiveness and a growing inability to provide reliable public transport services will hinder mode shift and result in potential delays in government achievement of policy objectives on climate change, described in detail in Chapter 2.

3.4.4 Efficiency of operations

Problem: The existing regional train operations are inflexible and inefficient

Inefficiencies such as fleets' incompatibility, separate operations, complex contractual maintenance relationships and limited locomotives' performance capability causes reduced reliability and punctuality, reduced interoperability, higher maintenance and operational costs and service frequency constraints due operational requirements.

This problem is driven by the following causes:

- **Fleets' incompatibility**. Even though both Wairarapa and Manawatū lines' fleets were rebuilt from the same 1970s ex-British Rail carriages, the SW/SE and S fleets are not compatible with each other. This incompatibility issue limits any interchangeability of fleet across the lines that could improve efficiency of operation and maintenance.
- **Separate operations**. As discussed in Chapter 1, the Wairarapa and Manawatū lines are run as separate operations involving multiple parties. The Wairarapa line is operated by Transdev under contract to Metlink (GWRC) using GWRC-owned rolling stock, while the Manawatū Line is operated by KiwiRail using KiwiRail-owned rolling stock. This arrangement reflects past differences between the two operations, where the Wairarapa Line had both a commuter and access focus with all-day service levels, and was subsidised accordingly, while the Capital Connection was run as commercial (unsubsidised) peak-only commuter service on the Manawatū Line[119].
- **Complex contractual maintenance relationships**. Maintenance is further complicated by a complex set of contractual relationships. Transdev subcontracts carriage maintenance to Hyundai Rotem and uses the KiwiRail-owned Wellington Carriage Depot through an access agreement as the location for this maintenance. A 2018 report by SNC-Lavalin[120] notes that maintenance of the Wairarapa fleet is highly sensitive to the ongoing shared use of this depot, which has an inefficient design and is also used by KiwiRail for carriage maintenance. Maintenance is significantly constrained, because Hyundai Rotem access to the depot is limited to a four-hour window on weekdays between the peaks and due to the requirement to not work on trains while vehicle movements are occurring post morning peak, and pre-evening peak.

[118] Source: Provided by GWRC

[119] Source: Lower North Island Longer-distance Rolling Stock Business Case. Stantec. 2 December 2019

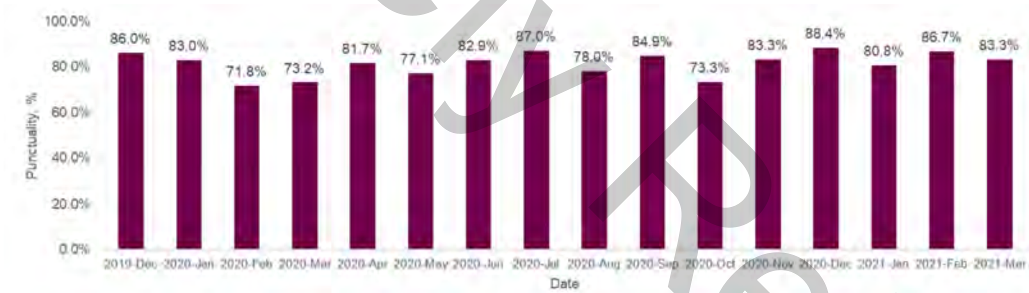
[120] Source: Investigation of Wairarapa Line Rail Services by SNC-Lavalin Rail & Transit NZ Ltd for GWRC.

- **Limited locomotives' performance capability**. The locomotive also needs to be decoupled, turned, and re-coupled to the train after each trip requiring at least 30 minutes at each terminus. This incurs high operating staff costs and slows the equipment cycle time leading to lower utilisation and less platform and service capacity[121]. Locomotive-hauled trains are also very operationally limiting. This process is complex, requires several steps and the involvement of several contractual parties, and differs at each terminus as described in the SNC-Lavalin report. It is considerable constraint in Wellington, where there is conflict with other services that limits the efficient operation of all services at peak times, and a barrier to frequency enhancements that might otherwise help to address capacity issues. The locomotive turning requirement also necessitates that trains that run for part of a line's length must have two locomotives to operate (either double-headed or at each end of the train), with consequent cost impacts[122].

The effects of these problems include:

- **Reduced reliability and punctuality.** Incompatible fleet and inefficient maintenance arrangements mean that some rolling stock would need to be taken out of service without due replacements, should any events lead to unplanned maintenance. Additionally, the overall journey time and service frequency of the service are constrained by the type of rolling stock used and the condition of the network. Waka Kotahi funded Track Infrastructure Catch Up Renewal programme is addressing the condition issues. NZUP Investment removing network constraints and safety improvements to enable increased service frequency that was proposed in the IBC. While the network conditions are being resolved, the rolling stock issue remains unaddressed. The locomotive hauled carriage operating model is dated and, as a result, journey times are sub-optimal. It has much lower acceleration and de-acceleration profiles in comparison to multiple unit trains like the Matangi fleet. Additionally, the actual journey time varied from the timetable. For example, Figure 3-6 shows that between 11.6% and 28.2% of services on the Wairarapa line ran late[123] in the period over 16 months from December 2019 to March 2021. This leads to reduced customer experience.

Figure 3-6 Monthly punctuality on Wairarapa from December 2019 to March 2021



- **Reduced interoperability, higher maintenance and operational costs**. As the fleet is not compatible with each other, interoperability is not possible, which constraints any potential opportunities for economies of scale. Additionally, the existing maintenance arrangement is inflexible and inefficient. There is no ability to manage operations between two lines, such as to minimise Wellington Station dwell times or match train capacity to demand. Nor is there the ability to manage rolling stock fleet allocation and maintenance in an effective way, with each fleet requiring its own maintenance arrangements and inventory. Both operations therefore carry a degree of overhead that would be reduced or eliminated if run as a single operation with inter-operability between the lines. Existing services on both lines are locomotive hauled through hook and tow arrangements with KiwiRail, which offers some locomotive fleet management efficiencies. However, locomotives are expensive to run, and the hook and tow cost is a sizeable proportion of the cost of running services on both lines. The marginal cost of an additional train, such as to address capacity issues, is consequently also high. Passenger locomotives are required to have special safety features, such as fire-suppression equipment for those that operate services through the Remutaka Tunnel. This limits the pool of locomotives that can be used on services and requires that additional so-equipped locomotives must be

[121] Source: GWRC. Draft Asset Management Plan. 2021

[122] Source: Lower North Island Longer-distance Rolling Stock Business Case. Stantec. 2 December 2019

[123] The punctuality assumes that if a train is late by more than 5 minutes at a timing point, it counts as 1 punctuality KPI failure. The timing points are Masterton, Featherston, Upper Hutt, Waterloo and Wellington stations.

held as spares to cover maintenance and provide redundancy to cover failures. This significantly increases fleet requirements and consequently cost[124].

3.5 Investment objectives

LNIRIM aims to resolve the overall problem of a growing inability of the existing rail service to deliver critical regional passenger commuter transport services necessary to enable the validated growth in population and network demand forecast for the Wairarapa and Manawatū Lines. Considering the need to address the overall problem and its sub-problems discussed in 3.4, their causes and effects, the proposed investment in LNIRIM has a strong alignment with and directly contributes to the broader government priorities reflected in the national and local government plans (Chapter 2).

LNIRIM's investments objectives are, therefore, to:

4. **Improve connectivity and access to opportunities** through safe and reliable transport options on the Manawatū and Wairarapa corridors.
5. **Improve corridor capacity** by providing for forecast demand for longer distance travel within the growth areas of the Manawatū and Wairarapa corridors of lower North Island.
6. **Improve attractiveness** of public transport within the corridors.
7. **Reduce carbon emissions** related to commuter travel within the corridors.
8. **Increase** network productivity and efficiency of operation of transport services.

Investment objectives connection to the problems, benefits and alignment of benefits and outcomes with Transport Outcomes Framework and GPS 2021 is summarised in Table 3-2.

3.6 Benefits sought and potential measures

The benefits sought were developed consistently with Waka Kotahi's Benefits Framework[125], which aligns with and contribute to the Ministry of Transport's Transport Outcomes Framework (TOF) and GPS 2021 (Table 3-2) as well as other national and local government strategies and plans summarised in Chapter 2.

Aligned with current national and regional policies and plans, LNIRIM aims to improve regional rail service levels to make them more attractive to commuters, improve connectivity, meet modern standards and improve operational efficiencies, while also meeting the policy expectations on decarbonisation. Service levels relate to quality, quantity, reliability, responsiveness, environmental acceptability and cost"[126]. These benefits are quantified and supported by specific measurable KPIs and benefit realisation plan in Chapter 12 – Management considerations.

Benefit sought: Inclusive access and improved mobility to unlock associated economic benefits

Description and potential measures:

- Improved access to economic centres

Investment in LNIRIM will maintain connectivity of the Greater Wellington and Manawatū-Whanganui regions with economic, social and health centres by public transport mode into the future. The longer-distance rail passenger services fulfil a critical regional connectivity role, providing residents of predominantly rural areas of the Greater Wellington and Manawatū-Whanganui regions with affordable access to many employments, educational and other opportunities and services that are not available locally. Additionally, it will enable a viable alternative to high-risk and high-impact road routes, susceptible to potential adverse environmental and weather events. A viable alternative access to road is needed to manage road congestion and associated travel time to provide equitable access, realise economic and freight opportunities. This benefit strongly aligns with TOF's resilience and security, inclusive access, economic prosperity and GPS 2021's

[124] Source: Lower North Island Longer-distance Rolling Stock Business Case. Stantec. 2 December 2019

[125] Source: Waka Kotahi. Benefits Framework. A technical paper prepared for the Investment Decision-Making Framework Review 2020. Accessed on 12 April 2021 on: https://www.nzta.govt.nz/assets/planning-and-investment/docs/benefits-framework-june-2020.pdf

[126] Source : http://www.lgam.info/level-of-service

better travel options objectives and improved freight connections. Additionally, it strongly contributes to New Zealand Rail Plan by supporting growth in New Zealand largest cities.

- Reduced risk of discontinuing public transport services due to inability to safely run the 1970s rolling stock

LNIRIM will help improve the public transport safety by meeting modern crashworthiness standards, increasing reliability of services and reducing the cost and need for unplanned maintenance. LNIRIM aims to deliver accessible critical commuter passenger services to enable regional and economically disadvantaged communities to access to social, health and economic opportunities not available locally. This benefit strongly aligns with TOF's resilience and security, healthy and safe people and GPS 2021's safety objectives. It also strongly contributes to RLTPs.

Benefit sought: Increased transport network resilience, safety and reliability by enabling mode shift

Description and potential measures :

- Increased connectivity between centres, across towns and associated urban planning benefits

The regional rail services offer transport network resilience benefits by providing a modal and route alternative to the road network. This is particularly critical on the Wairarapa Line, where the services frequently fulfil this role when the parallel State Highway 2 is closed, whether due to weather or crash-related incidents. Similarly, there are significant sections of State Highway 1 where there is no alternative. Additionally, an investment in LNIRIM will strengthen the transport network capacity and attractiveness on the Wairarapa and Manawatū lines, particularly to cater for the significant projected demand driven by population growth and desired land use. This will improve liveability and quality of life in these areas and help drive local economic activity and growth. Particularly, it will contribute to realisation of economic regional development plans such as Wellington Regional Growth Framework and Accelerate 25, described in Chapter 2. This benefit strongly contributes to TOF's resilience and security and economic prosperity and GPS 2021's better travel options objectives and improved freight connections. It also strongly contributes to RLTPs. The impact of any investment will be able to be measured through changes in service frequency, public transport patronage/boardings over time and car travel time savings from reduced congestion.

- Improved commuter safety

By improving public transport availability and attractiveness, an investment in LNIRIM will contribute to reducing road congestion and collective risk measured by annual fatal and serious injury crashes per kilometre. This benefit strongly contributes to TOF's healthy and safe people and GPS 2021's safety objectives. Additionally, it contributes to Road to Zero by improving safety through mode shift to public transport and reduced traffic volumes on roads.

Benefit sought: Impact on mode choice to enable meeting climate change targets and associated positive health impacts from reduced emissions

Description and potential measures :

- Increased public transport patronage

Increased attractiveness of the Wairarapa and Manawatū lines will lead to increased public transport patronage. The impact of any investment will be able to be measured through changes in service frequency, seat kilometres (seat km) and rail patronage over time. Patronage is a fundamental measure of response to any public transport investment, particularly when assessed over the medium to long term. This benefit strongly contributes to TOF's inclusive access and environmental sustainability and GPS 2021's better travel options and climate change. Additionally, this benefit contributes to New Zealand Rail Plan, Keeping Cities Moving, Wellington Regional Mode Shift Plan and Let's Get Wellington Moving. It also strongly contributes to RLTPs.

- Reduced carbon emissions from mode shift to rail

An investment in LNIRIM will contribute to decarbonisation of regional transport networks by achieving mode shift from road to rail. Viable and attractive public transport alternative on the Wairarapa and Manawatū transport corridors is a critical enabler to realise the government's commitments on climate change and help reduce congestion and associated CO_2 emissions, which will also likely lead to positive health impacts. This benefit strongly contributes to TOF's environmental sustainability and GPS 2021's climate change objectives. It also aligns with Climate Change Commission 2021 Advice and Wellington Regional Mode Shift Plan.

- Reduced carbon emissions of fleet

Investigating potential low carbon service options will align with the government's commitment on climate change, will assist with meeting community expectations on decarbonisation of fleet and reduce potential reputation risks. This benefit aligns with TOF's environmental sustainability and GPS 2021's climate change objectives.

Benefit sought: Optimised transport costs and value-for-money

Description and potential measures :

- Reduced operating risk and whole-of-life costs

The longer-distance rail rolling stock fleet has approached the end of its service life, which is being extended with minor refurbishments. The 1970s-design fleet is worn, it is neither able to meet modern crashworthiness, emission, fire, safety, accessibility and customer standards, nor provide sufficient capacity to meet demand. Complex contractual arrangements also contribute to increased operating risk of 50-year-old fleet. Operating risk could be reduced if operation and maintenance arrangements are streamlined and if the fleet can be managed between the two lines to allow short-term transport system or public transport network resilience-related capacity issues to be managed. Additionally, the extra service capacity may allow transport system growth to be accommodated without additional road capacity. The regional rail services will likely become increasingly expensive to maintain as the 50-year-old fleet will continue to age. An investment in LNIRIM will reduce some impending heavy maintenance, while additional benefits can be realised from maintenance and operational economies of scale. It would allow for a better value for money than at present. Investment in LNIRIM will ensure that the services remain running and operating reliably into the future, that they can cope with current and ongoing growth, and that they remain attractive to and are a preferred choice for users. The impact of any investment will be able to be measured through the level of maintenance and operational costs per unit of service delivered or per unit of benefit received, and potentially through other wider measures. This benefit aligns with TOF's resilience and security and GPS 2021's better travel options.

- Improved punctuality

Addressing the dated locomotive-hauled operating model with an investment in a modern fleet will likely improve journey times and punctuality. As a result of removing the rolling stock limitations, an investment in LNIRIM would help making the public transport on Wairarapa and Manawatū more reliable. The impact of any investment will be able to be measured through journey dependability, or a measure of service reliability and punctuality, the attributes important to regional commuters. This benefit aligns with TOF's resilience and security and GPS 2021's better travel options.

- Improved interface with increasing freight

Replacing dated diesel-powered locomotives and aged rolling stock with a more sealed and modern alternative will improve the interface of passenger and freight travel on shared track. A more modern fleet will likely allow for a shorter time gap between freight and passenger train passing through the tunnels without imposing any risks from gas emissions on travellers. This improved interface will become especially important as the freight is expected to substantially increase, as discussed in Chapter 2. This benefit aligns with TOF's economic prosperity and directly contributes to GPS 2021's improving freight connections objectives.

Table 3-2 Summary and alignment of benefits and outcomes with Transport Outcomes Framework and GPS 2021

#	Problem	Causes	Effects	Investment objectives	Benefits sought	Potential measures	Alignment with Transport Outcomes Framework: Healthy and safe people	Resilience and security	Economic prosperity	Environmental sustainability	Inclusive access	Alignment with GPS on Land Transport: Safety	Better travel options	Climate change	Improving freight connections
1	The current fleets are approaching the end of useful life and do not align with modern standards (crashworthiness, emission, fire, safety, accessibility, customer)	• Most of the rolling stock has approached 50 years in age • Retrofit to meet modern standards is uneconomical and technically challenging	• Increased risk of inability to connect regions with social and economic opportunities • Increased maintenance costs and safety risks • Limited accessibility • Service frequency constraints due to emissions in tunnels	• Improve connectivity and access to opportunities	• Inclusive access and improved mobility to unlock associated economic benefits	• Reduced risk of discontinuing public transport services • Improved access to economic centres	✓	✓	✓		✓	✓	✓		✓
2	The existing regional rail services are unattractive to commuters	• Services are close to capacity • Limited frequency makes the public transport option unattractive	• Decreased transport network resilience due to congestion pressures on parallel roads • Longer travel time • Reduced safety • Higher emissions from road transport • Increased crowding, limited potential for mode shift and untapped latent demand • Reduced economic development and limited planned land use	• Improve corridor capacity • Improve public transport attractiveness	• Increased transport network resilience, safety and reliability by enabling mode shift	• Increased connectivity between centres, across towns and associated urban planning benefits • Improved commuter safety	✓	✓	✓		✓	✓	✓	✓	✓
3	The current regional passenger services do not maximise the opportunity to meet the objectives on decarbonisation	• Higher emissions from road transport • Emissions from 1970s diesel locomotives	• Higher emissions for longer	• Reduce carbon emissions	• Impact on mode choice to enable meeting climate change targets and associated positive health impacts	• Increased public transport patronage • Reduced carbon emissions from mode shift and fleet				✓			✓	✓	
4	The existing regional train operations are inflexible and inefficient	• Fleets' incompatibility • Separate operations • Complex operational and maintenance arrangements • Limited locomotive performance capability	• Reduced reliability and punctuality • Reduced interoperability, higher maintenance and operational costs • Service frequency constraints due to operational requirements	• Increase value for money • Increase reliability	• Optimised transport costs and value-for-money	• Reduced operating risk and costs • Improved punctuality • Improved interface with increasing freight		✓	✓				✓	✓	

4 CHAPTER 4 – OPTIONS ASSESSMENT

CHAPTER SUMMARY AND CONCLUSIONS:

- The options assessment process covered in this DBC is consistent with the Waka Kotahi guidelines, intervention hierarchy and optioneering process, which encourages the identification and consideration of options beyond construction of a new asset.
- As a benchmark to compare and assess potential options, a 'do-minimum' base case option was identified. The 'do-minimum' base case assumes that the existing service levels on both Wairarapa and Manawatū lines are maintained, initially using the existing fleet until it reaches the end of its service life in FY2028 and subsequently through a purchased and reasonably refurbished second-hand fleet of Locomotive Hauled Coaching Stock (LHCS) and locomotives. The 'do-minimum' base case also includes related infrastructure upgrades with committed funding.
- The long list of options considered broader options presented in the IBC, including a mix of integrated planning, demand, supply and productivity related responses, variations in mode and fleet type, and variations in service levels. The long list also considered contemporary solutions, such as hydrogen and alternative fuels.
- Several non-asset options were considered in the analysis, however it was determined that investment in a new infrastructure solution is needed to address a growing inability of the existing commuter rail service, the only commuter alternative to road travel, to best achieve the service need.
- A range of rollingstock options were shortlisted for a more detailed analysis via a Multi-Criteria Analysis (MCA) process, including a mix of electric, compression-ignition (CI) and battery propulsion systems.
- The preferred rollingstock option selected for more detailed analysis throughout the remainder of this DBC is a tri-mode (1600 Volt (V) Direct Current (DC) + CI + battery) multiple unit (TMU). This option assumes utilisation of the existing 1600 V DC network in place on the Wellington commuter network and a CI engine as well battery on the non-electrified parts on the lines. The battery technology is expected to advance with the passage of time, allowing the battery range to be further extended in the later lifecycle of the trains, while reducing reliability on any form of fuel over time.

4.1 Purpose and overview of chapter

The purpose of this chapter is to identify and assess options to address the problems and opportunities summarised in Chapter 3 Need for Investment. The analysis builds on the confirmed strategic case and evaluates how shortlisted options will help achieve the outcomes and benefits sought. This chapter:

- summarises the approach to option assessment, including investment hierarchy
- provides an overview of the future service needs
- outlines the 'do-minimum' base case used for comparative purposes in the options assessment
- reviews the shortlisted options with a revised Multi-Criteria Analysis (MCA) that recognise key changes to objectives and priorities post IBC
- identifies a preferred solution for further detailed analysis through the remainder of the DBC.

4.2 Approach to options assessment

The methodology to assess options and determine the preferred option is consistent with the Waka Kotahi guidelines. To efficiently determine the preferred Project option, the options development and assessment process involved the steps shown in Figure 4-1.

Figure 4-1 Option assessment process

1	**Service needs**	Identify future service needs based on demand projections.
2	**Do Minimum Base case**	Define a 'do-minimum' base case, representing an approach occurring in the absence of a proposed project to be used as a benchmark for comparing and assessing options.
3	**Long list of options**	Reiterate the optioneering process considering Waka Kotahi's investment hierarchy and non-asset options. Review the IBC's long list of options and complement it with a further analysis of viable secondary propulsion and auxiliary energy modes.
4	**Shortlisted options**	Confirm shortlisted options to take through the revised MCA based on the identified future service needs.
5	**MCA analysis**	Develop a revised MCA that recognises key changes post IBC and reflects contemporary national and regional strategic priorities. Perform MCA review of the shortlisted options to identify a potential preferred option.
6	**Cost Benefit Analysis**	Undertake a rapid benefit-cost analysis to supplement the results of MCA review. Perform a detailed cost benefit analysis on the preferred option for an economic assessment of the option.
6	**Preferred solution**	Identify a preferred solution for further detailed analysis through the remainder of the DBC.

4.3 Service need

As discussed in Section 2.2 Service need drivers in Chapter 2, the Greater Wellington and Manawatū-Whanganui regions are projected to experience a significant population growth. The need for investment has been considered in the context of current and future service needs. These needs are driven by a high projected population growth in the vicinity of the Wairarapa and Manawatū lines and desired future land use areas, which are anticipated to have higher density development and include improved access to bus and rail services to enable the economic growth.

With current services reaching capacity, as discussed in Section 3.4.1 in Chapter 3, any future investment needs to cater not only for the existing but also for the expected future transport demand. This section considers the service level drivers and describes the future service need projections. It discusses the process undertaken to determine a preferred future service level, scenarios considered and aspirational future timetable integration aspects. Appendix A provides further detail on service level modelling.

4.3.1 Scenario development

The service modelling considers two main types of scenarios to predict the potential patronage demand for both Manawatū and Wairarapa lines:

- The “do minimum” scenario provides the expected patronage demand forecast under the current operational conditions of train frequency, capacity, journey time, and available amenities.
- The “improved service” scenarios incorporate the projected patronage demand as well as several key features of operations, to identify up to 19 different service offerings.

The next sections focus on the “improved service” scenarios, compared to the “do-minimum” scenario, and steps out through the process of determining the preferred service levels.

4.3.1.1 Methodology and approach

The “improved service” scenarios are intended to compare several potential options that would likely lead to high patronage demand with minimal investment. The demand modelling assumes the service improvement commences from FY2029. Evaluation of each option is based on the expected patronage demand at 2040, with stakeholders considering the likely investment impact of each option. The year for on the expected patronage demand for option evaluation was selected as 2040 because of:

- stabilisation of service after initial introduction
- ensuring capacity not exceeded too early in investment.

The projected peak patronage is considered as a basis to assess the “improved service” scenarios and determine the required capacity and the fleet size requirement, because the fleet capacity should be sufficient to cater for peak patronage demand. The peak patronage demand is generally higher than the off-peak demand, therefore, the fleet size capacity determined based on peak demand will provide sufficient opportunity for off-peak service improvements.

Key factors considered

The evaluation methodology proposed was a generalised journey time model (where all elements of a trip are ‘converted’ into a weighted “generalised” journey time and measured for attractiveness). This model is based on the Institute of Transport Studies’ (Leeds University, UK) and the UK’s Association of Train Operating Companies’ Passenger Demand Forecasting Council methodology, which is the world’s most empirically tested rail demand forecasting methodology. The generalised journey time is constructed from the journey time and service frequency. These factors were driven by the following operational factors that could reasonably be achieved:

- **Line Speed**: The maximum line speed can be improved through infrastructure investment, with the current line speed at 90km/h. Current technology allows trains to travel up to 160 km/h in a similar environment, thus the proposed options considered a realistic 110 km/h and an optimistic 160km/h for line speed.

- **Temporary Speed Restrictions (TSRs)**: The individual TSRs are not examined in detail to understand the potential benefit from removing them individually, rather we assume that some TSRs will be improved over the short to medium term by corridor renewal, including WMUP III, and improvement as a result of future infrastructure upgrade works.
- **Frequency**: The service frequency is also considered, as a high frequency service has a higher potential to achieve patronage growth because of improved travel choices and flexibility. The improved service options consider more services within the same peak period.
- **Stopping pattern**: As currently both lines only operate all stops trains, improved service options consider the introduction of an express train within the service. This is inherently linked to the service frequency, so the suggested scenario was varied depending on the line being modelled, acknowledging that alternating express and all-stopper services on a predominantly single line environment may be impractical. Specific express services are not defined in detail, rather a 10 min saving in journey time is assumed.
- **Capacity**: Variations in the consist configuration were considered to adjust the potential capacity of each trip. The current peak operations typically consider a 4-car consist, which will provide a seated capacity of 195, and an 8-car consist, which will provide a seated capacity of 390. A combination of four car modules into a 4-car consist and an 8-car consist is proposed to:
  - ensure sufficient seating capacity
  - avoid excessive capacity
  - allow for space to equip with toilets and bike storage
  - accommodate for underframe space for secondary propulsion equipment
  - fit within existing maintenance facilities (e.g., wheel lathe)
  - consider practical limitations of platform length and overhead line beyond 8-car.

The line speed and TSR improvements both impact the journey time, which is a direct input into the modelling. The improvements to the journey time, based on the increased line speed or improvements in TSRs, was based on results from modelling done in Open Track by stakeholders. The frequency and stopping pattern influence the perceived journey time and is modelled using an elasticity factor that was derived from research done on a similar network (using the empirical research base from the UK Passenger Demand Forecasting Council's handbook). The variation in the elasticity factor was increased or decreased according to the level of improvement described.

Wairarapa data availability and approach

The analysis was limited to the data available, which was provided as a total historical patronage for the full corridor without the number of patrons embarking or disembarking at each station. It is based on the passenger count crossing the Remutaka range (through the Remutaka tunnel) between Wairarapa and Hutt Valley. For patronage demand modelling purpose all passengers were assumed to travel between Wellington and Masterton.

The uncertainty in the project is encapsulated using the lower and upper bounds of the estimates. For all scenarios, both lower and upper bounds of the "do minimum" option are multiplied by the patronage demand growth caused by the generalised journey time impacts of the scenario.

For scenarios with express services, given the uncertainty of the patronage split between express and non-express services, the upper bound for the scenario is further modified to represent the maximum likely demand growth from the additional express-specific service improvements. This results in a slightly wider band of projections as compared with non-express services.

Manawatū data availability and approach

Data available for Manawatū summarised the number of patrons embarking at each station allowing for more detailed incorporation of where people get on the train. The Manawatū corridor was modelled as a full journey between Palmerston North and Wellington, which is consistent with the investment objectives of improving connectivity and access to opportunities, improving attractiveness of the public transport and improving corridor capacity. The key assumption remained that patrons travel to and from Wellington for each journey. However, a higher demand elasticity for patrons embarking closer to Wellington is incorporated to account for the different patronage patterns associated with local/city services and regional services.

Thus, it was possible to account for the different experiences from each patron at different stations. The aggregated patronage demand projections are higher under this approach, due to the greater effect of improvements on shorter journeys. Also given that frequency is a large driver of demand and the existing service is a single train each way, each day, any improvements in the service are more aligned with creating a new service. Therefore, the assumptions are shifted towards the benefit of modelling a new train service, rather than incremental improvements to the existing service, which further increases demand projections.

4.3.2 Scenario evaluation

Evaluation approach

The evaluation process of various "improved service" scenarios considers multiple factors aligned with the project investment objectives:

Investment objective	Service evaluation consideration
Improve connectivity and access to opportunities through safe and reliable transport options on the Manawatū and Wairarapa corridors.	• Is the demand likely to be capped by capacity by 2040? Will the capacity be sufficient in the long-term?
Improve corridor capacity by providing for forecast demand for longer distance travel within the growth areas of the Manawatū and Wairarapa corridors.	
Improve attractiveness of land public transport within the corridors.	• Is modelled service frequency likely to present an opportunity for a step change to encourage mode shift to public transport and associated reduction in road carbon emissions?
Reduce carbon emissions related to commuter travel within the corridors	
Enhance value for money through increased network productivity and efficiency of operation of transport services.	• Can it be delivered with the current infrastructure? • Will a significant infrastructure investment that may be required for the increased line speed be justified by a significant uplift in patronage? • Is there modelled excess capacity in 2040, which may indicate over investment in the fleet?

The main aim of the evaluation of the "improved service" scenarios is to maximise benefits from achieving the investment objectives with an optimised level of fleet required for the projected service demand.

Patronage can be maximised by increasing frequency (which requires more rollingstock) and/or by cutting journey time (which requires infrastructure investment). Generally, infrastructure to make significant time savings costs more (in initial investment and ongoing maintenance) than equivalent rollingstock. Doing both only results in relatively smaller patronage gain. Therefore, the "improved service" scenarios were sequentially discarded based on the following considerations whether:

1. an "improved scenario" requires significant track investment to enable the speed improvement
2. under an "improved scenario" the demand exceeds capacity before 2040
3. there is a significant excess capacity in 2040
4. the frequency is considered sufficient to make public service more attractive to commuters and maximise the opportunity for mode shift and associated reduction in carbon emissions.

Additional considerations included:

1. Integration with metro service timetable (RS1 timetable), 15 or 30 minute frequencies
2. Network constraints of single track sections and required train crossings (passenger and freight)

Wairarapa scenarios

The Wairarapa line currently runs three services each direction during the peak. Services run all stops between Masterton and Wellington. Improvements are modelled through improving one or more of the five characteristics described above, increased speeds, improving the infrastructure via removal of TSRs, increasing the service frequency, adding express services and consist configuration. Table 4-1 specifies each option considered and how each operational characteristic is modified, with the current operations represented as the baseline of all characteristics.

A guided decision was made by the stakeholders, where Lynxx provided the framework and modelling implications, and the stakeholders chose the preferred options for each line. The Stakeholders identified option 10a as the preferred option which expects to run 7 trains (six trains in an eight-car configuration and one train in a four-car configuration) at a 15 min headway during the peak period. This option is also expected to achieve 15 minutes of savings in the journey time by removing TSR's.

The distinguishing features of this option are:

- High frequency option which maximises service attractiveness and drives mode-shift
- Capacity not likely to limit demand before 2040.
- 15min peak hour frequency integrates well with metro timetable
- It does not require significant track infrastructure improvements beyond what has been planned in WMUP3.

Figure 4-2 shows the monthly patronage projections for both the current operations (black line) and those of option 10a (blue line). The red line indicates the average trend line for the projected demand for the improved service option chosen, 10a. The vertical line at 2020 represent the point where the projections begin, and the vertical line at 2040 represents the point where the estimates were evaluated compared to the other options. Option 10 was close to reaching capacity in 2040. Option 11 had more vehicles than would be optimal for the projected demand. Therefore, option 10a was developed to calbrate the service modelling to identify a compromise between the optimal number of vehicles needed and the projected demand.

Figure 4-2 Wairarapa monthly patronage projections (the preferred service levels)

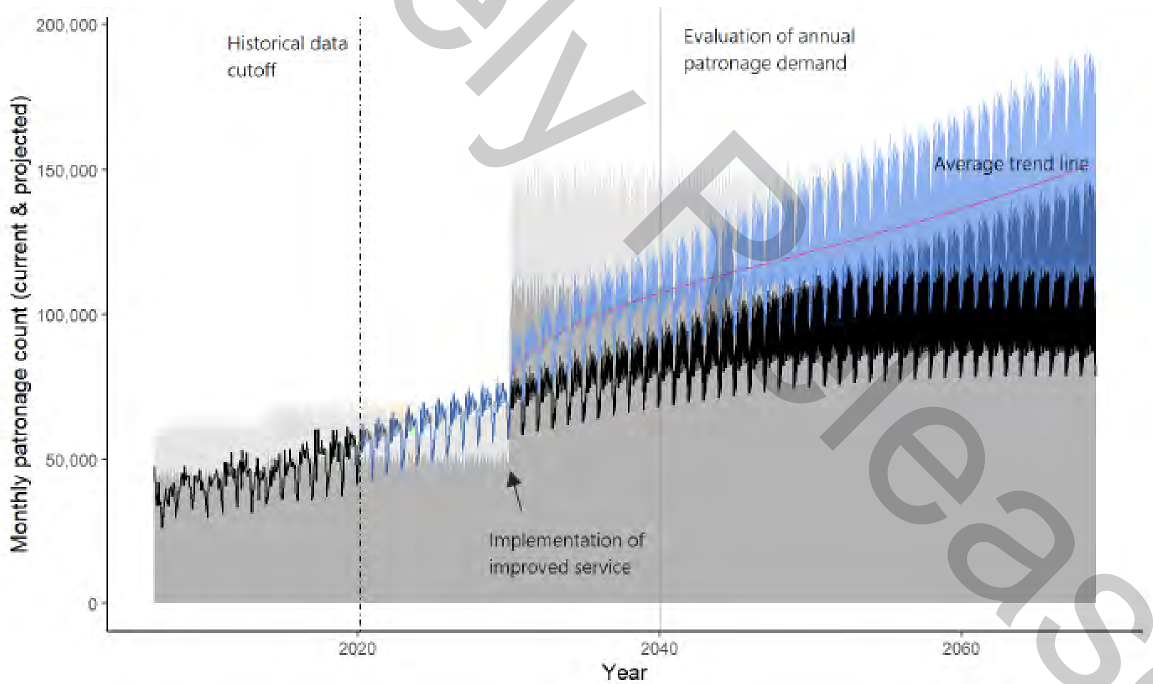


Figure 4-2 shows the capacity limitations of the current operations that were seen in the "do minimum" modelling. The improved services are assumed to be implemented in 2029, where there is a step change in capacity. The patronage is expected to significantly increase initially with the growth rate settling down after 4-5 years. The projections for both the current operations and the preferred option start to diverge significantly in the later years, with the initial divergence encapsulating the uncertainty in predictions due to variances and seasonality in the historical data. The uncertainty in the later years is predominantly driven by the long prediction windows relative to the historical data (forecasting 40 years ahead with 8 years of historical data). Over the first 5 years of improved services, the average annual growth rate is expected to be between 6.5% and 7.2% averaging out to between 1.5% and 2.5% over the 40 years forecast period.

Table 4-1 Wairarapa preferred service level selection

Option	Line Speed (km/hr)	TSRs	Frequency (# peak hour services)	Stopping Pattern	Consist	2040 peak demand (Lower)	2040 peak demand (Upper)	Requires track investment for speed improvement	Demand exceeds capacity before 2040	Significant excess capacity in 2040	Frequency sufficiency consideration	Decision
Current	90	All existing	3 (1 every 30 mins)	All stops	3x8 car train	955721	1089162	N	Y (discarded)			
1	90	All existing	4 (1 every 25 mins)	All stops + express	4x8 car train	982541	1259052	N	Y (discarded)			
2	90	All existing	5 (1 every 20 mins)	All stops + express	5x8 car train	1010747	1298852	N	N	N	N (discarded)	
3	90	All existing	8 (1 every 15 mins)	All stops + express	8x8 car train	1061130	1370447	N	N	Y (discarded)		
4	90	Some removed	3 (1 every 30 mins)	All stops	3x8 car train	1001185	1140974	N	Y (discarded)			
5	90	Some removed	5 (1 every 20 mins)	All stops + express	5x8 car train	1061130	1370447	N	N	N	N (discarded)	
6	90	Some removed	8 (1 every 15 mins)	All stops + express	8x8 car train	1116221	1449473	N	N	Y (discarded)		
7	90	None	3 (1 every 30 mins)	All stops	3x8 car train	1104796	1259052	N	Y (discarded)			
8	90	None	4 (1 every 25 mins)	All stops + express	4x8 car train	1139720	1483418	N	Y (discarded)			
9	90	None	5 (1 every 20 mins)	All stops + express	5x8 car train	1176682	1537098	N	Y (discarded)			
10	90	None	6 (1 every 15 mins)	All stops	6x8 car train	1243306	1416901	N	Maybe	N	Y	
10a	**90**	**None**	**7 (1 every 15 mins)**	**All stops**	**(6x8, 1x4) car train**	**1243306**	**1416901**	N	N	N	Y	**Selected**[127]
11	90	None	7 (1 every 15 mins)	All stops	7x8 car train	1243306	1416901	N	N	N	Y	
12	110	Some removed	4 (1 every 25 mins)	All stops + express	4x8 car train	1104796	1401105	Y (discarded)				
13	110	None	4 (1 every 25 mins)	All stops + express	4x8 car train	1229445	1574864	Y (discarded)				
14	110	None	5 (1 every 20 mins)	All stops + express	5x8 car train	1271887	1634742	Y (discarded)				
15	110	None	8 (1 every 15 mins)	All stops + express	8x8 car train	1348777	1744149	Y (discarded)				
16	160	None	4 (1 every 25 mins)	All stops + express	4x8 car train	1301673	1676983	Y (discarded)				
17	160	None	5 (1 every 20 mins)	All stops + express	5x8 car train	1348777	1744149	Y (discarded)				
18	160	None	8 (1 every 15 mins)	All stops + express	8x8 car train	1348777	1744149	Y (discarded)				

[127] Option 10 was close to reaching capacity in 2040. Option 11 had more vehicles than would be optimal for the projected demand. Therefore, option 10a was developed to calibrate the service modelling to identify a compromise between the optimal number of vehicles needed and the projected demand.

Manawatū scenarios

Alternate services are modelled through improving one or more of the five characteristics described above, increased speeds, improving the infrastructure via removal of TSRs, increasing the service frequency, adding express services, and consist configuration. Table 4-2 specifies each option considered and how each operational characteristic is modified, with the current operations represented as the baseline of all characteristics.

A guided decision was made by the stakeholders, where Lynxx provided the framework and modelling implications, and the stakeholders chose the preferred options. The Stakeholders identified option 4 as the preferred option which expects to run 4 trains (two trains in an eight-car configuration and two trains in a four-car configuration), one service will be an express service, with a headway of 40 minutes. Figure 4-3 shows the monthly patronage projections for both the current operations (black line) and those of option 4 (blue line). The red line indicates the average trend line for the projected demand for the alternate service option chosen. The vertical line at 2020 represents the point where the projections begin, and the vertical line at 2040 represents the point where the estimates were evaluated with the other options.

Figure 4-3 Manawatū monthly patronage projections (the preferred service levels)

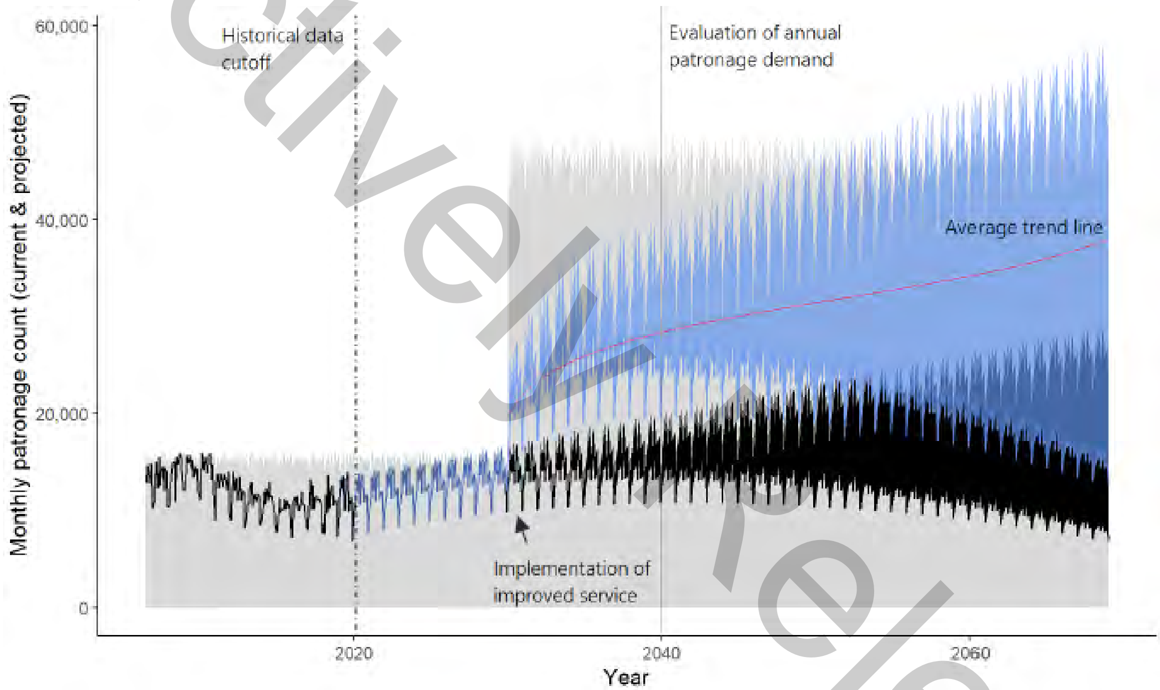


Figure 4-3 shows the capacity limitations of the current operations that are likely to be met circa 2025. The improved services are assumed to be implemented in 2029, where there is a step change in capacity. The patronage is expected to significantly increase initially with the growth rate settling down after 4-5 years. The projections for both the current operations and the preferred option start to diverge significantly in the later years, with the initial divergence encapsulating the uncertainty in predictions due to variances and seasonality in the historical data.

Additional patronage growth is expected to occur shortly after implementation of improved services, with the assumption that new patrons are sourced via mode shift from cars to trains. This initial additional growth will stabilise to a regular rate as future growth continues to be driven mostly by population growth The uncertainty in the later years is predominantly driven by the long prediction windows relative to the historical data (forecasting 40 years ahead with 6 years of historical data). Over the first 5 years of the alternative service, the average yearly growth rate is expected to be between 13.6% and 17.7% averaging out to between 0.7% and 3.5% over the 40 year forecast period. We note that, due to the frequency increase of the preferred option, total seating capacity is significantly more than required for the projected patronage demand for the initial decade of service. A consist configuration of 2x8 and 2x4 car trains per day was selected, but reduced capacity configurations for the first decade of service (such as 4x4 car trains) would suffice to minimise operating costs and early investment while retaining the required frequency.

4.3.3 Off Peak and Weekend Timetable

A modest increased off-peak service has also been assumed. This assumption is justified because while there will be a minimal incremental cost associated with a service upflift based on the already available fleet and train crew, it will provide benefits of access and connectivity across the region.

The availability of services may activate latent off-peak demand:

- Manawatū line – development of a true commuting option from no existing weekend services and to services available each day.
- Behaviour change – the availability of services could incentivise a reduced dependence on private car ownership, reduced resource consumption and energy footprints.

There will also be an opportunity for further improvements in the off-peak service frequencies at incremental costs with the available fleet, should the latent demand eventuate.

The timetabling will take into consideration any future interface with freight on both lines.

Table 4-2 Manawatū preferred service level selection

Option	Line Speed (km/hr)	TSRs	Frequency (# services per day each direction)	Stopping Pattern	Consist	Lower	Upper	Lower	Upper	Requires track investment for speed improvement	Demand exceeds capacity before 2040	Significant excess capacity in 2040	Frequency sufficiency consideration	Decision
Current	90	All existing	1	All stops	1x8 car train	166,859	213,950	639	820	N	Y (discarded)			
1	90	All existing	2 (1 every 90 mins)	All stops + express	2x8 car train	239,714	333,692	918	1,279	N	N		N (discarded)	
2	90	All existing	4 (1 every 40 mins)	All stops + express	4x8 car train	292,399	412,484	1,120	1,580	N	N	Y (discarded)		
3	90	Some removed	1	All stops	1x8 car train	171,031	219,301	655	840	N	Y (discarded)			
4	**90**	**Some removed**	**4 (1 every 40 mins)**	**All stops + express**	**(2x8, 2x4) car train**	**303,517**	**429,465**	**1,163**	**1,645**	**N**	**N**		**Y**	**Selected**
5	90	None	1	All stops	1x8 car train	179,984	230,780	690	884	N	Y (discarded)			
6	110	All existing	2 (1 every 90 mins)	All stops + express	2x8 car train	247,560	344,196	949	1,319	Y (discarded)				
7	110	All existing	4 (1 every 40 mins)	All stops + express	4x8 car train	303,517	427,710	1,163	1,639	Y (discarded)				
8	110	Some removed	2 (1 every 90 mins)	All stops + express	2x8 car train	255,887	356,596	980	1,366	Y (discarded)				
9	110	None	2 (1 every 90 mins)	All stops + express	2x8 car train	274,164	384,005	1,050	1,471	Y (discarded)				
10	110	None	4 (1 every 40 mins)	All stops + express	4x8 car train	341,934	486,655	1,310	1,865	Y (discarded)				
11	160	None	2 (1 every 90 mins)	All stops + express	2x8 car train	281,644	394,142	1,079	1,510	Y (discarded)				
12	160	None	4 (1 every 40 mins)	All stops + express	4x8 car train	352,937	501,981	1,352	1,923	Y (discarded)				

4.3.4 Conclusions

Table 4-3 shows a summary of the do-minimum and preferred service levels and considers 40 year planning horizon (pre-project 2020-2027, fleet life 2027- 2063).

Table 4-3 Wairarapa and Manawatū line frequencies in each peak and off-peak direction

Line	Day	Do-minimum service levels				Preferred service levels			
		Up to FY2028		FY2029 onwards		Up to FY2028		FY2029 onwards	
		Peak	Off-peak	Peak	Off-peak	Peak	Off-peak	Peak	Off-peak
Wairarapa	Monday	3	2	3	2	3	2	7	3
	Tuesday	3	2	3	2	3	2	7	3
	Wednesday	3	2	3	2	3	2	7	3
	Thursday	3	2	3	2	3	2	7	3
	Friday	3	3	3	3	3	3	7	4
	Saturday		2		2		2		3
	Sunday		2		2		2		3
Manawatū	Monday	1	0	1	0	1	0	4	1
	Tuesday	1	0	1	0	1	0	4	1
	Wednesday	1	0	1	0	1	0	4	1
	Thursday	1	0	1	0	1	0	4	1
	Friday	1	0	1	0	1	0	4	1
	Saturday		0		0		0		1
	Sunday		0		0		0		1

Do-minimum base case

The 'do-minimum' base case assumes a continuation of the current levels of service:

- Maintain existing Wairarapa service levels on an ongoing basis:
  - Weekday peak: 3 morning and 3 afternoon peak-direction trips
  - Weekday off-peak: 2 (plus 1 Friday evening) trips in each direction
  - Weekend: 2 trips in each direction.

  The end-to-end travel time of each service: 1 hour and 40 minutes to 1 hour and 50 minutes with the line speed of 90 km per hour, including all stops and all existing Temporary Speed Restrictions (TSR).
- Maintain existing Manawatū service levels on an ongoing basis:
  - Weekday peak: 1 morning and 1 afternoon peak-direction trips.

  The end-to-end travel time of each service: 2 hours and 5 minutes with the line speed of 90 kilometres (km) per hour, including all stops and all existing TSRs.

Figure 4-4 and Figure 4-5 show Wairarapa and Manawatū lines' historical monthly patronage (black line), modelled projected monthly patronage for the 'do minimum' base case (blue line)[128], seated capacity (dark grey shading for Wairarapa and light grey shading for Manawatū) and standing capacity (light grey shading for Wairarapa).

The 'do-minimum' base case assumes the existing capacity and frequency. The charts show that:

[128] The modelling is based on autoregressive integrated moving average (ARIMA) that projects future monthly patronage based on historical seasonality and overall trends. The projected patronage demand modelling assumptions include medium sub-regional population projection published by Stats NZ on 31 May 2021.

- the seated capacity is already exceeded for the Wairarapa line (on monthly aggregates) for most months of the year and will exceed seated capacity in all months by FY2026.
- the seated capacity for Manawatū will exceed seated capacity in various months from FY2030 and will exceed seated capacity in all months by FY2045.

The capacity is assumed to limit the growth in patronage because once the perceived crowding exceeds commuters' tolerance levels, they are likely to switch to other transport modes. Additionally, the current frequency limits any potential latent demand that would have been available if more services were available, especially on the Manawatū line.

Preferred service levels

The preferred Wairarapa option varies three of the five key features from the current operations, which include:

- The removal of temporary speed restrictions (TSR's), which is expected to result in a 15 minute benefit to the overall journey time.
- The frequency of services has been increased to seven (7) services during the peak period, with a headway of one service every 15 minutes.
- The consist configuration is varied from the standard in that one of the peak services is assumed to be a single four car train, with the remaining services all assuming a standard eight car train. The annual peak demand of the Wairarapa preferred option is expected to reach 1,400,000 by 2040.

The preferred Manawatū option varies four of the five key features from the current operations, which include:

- The removal of some Temporary speed restrictions (TSR's), which is expected to result in a 5 minute benefit to the overall journey time.
- The frequency of services has been increased to four services during the peak period, with a headway of one service every 40 minutes.
- The stopping pattern is varied to include one of the four peak hour services as an express train. This specific service is not defined, however it assumed to save an additional 10 minutes of journey time.
- The consist configuration is varied from the standard in that two of the peak hour services is assumed to be a single four car train, with the remaining two services a standard eight car train. The annual peak demand of the Manawatū preferred option is expected to reach 430,000 by 2040.

The regional commuters will benefit from extra 48 train services every week on the Wairarapa line and extra 42 train services per week from January 2029[129] , which include more frequent peak and off-peak services. This includes double the current peak services on the Wairarapa line and quadruple the current peak services on the Manawatū line. Additionally, the project will boost the transport capacity for off peak and weekend travel.

The increases in services are projected to translate into higher patronage numbers that would be observed under the do minimum case. This reflects more attractive more frequent services and associated increases in patronage from regional population growth, mode shift and activation of latent demand.

The assumed frequencies described in this section are translated into specific fleet requirements based on unconstrained future demand projections. Table 4-3 summarises estimated frequencies, considering the key constraint of platform lengths limiting consists to 8 car units. Therefore, the fleet requirement is expressed as a combination of trains with 4 and 8 car consists. The fleet requirement is driven by the capacity needs for peak demand patronage.

[129] Calculated as a difference between the total of peak and off-peak services in both direction per week based on the frequencies from FY2029 and the current frequencies.

Wairarapa line service level assumptions include:

- **Frequency**: The frequency of the peak hour services increase from 3 to 7 services during the peak period. This equates to a headway of 1 service every 15 minutes (15 minutes more frequent than current service). The off-peak frequency is assumed to be improved with one additional service to the existing levels from FY2029 onwards.
- **TSRs**: All TSR's are assumed to be removed by the funded renewal and upgrade work planned for the line in the coming years. The operational level of TSRs after the expected renewal works is expected to be less than 2 minutes.
- **Stopping pattern**: The stopping pattern is the same as existing services with all stops.
- **Capacity**: a 4-car consist will provide a seated capacity of 195 and an 8-car consist will provide a seated capacity of 390.

Manawatū line service level assumptions include:

- **Frequency**: The frequency of the services is increased from 1 to 4 services, which is assumed to be every 40 minutes. The off-peak frequency is assumed to be improved with one additional service to the existing levels from FY2029 onwards.
- **TSRs**: Some, not all, TSRs are assumed to be removed, which would produce a 5 min benefit to journey time. Should all current TSRs remain on the line, the resulting timetable impact would not have a significant impact on patronage.
- **Stopping pattern**: The stopping pattern is varied from the current service to include 1 of the 4 services as an express service. The specific service that is an express service or stations that it stops at are not specified. The journey time for the 3 standard services is 125 minutes, and the journey time for the express service is 115 minutes, compared to the current journey time of 130 minutes.
- **Consist**: a 4-car consist will provide a seated capacity of 195 and an 8-car consist will provide a seated capacity of 390.

Overall, Table 4-4 shows an estimated capacity needed to serve the projected demand, resulting in the total of 22 four-car trains, which are tailored for various shortlisted options in equivalent quantities.

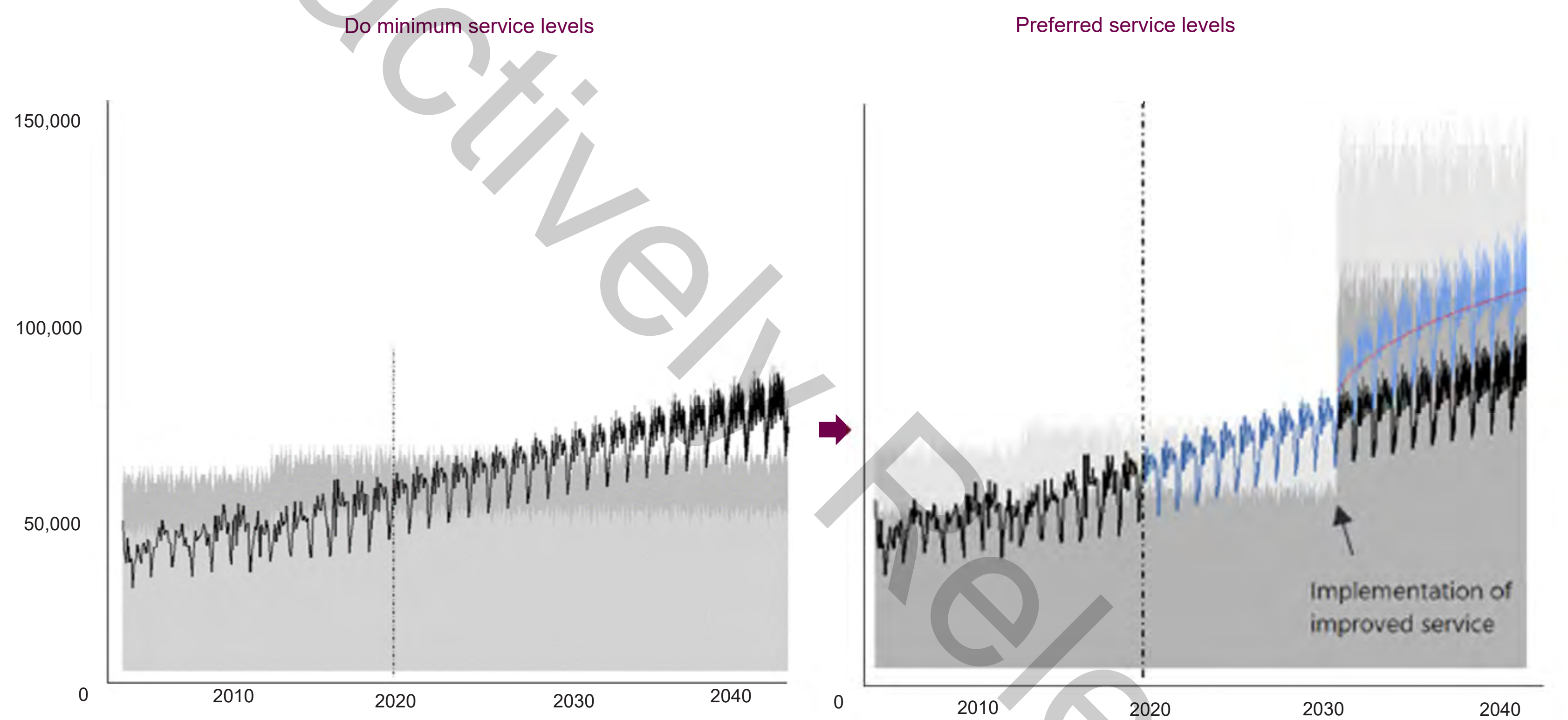
Table 4-4 Estimated capacity and fleet

Category	Consists	Seated capacity per one 4-car unit	4-car units
Wairarapa line	6 x 8 car 1 x 4 car	~195 seats[130]	13
Manawatū line	2 x 8 car 2 x 4 car	~195 seats	6
Maintenance spares	1 x 4 car Heavy Maintenance 1 x 4 car Preventive Maintenance		2
Contingency spares			1
Total			**22**

All shortlisted options described in Section 4.6 assume the preferred service level or its equivalents. Section 5.4.1 provides further details on the aspirational timetable for the preferred solution selected in this chapter.

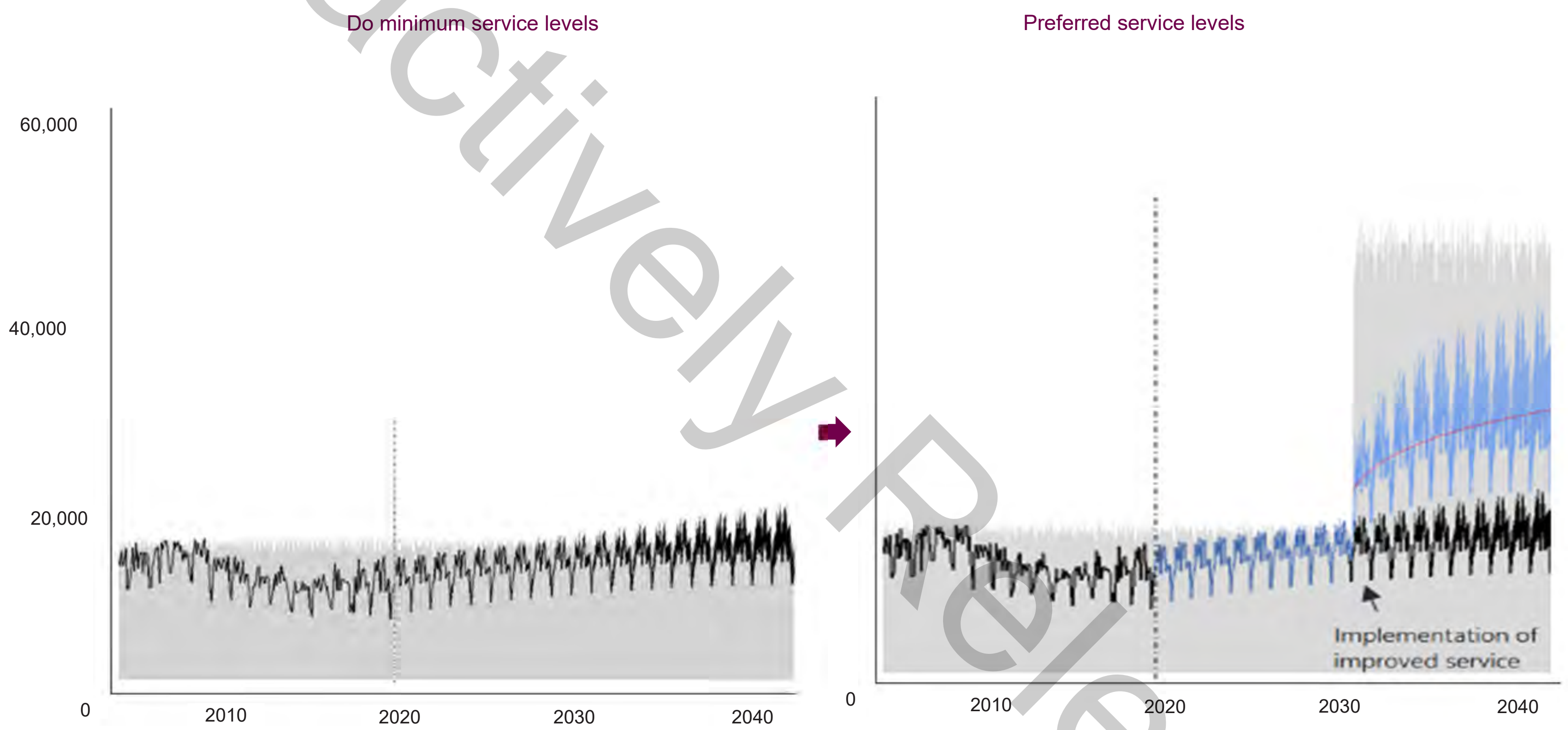
[130] A seated capacity of 195 was assumed for the analysis throughout the DBC, a seated capacity is possible up to 250 and will vary with specific design of the rolling stock

Figure 4-4 Wairarapa, monthly patronage count, current and projected



The project will improve the overall transport corridor resilience and capacity by doubling the peak services per week on the Wairarapa line, which will cater for future increased demand, reduce crowding and enable larger mode shift and associated environmental benefits.

Figure 4-5 Manawatū, monthly patronage count, current and projected



The project will create opportunities for the activation of the existing and latent demand, economic growth and land use and development through increased services on the line. The project will also enable mode shift and associated environmental benefits.

4.4 The 'do-minimum' base case

4.4.1 Definition of the 'do-minimum' base case option

The 'do minimum' base case is a counterfactual scenario defining a future in which the proposed activity does not occur. Accordingly, the 'do minimum' is not 'another option' to be assessed, but a robust base line against which all options can be assessed. The 'do-minimum' option acts as an important benchmark that can reveal the value of additional changes.

The IBC 'do minimum' could not be taken forward as it didn't fully meet Waka Kotahi's requirements at the time, didn't meet recent standards, and was defined on an investment context made obsolete by recent NZUP funding commitments. Accordingly, collaborative efforts have been applied early in the development of the analysis to define the do-minimum base case as a new baseline.

The resulting LNIRIM do-minimum base case meets the guidance and requirements provided by Waka Kotahi in workshops, identified best practice international guidelines[131], and was confirmed against the latest MCBM once released.

As per Waka Kotahi guidelines, the do minimum maintains current service levels and accounts for committed and funded transport activities. It does not take advantage of any further opportunities for change that may occur, such as any additional services. However, it does not reflect doing nothing, because continuing with current arrangements will have consequences and require action resulting in costs. In other words, the 'do minimum' includes maintaining the status quo and while it is not a 'do nothing' scenario, it represents a 'do nothing more than current practice' scenario. It is built on current New Zealand Rolling Stock asset management practice and costs[132] driven by short term, low upfront capital expenditure investments.

Table 4-5 provides a brief overview of the 'do-minimum' base case, further detailed in Section 4.4.2. Additional information relating to the cost of the do minimum are provided in Chapter 6 – Economic Analysis and in the appended Economic Appraisal Memo and Cost Estimate Memo. These demonstrate further that while the 'do minimum' whole of life cost maybe superior to some of the options' in real term, it likely provides the lowest lifecycle costs in present value terms, consistent with Waka Kotahi guidelines.

Table 4-5 Overview of the base case

Option	Brief description
The 'do-minimum' base case: second-hand LHCS + same service	• Maintains the existing frequencies and service levels • Use existing rolling stock until end of life. • Continuously buy and refurbish second-hand Locomotive Hauled Coaching Stock (LHCS) and locomotives • Upgrade infrastructure as committed New Zealand Upgrade Program (NZUP) investment (no further electrification) • Upgrade Wairarapa station platforms to meet accessibility standards.

While the 'do-minimum' base case assumes maintaining the use of locomotives and LHCS on both routes and meets the Waka Kotahi definition of the 'do-minimum' option, it has not been considered as a viable option during the long list review process since it does not address any of the problems identified. In particular, the 'do minimum' presents:

- operational inefficiencies
- high fuel consumption and emissions

[131] Her Majesty's Treasury's Green Book, confirmed by Waka Kotahi as useful guidelines before the publication of the August 2021 MCBM, defines the 'do-minimum' option as "the continuation of current arrangements that provides the current levels of service, even if such a course of action is completely unacceptable". Source: HM Treasury. The Green Book. Central Government Guidance on Appraisal and Evaluation. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/938046/The_Green_Book_2020.pdf

[132] Purchase and refurbishment of second hand passenger rolling stock has been the 'default' practice in New Zealand that led to the make up of the current fleets on both the Manawatū and Wairarapa lines as well as the newly refurbished Te Huia fleet, providing sufficient data for the LNIRIM 'Do minimum'.

- single points of failure in traction and electrical generation
- train length constraints because of engine and generator length reducing seating capacity
- tunnel egress constraints
- tunnel gas emissions constraints
- a lack of crashworthiness standard rating
- slow and difficult rescue when immobilised
- inability to cater for forecast demand (as shown in Section 1.3.2 of Chapter 1 Introduction and Background).
- safety and accessibility compliance upgrade constraints.

4.4.2 Fleet and infrastructure

Figure 4-6 and Figure 4-7 show the train architecture and propulsion mode assumed for the 'do-minimum' base case.

Figure 4-6 The 'do minimum' base case train architecture[133]

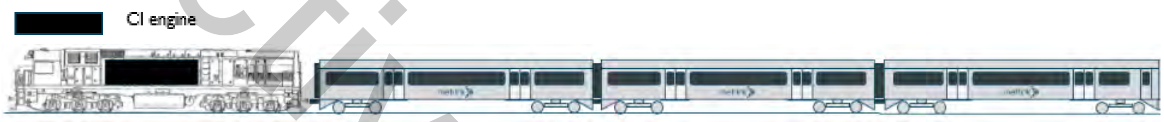
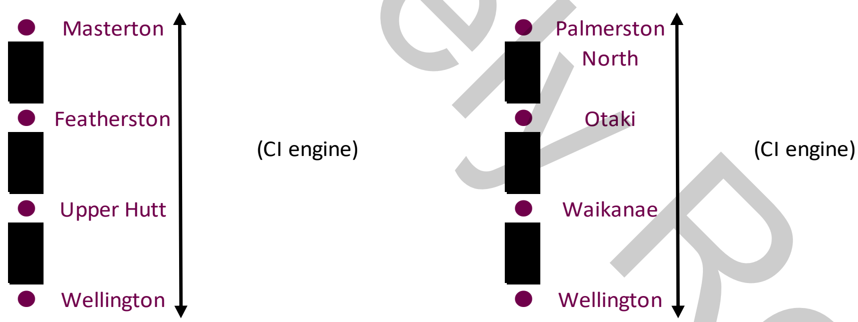


Figure 4-7 The 'do minimum' base case propulsion mode



The 'do-minimum' option (detailed in Appendix B**Error! Reference source not found.**) assumes the maintenance of existing service levels on both Wairarapa and Manawatū lines by:

- maintaining the existing fleet for the Wairarapa Fleet and the Capital Connection until it reaches the end of its service life between FY2027 and FY2028.
- purchasing and replacing the existing fleet every 10 years with refurbished second-hand or third-hand LHCS and locomotives equivalent to those in use today. LHCS are assumed to enter the service in FY2029 and reasonably maintained over 30 years of operation, including a 'mid-life' refurbishment after 5 years of operation.
- delivering related infrastructure upgrades with committed funding, such as those included in the NZUP, which estimates a rail infrastructure investment of $269 million with the start of construction in late 2020 and phased completion between 2022 and 2028.

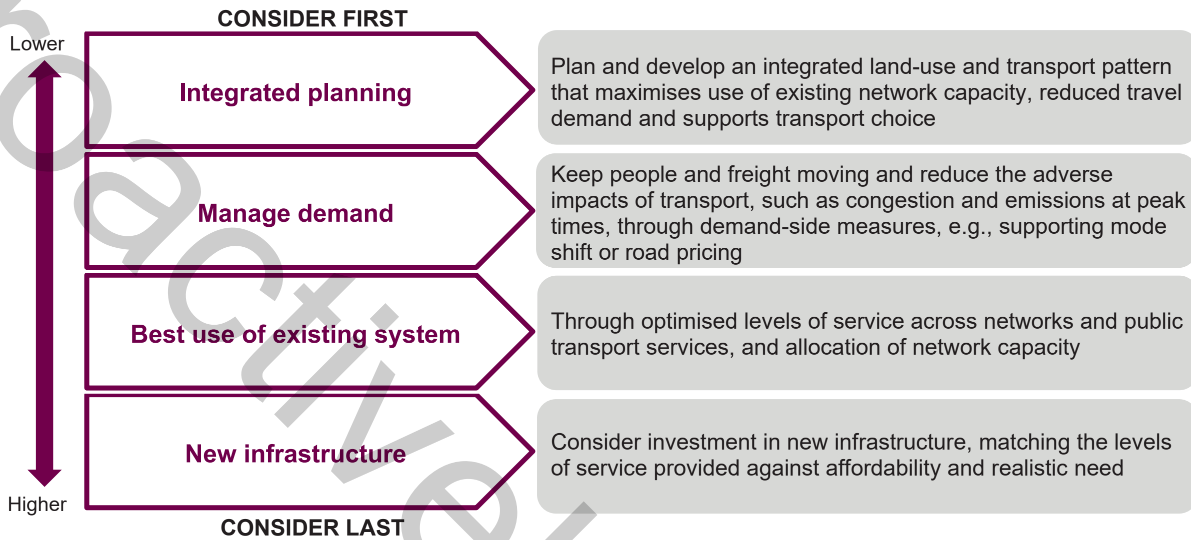
NZUP's $269 million investment in rail network improvements north of Wellington will help support capacity for growth in passenger and freight services and support increased frequency of Metlink and Capital Connection services, it is included under the 'do-minimum' option scenario as the NZUP provides guaranteed, fully funded pipeline of work. Refer to Appendix B for more details on the do-minimum base case.

[133] CI engine refers to compression-ignition engine. In case of the do-minimum base case CI involves diesel propulsion

4.5 Long list options assessment

The methodology to assess options and determine the preferred option is consistent with the Waka Kotahi guidelines and intervention hierarchy that encourages the identification and consideration of options beyond construction of a new asset. The framework for options assessment is presented in Figure 4-8.

Figure 4-8 Framework for options assessment



This options assessment framework recognises that there is often more than one way to solve a problem or address an opportunity, and that multiple options may be required to achieve the desired outcome. The framework seeks to ensure that construction of a new asset is only pursued following the identification and elimination of less capital-intensive options. The project options assessment process in this DBC has followed this framework. This DBC leverages the IBC's long list of potential project options and complements it with a further analysis of secondary propulsion and auxiliary energy modes that consider contemporary and emerging practices.

This DBC has considered a broader long list of options (Appendix C), including:

- a mix of integrated planning (change land use policy to reduce demand for regional commute)
- demand, supply and productivity related responses (incentivise decreased demand through increased charges)
- variations in mode (replacing rail services with buses)
- fleet type (life extension or various propulsion options, including full electrification, partial electrification, battery, hydrogen, multi-mode locomotives and carriages and alternative fuels)
- variations in service levels (discontinue regional rail services on both lines and encourage car use).

These considerations are discussed further below.

4.5.1 Non-asset options

The non-asset options considered were discounted as they did not align with and/or contradicted broader national and regional strategies for better transport options, as discussed in Chapter 2 Strategic Context. This includes strategies focused on:

- encouraging mode shift
- reduction in carbon emissions
- improved safety
- integration with freight.

Additionally, the assessment of broader strategies identified that these non-asset measures alone will not be sufficient to meet government's objectives.

Investment in a new infrastructure solution is needed to address the problem of a growing inability to deliver regional commuter rail services, the only commuter alternative to road travel, to best meet the increasing demand and realise opportunities for environmental, social and economic benefits.

4.5.1.1 Integrated planning initiatives

As outlined in Chapter 2 Strategic Context, a range of integrated planning initiatives have been introduced, which will be or are being implemented. This integrated planning considers the alignment of future land use and transport planning, including through the Wellington Regional Growth Framework Report 2021 and Accelerate 25 and the Accelerate 25 Economic Action Plan. Both plans are founded on growth in the vicinity of the Wairarapa and Manawatū rail corridors. The committed NZUP's $269 million investment in rail network improvements further establishes the government's commitments to rail within a context of population growth for the region. Therefore, an integrated planning option to change land use policy to reduce demand for regional commute was discounted.

Additionally, key strategic frameworks, such as GPS2021, Regional Land Transport Plans and Regional Public Transport Plans outline strategies to manage demand and better use of existing systems through better travel options and improved freight connections. These strategies, together with Road to Zero, Keeping Cities Moving and other strategies, aim to encourage safe travel options, encouraging mode shift to public transport and developing a low carbon transport system. The rising importance of environment considerations, specifically addressing the issue of climate change, is reflected in Climate Change Commission 2021 Advice for Consultation. It focuses on carbon neutral objectives and mode shift of freight from road to rail and people from road to active, public and shared transport modes. Therefore, any non-asset options that involved reduction in commuter services and encouraged road usage (a full replacement of services with buses) or private car usage (discontinuation of regional commuter rails services) were discounted.

An investment in new assets is necessary to deliver critical regional passenger transport services and enable the growth in population and network demand forecast for the Wairarapa and Manawatū transport corridors. Without a timely intervention, the region faces an increasing risk of ceasing operating services due to inability to meet minimum safety requirements with its aged and extensively used 50-year-old fleet. This in turn will result in an inability to connect regions with social and economic opportunities.

4.5.1.2 Better use of existing assets

Further refurbishment of the existing fleet was considered in the long list of options but was discounted as it would require a significant rebuilt that could be technically challenging (or even potentially not achievable, as shown by the limited certification given to the recent refurbishment of the Te Huis and Capital Connection fleets). Strongly aligned with the government objectives, a timely investment in new assets will improve the overall resilience of the transport network and enable a safe public transport option on the Wairarapa and Manawatū corridors. This investment will support reduction in carbon emissions and facilitate mode shift from road to public transport. Therefore, while broader options were considered, only new asset options were shortlisted from the long list.

4.5.2 Network electrification

As discussed in Chapter 1 Introduction and Background, even though the current fleet is fully operated by diesel locomotives, both Wairarapa and Manawatū lines include parts of the Wellington electrified commuter network at 1,600 Volt (V) Direct Current (DC) for the first stage of the journey:

- from Wellington to Upper Hutt (32 km) on the Wairarapa line, and
- from Wellington to Waikanae (55 km) on the Manawatū line.

Meanwhile, the following sections of the network are currently not electrified:

- from Upper Hutt to Masterton (59 km) on the Wairarapa line, and

- from Waikanae to Palmerston North (81 km) on the Manawatū line.

Chapter 2 Strategic Context also referred to KiwiRail's feasibility study of track electrification of the North Island Main Truck (Auckland to Wellington), outcomes of which can be a key dependency or constraint for LNIRIM. Therefore, the option assessment needed to consider possible options for flexibility in the propulsion systems to accommodate potential future changes.

4.5.3 Alternative propulsion options

The long list of options included a broader consideration of potential propulsion options as technology has evolved since the IBC development. The long list of options also considered contemporary solutions, tested in the market sounding exercise conducted for the DBC, such as hydrogen and alternative fuels:

- Hydrogen fuel options were not shortlisted due to the low maturity of the hydrogen industry in New Zealand. While it may become a compelling option for the NIMT or South Island in the future should electrification not progress, hydrogen options were not shortlisted due to:
  - the timescales involved in providing supporting infrastructure
  - the maturity of green hydrogen production in New Zealand and worldwide
  - the immaturity of the technology on trains fitting New Zealand's gauge, and
  - the low appetite and competition in the market.

  More details are provided in Appendix D.
- Alternative fuels, for which no established supplied chains exist yet in New Zealand, could be used in the future if the rolling stock relies on a CI engine, which can help reduce the emissions and include the following:
  - gas to liquid (GTL) fuel is a diesel substitute derived from natural gas and can be used with existing diesel infrastructure with no modification, while infrastructure can be returned to diesel use if required with no modification
  - a dual-fuel modification to diesel multiple units involves the installation of additional fuel tanks and control technology, which enables the engine to be fuelled both with diesel and natural gas, and determine the fuel mix for greatest economy and lowest emissions
  - hydro-treated vegetable oil (HVO) is a more recent development in alternative fuels that can be a viable alternative to diesel, which involves the hydro-treatment of vegetable oils or animal fats.

4.5.4 Partial electrification

Given a large portion of the routes on both Wairarapa and Manawatū lines are not electrified, some options considered potential partial electrification. Two approaches to partial electrification were considered - discontinuous electrification and smart or hub electrification. Key considerations on partial electrification include the following:

- Shortlisted options utilise hub electrification where wired sections could serve as a 'hub', from which operation on unwired sections could be supported by batteries, charged whilst at the hub.
- Stations would make suitable hubs because it is where the train will spend a significant amount of time (for charging batteries) for a given amount of wired section. Additionally, the energy-consuming acceleration away from the station could be on a wired section, turning what would otherwise be a heavy demand on battery usage into extended battery charging instead.
- As the unit enters the wired zone, a passive balise[134] would signal the unit to raise its pantograph, shut off battery power and then close the vacuum circuit breaker (VCB) to draw power from the wire. This

[134] A balise is an electronic beacon or transponder placed between the rails of a railway as part of an automatic train protection system.

could also be achieved manually as is the case with the Intercity Express Programme (IEP) units. However, a passive balise is a low-cost solution that can maximise effective time under the wires.

- Once on the move again, and as the units start braking in preparation for the next station stop, the regenerated kinetic energy would also be diverted to the battery recharging circuit. The unit then continues to recharge from the wire whilst at the station stop and as power is retaken for traction to accelerate the train away from the station. As the unit approaches the end of the electrified section, a second passive balise opens the VCB, switches the unit to battery power, and then lowers the pantograph.
- In addition, unless the non-electrified section to the terminus is short, it may be necessary also to electrify the terminus station. This could be managed differently, by fitting an auto-coupler arrangement to the buffer stop, enabling the unit to recharge through a special power plug, by "coupling up" in the same manner as coupling to another unit.

Section 4.6 provides descriptions of shortlisted options and their key characteristics.

4.6 Shortlisted option assessment

4.6.1 Approach to shortlisting

The IBC longlist of options was revised for contemporary practices and alternative propulsion choices. This DBC leveraged the IBC's shortlist of options, revised and complemented it with the contemporary market solutions, especially the emerging use of batteries, which were taken forward to the DBC shortlist. In shortlisting the longlist of options, this DBC considered the following aspects:

- Alignment with GPS2021
- Total project timescales
- Impact on any future infrastructure enhancements
- Contribution to reducing the carbon emissions
- Complexity of technology required, including supplier capacity to deliver will be explored in the market sounding activities
- Whether the approach fits in with the wider vision for the Wellington and Horizons regions
- Technology advances and established practices since IBC compilation.

4.6.2 Shortlisted options

Table 4-6 provides a summary of shortlisted options and how they relate to the IBC options.

Table 4-6 Brief description of shortlisted options[135]

Option group	Option	Brief description
	Option 1: EMU (1600V DC) + 1600V DC partial electrification + buses beyond Featherston and Ōtaki + increased services (Option 3 of the IBC)	• Buy new 1600V DC EMUs and buses. • Extend 1600V DC electrification to Featherston and Ōtaki, enabling EMU operations to those points with bus connections from outer points. • Develop further infrastructure upgrades: stabling, maintenance facilities/depots, track works. • Increase Wairarapa and Manawatū service levels.
	Option 2: B-DMU + increased services (Option 4 of the IBC, modified for changes in the contemporary practices, such as an addition of batteries)	• Buy new B-DMUs with CI generator with additional battery power. • Develop infrastructure upgrades: stabling, maintenance facilities/depots, track works (no further electrification). • Increase Wairarapa and Manawatū service levels.
Option 3: B-EMU options	Option 3-1: B-EMU (1600 V DC + extra battery) + no further electrification + increased services	• Buy new B-EMUs (1600V DC + extra battery) • Develop infrastructure upgrades: stabling and maintenance facilities/depots, track works (no further electrification). • Increase Wairarapa and Manawatū service levels.
Option 3: B-EMU options	Option 3-2: B-EMU (dual voltage + battery) + 25 kV AC partial electrification + increased services	• Buy new B-EMUs (dual voltage + battery). • Add partial electrification at 25 Kv. • Develop further infrastructure upgrades: stabling, maintenance facilities/depots, track works. • Increase Wairarapa and Manawatū service levels.
Option 3: B-EMU options	Option 3-3: B-EMU (1600 V DC + battery) + 1600 V DC partial electrification + increased services	• Buy new B-EMU fleet (1600V DC + battery). • Add partial electrification at 1600 V DC. • Develop further infrastructure upgrades: stabling, maintenance facilities/depots and track works. • Increase Wairarapa and Manawatū service levels.
Option 4: Tri-mode options	Option 4-1: Tri-mode (1600 V DC + battery + CI) multiple units + no further electrification + increased services (Option 5 of the IBC, modified for changes in the contemporary practices, such as an addition of batteries)	• Buy new tri-modes (1600 V DC + battery + CI). • Develop infrastructure upgrades: stabling, maintenance facilities/depots and track works (no further electrification). • Increase Wairarapa and Manawatū service levels.
Option 4: Tri-mode options	Option 4-2: Tri-mode (1600 V DC + battery + CI + 25 kV AC provision) multiple units + no further electrification + increased services (Option 5 of the IBC, modified for changes in the contemporary practices, such as an addition of batteries and dual-voltage provision)	• This option is the same as 4-1 but includes provision for dual voltage from the initial design phase. This option allows for a potential use of a 25kV electrified network, should the lines be further electrified in the future.
	Option 5: EMU (dual voltage) + 25 kV AC electrification over full current non electrified route sections + increased services (Option 6 of the IBC)	• Buy new dual-voltage EMUs (1600V DC + 25kV AC). • Fully electrify to Masterton and Palmerston North at 25kV, extending EMU operations to those points. • Develop infrastructure upgrades: stabling, maintenance facilities/depots and track works. • Increase Wairarapa and Manawatū service levels.

[135] EMU = electric multiple unit, B-DMU = battery-diesel multiple unit, B-EMU = battery-electric multiple unit

With the recent acceleration of technology development and maturity in battery technology, any new rolling stock of a multi-mode nature should also take advantage of battery technology to at least capture regenerative braking energy for re-use.

For example, manufacturers are moving away from pure DMU solutions, which was confirmed by the market sounding, and increasingly include batteries (B) in the DMU option. Therefore, the original IBC's DMU option was modified and included in the shortlist of options as B-DMU (option 2). Similarly, the original IBC's option of bi-mode multiple units (BMUs), which included diesel-electric multiple units, was also modified to include batteries and taken forward to the shortlist of options as a tri-mode option (option 4).

BMUs, trains that can operate using both overhead electrification and CI engines, were created around 20 years ago in Great Britain as a method to reduce the reliance on diesel traction while also not carrying out any further electrification. The main concept was to enable what would otherwise need to be a diesel unit to operate utilising the overhead wire for the portion of the journey that was under that overhead wire. This was particularly valuable for services such as Aberdeen to London where the railway was electrified between London and Edinburgh but the trains operating that service were utilising diesel traction for the whole length of the route.

Following the successful introduction of BMUs, and with the recent technological improvements in battery capacity, units that can work away from overhead wires have been developed in the form of battery-electric multiple units (B-EMUs) and TMUs. Currently the use of B-EMUs is limited by the range away from the electrified line achievable before the battery requires recharging. However, TMUs do not have that limitation as they are fitted with CI engines as well as using the overhead line and on-board batteries.

The benefits of the TMU over the BMU is that the battery can be:

- used to store energy captured during braking, which would otherwise be lost in off-wire mode
- charged while under the overhead wires
- provide a boost to the CI engine during acceleration
- once battery capacity technology improves further, replace the remaining CI engine(s).

Additionally, a TMU with the CI engine can be run at a more constant speed which generates even further savings. Estimations of the savings for a TMU over a BMU range from a 25% saving in fuel (and consequent reduction in emissions) for a unit with a small (1 km) range battery to a 50% saving with batteries replacing ½ to ¾ of the CI engine capacity. Given the fuel saving benefits and emissions reductions that can be achieved and given that the TMU concept is becoming a standard offering from manufacturers, the BMU offering is becoming obsolete and has, therefore, been discounted from this analysis.

The DBC shortlist also includes B-EMU options with and without further electrification to reflect contemporary battery technologies that have changed since the IBC.

All options assume a completion of the current fleet's light refurbishment to then operate and maintain the existing fleet up to FY2028, following which it is replaced with shortlisted options. Options 1 to 5 assume increased frequencies on both lines, as described in Section .

4.6.3 Description of shortlisted options

This section provides further descriptions of shortlisted options.

4.6.3.1 Option 1: EMU (1600 V) + partial electrification to Featherston/ Ōtaki + buses

Figure 4-9 and Figure 4-10 show option's train architecture and modes across parts of the routes.

Figure 4-9 Option 1 train architecture

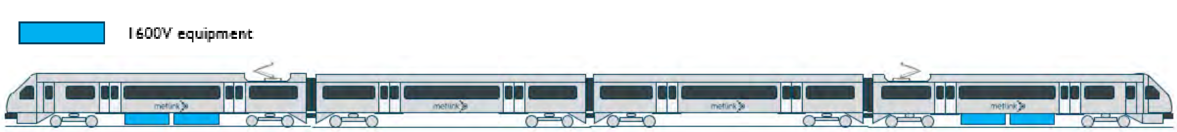
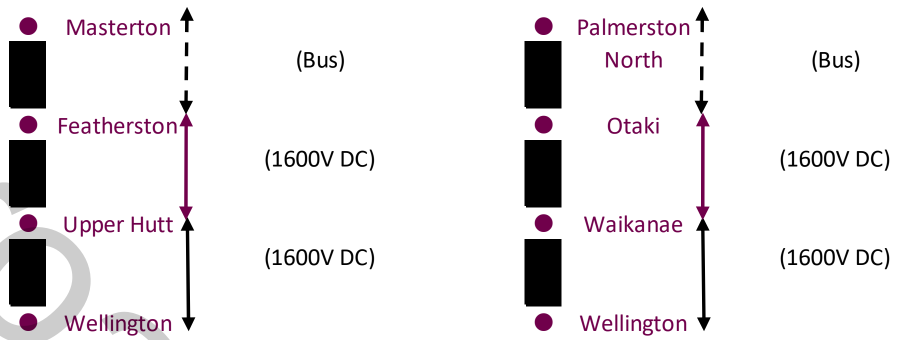


Figure 4-10 Option 1 propulsion modes



Option 1 assumes:

- maintaining the existing Wairarapa and Manawatū Line fleet and services until FY2028 when the fleet reached its useful life after the light refurbishment
- further electrifying the network between Upper Hutt and Featherston (2 stations) on the Wairarapa line and between Waikanae and Ōtaki (1 station) on the Manawatū line at 1600 V DC
- increasing service frequencies from FY2029 by purchasing and introducing new Electric Multiple Units (EMUs) in FY2029 and extending EMU operations to Featherston and Ōtaki, with bus connections linking these points to Masterton and Palmerston North.

This option was included in the IBC as option 3 and was carried forward to this DBC as option 1. Whilst the IBC did not explicitly indicate the new electrification would be an extension of the current 1600 V DC network, this assumption has been taken due to the following reasons:

- It is unlikely that regularly used routes that originate in Wellington with 1600 V DC metro network are electrified to anything other than 1600 V DC for 1-2 station electrified network extensions unless the Wellington commuter network is also electrified to 25 kV. Additionally, the Matangi trains used in the electrified metro area utilise 1600 V DV and are not up for renewal for more than two decades.
- The electrification changeover would make sense at the end of a distinct service rather than part way through it.

This option assumes purchasing similar rolling stock to the Matangi EMUs' that are in use on the 1600 V DC metro Wellington network.

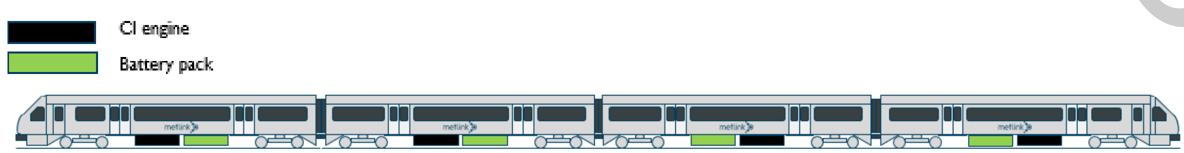
This option assumes the use of high-quality, high-capacity bus connections to all rail services at Featherston and Ōtaki to maintain public transport links to all towns that currently have rail services on each corridor north of those points to Masterton and Palmerston North.

New assets needed for this option include 12 EMUs and 8 to 10 buses to service these lines, extension of Overhead Line Electrification (OHLE) and supporting infrastructure to Featherston and Ōtaki, new stabling facilities, expanded park and ride and bus transfer facilities in Featherston and Ōtaki and expanded EMU maintenance facilities and stabling yards.

4.6.3.2 Option 2: B-DMU (CI + battery)

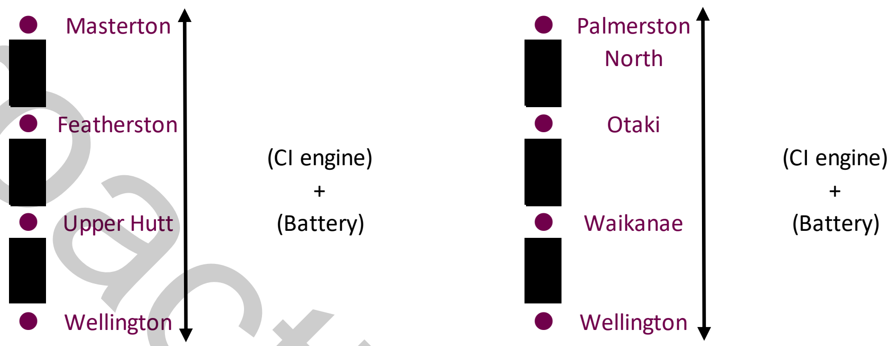
Figure 4-11 and Figure 4-12 show option's train architecture and propulsion modes across parts of the routes.

Figure 4-11 Option 2 train architecture



On a B-DMU, a generator/motor is placed within the mechanical drive train between the CI engine and the final drive gearbox. The battery can be charged by running the engine and by regenerative braking. The battery energy can then be used to boost the CI engine or to run the unit for a short distance without the CI engine running.

Figure 4-12 Option 1 propulsion modes



Option 2 assumes:

- maintaining the existing Wairarapa and Manawatū Line fleet and services until FY2028 when the fleet reached its useful life after the light refurbishment
- purchasing and introducing a new Battery Diesel Multiple Unit (B-DMU) fleet and improving service levels from FY2028.

This option was included in the IBC as option 4, a new DMU fleet, and was revised in this DBC to include battery. It was informed by market sounding: a few manufacturers have adopted a strategy based on no longer offering any DMUs for market. B-DMU will likely become the base offering for the remaining manufacturers available to New Zealand.

Research of the current market indicates an approximate 80 km battery range that would allow running zero carbon emissions in station/populated areas along the line. The battery technology is expected to advance with the time passage allowing that range to be further extended in the later lifecycle of the trains. At a minimum, the battery can be used to capture regenerative braking energy for re-use.

New assets needed for this option include 22 4-car B-DMUs to service these lines based on the demand projections and considering the aspirational LNIRIM timetable provided by GWRC, described in Chapter 5 Preferred Solution, and include all infrastructure covered in the do-minimum base case, expanded and new stabling facilities, and new DMU maintenance facilities.

4.6.3.3 Option 3-1: B-EMU (1600 V DC + extra battery)

Figure 4-13 and Figure 4-14 show option's train architecture and propulsion modes across parts of the routes.

Figure 4-13 Option 3-1 train architecture

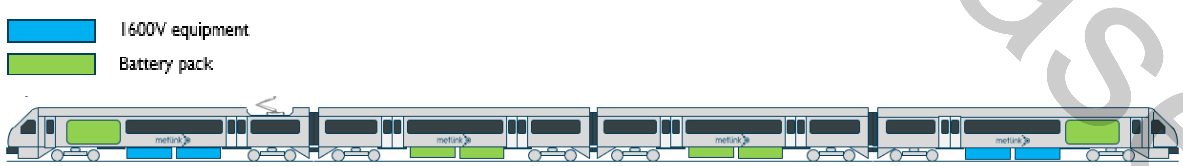
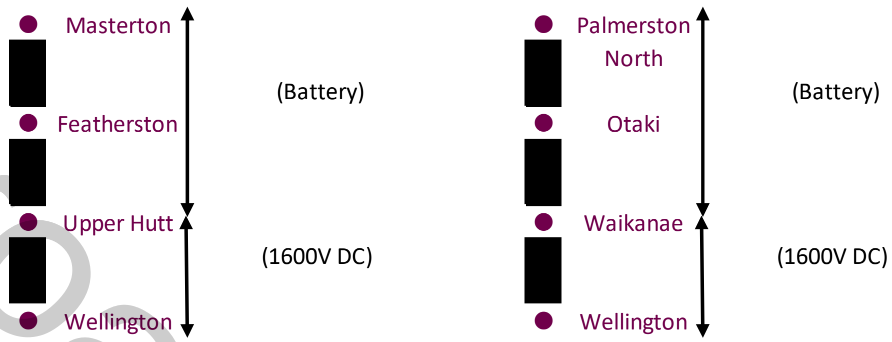


Figure 4-14 Option 3-1 propulsion modes



Option 3-1 assumes:

- maintaining the existing Wairarapa and Manawatū Line fleet and services until FY2028 when the fleet reached its useful life after the light refurbishment
- purchasing and introducing a new B-EMU fleet with extra battery capacity to service on the non-electrified parts of the routes and improving service levels from FY2028.

This option was not previously included in the IBC and included in this DBC due to advances in battery technology since the development of the IBC.

Option 3-1 involves electric multiple units with an additional battery power source to provide self-power capability. This option utilises the existing 1600 V DC network and assumes sufficient batteries on board to run for the remainder of the routes to Palmerston North and Masterton. This option does not warrant any infrastructure changes and does not require any further electrification as batteries will be charged once back on the electrified network. However, reduced seating capacity would be required to accommodate the additional batteries to support operating over the required distances.

New assets needed for this option include 22 B-EMUs (1600 V DC + battery) based on the assumed timetable provided by GWRC and demand projections and include stabling facilities, and new B-EMU maintenance facilities.

4.6.3.4 Option 3-2: B-EMU (1600 V DC + battery) + 25 kV AC partial electrification

Figure 4-15 and Figure 4-16 show option’s train architecture and propulsion modes across parts of the routes.

Figure 4-15 Option 3-2 train architecture

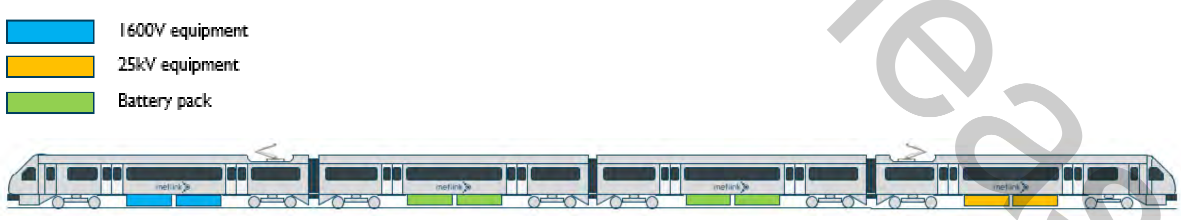
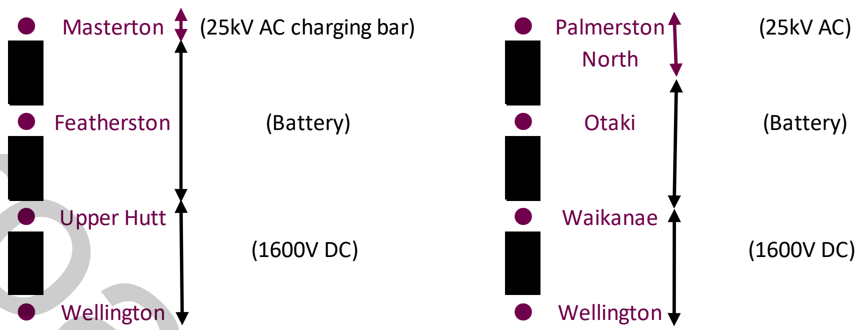


Figure 4-16 Option 3-2 propulsion modes



Option 3-2 assumes:

- maintaining the existing Wairarapa and Manawatū Line fleet and services until FY2028 when the fleet reached its useful life after the light refurbishment
- develop 25k V AC hub electrification comprising of charging bar at Masterton for the Wairarapa line. For the battery pack to extend to the full range of 80 km comfortably in both directions for completion of a return journey, approximately 9 km electrification approaching Palmerston North station will also be required will be required for the Manawatū line.
- purchasing and introducing a new B-EMU fleet and improving service levels from FY2029.

This option was not previously included in the IBC and included in this DBC due to advances in battery technology since the development of the IBC. Similar to Option 3-1, Option 3-2 involves electric multiple units with an additional battery power source to provide self-power capability. However, this option includes some form of 25 kV partial electrification, allowing batteries to be charged at both ends of the running line, therefore, requiring less batteries on board on board than Option 3-1.

New assets needed for this option include 22 new B-EMU based on the assumed timetable provided by GWRC and demand projections and include all infrastructure covered in the do-minimum option, partial electrification on both lines at 25 kV AC, stabling facilities, and new B-EMU maintenance facilities.

4.6.3.5 Option 3-3: B-EMU (1600 V DC + battery) + 1600 V DC partial electrification

Figure 4-17 and Figure 4-18 show option's train architecture and propulsion modes across parts of the routes.

Figure 4-17 Option 3-3 train architecture

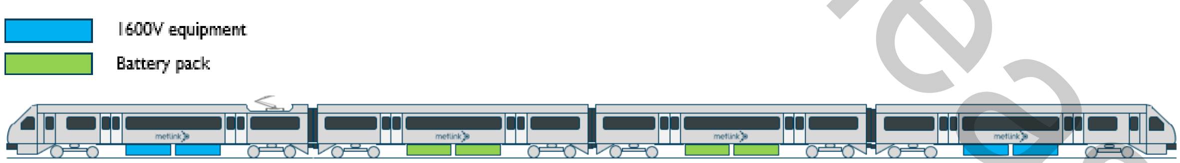
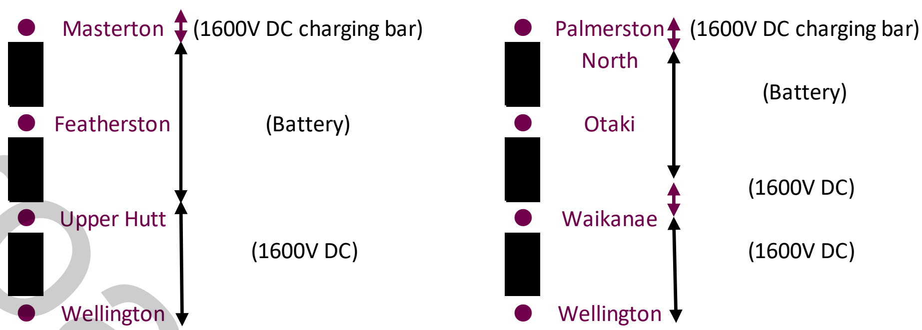


Figure 4-18 Option 3-3 propulsion modes



Option 3-3 assumes:

- maintaining the existing Wairarapa and Manawatū Line fleet and services until FY2028 when the fleet reached its useful life after the light refurbishment
- develop 1600 V DC hub electrification comprising of a charging bar at Masterton for the Wairarapa line. For the battery pack to extend to the full range of 80 km comfortably in both directions for a return journey, approximately 8 km electrification extension post Waikanae and a charging bar at Palmerston North will be required for the Manawatū line.
- purchasing and introducing a new B-EMU (1600 V DC + battery) fleet and improving service levels from FY2029.

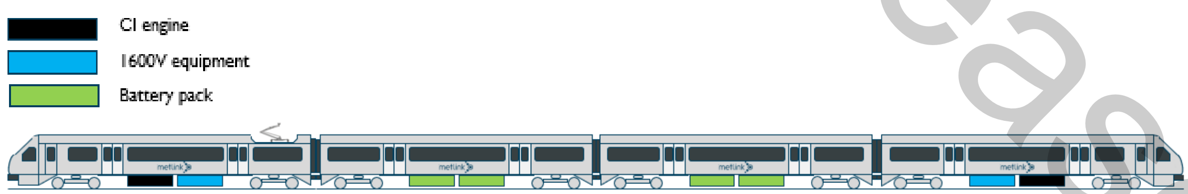
This option was not previously included in the IBC and included in this DBC due to advances in battery technology since the development of the IBC. Similar to Option 3-2, Option 3-3 involves electric multiple units with an additional battery power source to provide self-power capability. However, unlike Option 3-2, this option includes some form of 1600 V partial electrification, allowing batteries to be charged at both ends of the running line, therefore, requiring less batteries on board than option 3-1.

New assets needed for this option include 22 new B-EMU based on the assumed timetable provided by GWRC and demand projections and include all infrastructure covered in the do-minimum option, partial electrification on both lines at 25 kV AC, stabling facilities, and new B-EMU maintenance facilities.

4.6.3.6 Option 4-1: Tri-mode (1600 V DC + CI generator + battery)

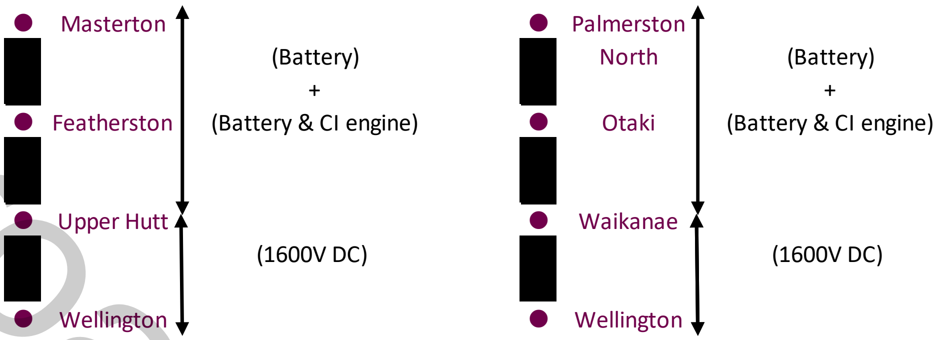
Figure 4-19 and Figure 4-20 show option's train architecture and propulsion modes across parts of the routes.

Figure 4-19 Option 4-1 train architecture



On a TMU, the CI engine has no mechanical drive and is connected to a generator. When in electric mode, the power is sourced from the overhead line for both traction and to recharge the battery. Energy from regenerative braking is used to charge the battery until the battery is fully charged when the energy is returned to the overhead line. In self-power mode, traction power is sourced from the battery or a combination of the battery and the CI engine. Energy from regenerative braking is used to recharge the battery. Additionally, the CI engine can be used to charge the battery.

Figure 4-20 Option 4-1 propulsion modes



Option 4-1 assumes:

- maintaining the existing Wairarapa and Manawatū Line fleet and services until FY2028 when the fleet reached its useful life after the light refurbishment
- purchasing and introducing a new tri-mode (1600 V DC + CI generator + battery) fleet and improving service levels from FY2029.

As described in Section 4.6, the TMU option (1600 V DC + CI generator + battery) replaces the proposal of the bi-mode train (1600 V DC + CI engine) listed in the IBC. This is due to the advantages and shift in propulsion mode options since the IBC development.

This option assumes utilising the existing 1600 V DC network in place from Wellington to Upper Hutt and from Wellington to Waikanae and utilising a CI engine as well battery on the non-electrified parts on the lines. The battery technology is expected to advance with the time passage allowing that range to be further extended in the later lifecycle of the trains, while reducing reliability on any form of diesel fuel over time.

New assets needed for this option include 22 new tri-mode (1600 V DC + battery + diesel) fleet based on the assumed timetable provided by GWRC and demand projections and include all infrastructure covered in the do-minimum option, expanded and new stabling facilities, and new maintenance facilities.

4.6.3.7 Option 4-2: Tri-mode (1600V DC + CI generator + battery + 25 kV provision)

Figure 4-21 and Figure 4-22 show option's train architecture and propulsion modes across parts of the routes.

Figure 4-21 Option 4-2 train architecture

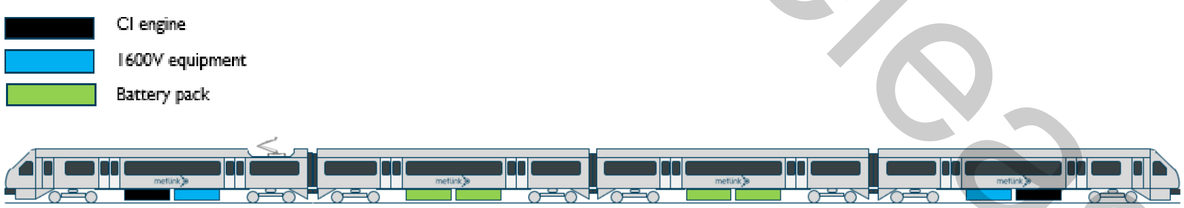
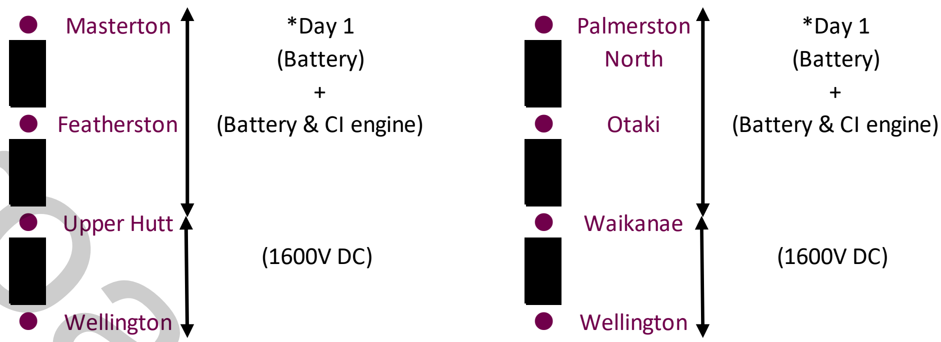


Figure 4-22 Option 4-2 propulsion modes



Option 4-2 assumes:

- maintaining the existing Wairarapa and Manawatū Line fleet and services until FY2028 when the fleet reached its useful life after the light refurbishment
- purchasing and introducing a new tri-mode (1600 V DC + CI generator + battery + 25 kV provision) fleet and improving service levels from FY2029.

This option is the same as 4-1 but provides an additional provisioning for dual voltage. The main difference with option 4-1 would be in design phase to pre plan future potential removal of CI engine and addition of electrical equipment for 25kV overhead line usage, namely transformers and rectifiers. This option has a flexibility of transforming to a B-EMU fleet (dual voltage + battery), should further electrification of the network happen in the future.

New assets needed for this option include 22 new tri-mode (1600 V DC + battery + CI + 25 kV provision) fleet based on the assumed timetable provided by GWRC and demand projections and include all infrastructure covered in the do-minimum option, expanded and new stabling facilities, and new maintenance facilities.

4.6.3.8 Option 5: EMU (dual voltage) + 25 kV AC electrification across full current non electrified lines

Figure 4-23 and Figure 4-24 show option's train architecture and propulsion modes across parts of the routes.

Figure 4-23 Option 5 train architecture

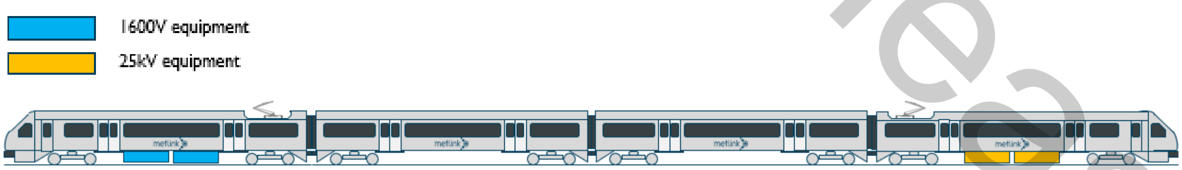
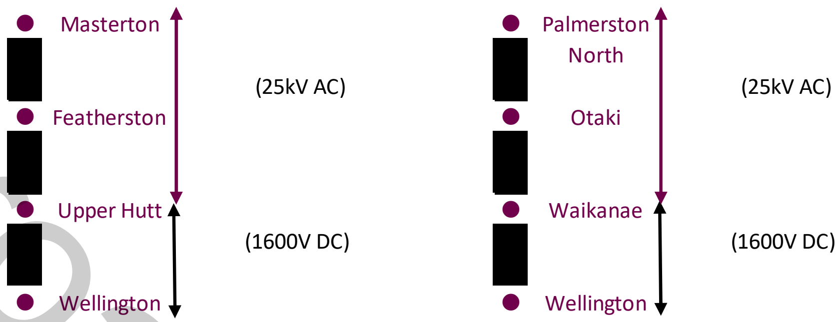


Figure 4-24 Option 5 propulsion modes



This option was included in the IBC as Option 6 and was carried forward to this DBC.

Option 5 assumes full electrification to Masterton and Palmerston North of the remaining non-electrified parts of the routes at 25 kV AC, extension of EMU operations to those points and improvement of service levels from FY2029.This option assumes a fixed formation train taking traction power from overhead wires from both the existing 1600 V DC network and the proposed 25 kV AC electrification.

New assets needed for this option include 22 new EMU fleet based on the assumed timetable provided by GWRC and demand projections and include all infrastructure covered in the do-minimum option, full network electrification from Upper Hutt to Masterton and from Waikanae to Palmerston North, expanded and new stabling facilities, and new maintenance facilities.

4.7 MCA assessment

A MCA was used to assess the shortlisted options, compared to the base case scenario, to inform decision making and identify the preferred option.

4.7.1 Approach

Following the development of the IBC, Waka Kotahi issued updated MCA Guidelines in August 2020[136], which this DBC has followed in the development and assessment of options. Additionally, numerous national and regional strategies were updated during 2020 and 2021, emphasising emerging focus areas such as climate change and carbon neutrality. Therefore, both the scoring system and MCA criteria used for this DBC vary from the IBC. Table 4-7 shows the MCA scoring system and definitions of scores used in this DBC. The scoring allows for enhanced differentiation between options by using a 7-point scale from -3 to +3. The options are scored relative to the 'do-minimum' base case, which records neutral scores for all criteria as a baseline. The total score for each option is calculated as a weighted average score (MCA criteria scores are influenced by the weights of each criteria).

[136] Source: Waka Kotahi. Multi-Criteria Analysis: User Guidance. August 2020. Accessed on: https://www.nzta.govt.nz/assets/resources/planning-policy-manual/docs/multi-criteria-assessment-user-guidance.pdf

Table 4-7 MCA scoring

Magnitude	Description	Score
Large positive (+++)	Major positive impacts resulting in substantial and long-term improvements or enhancements of the existing environment.	+3
Moderate positive (++)	Moderate positive impact, possibly of short-, medium- or long-term duration. Positive outcome may be in terms of new opportunities and outcomes of enhancement or improvement.	+2
Slight positive (+)	Minimal positive impact, possibly only lasting over the short term. May be confined to a limited area.	+1
Neutral (x)	Neutral – no discernible or predicted positive or negative impact.	0
Slight negative (-)	Minimal negative impact, possibly only lasting over the short term, and definitely able to be managed or mitigated. May be confined to a small area.	-1
Moderate negative (--)	Moderate negative impact. Impacts may be short, medium or long term and are highly likely to respond to management actions.	-2
Large negative (---)	Impacts with serious, long-term and possibly irreversible effect leading to serious damage, degradation or deterioration of the physical, economic, cultural or social environment. Required major rescope of concept, design, location and justification, or requires major commitment to extensive management strategies to mitigate the effect.	-3

The MCA assessment uses 12 criteria with assigned non-zero weights consisting of 6 criteria reflecting investment objectives, which contribute to 60% of the total option score, and the remaining 6 criteria relating to critical success factors, contributing to 40% of the total option score. Two additional mandatory opportunities and impacts were considered through other criteria and were assigned weights of zero to avoid double-counting. Investment objectives were determined in consultation with the Steering Committee members as part of the strategic case to address defined problems and opportunities. Critical success factors highlighted other areas important for successful delivery. Weights of each individual criterion reflected relative importance of those criteria. To test the sensitivity of outcomes, a sensitivity analysis using equal weights was also performed, which confirmed the outcomes.

The number of criteria is within Waka Kotahi recommended range of 8 to 12 criteria in an MCA and no more than 15. These MCA criteria aimed to assess the options' strategic alignment, target benefits and to reflect relative effects of options.

4.7.2 MCA Evaluation

The options were initially assessed against the MCA criteria in a facilitated workshop collaboratively with GWRC and project team technical experts. The MCA assessment was further confirmed with the broader members of the PSC delegates in a workshop with GWRC, Transdev, Horizons, KiwiRail and Waka Kotahi on 6 July 2021. Figure 4-25 summarises the results of this assessment, including weights applied to each criterion. This figure also provides a rapid benefit-cost ratio (BCR) over 40 years of operations.

A cost benefit analysis (CBA) is an approach that compares lifecycle costs and benefits of a proposed investment in real terms (that is, excluding financial transfers such as price escalation) relative to the status quo including minimum investments to maintain service levels and other committed investments (that is, a Do Minimum Base Case). The MCA process also included a Rapid CBA. A Rapid CBA is used as either a first step in establishing whether an initiative is worth developing further, or where there is a small-scale initiative, and the costs of sub-optimal decisions would be small. The key differences relative to a detailed appraisal are that the rapid appraisal focuses on the most significant costs and benefits (i.e. fewer elements are quantified), which may be estimated with less accuracy reflecting the stage of Project development (e.g. strategic rather than probabilistic capital cost estimates). A more detailed economic appraisal includes a detailed CBA, sensitivity analysis, as well as qualitative considerations (e.g. additional benefits/distribution).

Section 4.6.2 summarises shortlisted options. Sections 4.7.2.1, 4.7.2.2 and 4.7.2.3 provide detailed explanations of scoring.

Figure 4-25 Multi-Criteria Analysis outcomes

#	Criteria	Weight	Do-min.	O1	O2	O3-1	O3-2	O3-3	O4-1	O4-2	O5
	Investment Objectives (IO)										
1	Improve connectivity and access to opportunities through safe and reliable transport options on the corridors **(reliability)**	11%	x	--	+++	-	+++	+++	+++	+++	+++
2	Improve connectivity and access to opportunities through safe and reliable transport options on the corridors **(safety)**	11%	x	--	+++	+++	+++	+++	+++	+++	+++
3	Improve corridor capacity by providing for forecast demand for regional travel on the corridors **(capacity & crowding)**	11%	x	--	+++	+	+++	+++	+++	+++	+++
4	Improve attractiveness of land public transport within the corridors **(frequency, accessibility & travel time)**	11%	x	---	+++	+++	++	++	+++	+++	+++
5	Reduce carbon emissions related to commuter travel within the corridors **(CO2 emissions from fleet & mode shift)**	11%	x	---	+	+++	+++	+++	++	++	+++
6	Increased network productivity and efficiency of operation of transport services **(efficiency)**	5%	x	---	++	+	++	++	++	++	+++
	Critical Success Factors (CSF)										
7	Technical achievability	6%	x	+++	+++	--	+	+++	+++	++	++
8	Consideration of broader networks	6%	x	--	+++	x	++	x	+++	+++	x
9	Public acceptability	6%	x	---	+	+++	+++	+++	+++	+++	++
10	Affordability capital	10%	x	-	-	-	-	-	-	-	---
11	Affordability operational/maintenance	6%	x	+++	++	++	+	++	++	++	+
12	Delivery timeframes	6%	x	---	+++	+	--	--	+++	++	---
	Opportunities and impacts (OI)										
13	Climate Change mitigation (mandatory)	0%	Covered through criterion 5								
14	Impacts on Te Ao Māori (mandatory)	0%	Covered through criteria 1, 3, 4, 9								
	MCA score			-1.69	2.15	1.18	1.84	1.90	2.38	2.26	1.62
	Ranking			8	3	7	5	4	1	2	6
	Capital cost (not to be scored), real $M non-discounted			(175+ bus)	316	362	392	384	330	335	747
	Operation & maintenance cost[137] (not to be scored), real $M non-discounted			(543+ bus)	1,070	1,037	1,035	987	1,058	1,088	1,136
	Rapid CBA				1.51				1.52	1.46	
	Scenario: MCA score (equal weights)			*-1.50*	*2.17*	*1.08*	*1.67*	*1.75*	*2.42*	*2.25*	*1.42*
	Scenario: Ranking (equal weights)			*8*	*3*	*7*	*5*	*4*	*1*	*2*	*6*

Scoring legend:

Large positive (+++)	Moderate positive (++)	Slight positive (+)	Neutral (x)	Slight negative (-)	Moderate negative (--)	Large negative (---)

[137] Over the assumed operations period of 40 years

4.7.2.1 Investment Objectives (IO)

Criterion 1. Improve connectivity and access to opportunities through safe and reliable transport options on the corridors (reliability)

This criterion is a cumulative measure of:

- network reliability
  - the extent options improve the resilience of the Wairarapa and Manawatū transport corridors (including interfaces with both road and rail travel as well as passenger and freight)
  - the ability to provide punctual services regardless of the root cause (public performance measure).
- system reliability
  - the complexity of technology that may impact technical reliability and potential for a failure of the rolling stock element.

All options involving new rolling stock would provide benefits of a more reliable fleet than the base case.

Option 1's rail part of the trip would be relatively reliable involving a single electricity power source for EMUs. However, connecting bus services and needed change in type of transport will impact likely reliability due to the varied traffic conditions, potential congestion, onboarding and disembarking of passengers.

Options 2, 4-1 and 4-2 consist of double CI engines on board of a 4-car consist. The train can run on half power if one engine fails in service and which is not dependent on any OHLE failure.

Option 5 has an added reliance on the new OHLE installed. However, an EMU train including the configuration that described options 3-2 and 3-3 in Section 4.6.3, will typically benefit from higher miles between failure stock technical failure (MTIN), making options 3-2 and 3-3 also highly reliable.

Option 3-1 includes sole reliance on charging only on OHLE, increasing dependency on driving efficiency to cover the full range of off wire running, when compared to the base case. Utilising a battery range which is right on the edge of what is currently attainable is a risk that has been incorporated in the MCA scoring.

Criterion 2. Improve connectivity and access to opportunities through safe and reliable transport options on the corridors (safety)

This criterion refers to the alignment with modern standards (crashworthiness, fire, safety) and ability to safely connect regions with social and economic opportunities.

Options involving new rollingstock (Options 2, 3-1, 3-2, 3-3, 4-1, 4-2 and 5) are anticipated to be built to meet modern crashworthiness, fire, safety standards. While there could be a potential for fire risk of diesel or battery trains passing in a tunnel, any electric train would also pose potential risks of power outage and evacuation from the tunnels. As those risks are generally considered to have relatively low likelihood, those risks would not differentiate the rollingstock options.

While Option 1's new EMU services would also meet the safety standards, this option would involve bus travel on roads shared with other traffic, which would not reduce traffic volumes on roads to the same degree as the 'do-minimum' base case.

Criterion 3. Improve corridor capacity by providing for forecast demand for regional travel on the corridors (capacity & crowding)

This criterion captures:

- improvement in corridor capacity to serve commuters compared to the 'do-minimum' base case
- the extent the option's capacity allows for a full potential of mode shift and avoids overcrowding while supporting future population growth and land uses.

All shortlisted options assume increased service levels through increased services and the comfort of the new fleet.

For Option 1, buses generally have a lower seated capacity and less space on board than trains. While buses can be purchased in the quantity needed to reduce crowding on board, bus travel would impose additional pressure on already congested roads during peak times, therefore, reducing the overall capacity of the corridors.

Option 3-1 requires a significant amount of battery packs to allow the train to work off grid for the current non electrified distance on the Manawatū line. This would result in extra 4 tonnes of weight and up to an approximate potential of 25% reduced seating. The Wairarapa train could allow less space being required for batteries having a shorted distance to cover in length. However, this would then result in a different fleet for each line. The latter scenario has been discounted due to the lack of flexibility this would bring to the operational context of managing and operating the fleet as a whole. Therefore, assuming the same fleet is purchased for interchangeable use across line, there will be reduced capacity compared to other options even though improved compared to the 'do-minimum' base case.

For the frequency and type of service to be provided, there are no significant differences in terms of weight and space capacity that would warrant a different score for Options 2, 3-2, 3-3, 4-1 and 5. Compared to the 'do-minimum' base case, all options involve improved seating capacity in the driving cars compared to that of a locomotive train formation.

Criterion 4. Improve attractiveness of land public transport within the corridors (frequency, accessibility & travel time)

This criterion refers to:

- sufficient frequency to make the public transport option more attractive, activate latent demand and involve alignment with modern accessibility and customer standards
- the extent options include the removal of service frequency constraints due to operational requirements, for example, dwell and turnaround times.

As Option 1 includes connection with the bus service and the loss of a 'single seat' journey, this is likely to make this option less attractive for commuters, compared to the 'do-minimum' option. Additionally, option 1 may involve additional wait times for changes between rail and bus modes and buses would likely have less leg space and be less comfortable than modern trains.

All shortlisted options benefit from the acceleration improvements to that of a locomotive and LHCS train consist.

However, Options 3-2 and 3-3 would require dwell times to be added to all future timetables to allow battery charging to take place at either ends of the running line. Without this, the battery pack on board would not be able to complete the off-wire range required in a return journey.

For a battery of 700 kW/h, the assumed charging time for maximum battery range of 80 km would be 30 minutes. The assumed timetable that options have been assessed against could just allow this dwell time to be catered for. Therefore, the MCA scoring is moderately positive for Options 3-2 and 3-3 but would need to be considered in any future timetable planning.

Criterion 5. Reduce carbon emissions related to commuter travel within the corridors (CO2 emissions from fleet & mode shift)

This criterion is a combined effect of:

- the extent emissions can be reduced by shifting travel mode away from road
- the extent fleet emissions can be reduced
- alignment with modern emission standards.

Overall, mode shift from road to rail is considered to be a more material factor than fleet emissions. Increased frequency would offer a more attractive public transport option. Additionally, all new rollingstock fleet (rail component of option 1, Options 2, 3-1, 3-2, 3-2, 4-1, 4-2 and 5) would comply with Euro Stage V emissions standards, which is a higher standard than any second-hand LHCS would have been built to. All rollingstock options would significantly reduce carbon emissions compared to the 'do-minimum' base case.

However, buses in Option 1 would likely contribute to further road congestions and resulting increased CO_2 emissions from the traffic, even if bus fleet is decarbonised.

In terms of fleet emissions, Options 2, 4-1 and 4-2 train architecture includes a Stage V CI engine. However, the TMU options would consume less fuel than the B-DMU.

Table 4-8 Comparison of fuel consumption and carbon emissions, 2021/22 to 2068/69

	'Do-minimum'	Option 2	Option 4-1	Option 4-2
		Fuel Consumption		
Diesel Consumption (L)	50,221,827	91,592,744	32,913,866	33,054,604
Energy (kWh) – OLE	0	0	422,943,680	422,943,680
Energy (kWh) – Battery	0	388,913,728	388,913,728	388,913,728
		Carbon Emissions		
Diesel (kg CO2)	134,944,542	246,106,954	88,438,569	88,816,729
Energy – OLE (kg CO2)	0	0	3,129,783	3,129,783
Energy – Battery (kg CO2)	0	1,438,981	1,438,981	1,438,981
Total CO2 emissions (kg)	**134,944,542**	**247,545,935**	**93,007,333**	**93,385,493**

Climate Change Commission 2021 Advice for Consultation as well as the Wellington Regional Public Transport Plan 2021-2031's objectives highlight a critical role of transport sector decarbonisation to achieve the net zero emission targets. The Advice states that New Zealand can almost completely decarbonise land transport to meet the 2050 targets[138]. Therefore, Options 3-1, 3-2, 3-3 and 5 achieve the highest scoring in this category as aligning with this aspiration.

Criterion 6. Increased network productivity and efficiency of operation of transport services (efficiency)

This criterion refers to a potential for interoperability, streamlined maintenance and operation arrangements and the extent of a reduction in operating risks.

In Option 1, operation of bus services and coordination of rail and bus timetables would introduce additional complexities of planning, operation and maintenance, which could include multiple parties. Additionally, the new fleet of buses would require additional bus depot space and a larger number of drivers.

Option 5 provides a simple and streamlined service in terms of efficiency of operations, with OHLE lifecycle lengths doubling typical life spans for rolling stock.

Option 3-1 contains the operational risk associated with driving efficiency to allow battery range to cover the full return journey.

All other options do not contain significant risks for the type of service to be provided to differentiate them under this criterion. They would be a marked improvement from the 'do-minimum' base case in terms of multiple units' working arrangements and being able to interchange vehicles across both lines if necessary.

[138] Source: Climate Change Commission. Accessed on 5 March 2021 on: https://www.climatecommission.govt.nz/

A battery or CI engine on board may also provide at minimum a rescue mode should OHLE issues occur on the network.

4.7.2.2 Critical Success Factors (CSF)

Criterion 7. Technical achievability

This criterion covers technical or practical considerations and technical risks involved in developing or implementing this option that may prevent an option from achieving investment objectives.

All options are technically achievable. However, Option 3-1 relies on a battery range above what is currently being offered in the market and presents a higher risk in technical achievability.

Option 3-2 requires dual voltage equipment installed as well as battery equipment and this configuration would need to be further evaluated to suit a narrow-gauge train application.

Option 5 on the rolling stock achievability scores highly but involves potential challenges with installation of 25kV AC across the full length of the current non electrified parts of the lines.

Option 4-2 requires design analysis on the best way to incorporate 25 kV AC provision as this would be a bespoke product.

Options 1, 2, 3-3 and 4-1 score highly as similar trains of these types have been successfully delivered. One example of a tri-mode multiple unit is the Stadler FLIRT, which uses 25 kV OHLE and an on-board traction battery power supply. A diesel-electric power supply enables batteries to be charged. The three and four-car units will operate on the South Wales railway network in the UK.

Criterion 8. Consideration of broader networks

This criterion relates to considerations for broader network and compatibility or scalability of the rollingstock platform, while reducing investment redundancies.

While Option 1's buses may be able to be used for broader networks, they will not be able to be used if roads do not duplicate rail routes elsewhere in New Zealand. Additionally, buses may not be able to be scaled due to road congestion and carbon aspects. The rail part of the journey relies solely on electricity propulsion at 1600 V DC, which would be limiting.

Using the same rationale above, Options 3-1 and 3-3 is also very limited to work beyond the battery range as 1600V DC is not an OHLE configuration in use elsewhere and would be the required power source for battery charging. Option 3-2 has the advantage of being able to run on 25 kV AC and could, therefore, be utilised between Auckland and Hamilton.

Option 5 has an advantage of being utilised on any 25 kV or 1600 V electrified network, but 1600 V DC OHLE is very limited outside of the Wellington region.

Options 2, 4.1 and 4.2 could run on any network regardless of electrification due to CI engine on board.

Criterion 9. Public acceptability

This criterion refers to attractiveness to the wider public and public interest considerations.

The increase in services and new asset conditions and comfort for all shortlisted options would likely be seen as a positive change, compared to the 'do-minimum' base case.

Option 1 does not assist the decongestion of the road to the same degree as other rail options. Additionally, such option would likely be perceived largely inconvenient for regional commuters who would have to change transport modes over their journey. The wider public may see this option as a reduction in service quality and accessibility for regional communities.

For Option 2, the wider public may unfavourably see any investment in new fleet that would potentially rely on diesel over a large part of the route. Option 2 may be perceived slightly negatively by the wider public due to any associated carbon emissions. However, the fleet would have a relatively small contribution of the overall CO2 emissions compared to emissions from road users.

While overall positive, Option 5 may involve other environmental and property issues, especially for farming communities on the corridor. There could also be potential safety concerns for any people entering restricted areas or farm animals crossing the electrified lines.

Options 3-1, 3-2, 3-3, 4-1, 4-2 could be seen as a progressive way forward, with commitment to carbon reduction without significant change to the surrounding infrastructure and score the highest against this criterion.

Criterion 10. Affordability capital

This criterion refers to the capital investment levels required and how they fit within the likely funding available.

As shortlisted options assume increased services, the initial investment in rollingstock would involve a higher number of assets (rollingstock and buses) than the 'do-minimum' base case.

Option 5 is estimated to require the largest initial investment due to the cost of installing electrification across the full length of the electrified line.

Overall, Options 1, 2, 3-1, 3-2, 3-3, 4-1 and 4-2 require comparable total capital investments, even though various cost items within capex would be different. 1600 V DC electrification includes costs for a larger number of substations per km that 25 kV AC electrification. This has been factored into Options 1 and 3-3 in particular. The more costly train configurations are included within Options 3-1 due to the cost of the extra battery capacity, as well as 4-2 which takes into account the extra design costs.

Affordability can be improved by phasing capital works. Estimates also show that a smaller proportion of rollingstock capital costs would be required in the next triennium (about 40% of the total). Additionally, manufacturers will likely be able to offer additional whole-of-life value-add that would be included in the initial price.

Criterion 11. Affordability operational/maintenance

This criterion relates to ongoing investment levels that might affect the ability of the project owner to afford the cost to operate and maintain the option over its projected life.

New fleet is likely to require lower maintenance costs than a second-hand fleet. However, the larger quantity of the fleet would require additional maintenance and operating costs.

For all options involving new rolling stock, maintenance of units is planned within manufacturers' maintenance planning. This means that in practice, there would not be significant differences in operational maintenance across options.

Multiple units with batteries need very little maintenance, except in the case of cell failure when it becomes a rotable spare. Batteries are usually fitted within racks that can be withdrawn from the underframe to allow cell replacement within a maintenance shift. Units with CI engines will require maintenance of the engine, but this is a planned maintenance activity, and the reliability of such engines is extremely high. Full overhaul of a CI engine where it is maintained off the unit is also a planned activity but occurs as infrequently as full battery changes. For this reason, the majority of the options have been ranked equal for operational maintenance.

Option 5 scores slightly lower due to higher maintenance requirements of the fully electrified infrastructure.

Criterion 12. Delivery timeframes

This criterion reflects the considerations of when the option could be delivered and other timing requirements. It includes a key timing consideration of the existing fleet's ending service life after light refurbishment in FY2028.

Given the market sounding feedback, the delivery timeframes to meet the target of FY2029 operation are tight.

It is unlikely than any options involving electrification (Option 1, 3-2, 3-3 and 5) would be able to meet the required timeframes, especially full electrification of both Wairarapa and Manawatū lines (Option 5) or extension of electrification (Option 1).

Tri-mode Option 4-2 and Option 3-1 B-EMU with extra batteries are likely to involve extensive design work and associated time needed due to their bespoke nature, compared to more standard products in Options 2 and 4-1 that score highest. Additionally, Options 2 and 4-1 are also not reliant on electrification timescales.

4.7.2.3 Opportunities and impacts (OI)

Mandatory opportunities and impacts of Climate Change mitigation and Impacts on Te Ao Māori were considered and covered through investment objectives and critical success factors. Therefore, to avoid double counting, these mandatory criteria had a weight of zero as they are covered in other MCA criteria.

Criterion 13. Climate Change mitigation (mandatory)

This criterion considers the long-term carbon emissions impact of the option. It is addressed through criterion 5. Therefore, weighting of zero was adopted to avoid double counting.

Criterion 14. Impacts on Te Ao Māori (mandatory)

This criterion includes impacts on Te Ao Māori, including areas of significance for Māori, Māori land and Kaitiakitanga (recognition that the environment is a taonga). It is addressed through criteria 1, 3, 4 and 9. Therefore, weighting of zero was adopted to avoid double counting.

4.8 Results

Shortlisted options were evaluated with the revised MCA, resulting in the following rankings:

1. *Preferred option:* Tri-mode (1600 V DC + CI generator + battery) + no further electrification + increased services (Option 4-1)
2. Tri-mode (1600 V DC + battery + CI generator + 25 kV AC provision) + no further electrification + increased services (Option 4-2)
3. B-DMU + increased services (Option 2)
4. B-EMU (dual voltage + battery) + 25 kV AC partial electrification + increased services (Option 3-2)
5. B-EMU (1600 V DC + battery) + 1600 V DC partial electrification + increased services (Option 3-3)
6. EMU (dual voltage) + 25 kV AC partial electrification + increased services (Option 5)
7. B-EMU (1600 V DC + extra battery) + increased services (Option 3-1)
8. EMU (1600 V DC) + 1600 V DC partial electrification + buses beyond Featherston and Ōtaki + increased services (Option 1).

Option 4-1 is estimated to have the highest benefit cost ratio (BCR) and net present value (NPV) of 1.52 and $409 million respectively (Table 4-). All short-listed options are estimated to provide similar benefits, considering avoided Base Case costs, rail user travel time savings, road user travel time savings, safety, greenhouse gas emissions and other environmental externalities. As such, costs were the key differentiator between the options and Option 4-1 was preferred as the lowest cost option and the option offering the highest MCA score.

Table 4-9 Rapid CBA results

	Option 2	Option 4-1	Option 4-2
Total costs (PV)	$788m	$785m	$818m
Total benefits (PV)	$1,190m	$1,194m	$1,194m
BCR	1.51	1.52	1.46
NPV	**$402m**	**$409m**	**$376m**

On the basis of the rapid CBA, Option 4-1 was short-listed for the detailed appraisal including amenity benefits, reduced road maintenance benefits, impact of mode on health benefits, updated cost estimates and P50 contingency.

4.8.1 Preferred option selection

The investment proposal entails the replacement of all existing regional rail rolling stock with a fleet of 22 four-car tri-mode units (1600 V DC & CI generator & battery), which will enter service in the 2028 financial year. The new rolling stock will operate all services on the Wairarapa and Manawatū lines, which will run at improved frequencies to provide better access and capacity between Masterton/Palmerston North and Wellington.

The preferred option will contribute to improving safe and reliable access to economic and social opportunities, provide for future demand and be more attractive for commuters on the Wairarapa and Manawatū lines. Additionally, it will allow for a shared train consist across both lines. The preferred option scores highest, compared to other options, as it provides the following benefits:

- it aligns with all strategic objectives and can be implemented to meet the project timescales
- this option is technically achievable, where similar trains of these types have been successfully delivered, for example, the Stadler FLIRT
- this rollingstock platform has a potential to be scaled to the broader New Zealand rail network as it could run on any network regardless of electrification due to CI engine on board
- this option can be more attractive to the wider public as it could be seen as a progressive way forward, with commitment to carbon reduction without significant change to the surrounding infrastructure

The preferred rollingstock solution will need to be supported by associated infrastructure such as a maintenance depot, stabling facilities, and station and other infrastructure upgrades (altogether, the "preferred solution"). Refer to the Chapter 5 Preferred Solution for details on full scope of the preferred solution.

5 CHAPTER 5 – PREFERRED SOLUTION

CHAPTER SUMMARY AND CONCLUSIONS:

- The scope of the preferred solution, representing the preferred rollingstock option identified in Chapter 4 and supporting infrastructure, includes the following components:

Scope element	Key assumptions
Rollingstock	• A fleet of 22 four-car tri-mode units (1600V DC & CI generator & battery)
Simulators	• One simulator (the location is flexible)
Depot	• One depot at Masterton (station area) located at a brownfield site, currently owned by KiwiRail, which will require KiwiRail's consent to build a new depot building for the new fleet.
Stabling facilities	• Three stabling facilities: – interpeak daytime stabling is within the Wellington yard region, currently owned by KiwiRail – overnight stabling would be required at Masterton (16 units) and Palmerston North (6 units) • The stabling facilities are assumed to be located at a brownfield site, currently owned by KiwiRail.
Track and other upgrades	• An allowance for the equivalent of two non-electrified passing loops extensions north of Waikanae to ease the interface with freight service and de-risk the proposed increased service, to be delivered through future KiwiRail NIMT capacity improvements. • Selective Door Operation (SDO) and automatic changeover track balises across both lines.
Stations	• Basic platform and stations upgrade on the eight Wairarapa line stations north of Upper Hutt. • One additional platform and pedestrian access at Maymorn station. • Upgrade of the four Manawatū stations north of Waikanae, including allowances for refurbishment of Ōtaki and Levin station buildings and lease of station land.

- The chapter provides further details on asset specifications.
- No land or property acquisition requirements have been identified at this stage of the analysis. However, as the land for depot and stabling facilities is currently owned by KiwiRail, it will require KiwiRail's consent to build new facilities for the new fleet. Additionally, land for two existing stations on the Manawatū line at Ōtaki and Levin is assumed to be leased by GWRC for further station upgrades. Therefore, approvals from the railway station owners and/or relevant authorities would be required. Any specific consents and approvals will be further analysed in the next project phase.
- The preliminary delivery schedule indicates a delivery timeframe of approximately 4.5 years from contract award.
- Operational aspects, including the service levels and potential timetable, have been considered to realise the project investment objectives and include potential measures for future benefit realisation, also detailed in Chapter 12 Management Considerations.

5.1 Purpose and overview of the chapter

The purpose of this chapter is to define the project scope by presenting a detailed overview of the key technical features of the proposed solution identified the options analysis process presented in Chapter 4 Options Assessment, including rollingstock and associated facilities and infrastructure upgrades.

This chapter outlines:

- the scope of the preferred solution' assets, including rollingstock, upgrades in stations, depot/stabling, services and systems, and other requirements comprising (Section 5.2)
- the preliminary delivery schedule (Section 5.3)
- a summary of the operational requirements of the preferred solution, including operations and maintenance (Section 5.4).

The preferred solution outlined in this chapter is used as the basis for the analysis throughout the remainder of this DBC. The information presented in this chapter is supported by more detailed analysis provided in Appendix F and Appendix G.

5.2 Scope of the preferred solution's assets

The key components of the preferred option are summarised below and elaborated on in the next sections:

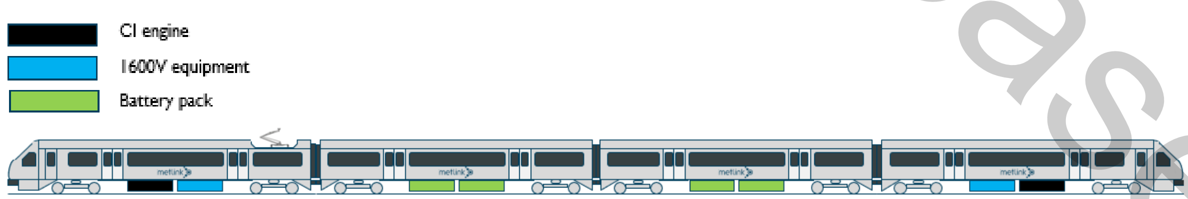
- Rollingstock
- Simulators
- Depot
- Stabling facilities
- Track and other upgrades
- Stations.

5.2.1 Rollingstock

As discussed in Chapter 4 options Assessment, the investment proposal entails the replacement of all existing regional rail rolling stock with a fleet of 22 four-car tri-mode units (1600 V DC & CI generator & battery), which will enter service in the 2029 financial year (see Section 5.3 for a preliminary delivery schedule). The new rolling stock will operate all services on the Wairarapa and Manawatū lines, which will run at improved frequencies to provide better access and capacity between Masterton/Palmerston North and Wellington.

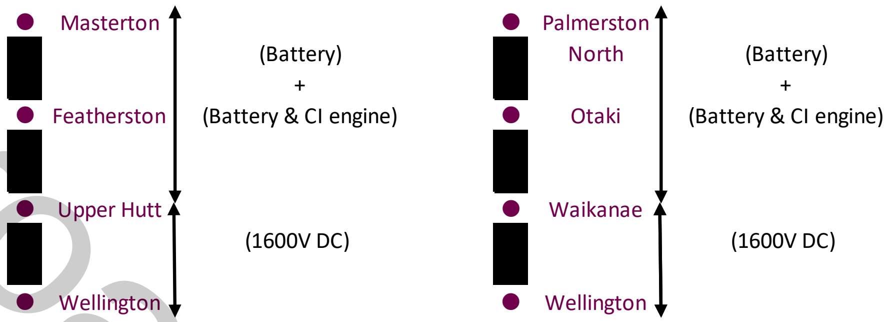
Figure 5-1 and Figure 5-2 option's train architecture and propulsion modes across parts of the routes.

Figure 5-1 Option 4-1 indicative train architecture



On a TMU, the CI engine has no mechanical drive and is connected to a generator. When in electric mode, the power is sourced from the overhead line for both traction and to recharge the battery. Energy from regenerative braking is used to charge the battery until the battery is fully charged when the energy is returned to the overhead line. In self-power mode, traction power is sourced from the battery or a combination of the battery and the CI engine. Energy from regenerative braking is used to recharge the battery.

Figure 5-2 Option 4-1 propulsion modes



The preferred solution will use the existing 1600 V DC network in place from Wellington to Upper Hutt and from Wellington to Waikanae and a CI engine as well as a battery on the non-electrified parts on the lines. Additionally, it is assumed that battery rather than CI engine would be used in the vicinity of stations and in tunnels on the non-electrified parts of the network to reduce emissions in those areas. The feedback from market sounding has provided an estimated 80 km battery range. With advances in battery technology, reliance on the CI engine is expected to reduce over time as an extended battery range, developed before procurement of the fleet or by the first cycle of battery replacement, becomes capable of covering a larger proportion of the non-electrified network.

The advantages operating train services with multiple units over locomotives are described in Chapter 4 Options Assessment and Appendix D. The preferred option incorporates all listed multiple unit benefits, in particular the operational flexibility that comes from having cabs at both ends, resulting in quicker turnaround times, ease of forming 8-car consists, and ease of recovery of immobilised units.

The preferred option includes new tri-mode rolling stock with a 35-year life[139]. It is dimensioned to meet the service needs defined in Chapter 4, and includes committed infrastructure upgrades. The preferred solution also includes a simulator to train drivers, new stabling facilities and maintenance facilities required for operations and maintenance of the new fleet, station and track upgrades, which are covered further within this chapter.

In comparison to the existing rolling stock, the preferred option fleet of trains will increase:

- train safety with new rolling stock design for notable features such as crashworthiness and fire in line with the latest standards
- train system reliability and less time managing component obsolescence issues
- train service performance due to increased levels of train reliability as well as operational efficiencies, including time savings due to quicker acceleration and braking, concerning SDO, automatic power changeover, improved dwell times and time required to turn around locomotives removed from the working timetable
- customer satisfaction levels with newer cleaner surroundings, improved accessibility, real time passenger information systems, automated public announcements
- carbon reduction due to reliance on the CI engine for a lower proportion of the overall train journey
- improved air-quality for train occupants within tunnels with sealed carriages, improved ventilation and reduced fleet emissions.

A train technical specification (TTS) will be formalised for the new rolling stock in the next phase of the project. A high-level summary of the key features to be included are summarised in Table 5-1. Appendix F provides further details.

[139] Noting that the financial analysis assumes a 30-year operations period and the economic analysis assumes a 40-year operations period as per Waka Kotahi guidelines and as agreed with the project team.

Table 5-1 Rollingstock requirements

Parameter	Requirement
New Zealand topography	Narrow gauge (1,067mm)
Fleet size	22 units
Formation	4 vehicles per unit. (Ability for operation in multiple units)
Length, width	Car length between 21-23 m, body width 2.75 m
Route compatibility	Wellington – Masterton (Wairarapa line) & Wellington – Palmerston North (Manawatū line). To comply with NRSS/6, potentially defining the foundations to a future national standard.
Service type	Regional
Train type	Tri-mode (1600 V DC + compression ignition generator + battery)
Pantograph	1 per 4-car unit
CI generator[140]	390 kW x 2 per 4-car unit possibility, built to latest emissions stage, expected to meet Euro V standards (to be confirmed by manufacturer)
On board energy storage (OBES) range[2]	700 kWh battery possible (80 km assumed) (to be confirmed by manufacturer)
Maximum speed	120 km/h (both 1600 V DC overhead line OHLE mode and self-power mode)
Regeneration / energy storage	Yes, minimising overall energy consumption, enabling emission-free station stops, dwells and restarts (emission free while any part of the unit is in the station)
Power supply changeover time	Automatic changeover with unit/train in uninterrupted motion.
Air conditioning	Yes
Driving cab	One at each end, offset driving position to allow end door access, space for instructor seat
Train Manager's office	Yes
Unit gangways	End door exit (allowing required tunnel evacuation)
Floor height	Low floor (at least two doors each side to cater for level boarding at a platform height of 680 mm above rail level, ARL)
Passenger doors	2 doors per side at ends (or equivalent to manage dwell times)
Powered bogies[2]	Expected 4 of 8 per unit (to be confirmed by manufacturer)
Automatic selective door opening and correct side door enabled	Yes
Dwell time	Expected 7 - 33 minutes (intermediary stations[141])
Fixed seats	250 per unit[142]
Wheelchair spaces	4 per 4-car unit
Storage	Overhead racks and luggage stacks, bicycle storage of 6 bicycles per 4-car unit[143]
Toilets	2 in total per 4-car unit, 1 or 2 to be accessible
Catering provision	No

[140] Although it has been determined as a workable solution, this should be left open for the manufacturers to bring their expertise.
[141] Times are for intermediary stations as per the timetable aspiration
[142] A seated capacity of 195 was assumed for the analysis throughout the DBC, a seated capacity is possible up to 250 and will vary with specific design of the rolling stock
[143] The units shall have sufficient space available for luggage and bicycles for a suburban railway, with specified amount as required.

5.2.2 Simulators

One simulator has been budgeted for supporting operational readiness for the new rolling stock. Most train simulators for railway training purposes combine software with physical replication of the train desk and driver's viewpoint. The location of the simulator is dependent on the business needs and can be affected by the contractual arrangements in place. The Matangi EMUs simulator is located in Transdev's training centre at Wellington station. A simulator however may be under the maintenance and upkeep of the rollingstock manufacturer if the simulator is listed along with spares and special tools under the main rolling stock manufacture and supply agreement (MSA).

5.2.3 Depot

The preferred solution includes a new depot facility to support the associated new rollingstock. The maintenance strategy detailed in Section 5.4.2 drives the specifics of the future depot requirements.

The next sections provide more details on:

- depot location
- depot facilities
- depot footprint.

5.2.3.1 Depot location

A long list of options has been explored and evaluated using MCA against specified requirements and assessment criteria. MCA workshops were held with GWRC and some input was also gained from KiwiRail. Appendix G provides further details on the MCA process and analysis.

The results of the MCA workshops supported the decision-making process of presenting Masterton station area as a viable option for a depot location, because of the following reasons listed in Table 5-2.

Table 5-2 Decision-making process to select Masterton station area as a viable option

Assessment criteria	Comments on the Masterton station area
The potential of acquiring a site within the timeframes required	This option covers land already in use for railway activity so would not have to undergo a significant change of land use.
Capacity to absorb maintenance requirements and workload	This option involves new build depots being built to suit exact requirements for needed maintenance capacity.
Ability to connect to the existing rail network and services	This option is considered suitable for railway network connectivity.
Allowances for operational flexibility	This option sufficiently allows for operational flexibility.
Assessment of geotechnical conditions with respect to site construction	This option relative to the other viable choices presents no known major constraints from a civil engineering perspective. It is outside the tsunami risk zone (123 m elevation, 42 km from coast) and in the Low Risk of liquefaction zone.
Immunity to flooding	This option is not known to be the area of material flooding risk.
Accessibility to the site for construction and operational phases	This option offers good connection to the existing roads within the region.
Availability of skilled workforce	This option has the advantage of managing staff across two sites (depot and stabling both in Masterton).
Value For Money (VFM)	This option, in comparison to other options, shows a potential for an effective combination of cost, quality, benefit and risk to meet the desired outcome. Operational considerations such as dead running, early departures and the ability to swap sets out from this location is an important differentiator.

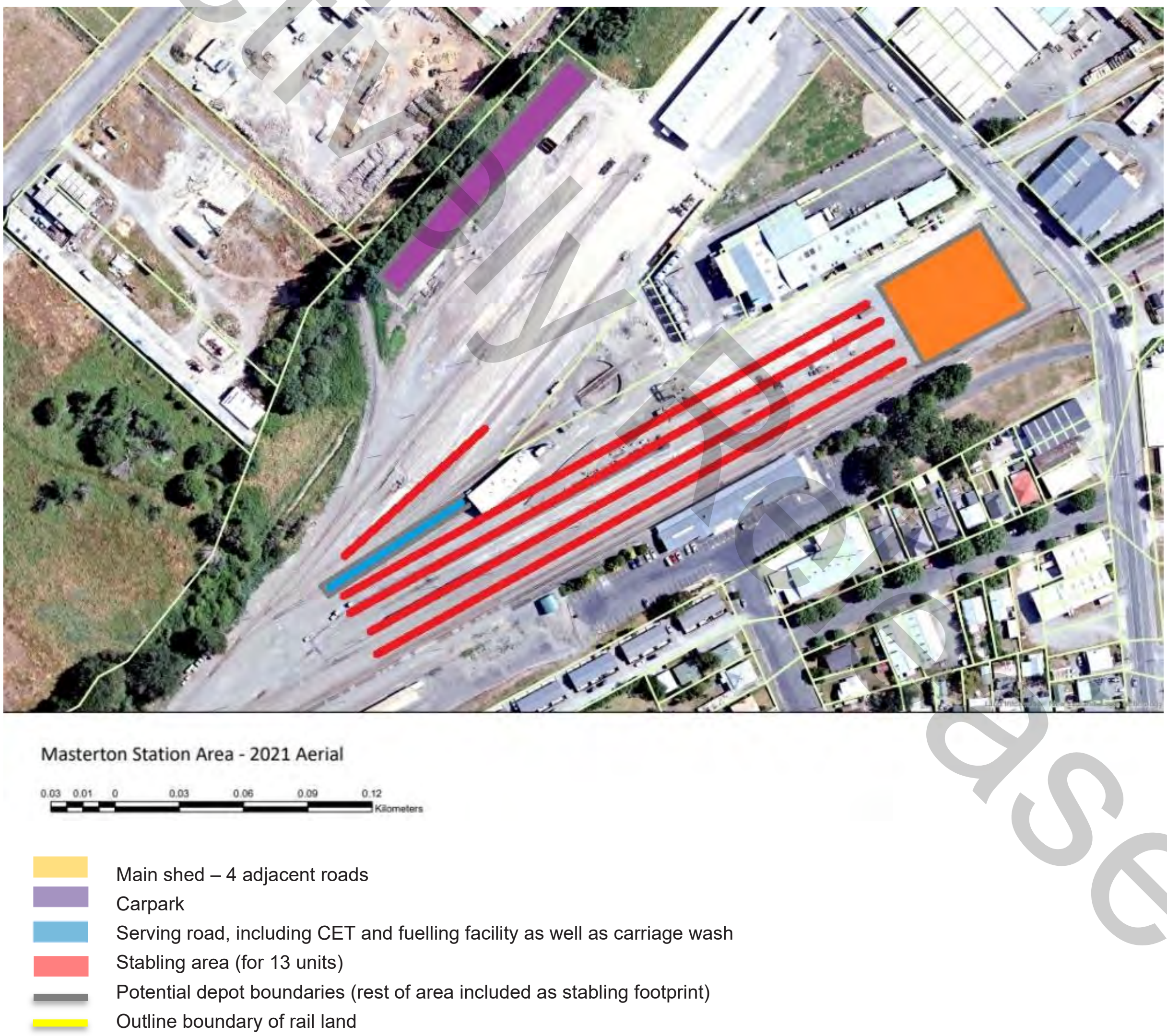
Currently Masterton yard area can fit up to 21 carriages. The area northwest of the station is currently used as freight stabling and this option explores adding a depot location along with the additional stabling within this area of land.

No land or property acquisition requirements have been identified at this stage of the analysis. However, as the land for depot is currently owned by KiwiRail, it will require KiwiRail's consent to build a brand-new depot building within the locations stipulated.

Validation of MCA scores will need to be carried out in the next phase of the project to confirm the depot location and depot boundary design (Figure 5-3Figure 5-3). Additionally, freight requirements, which need to be accommodated, will need to be further discussed and agreed upon with KiwiRail in the next phase of the project.

Phase 2 of the project would need to validate assumptions and options of the initial depot location MCA, as well as detail a preferred design for Masterton station area location that is currently looking the most favourable. An initial proposal is highlighted in the following concept diagram, which merges both depot and stabling facilities within the same location. Additional investigation and concept design work carried out by GWRC is underway and has provided initial confirmation of the feasibility of this option.

Figure 5-3 Indicative depot boundary footprint



5.2.3.2 Depot facilities

The depot will be built to enable the following maintenance activities:

- regularly servicing
- preventative maintenance activities
- corrective maintenance activities
- heavy maintenance (component exchange) activities.

It is assumed that component heavy maintenance repairs will be conducted off site, along with the main component warehousing.

It is expected that the new rolling stock will be designed and manufactured to the latest specifications. The locations assumed for key train equipment and systems are:

- air conditioning system located on the roof
- battery banks located underfloor and accessible from the train side
- pantograph and main circuit breaker systems located on the roof
- fuel reservoir tanks and engine located underfloor and accessible from the train side.

The depot confines will include the maintenance shed as well as the depot facilities required below to carry out the anticipated maintenance activities on the fleet of 4-car trains tri-mode trains.

A key assumption is that a wheel lathe will not need to be incorporated within the depot boundary as there is sufficient capacity for the new fleet to use the wheel lathe currently situated in Wellington EMU depot.

Table 5-3 Depot facilities external the main shed

Feature	Description
Underfloor wheel lathe	Assumed use of Wellington EMU wheel lathe
Trainwash	Trains will be washed on their routine maintenance depot visit cycle
Underfloor cleaning area	Steam washing for deep cleans
Walkways and lighting	For staff safety and access around site
Perimeter boundary fencing	For site security
Controlled Emission Toilet (CET) system	CET tanks will require emptying on depot site as part of the maintenance regime
Fuel bay	Allows diesel engines to be re-fuelled when units come on to depot site
OHLE	Small solid bar or catenary section will allow use of pantograph testing installed external to the depot shed but within the depot boundary area.
Carpark	Access to depot boundary from road side, parking for maintenance and traincrew staff of up to 50 cars

5.2.3.3 Depot footprint

Figure 5-4 shows a proposed depot footprint that would fulfil the requirements listed in Table 5-4.

Figure 5-4 Depot footprint

Table 5-4 Depot facilities which forms part of the maintenance shed

Feature	Description
Depot protection system (DPS)	For green zone working within the depot confines.
Servicing roads	Assumptions: 1 dedicated re-enforced road for lifting and heavy maintenance activities. 3 roads for light maintenance/warranty/repairs/cleaning, of which x 1 road to have roof access platforms for working at height and roof mounted equipment inspections. All roads with pit access with direct access from both ends
Main shed roof ventilation	Fume extraction should CI generators be tested within the vicinity of the depot.
Main shed general dimensions	3,960 m^2, 440 m rail laid Length = 110 m, Depot Width = 36 m Height = Approximately 11 m high to take into account sufficient clearance for overhead crane. From industry standard and best practice, each road with clear access to each side of the unit. Minimum distance between shed wall and centre of closest road is 6 m. Minimum distance between 2 adjacent road centres to be 8 m.
Battery and electronics room	For equipment testing and repairs
Depot offices and welfare facilities	For maintenance management and depot staff facilities, such as messroom, toilets and showers. Provision for lighting and heating to all work areas, as well as connection to WIFI and utilities such as gas and water supplies.
Storage	Allows maintainer to control spares that will be unique to this rolling stock and depot. Storage facilities include spares, inventory racking, stillages for heavy maintenance equipment, tools, liquids and personal protective equipment.
Lifting equipment: engine table	Engine lift table to facilitate removal of engine from the train for transportation to the original equipment overhauler's facility.
Lifting equipment: 10 T crane, jacks, 5 T Forklift	Use of jacks for train lifting and removal of line replaceable items (LRUs) underframe. Crane to transport goods on to the pick-up truck for transportation off/on site. Forklift used by stores team to carry goods in and out of the shed.
Sand supply	Automatic sanding dispenser to allow topping up of train sanding hoppers
Air supply	Required for supply to pneumatic train systems
Shore supply: 230 V, 415V	Allows for charging train batteries and supplying power to trains, tools and machinery during maintenance work.

5.2.4 Stabling facilities

The preferred solution includes three stabling facilities:

- interpeak daytime stabling is within the Wellington yard region, currently owned by KiwiRail
- overnight stabling would be required at Masterton (16 units) and Palmerston North (6 units).

The stabling facilities are located at a brownfield site, currently owned by KiwiRail, which will require KiwiRail to deliver their design and construction. Refer to Appendix G for further detail on stabling facilities.

5.2.4.1 Interpeak stabling

As per the timetable aspiration provided by GWRC, units will have to be stabled between peak periods. Day time stabling is proposed within the Wellington yard region as defined in the RIC infrastructure assessment performed as part of the IBC. Development of the site will result in additional stabling capacity. The site has been previously costed at $20.65 M. This includes pre implementation costs which would be high due to the disruption to the normal working practices of this traditionally busy stabling yard.

Table 5-5 Wellington stabling capacity

	Current capacity EMU	Current capacity carriages	Total capacity	Operational capacity (cars)
Wellington stabling	134	28	162	145.2

Table 5-6 Wellington stabling development areas

Feature	Description
Infrastructure	Includes civils works, CCTV, fencing, lighting
Track and signals	Track laying and removal of old track, approximately 1500m and 13 turnouts Signalling provision for new track includes design and commissioning
Other	Design and project management Contractors' costs Operational corridor working costs

5.2.4.2 Overnight stabling

A Masterton stabling facility based on the IBC requirement of 8 x 4-car spaces has been funded as part of the WMUP 6b infrastructure upgrade project.

Overnight stabling has been reviewed and is expected to require 16 x 4-car units at Masterton and 6 x 4-car units at Palmerston North (Table 5-). Masterton and Palmerston North station areas would be ideal as early train departures start from these locations. Both berthing locations would require upgrading to support the extra demand. Management and delivery of the upgrade works are estimated to be an additional $11.55 M for Masterton and $3.70 M for Palmerston North stabling concept.

Table 5-7 Overnight stabling location upgrades

Feature	Description
Utilities	Connection to power, water and sewer at both stabling areas. Both locations should be suitable for potable water refilling for CET and WC sink facilities on board the train.
Civils	Including drainage, and bulk excavation works
Track and signalling	Including signalling design and commissioning works at both sites 500 m track removal, 1000 m track laying and 3 turnouts for Masterton stabling & 250 m track and 2 turnouts for Palmerston North stabling
Infrastructure	Includes existing traincrew facilities in the station building being refurbished, platform fit out, CCTV, asphalt walkways, security gate and fencing at Masterton & existing traincrew facilities refurbishments, security fencing, CCTV and manual gates for Palmerston North stabling
Shore supply	Slow trickle charge for OBES batteries on board the train (2 battery packs per 4-car unit). This is not a mandatory requirement as the CI engine is available off wire to charge the batteries, and the batteries can be used within a certain range before requiring re charging. However, this infrastructure makes use of leaning towards decreasing emissions.

Figure 5-5 Palmerston North overnight stabling concept

Legend: 4-car berthing location

New stabling road

5.2.5 Track and other network upgrades

The preferred solution's service, outlined in Chapter 4 Options Assessment, introduces some significant increases in frequencies on both lines. To ensure the resulting traffic on the lines interfaces properly with other users, an indicative timetable (described in Section 5.4.1), meeting the service assumptions for the Wairarapa Line and Manawatū Line, the current KiwiRail freight timetable, and the proposed RS1.3 metro timetable were simulated in the OpenTrack™ operational modelling software by KSP Consulting.

This initial modelling was based on a realistic indicative timetable and high-level assumptions as to the network changes resulting from existing programmes of work.

The modelling identified constraints on the Manawatū line, north of Waikanae. With about 80 km of single track, this part of the network does not offer many options for freight trains and regional trains to meet their timetables without precise coordination.

Therefore, to enable the frequency proposed under the preferred solution and its investment objectives, the following additional system capacity need to be realised by:

- increasing the coordination of freight and passenger services to reduce the service punctuality risk
- increasing the capacity of the network to allow sufficient extra capacity that absorbs potential delays without knock-on effect on either service.

The preferred solution includes allowances for physical track works that will target the key constraint of the line. Increasing the length of passing loops north of Waikanae would be a sufficient mid-term solution to enable the proposed solution. This would allow for sufficient capacity for the proposed service levels to be met with reasonable allowance for freight. However, KiwiRail has been funded to start a Preliminary Business Case (PBC) level investigation of a long-term solution for NIMT under WMUP7, which is likely to include more significant treatments of the constraints to account for the forecast growth of the freight service.

Table 5-8 Assumptions for trackwork and other network upgrades

Line	Wairarapa line	Manawatū line
Current KiwiRail infrastructure capacity building programme	WMUP6b	WMUP 7
Description	Passing loops at Featherston, Maymorn and Carterton	additional capacity improvements aligned with the long-distance rolling stock business case (beyond those delivered by the NZ Upgrade programme – 6B Wairarapa and 6A Wellington rail improvements)
Additional allowance as part of the preferred solution	None	Cost allowance for two non-electrified passing loop extensions of 1,000 m each, north of Waikanae.

5.2.6 SDO and automatic changeover

The preferred solution provides for SDO and automatic changeover systems. It includes the provision of beacons to submit information to the train. This ensures the pantograph is dropped or raised at the appropriate points on the route and correct door sequences are operated at the respective stations. Train borne equipment will be covered in the rolling stock specification during procurement and route proving tests will supplement the testing requirements for the added benefit of this safety feature.

5.2.7 Stations upgrades

The investment proposal includes the revitalisation of the Wairarapa and Manawatū line stations to a standard similar to the Metlink metro stations.

Establishing a standard of safety, accessibility, quality of amenities and reliability across the stations services by the proposed fleet is essential to the realisation of the service uptake by the corridors' communities. Stations are a key interface between the communities and the service proposed, and their upgrades have therefore been included in the preferred solution.

There are upgrade and redevelopment works currently planned on some of the Wairarapa station as part, notably, of the WMUP programme delivered by KiwiRail. Similarly, the NZUP programme includes works on the Palmerston North station.

While these projects and other GWRC driven works on the Metro Stations will improve stations and are acknowledged in the analysis that led to this preferred solution, the investment proposal includes nominal allowances for further station upgrade, scaled to high level future patronage expectations.

5.2.7.1 Standard of upgrade

It is accepted that stations will evolve beyond the investment's delivery period, with the community surrounding them and with patronage increase. Amenities and facilities will be created and improved as investments in them becomes fundable by increased benefits. The long-term development of each of these stations and the level of service they will provide will have to be defined beyond this business case.

However, the realisation of the investment's objectives will be reinforced by the provision of a consistent standard across the regional lines' stations from the first day of operation of the new rolling stock in 2028. To enable the benefits of a coherent network of stations the preferred solution includes allowances for the works outlined in Table 5-9. Despite the fact that Wairarapa stations are already at the current 'Metlink standard' it is expected, and allowed for, that further works will be required as part of LNIRIM to bring these up to the standard as it will be defined as part of the detailed design phase of the LNIRIM delivery in 2023.

The detail of works required is not defined at this stage for each station. The 'Metlink standard' that will be sought is only broadly defined by the current level of service and amenities that can be observed on the metro network's stations. However, existing station assessments have confirmed the current condition of the Manawatū Line stations assets and the base costs to undertake deferred maintenance and upgrades that will ensure facilities are safe and accessibility compliant. Detail design will have to be undertaken after the commitment to this investment and before service starts.

Table 5-9 Summary of Stations Upgrade Works

Line	Station	General upgrade works required for the preferred solution	Specific acquisitions, redesign and upgrade works (including by others) required for the preferred solution
Manawatū	Palmerston North	Platforms upgrade and nominal improvements to Metlink Standard, in addition to current Capital Connection works.	
	Shannon	Nominal improvements to Metlink Standard.	
	Levin	Stations platform and customer interfaces upgrades to 'Metlink Standard'.	Station buildings full refurbishment. Land agreement for long term lease.
	Ōtaki		
	Waikanae	No works included in the preferred solution beyond current and planned developments driven by the Metro service.	
	Paraparaumu		
	Plimmerton		
	Porirua		
Both Lines	Wellington		
Wairarapa	Petone		
	Waterloo		
	Taita		
	Upper Hutt		
	Maymorn	Stations platform and customer interfaces upgrades to 'Metlink Standard'	Additional station redesign with 2nd platform and pedestrian path to allow for access to train in both side of the loop.
	Featherston	Stations platform and customer interfaces upgrades to 'Metlink Standard'	Additional platform by KR in WMUP6b
	Woodside	Minimal stations platform and customer interfaces upgrades to 'Metlink Standard'.	
	Matarawa	Minimal stations platform and customer interfaces upgrades to 'Metlink Standard'.	
	Carterton	Stations platform and customer interfaces upgrades to 'Metlink Standard'.	
	Solway	Stations platform and customer interfaces upgrades to 'Metlink Standard'.	
	Renall street	Stations platform and customer interfaces upgrades to 'Metlink Standard'.	
	Masterton	Stations platform and customer interfaces upgrades to 'Metlink Standard'.	

5.2.7.2 Interface with metro services

With the proposed rolling stock being designed to fit the broad design of Metlink stations, there will be minimum upgrades required on metro stations that will be driven by the proposed regional service. As the Metlink Metro service's patronage is superior the patronage expected from the regional rail service, the driving forces for upgrade and redevelopment of metro stations, including Wellington Central Station, will come from the needs and objectives of the metro service. The preferred solution therefore includes the use of metro stations by the regional service without any regional service driven upgrade requirement.

5.2.7.3 Ōtaki and Levin stations ownership

The Ōtaki and Levin stations are currently listed on the Land Information New Zealand (LINZ) Treaty Settlement Land Bank and are subject to future Te Tiriti o Waitangi claims. The station buildings, of Heritage value, are significantly deteriorated and require significant work, including seismic strengthening, to be appropriate for use.

With large population growth planned for these areas and some significant patronage forecast for the regional rail service, the preferred solution includes allowances for both Ōtaki and Levin stations to be upgraded and made serviceable to the Metlink standard before the start of the service. Beyond the functional safety of the sites and the minimum vehicle platform interface upgrade required, the refurbishment and usage of the station buildings as enablers of community benefits is considered. The preferred solution therefore includes the long-term lease of the land and the refurbishment of the buildings. While not assumed, there may be a need for purchasing of the building.

Several options are currently being investigated outside of this business case by GWRC to determine a culturally beneficial approach to the revitalisation of these sites and built assets. Engagement with Horizons, LINZ, Te Arawhiti and community stakeholders is ongoing. Approvals from the railway station owners and/or relevant authorities may be required. Any specific consents and approvals will be further analysed in the next project phase.

5.3 Preliminary delivery schedule

The key driver for the preferred solution is the need to provide continuity of service on both lines as the existing fleet end its service life in 2028. To achieve this, the key constraint to the timely introduction of new rolling stock relates to the specification, procurement, design, manufacture, testing and commissioning of the rolling stock.

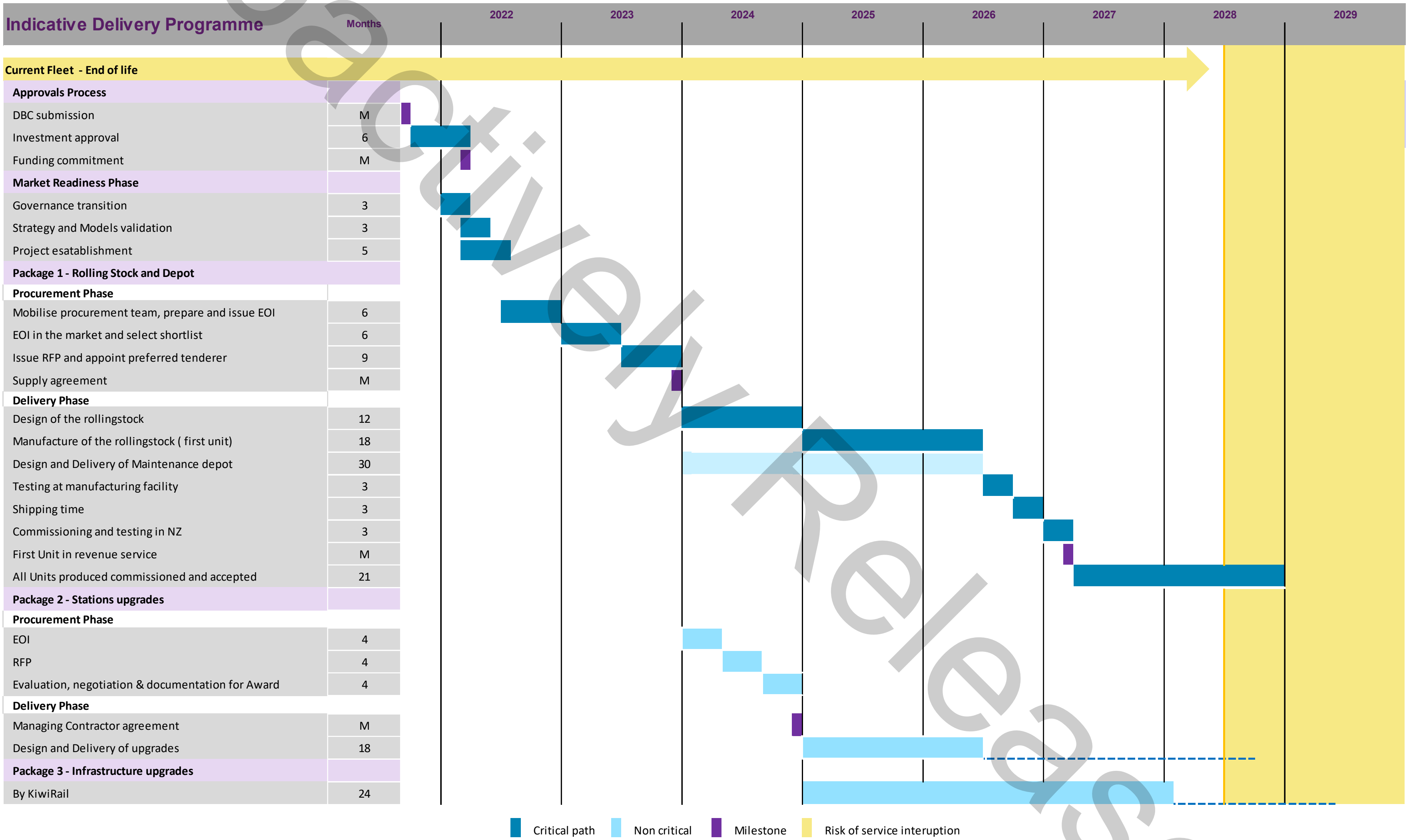
Conservative but realistic timeframe assumptions, informed by the delivery timeframe of current international transactions of similar nature and confirmed by market sounding, indicates that the full new fleet included in this preferred solution may not be in service before the end of 2028, as shown in Figure 5-6.

Consequently, the preferred solution's critical path follows the procurement of rolling stock.

The time constraints related to the investigation, design and construction of the new maintenance depot, can be adequately integrated in the rolling stock delivery schedule.

Time constraints related to infrastructure and station upgrades are of secondary importance and can fit within the rolling stock procurement timeframe.

Figure 5-6 Preliminary delivery schedule



5.4 Operations and operational readiness

As discussed in Section 5.2.5, the aspirational LNIRIM timetable was developed and provided by GWRC to enable the preferred solution. This timetable was developed to test infrastructure assumptions and considered a variety of factors:

- required frequency/capacity to meet demand (from demand modelling)
- peak travel times to get people to/from work in Wellington
- off-peak services to maximise travel choice
- integration with metro RS1 timetable and freight services
- consideration of train crossings.

The operational capacity assumptions are informed by factors such as the demand projections, agreed future service frequencies and travelled track km, locations of the depot and stabling facilities and the aspirational LNIRIM timetable. Key considerations for operations and operational readiness covered in this chapter include:

- operations, including train service frequency and driver training
- maintenance, including maintenance strategy, light and heavy maintenance management
- potential operational Key Performance Indicators (KPIs).

5.4.1 Operations

5.4.1.1 Train service frequency

The preferred solution assumes an eventual timetable as represented in LNIRIM timetable, as presented in Section 4.3.4. The peak periods derived from the timetable are 0530 - 0700 and 1630 – 1800. The morning peak services are timetabled to arrive at Wellington station before 0900, while the evening peak services timetabled to commence departing from 1630 onwards, both of which are spaced to allow a variety of travel time options.

5.4.1.2 Driver training

Training to be a train driver typically comprises of a series of tests and a certain amount of accompanied driving, including hours spent driving in the dark. When maximum realism is required, a driving simulator can offer an immersive environment for traction or route conversion courses, as well as supporting a new train driver's initial training programme. Simulator options typically include replicating the driving desk environment for the new rolling stock, as well as simulating conditions external to the train, such as re-enacting driving conditions for specific weather and routes. Therefore, the simulator needed to support driver training has been included as an identified need in Section 5.2.2 to operationalise the preferred solution.

5.4.2 Maintenance

The maintenance strategy informed the requirements for the depot considers both light and heavy maintenance management.

5.4.2.1 Maintenance strategy

Two types of planned maintenance are commonly carried out on rolling stock:

- light maintenance
- heavy maintenance.

Heavy maintenance consists of tasks that are generally more in-depth and long lasting but are performed less frequently than inspections, checks, minor component replacements and rectifications that are considered in the light maintenance category. In contrast to planned maintenance, heavy unplanned maintenance is reactive and can range from minor incident damage all the way up to collision repair.

Maintenance periodicities are normally stipulated in the vehicle maintenance manual. Tasks can be time or distance based and must take into account original equipment manufacturer (OEM) guidelines for the components design life with respect to the trains anticipated duty cycle. A typical maintenance schedule is given below, noting that these assumptions would need to be confirmed by the rolling stock manufacturer and will be continually improved by the rolling stock maintainer.

Table 5-10 Average allotted maintenance windows for a typical planned maintenance schedule

Periodicity (days)	Indicative average maintenance window duration	Maintenance work type
1	3.2 hours	General daily functional checks
10	3.6 hours	Bodyside, underframe and roof inspections
50	13.55 hours	~Minor light maintenance exam + repairs
100	7.7 hours	~Major light maintenance exam + repairs
200	14.6 hours	Light overhaul tasks
400	64.45 hours	Heavy overhaul tasks

Maintenance exam structures can be balanced or escalating. Balanced exams can provide flexibility in maintenance planning with workload generally more evenly spread for the planned maintenance windows across the entire fleet.

In addition to the periodic time-based exam tasks, engine changes would have a completely separate timer based on actual engine running hours. Distance based tasks also need to be tracked and would include large component replacements such as pantograph, wheelset and traction motor changes. ased on LNIRIM timetable aspirations, it is expected that toilet retention tank emptying, toilet water tank refilling and CI engine refuelling would take place approximately every 5.4 days.

In order to fulfil the timetable requirements, at peak 19 units are to be made available for service with:

- x 1 unit expected to be on a planned heavy maintenance exam
- x 1 unit to be on an expected light maintenance exam
- x 1 unit contingency allowance for immediate defect rectification.

The maintenance schedule assumes that trains are not dedicated to either of the Manawutu or Wairarapa lines. Maintenance will be in line with the train planning and all trains required for maintenance would complete its end of day running at Masterton where the maintenance depot is located.

5.4.2.2 Light and heavy maintenance management

Heavy maintenance needs to take into account the supply chain and logistics for large items to be removed and sent away for overhaul, as well as the purchase and delivery of any new or overhauled items, which will also need to be re-fitted to the train before testing. Performing heavy maintenance in the same vicinity as light maintenance would allow some benefits to be realised, namely:

- any delays in between the heavy maintenance programme may be utilised by carrying out deferred light maintenance work or additional modification / enhancement programmes
- the workforce carrying out light maintenance, modifications and heavy maintenance can potentially work closely together and share lessons learnt, allowing for better quality maintenance across the full maintenance cycle
- avoidance in losing time to transport units to a separate heavy maintenance location that could be much further away
- avoidance in having to manage a strict inventory of the train's condition prior to departure and also on leaving the heavy maintenance facility to understand if defects during transportation are recorded or any faults occurring are apportioned to the right parties involved

- if a separate heavy maintenance facility existed which covered a multitude of different fleets, some training and knowledge of specific fleets would need to be absorbed by this workforce and would need to be refreshed or kept up to date in line with any modifications over time
- if a separate maintenance facility exists, a national strategy would need to be committed to in order to allow a constant throughput of work that could cover any separate heavy maintenance depot overhead costs
- the commercial arrangements involved in a design/ build/ maintain train service contractual agreement with the rolling stock manufacturer may prove this difficult to implement.

For these reasons, the preferred option will look at maintenance requirements in its entirety. This methodology will also follow suit with the maintenance structure in place suit for the Wellington suburban Matangi fleet, whereby heavy maintenance is carried out at the EMU depot.

Hutt Workshops is regionally the only central overhaul facility but caters primarily towards freight locomotives and wagons. It is acknowledged that should the design/ build/ maintain contract be successfully re-negotiated, a national strategy for a combined heavy maintenance location for passenger trains could exist one day for trains within New Zealand. However, the maintenance strategy at this stage in the project is that that there will only be one location and one entity in charge of all maintenance activities for the new fleet of trains.

5.5 Benefits of the preferred solution

The purpose of this section is to present the expected benefits from delivering the preferred solution. The project benefits in respond to the problems and service needs outlined in Chapter 3 Need for Investment. The preferred solution investment ranks very high in its alignment with GPS2021 priorities. With a timely investment, the preferred solution provides a unique, significant and compelling opportunity to:

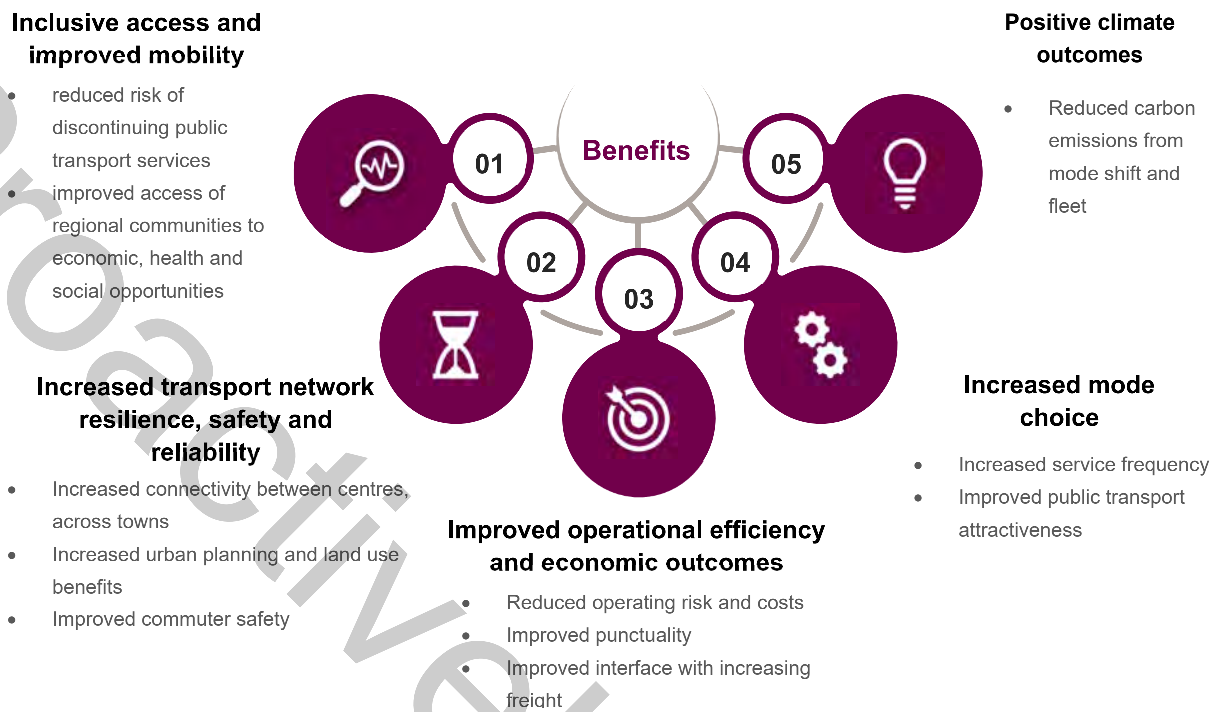
- meets the **service needs** for **accessing** social and economic opportunities
- maximises value for money and **operational efficiency**
- providing a **safe** and **reliable** transportation mode
- reduce the **carbon emissions** through mode shift and new purposely build fleet.

As discussed in Chapter 2 Strategic Context, the LNIRIM project aligns with and contributes to the strategic direction of the national and regional transport priorities, reflected in critical government plans and policies, including the Government Policy Statement on land transport 2021-2031. The LNIRIM project aims to support the government facilitate mode shift, safety, decarbonisation, access and enable future economic opportunities.

The preferred option's increased services over the 40-year period will:

- provide a critical public transport commuter alternative to road to access social, economic and health opportunities
- cater for current and future transport demand projections to reduce crowding
- enable future land use opportunities consistent with regional land use plans
- improve attractiveness of the public transport alternative to roads (with higher frequencies and improved amenities)
- activate mode shift opportunities (divert 23.8 million trips from the roads), resulting in ~618,000 tonnes of avoided carbon emissions
- deliver better outcomes for the environment (8.1 times less carbon emissions from fleet per service km)
- prevent over 100 crashes on the roads resulting in serious injuries or death.

Figure 5-7 Preferred solution's benefits



Refer to Chapter 6 Economic Appraisal on monetised and non-monetised benefits and Chapter 8 Financial Analysis for further detail.

5.5.1 Potential measures

The key output measure for a rail system is the availability and reliability of passenger services.

- service availability (ensuring timetabled passenger services are completed)
- service reliability (ensuring on-time performance of services).

In addition, the key project objectives and service requirements can also be reflected in high level measures.

Table 5-11 Potential measures

Investment objective	Potential measures
Improve connectivity and access to opportunities	• service availability (ensuring timetabled passenger services are completed) • service frequency and availability of travel options • network reliability (public performance measure) • availability of a viable alternative to high-risk and high-impact route
Improve corridor capacity	• travel time reliability – motor vehicles[144] (travel time savings) • collective risk (average annual fatal and serious injury crashes per kilometre of parallel roads) • number of deaths and serious injuries on roads
Improve public transport attractiveness	• impact on user experience of the transport system – number of public transport boardings – satisfaction surveys • amenities – on board noise

[144] Coefficient of variation; standard deviation of travel time divided by average minutes travel time (as per Austroads)

Investment objective	Potential measures
	– on board temperature – cleanliness and condition – station condition, furniture, cleanliness and graffiti
Reduce carbon emissions	• mode shift from private vehicles • increased public transport patronage • CO_2 emissions from fleet (tonnes)
Increase value for money	• cost per passenger-km
Increase reliability	• system reliability (potential for a failure of the rolling stock element) • service reliability (ensuring on-time performance of services)[145]

A detailed benefit realisation plan is included in Chapter 12 Management Considerations.

[145] Percentage of scheduled service trips between 59 seconds before and 4 minutes 59 seconds after the scheduled departure time of selected point

6 CHAPTER 6 – ECONOMIC APPRAISAL

CHAPTER SUMMARY AND CONCLUSIONS:

- The benefits of the project significantly exceed its cost. A full economic appraisal including CBA and robust sensitivity testing, estimates that the present value (PV) benefits of the project will exceed the PV costs over 40 years of operation.
- The detailed CBA estimates that the preferred solution has a BCR of 1.83 and NPV of $218 million.

Category	Preferred solution (PV, P50)	% Total
Capital costs	$501m	
Operating and maintenance costs	$565m	
Avoided costs	-$803m	
Total costs (PV)	$263m	
Rail user benefits	$186m	39%
Road user benefits	$146m	30%
Environmental benefits	$68m	14%
Community benefits	$81m	17%
Total benefits (PV)	$481m	100%
BCR	1.83	
NPV	$218m	

- The analysis is performed on the incremental differences in costs and benefits between the preferred solution, defined in Chapter 5, and the do-minimum base case, defined in Chapter 4.
- The analysis considers capital costs, operating and maintenance costs, rail user benefits, road user benefits, environmental benefits, community benefits and avoided costs.
- Additional benefits were identified but were not able to be quantified in the economic appraisal. However, they should be considered by decision-makers in assessing the project's expected value for money. These include the increased safety of a new rollingstock fleet relative to an older fleet, resilience benefits, active transport benefits and wider economic benefits, such as productivity uplifts associated with agglomeration effects, increases in labour supply due to increased availability in public transport, land use and renewal benefits, increased knowledge sharing of workers along the corridor and social benefits around access to health and educations.
- Robust sensitivity tests have been conducted for changes in discount rate, 20% changes in total costs and/or benefits, COVID-19 impacts on transport modelling, increased risk contingencies (P95), alternative peak and off-peak period time assumptions, and lower bound patronage forecasts. The BCR doesn't decreases below the threshold of 1.0 in any of the tested scenarios.

6.1 Purpose and overview of the chapter

This chapter outlines the economic impacts of the project, including sensitivity testing and consideration of risks in the economic evaluation outcomes. The chapter also reconfirms the investment prioritisation method profile in line with Waka Kotahi guidelines.

The economic analysis uses a CBA framework that applies a discounted cashflow technique to the benefits and costs of the project. This CBA seeks to assess the impacts across the Greater Wellington and Horizons regions, including users of public transport services, private vehicle users, government, and the broader community.

Consistent with the Waka Kotahi guidelines, the Appraisal Summary Table was also prepared for the project and included in Appendix H.

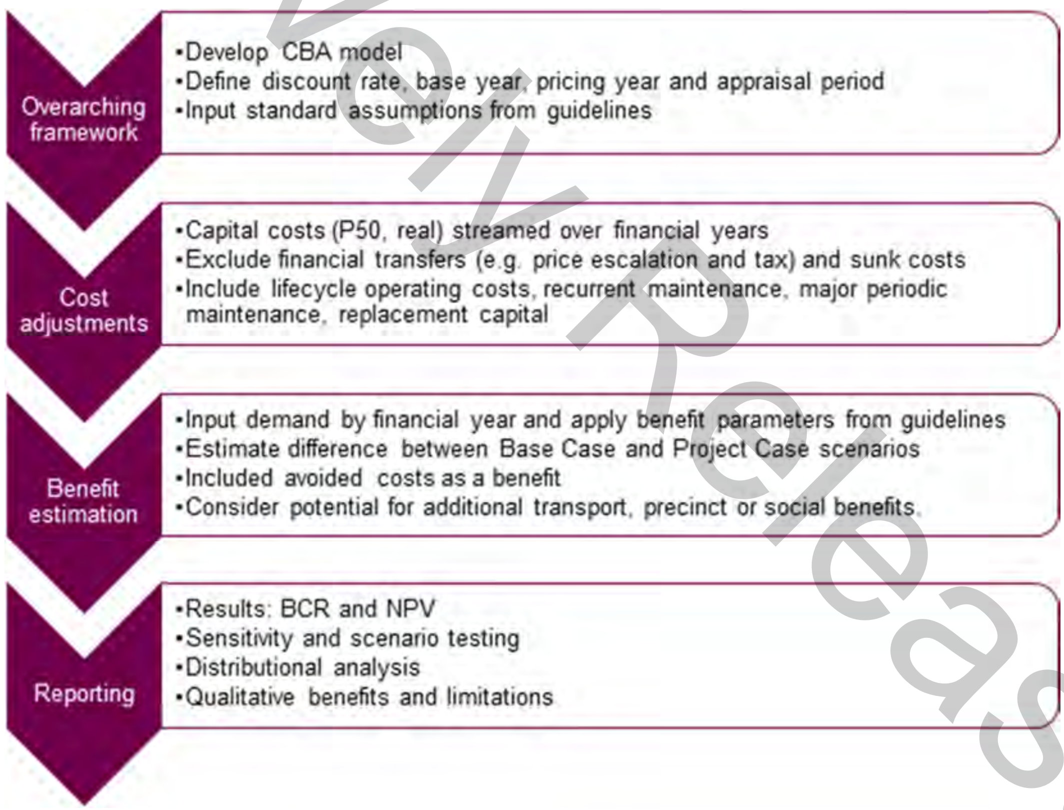
Additional detail on the approach and methodology applied in this CBA can be found in Appendix I.

6.2 Approach

6.2.1 Economic appraisal methodology

Figure 6-1 shows the key steps in the development and reporting of a cost benefit analysis with an expanded discussion of a number of these key elements in subsequent sections.

Figure 6-1 Key steps in the economic appraisal methodology



The economic appraisal includes cost benefit analysis, sensitivity testing and qualitative assessment. Both the rapid and detailed economic appraisal approaches are consistent with the Waka Kotahi Monetised Benefits and Costs Manual, version 1.5, August 2021 (MBCM) including a 4% discount rate, 40-year appraisal period and key assumptions such as the value of travel time. Cost benefit analysis estimates the difference between costs and benefits over the life of the asset (40 years), with future cashflows discounted to their present value (PV).

6.2.2 Key Inputs

Key inputs to the rapid and detailed economic appraisals include costs, energy, transport demand modelling. Additional input was obtained from, Monetised Cost and Benefit Manual from Waka Kotahi, the NZ Household Travel Survey and Transport for New South Wales (NSW) Economic Parameter Values. These are detailed in the Economic Appraisal Memo and are summarised below.

Energy demand and rail carbon emission modelling

The estimation of costs related to the LNIRIM DBC incorporated the best available sources of cost information in relation to each element of the preferred solution. This approach has allowed capital costs, operating and maintenance costs, fuel consumption rates and emission generation rates to be anchored on costs related to current practice for cost elements related to local supply, and to internationally validated data for cost elements related to imported rolling stock and specialist equipment.

The cost estimate process aligns with Waka Kotahi SM014 Manual and Z44 Standard. Details of the preferred solution estimate and the base case estimate are provided in Appendix J.

Costs were adjusted for inclusion in the economic appraisal by excluding price escalation, assuming the same indirect costs across all options, including contingency (P50), removing the costs of committed and funded investment, removing sunk costs that have already been incurred, matching cashflows to construction/operating periods and supplementing with New Zealand specific values where appropriate (e.g. cost of carbon from the MBCM).

Energy demand modelling captures changes in fuel type (diesel and electric) and the consequential change in emissions (tonnes of carbon dioxide equivalent). These inputs were necessary to model rail carbon emissions.

Avoided Base Case costs

The Do Minimum Base Case, defined in Chapter 4 Options Assessment of the DBC, assumes the purchase and refurbishment of second hand rollingstock identical to the stock currently in use, to enable the continuation of a constant service. This counter factual follows guidance by Waka Kotahi and meets the requirements of HM Treasury Green Book. It extends the practise followed in the past decades into the future. The do minimum base case is therefore a ‘do nothing more’ than current practice. Maintaining constant service with increasingly obsolete second-hand rolling stock inevitably leads to increasingly important capital, operating and maintenance costs and emissions that would be avoided with investment in the preferred solution. Further details of the avoided base case cost estimates are provided in Appendix J.

Economic Appraisal

Unit cost and willingness to pay parameters were sourced from the MBCM, including the value of travel time, vehicle operating costs, crash rates and costs, road maintenance costs, amenity feature valuations, shadow pricing of carbon and health benefits from walking and cycling. These were also supplemented by Transport for NSW Economic Parameter Values (environmental externalities expressed per kilometre rather than per tonne of emissions as in the MBCM) and the NSW Household Travel Survey (business and commuting purpose to weight the value of travel time in the rapid economic appraisal). The NZ Household Travel Survey was used to update business and commuting purpose assumptions in the detailed economic appraisal.

Transport demand modelling

Transport demand modelling includes annual rail patronage by line, generalised costs of rail travel by line (including wait time, in-vehicle time and penalties), road diversion assumptions, alternative road routes and gradients and vehicle occupancy factors. These were already provided in annual terms so there was no requirement to expand/annualise demand outputs. A mathematical and endogenous model was completed for peak and off-peak patronage projections for the Wairarapa and Manawatū lines. The peak and off-peak patronage have been modelled separately due to different growth patterns.

The basis of this modelling are integrated moving average (ARIMA) models that project future monthly patronage based on historical seasonality and overall trends. Historical patronage shifts through multiple trend patterns due to external factors, such as line electrification and fleet replacements. These external factors are removed by modelling the data from the more stable and recent subsets of the data depending on the line. This provides a significantly more stable pattern and improves the model’s statistical robustness. These projections are then transformed to incorporate available exogenous factors such as population projections, fare history, crowding and seat capacity, and alternative transport options. Further details of the transport demand modelling methodology and outcomes are provided in Appendix A.

Transport demand modelling has been supplemented by RPS research on traffic counts/speeds on alternative road routes, trip purposes, rail access modes.

COVID-19 impact scenario on transport demand modelling

Lynxx has undertaken a COVID-19 modelling scenario for patronage forecasts. This model has been based on the following:

- Work from home trends are likely to suppress patronage growth, due to proportions of the rail users now working from home an additional 1-2 days a week or permanently. These trends are likely to be long-term due to the growing acceptance of working from home.
- Mode Shift trends are likely to suppress patronage growth in the short-term but are not expected to persist in the long-term due to the likelihood of vaccination roll-out and a return to pre-COVID-19 behaviour.
- Population trends could have opposing effects on patronage growth, depending on which effect becomes more dominant in the long-term. In the long-term, regional relocation (due to improved work from home opportunities) is likely to offset reduced immigration from border closures (which are expected to open after New Zealand & worldwide vaccination roll-out). This regional relocation will drive greater population growth to the rail catchment areas and increase patronage growth in the long-term.
- Fare trends may have minor suppression of patronage growth due to rail users not finding value in monthly/multi-trip tickets (when working from home more) and choosing to travel even less. This is not likely to be a long-term significant impact, particularly if fares are modified to compensate for reduced travel.

Further details of the COVID-19 modelling scenario are provided in Appendix K.

6.2.3 Key assumptions

Table 6- sets out the key assumptions for the CBA consistent with the MBCM. This includes a discount rate of 4% and an appraisal period of 40 years.

Table 6-1 Overarching CBA framework

Assumption	Value	Source / Comments
Base Year	2021/22	Current financial year when appraisal commenced and consistent with the agreed approach for the financial appraisal
Pricing year	Q1 2021	Latest year for which consumer price index data is available from Stats NZ to inflate parameters to current year
Appraisal period	40 years	Standard appraisal period in Waka Kotahi guidelines. Consistent with 50 year life for enabling improvements for stations.
Discount Rate	4% (3%, 6%)	MBCM
Residual value	N/A	5 years of replacement capital included for rollingstock (35 year design life) to extend to the end of the appraisal period.
Cost risk contingency level	P50	MBCM
Cash flows	Real	MBCM

6.3 Cost benefit analysis results

The results of the detailed appraisal, shown in Table 6-2, indicate that the preferred solution yields a net benefit, with an NPV of $218m and a BCR of 1.83 relative to the do minimum base case. Most benefits come from rail and road user travel time savings, which collectively comprises 67% of benefits.

Table 6-2 Detailed CBA results (PV, $m)

Category	Preferred solution	% Total
Capital costs	$501m	
Operating and maintenance costs	$565m	
Avoided costs	-$803m	
Total costs	**$263m**	
Rail user travel time savings	$179m	37%
Decongestion travel time savings	$142m	30%
Reduced rail carbon emissions	$2m	0%
Reduced road vehicle emissions	$32m	7%
Reduced other road vehicle externalities	$33m	7%
Reduced road maintenance	$6m	1%
Reduced vehicle operating costs	$4m	1%
Safety	$39m	8%
Impact of mode on health	$37m	8%
Amenity	$7m	2%
Residual value of assets	$0m	0%
Total benefits	**$481m**	
Net Present value	**$218m**	
Benefit cost ratio	**1.83**	

6.3.1 Costs

Preferred solution costs

Capital costs for the project, shown in Table 6-3, have been adjusted for the purposes of the economic appraisal by applying P50 contingency reflecting 'the most likely' outcomes consistent with CBA being prepared on an 'expected value' basis. The cost estimate process followed aligns with Waka Kotahi SM014 Manual and Z44 Standard. Details of the Reference Case Estimate and the Base Case estimate are provided in Appendix J.

Table 6-3 Capital costs for detailed CBA, preferred solution (undiscounted, $m)

Capital cost element	Preferred solution
Pre-implementation	[redacted]
Implementation	[redacted]
Rollingstock	[redacted]
Infrastructure	[redacted]
Contingency (P50)	[redacted]
Total	**587.3**

Operating and maintenance costs, shown in Table 6-4, have been provided by IPEX in real terms with P50 contingency.

Table 6-4 Operating costs for detailed CBA, preferred solution (undiscounted, $m)

Operating cost element	Preferred solution
Operating	[redacted]
Maintenance	[redacted]
Renewal and refurbishment	[redacted]
Network maintenance	[redacted]
Client/owners costs	[redacted]
Contingency (P50)	[redacted]
Total	**1,507.6**

Avoided Base Case Costs

Avoided capital costs for the Base Case, are shown in Table 6-5. The probabilistic contingency is refined to (P50 – 40%) to reflect the uncertainty related to the scenario. Further details on avoided base case costs are provided in Appendix J.

Table 6-5 Capital costs for detailed CBA, avoided base case (undiscounted, $m)

Renewal and Refurbishment	Avoided base case
Renewal and Refurbishment	[redacted]
Infrastructure Upgrades	[redacted]
Client/owner costs	[redacted]
Contingency (P50 – 40%)	[redacted]
Total	**908.9**

Avoided operating and maintenance costs, are shown in Table 6-, and are assumed to commence in January 2029.

Table 6-6 Operating costs for detailed CBA, avoided base case (undiscounted, $m)

Operating cost element	Avoided base case
Operating Costs	[redacted]
Maintenance Costs	[redacted]
Network Maintenance	[redacted]
Contingency (P50 – 40%)	[redacted]
Total	**1,108.5**

6.3.2 Benefits

Table 6-7 provides a summary of benefits quantified in the economic appraisal, including what drives each benefit, and what demand inputs were required to quantify them.

Table 6-7 List of Benefits

Benefit	Parameter ($2020/21)	Benefit Driver	Demand inputs required
Rail User Travel time savings	$12.71 /hr	Increased service frequency Increased service speeds Increased patronage	Hours by public transport (PT) mode and vehicle type Existing and new users to enable rule of a half
Road user travel time savings	$12.71/hr (passenger cars) $32.72 (heavy vehicles)	Speed increase for existing road users Reduction in car trips due to mode shift to rail.	Average travel speed along road routes Average speed increase for road users Average alternative route distance Average annual daily traffic Diverted traffic Peak congestion period times

Benefit	Parameter ($2020/21)	Benefit Driver	Demand inputs required
Reduced rail carbon emissions	$93 /tonne - prices escalate until 2050 as per the MBCM.	Reduced carbon emission rates and fuel consumption.	Service kilometres Fuel consumption Carbon emission rate by energy type
Vehicle emission cost savings	$93 /tonne - prices escalate until 2050 as per the MBCM.	Reduction in car trips due to mode shift to rail.	Vehicle kilometres travelled (VKT) by vehicle type
Other vehicle externality cost savings	$0.058 /km		
Road maintenance	$0.01 /km		
Reduced vehicle operating costs	$0.217 /km (55 km/hr) $0.216 /km (60-65 km/hr)	Incremental patronage driving increased road speeds due to diverted traffic	Average travel speed along road routes Average speed increase for road users Average alternative route distance Average annual daily traffic Diverted traffic Peak congestion period times
Crash cost savings (safety)	$316,431 per reported injury crash (motorways)	Reduction in car trips due to mode shift to rail.	Average annual daily traffic Number of trips diverted Length of section Waka Kotahi Crash Compendium model parameters
Impact of mode on health	$4.4 per pedestrian km $2.2 per cyclist km	Increased rail patronage	Mode share of access and egress to and from rail stations Average distance by mode share of access and egress to and from rail stations
Amenity	$0.81 per rail user	Increased rail patronage	Vehicle feature valuation Existing users New users to enable rule of half
Residual value of assets	Economic lives by asset type		N/A (based on straight-line depreciation of capital costs)

Each of these benefits will impact mode shift to/from rail (and generates a series of flow on disbenefits/benefits such as vehicle operating costs and externalities). These have also been quantified in the appraisal. Each of these is discussed further in the following sections.

Additionally, some benefits were identified but could not be quantified in a monetised way, which include:

- Rollingstock safety
  - Improved crashworthiness
  - Improved fire resistance
  - Improved tunnel egress
  - Reduced stopping distances
  - Improved passenger and crew air quality
  - Improved emergency systems
- Rollingstock accessibility
  - Compliant with modern disability standards
  - Low floor level boarding
  - Efficient wheelchair boarding
  - Bicycle spaces
- Resilience benefits

- Wider economic benefits from improved connectivity
  - Agglomeration (productivity uplift) –connectivity between and colocation businesses.
  - Labour supply – connectivity between businesses and labour markets.
- Land use and renewal benefits.
- Social benefits around access to health care and higher education.

6.3.3 Sensitivity testing and risk assessment

The results reported are based on the best estimates of costs and benefits at this stage. Different outcomes could occur in practice as a range of factors may influence final costs. Consequently, the robustness of the economic evaluation results has been assessed in a series of sensitivity tests. The results and rationale for each of the sensitivity tests are outlined below.

6.3.3.1 Core sensitivity tests

Tests 1 & 2: Discount rates (Table 6-8)

There are no single agreed means of determining social opportunity costs. Sensitivity tests are recommended for the discount rate applied in the analysis. As per the MBCM, alternative discount rates of 3% and 6% have been tested. The BCR is estimated to range from 1.22 to 1.83 under these alternative assumptions (NPV $57m to $347m).

Table 6-8 Sensitivity test results ($2020/21 real, discounted) – Discount rates

	Core appraisal	Test 1	Test 2
Discount Rate	4%	3%	6%
Total costs (PV)	$263m	$265m	$253m
Total benefits (PV)	$481m	$612m	$310m
BCR	1.83	2.31	1.22
NPV	$218m	$347m	$57m

Tests 3, 4, 5, 6, 7, 8: Cost and benefit confidence (Table 6-9)

As with any major project, there is a degree of uncertainty to the total level of costs and benefits described. In particular, the choice of 'do minimum' counter factual impacts the appraisal's incremental costs and benefits. It is therefore informative to carry out sensitivity tests on Total Costs (Capital & Operating) ±20%, Total Benefits ±20%, Worst Case Scenario (Total Costs +20%, Total Benefits -20%) and Best Case Scenario (Total Costs -20%, Total Benefits +20%), as is standard practice.

The BCR is estimated to range from 1.21 to 2.79 under these alternative assumptions (NPV $67m to $370m)

Table 6-9 Sensitivity test results ($2020/21 real, discounted) – Cost and benefit confidence

	Core Appraisal	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8
Cost/Benefit Adjustment	N/A	Costs +20%	Costs -20%	Benefits +20%	Benefits-20%	Worst Case Scenario (Costs +20%, Benefits - 20%)	Best Case Scenario (Costs -20%, Benefits +20%)
Total costs (PV)	$263m	$318m	$207m	$263m	$263m	$318m	$207m
Total benefits (PV)	$481m	$481m	$481m	$577m	$385m	$385m	$577m
BCR	1.83	1.51	2.32	2.20	1.47	1.21	2.79
NPV	$218m	$163m	$274m	$315m	$122m	$67m	$370m

Tests 9 & 10: Decongestion parameters (Table 6-10)

The benefits from decongestion include road user travel times savings, vehicle operating cost savings, safety improvement and reduced emissions. These may be estimated bottom-up (as proposed in the core economic appraisal) or by a single parameter that includes estimates of all of these impacts on a cost per kilometre basis.

Two alternatives are tested; one alternative (Test 9) is the Transport for NSW estimate of the marginal cost of congestion from accommodating future growth in greater Sydney ($0.49 per car kilometre). Another alternative is an approach (Test 10) based on the estimated value of the entire rail network in New Zealand ($1.04 per passenger kilometre) [146] [147].

The BCR is estimated to range from 1.74 to 3.25 under these alternative assumptions (NPV $195m to $590m).

Table 6-10 Sensitivity test results ($2020/21 real, discounted) – Decongestion parameters

	Core appraisal	Test 9*	Test 10
Decongestion Method	Bottom-up	Top-down (TfNSW)	Top-down (average value of NZ rail network)
Decongestion Parameter	Time savings – $12.71 /hr (passenger car) & $32.72 /hr (heavy vehicle)	Marginal urban congestion cost (passenger cars) - $0.49 /vkt	Average per passenger km – $1.04 /km
Total costs (PV)	$263m	$263m	$263m
Total benefits (PV)	$481m	$458m	$853m
BCR	1.83	1.74	3.25
NPV	$218m	$195m	$590m

**Note that this parameter is based on passenger cars only ie. excludes adjustments for heavy vehicles.*

Test 11: COVID-19 impact on transport modelling Table 6-11)

An indicative scenario estimating the potential negative impact of COVID-19 under a number of combined hypotheses were modelled by the transport demand modellers, and indicated a potential 16% to 54% reduction in rail patronage across both the Base and Project Cases (2028/29 to 2068/69). The final combined hypothesis result is included as a sensitivity test in order to test the impact of COVID-19 on the economic analysis.

Sensitivity testing assuming the Combined Hypothesis Projection is estimated to result in a BCR of 1.26 (NPV $69m). It is noted that this scenario does not include cost savings from potential reductions in service frequency or train capacity as a result of reduced rail patronage which drives the estimated reduction in net benefits.

Table 6-11 Sensitivity test results ($2020/21 real, discounted) – COVID-19 impact on transport modelling

	Core appraisal	Test 11
COVID-19 Projection	N/A	Combined Hypothesis Projection
Total costs (PV)	$263m	$263m
Total benefits (PV)	$481m	$332m
BCR	1.83	1.26
NPV	$218m	$69m

Tests 12, 13, 14: Increased risk contingencies (Table 6-12)

Cost estimates used in the economic appraisal include contingencies related to planned and unplanned risks determined by probabilistic analysis carried on quantified risks. They represent the 50th percentile (P50) or

[146] Initial Business Case, Stantec (2019)

[147] The Value of Rail in New Zealand, EY, (2016)

‘most likely’ cost of the project. While less likely, higher costs are probabilistically possible. The 95th percentile (P95), which includes funding risk contingencies, has therefore been tested.

Results improve with P95 contingency because the contingency risk for the base case is greater than the risk for the project case and these are subtracted from project case capital costs.

The BCR is estimated to range from 1.10 to 4.57 under these alternative assumptions (NPV $43m to $376m). Although, it is noted that the test where both Base and Project Case costs have P95 contingency included simultaneously is considered to be the most likely in practice (BCR 1.72, NPV $201m)

Table 6-12 Sensitivity test results ($2020/21 real, discounted) – Increased risk contingencies

	Core Appraisal	Test 12	Test 13	Test 14
Project Case Contingency	P50	P95	P50	P95
Base Case Contingency	P50	P50	P95	P95
Total costs (PV)	$263m	$438m	$105m	$280m
Total benefits (PV)	$481m	$481m	$481m	$481m
BCR	1.83	1.10	4.57	1.72

**Note that this parameter is based on passenger cars only ie. excludes adjustments for heavy vehicles.*

Test 15: Lower bound patronage forecasts

The demand modellers also provided patronage forecasts with a lower bound projection. The lower bound assumes a post-2018 slump in demand patterns continue, and demand will slowly continue decreasing. The core appraisal assumes a less aggressive decrease, given that historical patronage was much higher and has potential to return to previous levels. As capacity starts to hit maximum and as the car alternatives continue improving, patronage is expected to slowly plateau 2030 as travellers consistently choose to rely on improved car alternatives over potentially unavailable train seats. This plateau over time, combined with the plateau of population growth, drives our lower bound projection. No external data was available to suggest a notable acceleration in demand, so the core appraisal forecast is informed by historical growth patterns only. the core appraisal is further modified to represent the most likely demand growth from the additional express-specific service improvements. It is assumed passengers travelling the full length of the line experience the small but disproportionate increase in fares relative to those travelling from the middle of the line.

These combined factors are likely to reduce demand growth from regional Wairarapa passengers who travel into Wellington from the end of the line. This reduction over time has a significant impact on the lower bound projections. Sensitivity testing assuming the lower bound patronage forecast is estimated to result in a BCR of 1.35 (NPV $92m).

Table 6-13 Sensitivity test results ($2020/21 real, discounted) – Lower bound patronage forecasts

	Core Appraisal	Test 15
Patronage forecast	Core	Lower Bound
Total costs (PV)	$263m	$263m
Total benefits (PV)	$481m	$355m
BCR	1.83	1.35
NPV	$218m	$92m

The following results are potentially sensitive to changes in assumptions (that is they reduce below a BCR of 1.5):

- Test 2: Applying a 6% discount rate discounts the benefits over time more significantly.
- Tests 6 and 7: Results are sensitive to reduction of benefits of -20% and the worst case scenario (costs +20% and benefits -20%).
- Test 11: Results are sensitive to reduced patronage forecasts due to COVID-19
- Test 12: Results are sensitive to increased risk contingencies on the project case.
- Test 15: Results are sensitive to lower bound patronage forecast scenarios

There are also opportunities for the economic appraisal to improve their BCR above 2.5 above the following changes in assumptions.

- Test 8: Under the 'Best Case Scenario' (costs -20% and benefits +20%) the BCR improves to 2.79.
- Test 10: Results are favourably sensitive to the adoption of the top-down decongestion parameter assumptions used in the IBC, giving a BCR of 3.25. This parameter likely overstates the value of congestion as it is based on the total value of congestion savings due to the rail network, as opposed to the marginal value.
- Test 13: The highest BCR occurs under the scenario where base case costs have increased risk contingencies. This reflects the fact the contingency risks are significantly greater than the preferred solution, making it a more attractive investment.

6.3.3.2 Response to peer review comments

Comments raised by peer reviewers acknowledged a number of potential different approaches to calculating benefits. This sub-section outlines the impacts these may have on the core appraisal.

Test 16: Waka Kotahi benefit parameter update factors

Benefit parameters in the core appraisal expressed in earlier pricing years have been inflated to the current pricing year based on New Zealand Consumer Price Index, an approach that is widely used internationally. Update factors are presented in the Waka Kotahi Monetised Cost Benefit Manual (MBCM) and would be expected to result in a modest net improvement in the economic appraisal results. Sensitivity testing assuming the MBCM update factors is estimated to result in a BCR of 1.98 (NPV $257m).

Table 6-14 Sensitivity test results ($2020/21 real, discounted) – Waka Kotahi benefit parameter update factors

	Core Appraisal	Test 16
Benefit parameter adjustment	Consumer Price Index	MBCM update factors
Total costs (PV)	$263m	$263m
Total benefits (PV)	$481m	$520m
BCR	1.83	1.98
NPV	$218m	$257m

Test 17: Vehicle occupancy factors

Vehicle occupancy factors have been advised by the demand modellers. This was based on NZ 2018 NZ Census data. Alternative values from Table A50 in MBCM provide vehicle occupancy factors which accompany the vehicle occupancy factors above. Sensitivity testing assuming the MBCM vehicle occupancy factors for rural strategic roads is estimated to result in a BCR of 1.72 (NPV $189m). The impact on remaining road user travel times is proportionally less than the change in vehicle occupancy factors reflecting the same factors having been applied to both the project case and the base case.

Table 6-15 Sensitivity test results ($2020/21 real, discounted) – Vehicle occupancy factors

	Core Appraisal	Test 17
Manawatū Vehicle Occupancy Factors	1.05 (0.9546 veh/pax)	1.7 (0.5882 veh/pax)
Wairarapa Vehicle Occupancy Factors	1.06 (0.9464 veh/pax)	1.7 (0.5882 veh/pax)
Total costs (PV)	$263m	$263m
Total benefits (PV)	$481m	$452m
BCR	1.83	1.72
NPV	$218m	$189m

Test 18: Travel purpose breakdowns

The New Zealand Household Travel Survey was used to weight the value of time for business, commute, and other purposes. This is appropriate as it reflects all-day travel (not just commuting peaks in the morning or evening) and is multi-modal (because the Project benefits both rail and remaining road users).

Table A50 of the MBCM suggests all day rural values of 30% for work, 10% for commute and 60% for other. The BCR is estimated at 2.27 under these alternative assumptions (NPV $333m). Testing the effects of alternative travel purpose breakdowns results in the following.

Table 6-16 Sensitivity test results ($2020/21 real, discounted) – Vehicle occupancy factors

	Core Appraisal	Test 18
Value of time	$12.71/hr (NZ HTS)	$17.56/hr (MBCM)
Total costs (PV)	$263m	$263m
Total benefits (PV)	$481m	$596m
BCR	1.83	2.27
NPV	$218m	$333m

Test 19: Crash costs

In the core appraisal, a conservative assumption was used where crash costs per reported injury crash for motorways are applied throughout both corridors. An alternative approach is to apply the cost per reported injury crash for all other sites in 100km/h speed limit areas near rural. This would only apply to two lane areas, where four lane divided roads still have motorway crash costs applied. Sensitivity testing assuming costs per reported injury crash for two lane roads under near rural rates is estimated to result in a BCR of 1.96 (NPV $252m).

Table 6-17 Sensitivity test results ($2020/21 real, discounted) – Crash costs

	Core Appraisal	Test 19
Cost per reported injury crash – two lane	$316,431	$632,861
Cost per reported injury crash – four lane	$316,431	$316,431
Total costs (PV)	$263m	$263m
Total benefits (PV)	$481m	$515m
BCR	1.83	1.96
NPV	$218m	$252m

Test 20: Crash trend adjustment factors

In the core appraisal no crash trend adjustment factors were applied. Empirical evidence suggests that over time there has been a downward trend in reported traffic crashes. At the same time crash numbers have decreased and traffic volumes have increased. The MBCM provides methods for adjusting crash costs which have been applied in a sensitivity test to demonstrate the impact.

Table 6-18 Sensitivity test results ($2020/21 real, discounted) – Crash trend adjustment factors

	Core Appraisal	Test 20
Crash trend adjustment factors	Not applied	Applied
Total costs (PV)	$263m	$263m
Total benefits (PV)	$481m	$480m
BCR	1.83	1.83
NPV	$218m	$217m

Test 21: All factors

The combined effect of all peer review comments have been included to demonstrate the net change to the core appraisal. The MBCM value of time adjustments have been used for this sensitivity test since there are significant limitations of the GWRC survey. The results of the combined factors are illustrated in the table below. Sensitivity testing assuming all factors results in a BCR of 2.29 (NPV $340m).

Table 6-19 Sensitivity test results ($2020/21 real, discounted) – All factors

	Core Appraisal	Test 21
Manawatū Vehicle Occupancy Factors	1.05 (0.9546 veh/pax)	1.7 (0.5882 veh/pax)
Wairarapa Vehicle Occupancy Factors	1.06 (0.9464 veh/pax)	1.7 (0.5882 veh/pax)
Benefit parameter adjustment	Consumer Price Index	MBCM update factors
Value of time	$12.71/hr (NZ HTS)	$17.56/hr (MBCM)
Cost per reported injury crash – two lane	$316,431	$632,861
Cost per reported injury crash – four lane	$316,431	$316,431
Crash trend adjustment factors	Applied	Not applied
Total costs (PV)	$263m	$263m
Total benefits (PV)	$481m	$602m
BCR	1.83	2.29
NPV	$218m	$339m

Overall, the combined effect of peer review comments is not materially significant and provides more upside to the results of the core appraisal.

6.3.3.3 Breakeven Analysis

A break-even analysis on the core results is suitable to test how much remaining road user travel time savings benefits can be reduced to break even with benefits and costs on the project. This analysis determined that if remaining road user travel time savings benefits were reduced from $142m to $0m, there would still be a positive BCR of 1.29, and $76m in NPV. All else held equal; if the BCR were reduced to 1.0 (such that total benefits are equal to total costs), remaining road user travel time savings benefits could reduce by a further $76m in PV.

Table 6-20 Breakeven analysis ($2020/21 real, discounted) – Remaining road user travel time savings

	Core Appraisal	Break-even
Total costs (PV)	$263m	$263m
Remaining road user travel time savings (PV)	$142m	$0m
Total benefits (PV)	$481m	$339m
BCR	1.83	1.29
NPV	**$218m**	**$76m**

6.3.4 Limitations of the economic appraisal

CBA is based on estimates of the direct costs and benefits that can be monetised over 40 years following the completion of construction, and there are a range of other qualitative factors that should be taken into account when interpreting the results of this economic appraisal:

- Crash costs from additional rail service kilometres have not been quantified, although these are expected to be insignificant (for example, when compared to road alternatives) reflecting more passengers transported per kilometre in a fully segregated network and continually improving safety technology.
- The new rollingstock will also provide improved crashworthiness, fire resistance, tunnel egress, stopping distances, passenger and crew air quality and emergency systems compared to the Base Case. These have not been quantified given the complexity of calculating the weighted average cost of these avoided incidents in the Base Case (that is, the avoided costs of low frequency, high consequence and long term impacts on health, wellbeing, disability or mortality).
- Road users were not directly modelled, for example, using a network-wide strategic model. Rather, diverted car trips were estimated based on new rail users and travel times were estimated based on current traffic counts and speeds and have been adjusted linearly in response to the proportional reduction in cars on parallel roads. These could be significantly understated because they do not account for Base Case growth in traffic volumes and there is likely to be a greater, non-linear speed response even at current levels of congestion (but increasing as traffic grows over time).
- Traffic growth has been assumed to be based on the forecast increase in rail patronage rather than historic growth on the current parallel roads as suggested by the MBCM. This requires a suitably large sample of historical data points for a robust trend analysis. Generally, the longer the forecast horizon, the more historical data points are required to be examined. Considering the scale of the appraisal period, this would require a significant number of historical traffic samples in order to forecast traffic volume with a degree of accuracy, hence given the lack of available data, this forecast method was not implemented.
- Perceived congestion costs for drivers (e.g. stress, frustration, difficulty to manoeuvre) which would be reduced as a result of the Project have not been quantified as applying the approach in the MBCM would require additional simulation or strategic modelling of volume to on capacity ratios on parallel roads.
- Increased crash rates due to congestion have not been quantified (that is, safety benefits are based on average network crash rates which could understate these benefits).
- National road user charge revenue per kilometre is used as a proxy for road maintenance resource cost and this does not quantify additional replacement costs expected under the Base Case as a result of greater forecast traffic volumes.
- Travel time savings for both rail and remaining road users are based on an average journey and exclude additional benefits from travel time reliability (for example, having to build additional buffer times in to trips to ensure on time arrival or penalties from unexpected delays).
- There are also expected to be additional wider economic benefits from consolidation of land use around rail stations, increased labour supply and productivity for businesses, resilience to road incidents by providing an alternative route and social benefits from improved access to essential services (particularly where use of a motor vehicle may not be a viable alternative).

6.4 Investment prioritisation method profile

The table below summarises the investment prioritisation method profile in line with Waka Kotahi guidelines.

Table 6-21 Investment Prioritisation 3-factor Matrix for Improvement Activities

GPS alignment	Scheduling	Efficiency				
		VL (BCR<1.0)	L (BCR 1.0-2.9)	M (BCR 3.0-5.9)	H (BCR 6.0-9.9)	VH (BCR>=10.0)
VH	H	7	2	1	1	1
VH	M	8	3	2	2	1
VH	L	9	4	3	2	2
H	H	9	5	4	4	3
H	M	10	6	5	5	3
M	H	10	7	6	6	4
M	M	10	9	8	6	5
H	L	11	8	8	6	5
M	L	11	10	10	9	8
L	H/M/L	12	12	12	12	12

GPS alignment

- The investment proposal responds strongly to the outcomes sought by the GPS, as it 'enables a substantial increase in access to social and economic opportunities for large numbers of people along dedicated key corridors and enables transit-oriented development.
- The capacity and frequency improvements, both outside of and within the electrified area, will address significant capacity constraints and allow the network to accommodate the projected growth. It will improve overall access and connectivity as a result.
- The investment proposal is also expected to increase the viability of transit-oriented development at the key stations used by the services within the electrified area, where land use intensification is currently being actively investigated and the longer distance Wairarapa and Manawatū services are integral to the overall capacity and service offering.

Schedule

- The schedule is tight due to replacement of end-of-life assets being required, growing capacity constraints and long lead times for purchase.

Efficiency

- The detailed CBA estimates that the preferred solution has a BCR of 1.83 and NPV of $218 million.

7 CHAPTER 7 – COST AND RISK ANALYSIS

CHAPTER SUMMARY AND CONCLUSIONS:

- The cost estimate and risk analysis has been completed according to Waka Kotahi guidelines to include a Quatified Risk Assessment of both the implementation and operation components of the preferred solution.
- The outcomes of a risk assessment indicate that there are risks associated with the project, which were quantified to calculate suitable risk contingencies. The delivery phase costs (in real 2021 dollars) include:
  - a base cost estimate of **$476 million**, which forms the basis for risk adjusted costs
  - a P50 risk adjusted cost of **$587 million**, which is used for the economic cost-benefit analysis
  - a P95 risk adjusted cost of **$690 million**, which is used for the financial analysis.
- A comprehensive risk assessment identified 102 risks, which are documented in a live risk register. The risks identified are typical of risks found in rail/rollingstock projects. However, some typically expected risks were avoided, as the preferred solution:
  - does not require land acquisition or urban planning management to deliver planned benefits
  - does not rely on unproven technologies or supply chains to function as planned
  - does not require track electrification work to provide reliable service.
- The key risks of the LNIRIM project, to be further mitigated in the next phases of the project, include:
  - risks of delay in delivery of the project due to late funding commitment or exceptional international supply chain disruption.
  - risks of technical incompatibility between modern trains and the local rail network.
  - risks related to foreign exchange volatility between the estimate date and the supply agreement
- A key opportunity from the LNIRIM project is to exploit synergies between the Connector, Te Huia and LNIRIM projects, by designing the LNIRIM fleet as a national platform for Passenger Rail and leverage more advantageous supply conditions from train manufacturers by increasing the size of the order or including options for further units.

7.1 Purpose and overview of chapter

This chapter identifies and assesses the opportunities and risks that may positively or adversely impact the delivery of the LNIRIM project and the benefits sought through the proposed investment.

This chapter:

- describes the methodology applied to develop capital and operating cost estimates
- documents the approach to risk identification and analysis
- confirms how outcomes of the risk analysis process informed the cost estimation process
- confirms the risk adjusted capital cost estimate and the operating cost estimates.

The risk analysis presented in this chapter inform the risk adjusted costs used in the Cost Benefit Analysis detailed in Chapter 6 and the financial analysis carried out through Chapters 8 and 9.

7.2 Methodology and approach

Projects are inherently uncertain, creating the potential for a range of possible outcomes to materialise over time. Identifying and quantifying project risks enables the potential overall cost to deliver a project to be estimated. In this way, the risk assessment informs the project's overall cost profile and ultimately helps guide implementation planning for the project.

7.2.1 Approach

The main aim of the comprehensive risk analysis conducted as part of this DBC development is to reduce the adverse risks of the project as early as possible to maximise the chances for successful delivery. Additionally, the risks were quantified to derive risk contingencies and risk adjusted costs that informed the economic and financial analysis.

The risk management approach followed the Risk Management Practice Guide (Minimum standard Z/44), version 5, Feb 2018. The 'Advanced Approach' was followed to complete a quantitative risk analysis and management appropriate for a DBC of this nature and scale.

Risk analysis comprised the following six key stages:

- **Risk identification** – identifying and documenting the contingent risks which may impact the project.
- **Qualitative risk analysis** – determining quantification factors (likelihood and impact of consequences) using the project risk register to assess each risk and identify the probability factors and cost of consequences.
- **Quantitative risk analysis** – using @Risk software to complete a Monte Carlo analysis to derive risk contingency values for both inherent and contingent risks.
- **Risk allocation** – identifying which parties will be able to best manage the identified risks.
- **Risk mitigation** – identifying risk management strategies and contingency planning approaches to mitigate risks.
- **Monitoring and review** – continuous review and update of the risk register to reflect the evolution of the Project.

As part of developing this DBC, the first three stages have been completed. While the mitigation treatments have been considered, the latter three stages will be further analysed and completed during the detailed design, procurement, and delivery stages of the project. Mitigation strategies for key risks have been identified, at a high level, to ensure relevant risks are not 'overpriced', can be managed, and will not jeopardise the viability and constructability of the project.

The approach to assessing each type of risk is summarised below:

- **Planned (inherent) risk** – is risk on items which will occur, however the quantum or rate is variable. Planned risk was quantified by including a range in relation to the quantities (quantity variance) and rates (unit rate variance) in the submission schedules.
- **Unplanned (contingent) risk** – relates to potential changes in conditions, which may, upon occurrence, impact on the scope and/or nature of project works to be undertaken, relative to current project planning. Unplanned risks are two-dimensional. One dimension is the risk consequence, and the other is the likelihood. Each dimension can act independent of the other and can have a significant impact on the overall costs.

The cost estimate for the preferred solution, detailed in Appendix J, follows the Waka Kotahi Cost Estimation Manual (SM014), Second Edition, Aug 2021. The cost models used in preparing the elements of the estimates were tailored to the relative importance of these elements in terms of percentage of the total cost and risk profile. As a result, the largest, riskiest elements of cost were sourced from international specialists, using models built on statistically relevant analysis of recent and relevant projects. Then the costs were risk-adjusted using probabilistic analysis to strengthen the risk adjusted cost estimate with the appropriate levels of contingencies (P50 and P95).

Additionally, international references were used to further inform the process, estimates and contingencies. These were primarily The Green Book, HM Central Government Guidance on Appraisal and Evaluation, 2020, and the British Department for Transport, Procedures for Dealing with Optimism Bias in Transport Planning, June 2004.

7.2.2 Risk identification and assessment

This DBC leveraged and reviewed the prior IBC work and existing risk registers. The risk management process followed accepted best practice aligning with Waka Kotahi guidelines and standards before the start of this DBC. The general approach to risk management followed by GWRC, and already identified through the IBC, led to the identification of the key elements of risk related to the provision of rail integrated mobility solutions in the future. The analytical and planning work completed in the earlier phases of the project by GWRC, its professional advisors, and Waka Kotahi in its reviews of the IBC, have considerably de-risked it by refining its scope and focusing this DBC on key residual risks.

These risks have driven the analysis by focusing the definition of the problem statements, objectives, selection criteria and the definition of the benefits sought through the investment proposed in this DBC. At a high level, the preferred solution proposed is itself the result of this longitudinal risk management process.

Table 7-1 Project high level risk profile with proposed option

High level risk	Pre DBC mitigation, including IBC process, Waka Kotahi direction, and GWRC scoping of DBC	LNIRIM Phase 1 (DBC) mitigation	Resulting high level risk profile of the proposed investment
Risk that aging fleet end its life before a solution is implemented, reversing mode shift and constraining communities.	Identification and strategic approach, IBC, Creation of the LNIRIM project Select a Passenger Rail DBC specialist with current experience in similar projects	Integration of time constraint in selection of solution Integration of time constraints in risk adjusted programmes and contingencies.	**High,** Because severe consequences are possible if the investment is delayed.
Risk that outturns cost of the fleet outweighs the benefits sought	Select a Passenger Rail DBC specialist with current experience in cost management of similar projects Select a DBC Rolling Stock specialist with current cost data models. Focus DBC work by bespoke analysis report on whole of life cost Rolling Stock	Integration of risk adjusted cost estimates based on statistical analysis of relevant and current fleet costs sampled worldwide. CBA and Financial analysis including wide spectrum sensitivity analysis. Investigation of COVID 19 impact on travel and patronage forecast.	**Medium,** Because the cost of the technology chosen is very well known. Also, residual financial risks associated with an international procurement are integrated in contingencies. Severe consequences but unlikely to happen.
Risk that infrastructure or supply chain constraints limit the feasibility of using advantageous technologies	Continuous review of network electrification initiatives Select a DBC Rolling Stock specialist with current best practice experience in new technologies (e.g., Hydrogen cells)	Integration of infrastructure and supply chain constraints into selection criteria Selection of a fleet type and service that meet benefits without reliance on large infrastructure upgrades.	**Low,** Because the technology chosen does not rely on electrification of the lines and requires little rail network infrastructure upgrade. Severe consequences but rare.
Risk that technology of a new fleet does not provide the benefits sought because it is either obsolete, unproven, or inadequate.	Select a DBC Rolling Stock specialist with current best practice experience. Focus DBC work by bespoke analysis report on Rolling Stock.	Integration of technology and resulting safety, emissions, and effectiveness of the solution into selection criteria De-risk technology by assessing options against insights of current fleets	**Low,** Because the technology chosen is very well proven. Severe consequences but rare.
Risk that land acquisition, urban planning, or Treaty regulations prevents the implementation of the solution	Integration of KiwiRail interface in Governance Group and DBC scope to ensure rail land opportunities are considered.	Integration of land requirements and constraints into selection criteria. Selection of fleet and service solution that fits on rail land and does not require land acquisition	**Low,** Because the preferred solution's footprint fits in rail designated brownfield. Severe consequences but rare.

Two risk review workshops were conducted to review and update the risk register produced for the LNIRIM DBC. In addition, meetings were conducted with subject matter experts and specialist consultants to challenge, update and refine the risks, consequences, estimation and mitigation strategies.

The nature of the RPS led consortium including external suppliers LYNXX (Modelling and patronage forecast) and IPEX (Rolling Stock Specialist), allowed the constant challenge of the project teams' perception of risk, thus minimising bias. Using an open and integrative approach, the DBC team included key members of the client's team. This allowed the challenge of the risk identification and assessment done by international experts against current local practice.

7.2.3 Rating scales

The risk rating process applied Waka Kotahi's risk rating matrix (Table 7-2) to:

- assess the likelihood of each risk occurring
- determine the consequence should the risk occur.

Table 7-2 Risk ranking matrix

	Insignificant	Minor	Moderate	Severe	Extreme
Almost certain	Low	Medium	High	Critical	Critical
Likely	Low	Medium	High	Critical	Critical
Possible	Low	Medium	Medium	High	Critical
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Low	High

The risk likelihood definitions (Table 7-3) were based on Waka Kotahi's guidelines.

Table 7-3 Risk likelihood definitions

Likelihood	Definition
Almost certain	The risk has a >85% change of occurring
Likely	The risk has a 55-85% change of occurring
Possible	The risk has a 30-55% change of occurring
Unlikely	The risk has a 5-30% change of occurring
Rare	The risk has a <5% change of occurring

The consequence definitions for delivery and cost categories were tailored for the size and scale of the preferred solution (Table 7-4), while the remaining categories' consequence definitions using the exact Waka Kotahi definitions.

Table 7-4 Risk consequence definitions tailored for LNIRIM

Rating Scale	Delivery	Cost
Extreme	Programme slippage resulting in late delivery by more than 1 year.	Negative financial impact of more than $100m
Severe	Programme slippage resulting in late delivery by between 6 months and 1 year.	Negative financial impact between $50m to $99m.
Moderate	Programme slippage resulting in late delivery by between 3 and 6 months.	Negative financial impact between $20m to $49m.
Minor	Programme slippage resulting in late delivery by between 30days and 3 months.	Negative financial impact between $5m to $19m.
Insignificant	Programme slippage resulting in late delivery by less than 30 days.	Negative financial impact of less than $5m.

7.3 Qualitative risk assessment

The Project risk register is a live document and has been updated throughout the course of the Project. Within the current version of the risk register, a total of 102 active risks have been identified and qualitatively assessed. Most of risks were reduced after the proposed mitigation measures. Table 7-5 provides a summary of risks.

Table 7-5 Risk levels pre and post risk treatment mitigation measures

Risk Level	Pre-treatment risks	Post-treatment risks
Critical	11	4
High	21	8
Medium	69	88
Low	1	2

Table 7-6 provides a more detailed breakdown of the risks by category.

Table 7-6 Risk levels pre and post risk treatment mitigation measures by category

Risk category	Pre-treatment				Post-treatment				Total
	Critical	High	Medium	Low	Critical	High	Medium	Low	
Fleet	3	5	21		2	3	24		29
Maintenance depot	2	1	11	1		2	12	1	15
Commercial	1	4	9			1	13		14
Facilities		1	9				10		10
Stakeholders		1	6				6	1	7
Network		4	3			1	6		7
Maintenance	1	1	4		1		5		6
Procurement	2	1	2		1		4		5
Stabling			4				4		4
Planning		3					3		3
Schedule	2					1	1		2
Grand Total	**11**	**21**	**69**	**1**	**4**	**8**	**88**	**2**	**102**

The fleet category naturally records the most risks, including two that remain at critical level post DBC mitigation. The continuous management of risk has led to the mitigation of 19 risks below the high ranking.

Additional risk categories may be added as required as reviews and updates of the Risk Register are made during and after the review of the DBC by funding authorities.

Table 7-7 Key risks above the acceptability threshold remain Critical or High after Phase 1 mitigation.

ID	Category	Title	Description	Type	Risk level before Phase 1	Planned treatment actions	Treatment phase	Risk Level post Phase 1
1	Fleet	Delay in delivery	Train supplier unable to meet assumed delivery rate causing operational shortfall.	Delivery	Critical	• Design the payment mechanism to include liquidated damage or delayed payments until the trains arrive • Provide Funding Risk Contingency	Phase 2/3	Critical
3	Maintenance	Unrelated safety incidents impact on this project - Maintenance Phase	Unrelated safety incident (on road/rail networks) impacts on requirements for this project (i.e. train safety incident on network/another project leads to rail operator/regulator requiring much greater safety requirements leading to delay/additional costs).	Legal / Compliance	Critical	• Ensure that safety is a key priority in Supplier's management and operational plans • Provide Funding Risk Contingency	Phase 2/3	Critical
7	Procurement	Foreign exchange rate risk - Procurement	The risk of additional costs resulting from major exchange rate movements during procurement	Cost	Critical	• To be accounted for in Value for Money assessments of the bids • Provide Funding Risk Contingency	Phase 1/2	Critical
54	Fleet	Unrelated safety incidents impact on this project - Delivery Phase	Unrelated safety incident (on road/rail networks) impacts on requirements for this project (i.e. train safety incident on network/another project leads to rail operator/regulator requiring much greater safety requirements leading to delay/additional costs).	Delivery	Critical	• Ensure that safety is a key priority in management and construction plans • Provide Funding Risk Contingency	Phase 2/3	Critical
2	Fleet	Network Interface - Supplier	The underlying characteristics of the network are incompatible with the trains. There is a risk that Supplier does not identify all issues and notify GWRC in sufficient time to enable the network and systems to be upgraded or re-designed. For example, delays related to Waka Kotahi / KiwiRail Network Safety regulations. This may result in delays to the train delivery and rework of the trains or network.	Legal / Compliance	Critical	• Provide the bidders with a detailed understanding of the network requirement and assess how their proposed product would operate on the network. Require a commitment during bid that bidders are comfortable their train can operate on the network. • Obtain from Waka Kotahi / KiwiRail / CRLL the interface requirements beyond what is currently required for the existing GWRC network and incorporate these into the procurement. • Develop and implement a clear process for identifying and achieving agreement from all stakeholders on the requirements before they are released to the bidders. • Provide Funding Risk Contingency	Phase 2/3	High
4	Maintenance Depot	H&S during design and construction for the Maintenance Depot	Serious Safety (H&S) incident to employee on-site during design and construction.	Health & Safety	Critical	• Incorporate safety KPIs in the Contract	Phase 2/3	High

ID	Category	Title	Description	Type	Risk level before Phase 1	Planned treatment actions	Treatment phase	Risk Level post Phase 1
5	Maintenance Depot	OH&S during the maintenance phase at the Maintenance Depot	Serious Safety (OH&S) incident to employee on-site during maintenance phase	Health & Safety	Critical	• Incorporate safety KPIs in the Contract	Operation	High
8	Schedule	COVID Risk	Delays in the delivery of either the trains, or one of the facilities due to a worsening of the COVID pandemic and consequential impact on resources and supply chains	Delivery	Critical	• Ensure that bidders include a detailed analysis of the potential impact of COVID or another pandemic on either delivery schedule and supply chain • Provide Funding Risk Contingency	Phase 2/3	High
17	Commercial	Foreign exchange rate risk - Delivery	The risk of additional costs resulting from exchange rate movements during delivery	Cost	Critical	• Risk to be transferred to Supplier • Review the commercial submission to ensure that suppliers take appropriate security measures with respect to forex.	Phase 2	High
22	Fleet	H&S during manufacturing	Serious Safety (H&S) incident to employee on-site during testing of the train or there is a safety incident on rail network as a result of testing and commissioning activities.	Health & Safety	High	• Incorporate safety KPIs in the Contract	Phase 3	High
28	Network	Infrastructure solution poorly defined	Infrastructure options used to build the case are not adequate / sufficient to support the delivery of the targeted service. Clear definitions of infrastructure options available for consideration. This will include start and end points of upgrades, effect of upgrade, etc.	Stakeholders	High	• Regular communications with all stakeholders, discussing progress and potential options. This will require all stakeholders to respond to requests in a timely manner • Integration of Network owner in delivery group.	Phase 2/3	High
53	Fleet	Change in Mandatory Requirements - delivery	Change in Mandatory Requirements during delivery phase resulting in change to specification.	Legal/Compliance	High	• Provide Funding Risk Contingency	Phase 2/3	High
21	Fleet	Change in Mandatory Requirements - maintenance	Change in Mandatory Requirements during maintenance phase resulting in change to specification.	Delivery	High	• Provide Funding Risk Contingency	Phase 1	High

7.4 Quantitative risk assessment

The planned cost data for the estimate was derived from several sources with differing levels in confidence. It is therefore not appropriate to add a single percentage contingency across every line item as this will tend to overestimate the cost risk of some items as well as underestimate the risk of other items. For example, there has been considerable effort and analysis of rolling stock and associated costs due to the high proportion of the total costs this represents. This enabled the team to reduce the uncertainty of these items and in turn reduce the planned P50 and P95 range for rollingstock. There are however other planned line items which have greater uncertainty but make up a lower proportion of the total cost and therefore have a proportionally greater P50 – P95 range.

Furthermore, the range in planned costs only reflect the expected variations of the cost estimate itself while extraordinary events that could affect these costs are dealt with in the unplanned risk section of the analysis.

7.4.1 Probabilistic risk model approach

Due to the variation in costs, confidence levels and proportions of the total cost for each item in the estimate, a probabilistic approach was taken to ascertain the P50 and P95 of the total LNIRIM project cost.

A risk model was created using Palisade’s @Risk software (ver8.2) following which a Monte-Carlo analysis using 10,000 simulations was run for the model to calculate the P50 and P95 outcomes for each cost group in the estimate as well the total P50 and P95 for the whole LNIRIM project. Probability distributions for the planned and unplanned risks were based on the confidence of the cost data available and the parameters for minimum, maximum and most likely, were based on the confidence in the estimate.

7.4.1.1 Planned Risks

For Planned risks, a pert distribution was used to represent how outturn costs tend on average to be somewhat greater than the estimate with a relatively low chance of the outturn cost being significantly below that of the estimate and therefore the probability distribution would be expected to be skewed to the right.

7.4.1.2 Unplanned Risks

Unplanned risks are the contingent or discrete risks identified in the project risk register. They represent ‘known unknowns’. The impact of unplanned risks is not directly attributable to a particular schedule item in the cost estimate. Therefore, unplanned risks were defined from the analysis of the risks listed in the register, to identify material risks to include in the quantification, and aggregated by nature and consequences to maintain the integrity of the Monte Carlo analysis.

After the identification of unplanned risks, the risk register was reviewed against the cost estimate to ensure that duplication of planned and unplanned risks did not occur.

Resulting aggregated unplanned risk quantified for the purpose of the QRA are presented in the table below.

Table 7-8 Aggregated unplanned risks

Type	Risk	Risk Definition	Consequence
Financial	P1	FOREX movement between cost estimate and procurement leads to unfavourable cost fluctuations	Rollingstock cost increase
Time	P2	Delay in supply / delivery of imported goods due to unforeseen supply chain disruption (COVID or other)	Delay in delivery of fleet, loss of benefits, cost of extending old fleet.
Time	P3	Delay of service start due to unforeseen local disruption of supply chain (COVID or other)	
Time	P4	Delay in rail infrastructure delivery (Passing loops or alternative, depot track connection...) other than COVID related	
Schedule	P5	Increase of scope of building, stabling, infrastructure and equipment requirement due to unforeseen changes in legislation or regulation.	Cost increase
Schedule	P6	Increase of scope of station platform, building, infrastructure and equipment requirement due to unforeseen changes in legislation or regulation.	Cost increase by up to 100%

For unplanned risks, a separate methodology was used where a probability of the risk occurring was assigned to each risk item and only when the simulation showed an occurrence of that risk the simulated cost of that risk was sampled. For example, if a risk were allocated a 20% probability of occurring, on average, only 1 in 5 of the simulations would be sampled for cost. Each unplanned risk was modelled independently to represent more realistic scenarios in which different numbers of risks with different levels of consequence occur for each simulation.

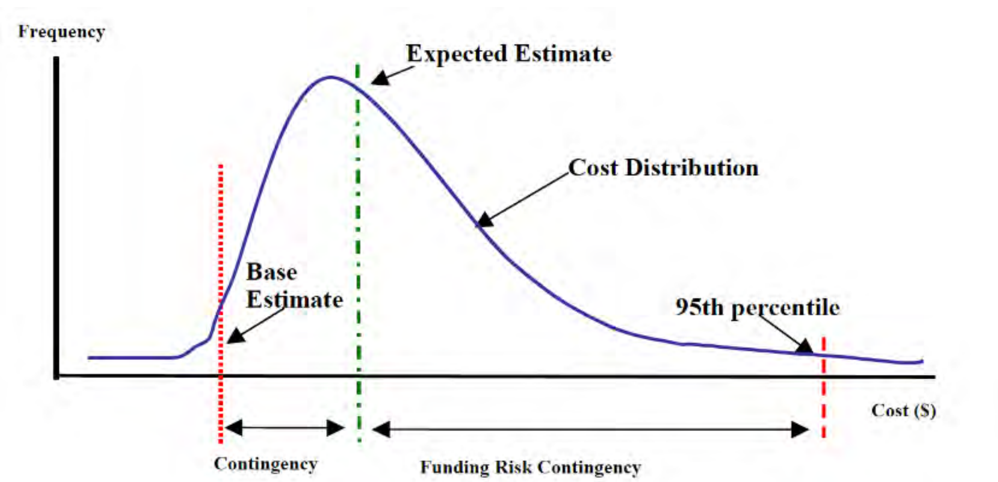
7.4.2 Risk adjusted costs

Contingencies for planned and unplanned risk resulting from the Monte Carlo analysis are presented below.

Simulations were made for a range of combinations of planned and/or unplanned risks applied to implementation (pre-delivery and delivery phase) and/or operation costs (operations phase) to determine the resulting appropriate contingency (P50) and funding risk contingency (P95) adjustments to the base cost estimate. The sequence of possible risks realisations was accounted for to prevent a duplication of contingencies arising from unplanned risks correlating to both implementation and operation costs simulations. Similarly slight adjustments were made to ensure the impact of unplanned risks were adequately represented across implementation and operation costs.

Figure 7-1 shows an illustrative cost distribution and associated definitions of the contingency levels as per Waka Kotahi guidelines.

Figure 7-1 Waka Kotahi’s illustrative cost distribution: contingency and funding risk contingency



As per Figure 7-1, the risk adjusted cost consists of:

- The base cost representing the sum of the costs at the applicable base date. It represents the best prediction of the quantities and current rates which are likely to be associated with the delivery of a given scope of work. It does not include any allowance for risk (contingency) or escalation.
- The “contingency”, defined as the difference between the expected (P50) estimate and the base cost estimate.
- The “funding risk contingency”, defined as the difference between the 95th percentile of costs (P95) and the expected (P50) estimate.

The next sections summarise the outcomes of the probabilistic modelling and resulting cost adjustments to the preferred solution’s base costs.

7.4.2.1 Pre-delivery and delivery phase

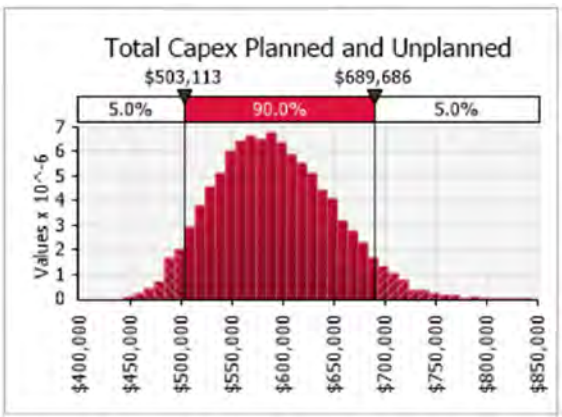
Figure 7-2 shows the risk-adjusted cost estimates at the P50 ($587.7 million) and P95 ($690.1 million) confidence intervals.

Figure 7-2 Risk adjusted pre-delivery and delivery phase capital costs

Pre-delivery and delivery phase costs	Real ($ million)	As a percentage of base estimate
Base estimate	476.3	
Contingency	111.4	23.4%
Funding risk contingency	102.4	21.5%
Total risk-adjusted cost at the P50 confidence level	**587.7**	
Total risk-adjusted cost at the P95 confidence level	**690.1**	

Figure 7-3 shows a distribution of the pre-delivery and delivery phase costs and a breakdown of associated cost percentiles.

Figure 7-3 Planned and unplanned risks – pre-delivery and delivery phase costs simulations



Note: all values in the figure on the left are expressed in real $000.

Percentiles	
Percentile	Value ($million)
1%	479
2.5%	490
5%	503
10%	518
20%	540
25%	549
50%	**587**
75%	629
80%	640
90%	667
95%	**690**
97.5%	708
99%	731

7.4.2.2 Operations phase

Figure 7-4 shows the risk-adjusted cost estimates at the P50 ($1,478.8 million) and P95 ($1,708.0 million) confidence intervals.

Figure 7-4 Risk adjusted operations phase capital costs, total for period ending June 2068.

Operations phase costs	Real ($ million)	As a percentage of base estimate
Base estimate	1,364.2	
Contingency	114.6	8.4%
Funding risk contingency	229.2	16.8%
Total risk-adjusted cost at the P50 confidence level	**1,478.8**	
Total risk-adjusted cost at the P95 confidence level	**1,708.0**	

Figure 7-5 shows a distribution of the operations phase costs and a breakdown of associated cost percentiles.

Figure 7-5 Planned risks - operations costs simulations

Note: all values in the figure on the left are expressed in real $000.

Percentiles	
Percentile	Value ($million)
1%	1279
2.5%	1298
5%	1316
10%	1343
20%	1379
25%	1396
50%	1472
75%	1564
80%	1588
90%	1655
95%	**1709**
97.5%	1757
99%	1812

7.4.3 Sensitivity analysis

The largest financial risk to the Expected Estimate relates to the Rolling Stock related risks.

Planned and unplanned risks related to the cost of rolling stock have the largest impact (top 2) on the risk adjustments. These risks are treated through the delivery model selected in Chapter 10, the commercial approach presented in Chapter 11 and the risk management process detailed in Chapter 12.

Unplanned risks related to the timeliness of delivery and consequential costs are also having a notable impact on the risk adjustments. These risks are partially treated through the delivery model selected in Chapter 10, the commercial approach presented in Chapter 11 and the risk management process and benefit realisation management process detailed in Chapter 12.

Figure 7-6 Sensitivity analysis of planned and unplanned risk related to implementation costs. Values expressed in $000s, real.

[redacted]

7.5 Cost and risk quality assurance and review

In addition to internal reviews and quality assurance processes, an ongoing review of costs between the members of the consortium delivering the DBC and the client organisation GWRC has been used to reinforce certainty of assumptions and costs. This has created buy-in to the estimate from the whole team, client and supplier, delivering the Detailed Business Case

The output of the QRA was sense checked against data and institutional knowledge of both RPS and IPEX to ensure a realistic alignment of contingency with the risk profile of the project.

International guidelines and literature were used to benchmark the resulting contingencies with consideration for the stage of the project, the absence of land risks and the strength of the Rolling Stock cost analysis used for the estimate. These included The Green Book, HM Central Government Guidance on Appraisal and Evaluation, 2020, the British Department for Transport, Procedures for Dealing with Optimism Bias in Transport Planning, June 2004 and the recent draft of the Government of South Australia, Estimating Manual, Transport Infrastructure Projects, EST 600.

8 CHAPTER 8 – FINANCIAL ANALYSIS

CHAPTER SUMMARY AND CONCLUSIONS:

- The financial analysis reflects the financial impacts of the preferred solution, defined in Chapter 5, compared to the do-minimum case, defined in Chapter 4. Overall, the preferred solution demonstrates a higher value-for-money than the do minimum case, based on the whole of life cost per service.
- While the initial delivery phase cost of the preferred solution is higher than the do-minimum case (by $572.6 million in nominal terms), the total whole of life cost of the preferred solution is lower than the net whole of life cost for the do minimum case by $166.4 million. This is explained by:
  - the do minimum case's higher operating phase costs (by $431.6 million) due to the need to continuously refurbish and maintain the second-hand fleet
  - the do minimum case's lower farebox revenue (by $307.4 million), as it assumes current service frequencies compared to the preferred solution assuming increased service frequencies (see Chapter 4).
- The investment in the preferred solution will provide a greater value-for-money return, despite a higher net whole of life cost in Present Value (PV) terms by $181.8 million) as:
  - the cost per service provided is substantially lower for the preferred solution by about ~$3,800 per service (measured on a PV net of whole of life basis)
  - the preferred solution accounts for about 151,000 more services (higher frequencies) over the operations period compared to the do minimum case.
- The preferred solution therefore provides for a 143% increase in services with the cost per service being reduced by 50% than the do-minimum case.
- In addition to increased services enabling increased mode shift, the communities would benefit from safety and environmental benefits associated with an investment in a modern brand-new fleet that would utilise electrified parts of the Manawatū and Wairarapa rail lines, while also leveraging the opportunities for carbon reduction through batteries on the non-electrified parts of the network
- A sensitivity analysis of the preferred solution's net whole-of-life costs reflects that it is most sensitive to large increases in operating phase costs and delivery phase costs than changes in escalation and discount rates. It is less sensitive to changes in farebox revenue.

8.1 Purpose and overview

This chapter outlines the financial impact of the preferred solution outlined in Chapter 5 Preferred Solution compared to the do-minimum case, defined in Chapter 4 Option Analysis. The financial analysis includes revenue and costs associated with delivery and operation of the preferred solution over the assessment period.

This chapter outlines the financial analysis:

- approach, including methodology, key assumptions and definitions
- assessment outcomes
- sensitivities.

8.2 Approach

8.2.1 Methodology

The whole-of-life financial analysis of the preferred solution has been conducted in line with Waka Kotahi Guidelines for the detailed business case.

Figure 8-1 outlines the financial analysis methodology.

Figure 8-1 Financial analysis methodology

Step	Description
1	**Agree on the model methodology and develop assumptions** The financial modelling methodology was developed in consultation with and reviewed by GWRC and key stakeholders, including Waka Kotahi.
2	**Develop model** The financial model was developed based on the agreed methodology and assumptions.
3	**Review and test model** The draft model was internally reviewed and tested for robustness.
	Internal Review 1: Draft
4	**Import input data and analyse the outcomes** As the preferred solution was refined, input data was imported into the model. Allowance was made for several project options to be analysed via the financial model, including the do minimum case.
5	**Scenario and sensitivity testing** A range of scenarios and sensitivity tests were analysed, including variations in key financial assumptions.
6	**Financial analysis** Financial analysis (this chapter) included analysis of the whole of life real, nominal and present value cashflows of the preferred solution, shown in comparison with the do-minimum case.
7	**Affordability analysis** Affordability analysis (Chapter 9) included annual funding requirements for the preferred solution during the delivery and operations phases. It also included sponsor funding contribution profiles and potential options to improve affordability.
	Internal Review 2: Final
8	**Independent peer review of the financial analysis** The financial analysis was made available for an independent peer review.
9	**Financial analysis report** A financial analysis report was developed to provide further details of the methodology, assumptions used in the model and financial modelling outcomes.

The financial analysis and modelling process involved an ongoing and iterative engagement with GWRC, Horizons and Waka Kotahi to ensure open collaboration and considered funding application requirements.

The key outcome of the financial modelling process is the assessment of the financial impact of the preferred solution, affordability analysis, sensitivity and scenario analysis to equip investors with information necessary for their decision making.

In combination with other analyses, such as risk analysis (Chapter 7), the financial analysis is used to build up a detailed analytical picture of the preferred solution.

Each of the project cost and revenue elements and the net whole-of-life project cost is represented in real, nominal and present value terms. The analysis relies on inputs and assumptions provided:

- costs were provided by GWRC and IPEX technical advisors and were estimated in accordance with Waka Kotahi Cost Estimation Manual (SM014), second edition, for transport services issued on 1 August 2021
- revenue assumptions were provided by Lynxx demand modelling advisors.

A financial model was developed to capture the pre-delivery, delivery and operations periods to present the net cash flows up to the end of the assessment period (30 June 2059). This approach reflects a discounted cash flow analysis methodology typical for the assessment of infrastructure projects.

Figure 8-2 shows the structure of the financial model.

Figure 8-2 The financial modelling methodology

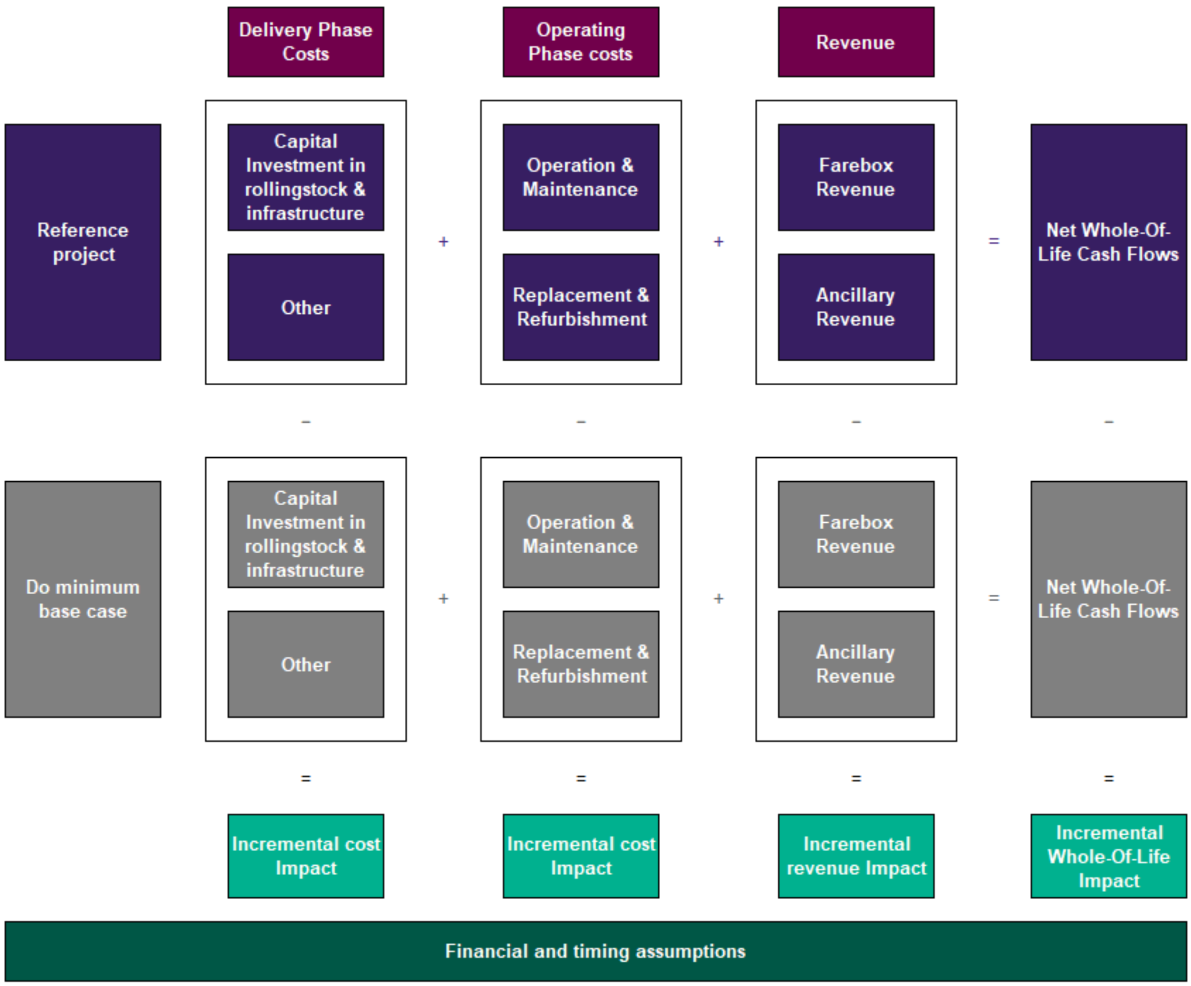


Figure 8-2 shows that the financial modelling includes:

- a whole of life analysis of both the preferred solution and the do minimum case to reflect the incremental financial impact of the preferred solution
- an analysis of the financial impact of the project during the pre-delivery, delivery and operations phases of the project
- the delivery phase costs, operations phase costs and the revenue to be earned in the project operations phase. The revenue consists of farebox revenue. Other commercial opportunities will be further explored in future stages of the project.
- financial and timing assumptions (these are further defined in the next sections).

The model undertakes the following key steps in developing the outputs of the project's financial impacts:

- general and project specific data is entered as factors into the model's input page, which applies variables and indices to create a projection of the most likely potential future financial environment
- the calculations step takes the data and applies a series of calculations (based on the variables) to produce output figures that provide an estimate of the total project costs and revenues

- key input variables are varied, and the results recorded in a process called sensitivity testing to understand the possible range of impacts
- an affordability analysis is then applied to estimate the funding needs of the project.

8.2.2 Definitions

This section outlines key definitions used in the financial analysis.

Table 8-1 Key definitions

Term	Explanation
Ancillary revenue	Typically, this is revenue earned through means other than fare ticketing, such as advertising placed on stations along the route. For the purposes of LNIRIM, commercial opportunities other than farebox revenue will be explored further in future stages of the project.
Assessment period	The period from the base date until the end of the operations phase.
Base cost estimate	The sum of the costs at the applicable base date. It represents the best prediction of the quantities and current rates which are likely to be associated with the delivery of a given scope of work. It does not include any allowance for risk (contingency) or escalation.
Base date	A 'base date' is a reference date from which changes in conditions can be assessed. In the context of a base estimate, it is the date for which the rates included in the cost estimate reflect current market conditions.
Contingency	Waka Kotahi guidelines defines "contingency" as the difference between the expected (P50) estimate and the base cost estimate (Figure 7-1).
Delivery phase costs	This includes physical works and costs related to delivery of a new solution upon the appointment of a selected contactor. Delivery phase costs mostly relate to capital expenditure. For the purposes of LNIRIM, delivery phase costs also include any refurbishment and renewal of the existing fleet to continue existing services until a new solution can be implemented.
Deterministic risk contingency estimation	In deterministic methods, contingency is estimated as a predetermined percentage of base cost depending on the project phase.
Escalation	The component of a project's total cost at any point in time that reflects changes in prices and costs since the Base Cost Estimate date. Escalation is added to the Project Cost to obtain the Outturn Cost.
Escalation rate	The rate of change in price for goods or services associated with an asset.
Farebox revenue	This consists of farebox revenue collected during the operations phase. The farebox revenue was estimated by the demand modelling advisor Lynxx and provided in annual demand forecasts in real terms, exclusive of GST, for each financial year. For the purposes of LNIRIM, the 5% fare evasion was assumed to reflect commuters avoiding paying for their travel. The farebox revenue is based on an average fare that incorporates peak, off-peak and concession fares.
Funding risk contingency	Waka Kotahi guidelines defines "funding risk contingency" as the difference between the 95th percentile of costs (P95) and the expected (P50) estimate (Figure 7-1).
Nominal	Outturn (escalated / inflated) costs, used for the budgeting purposes
Operations phase costs	This includes both operational and sustaining capital expenditure required during the operations phase.
Outturn costs	The sum of the price-escalated costs for each year of a project's duration. Outturn cost calculation requires the non-escalated project cost to be presented as a cash flow and the application of an escalation factor for each project year to derive the price escalated cost for each year. The outturn costs are used for the budgeting purposes.
Pre-delivery phase costs	This includes pre-implementation phase fees and implementation phase fees up to the preferred solution. This phase typically includes detailed planning (such as environmental approvals, community consultation) and design (such as field studies, detailed design, quantity estimates), the development of detailed and refined project budgets/timings (including a pre-tender estimate) and a procurement method. This phase lasts up to the date a selected contractor is appointed to deliver the preferred solution.

Present Value (PV)	PV, also known as present discounted value, is the value of an expected cash flow stream determined as of the base date. This is the value when the nominal or real cost is discounted by the appropriate discount rate. It represents the cost equivalent in today's (present value) dollars. The PV is often used for a comparison between options.
Probabilistic risk contingency estimate	Probabilistic or risk-based cost estimation methods are a form of quantitative risk analysis which generally use computerised Monte Carlo simulation to estimate contingency, i.e., the component of a project's cost in excess of the base cost estimate that accounts for, or reflects, risk.
Real	Non-escalated (non-inflated) costs
Risk assessment	This includes both the retained and transferred cost of planned and unplanned risks. The costs were provided at P50 and P95 confidence levels in real terms.
Whole of life costs	This is the total cost of delivering and operating the asset over its assumed life.

Further detail on cost and risk estimation is covered in Chapter 7.

8.2.3 Assumptions

The following key assumptions have been included in the financial modelling:

Table 8-2 Key Assumptions

Description	Assumption	Source
Base Date for PV	30 Jun 2021	RPS
Pre-delivery phase period	3 years, July 2021 – June 2024	Project Team
Delivery phase period	4.5 years, July 2024 – December 2028	IPEX
Operations phase period	30.5 financial years, January 2029 – June 2059	Project Team
Revenue and cost inflation	1.6% to 2.3% for financial years	GWRC
Revenue leakage rate	5%	Lynxx
Discount rate[148]	4%	Waka Kotahi

The revenue assumptions such as patronage projections, evasion (revenue leakage) rate and fare were provided by the Project's transport demand modellers. Key revenue assumptions include:

- only the operations phase farebox revenue is included and the analysis does not consider any revenue prior to the start of operations of the new fleet in the preferred solution
- the farebox revenue is based on an average fare that incorporates peak, off-peak and concession fares
- a revenue leakage assumption of 5% was made to account for any lost revenue due to those patrons who avoid paying the fare

The lower bound patronage projections over the operations period are used for the revenue calculation purposes for both the preferred solution and the do minimum case (shown in Figure 8-3 and Figure 8-4). This represents a conservative approach to revenue estimation, because the patronage in both cases can fall between the lower and upper bound projections.

[148] For the financial analysis purposes, it is assumed to be a nominal rate to be applied to nominal cash flows

Figure 8-3 Wairarapa patronage lower and upper bounds: preferred solution vs do minimum case, number of trips

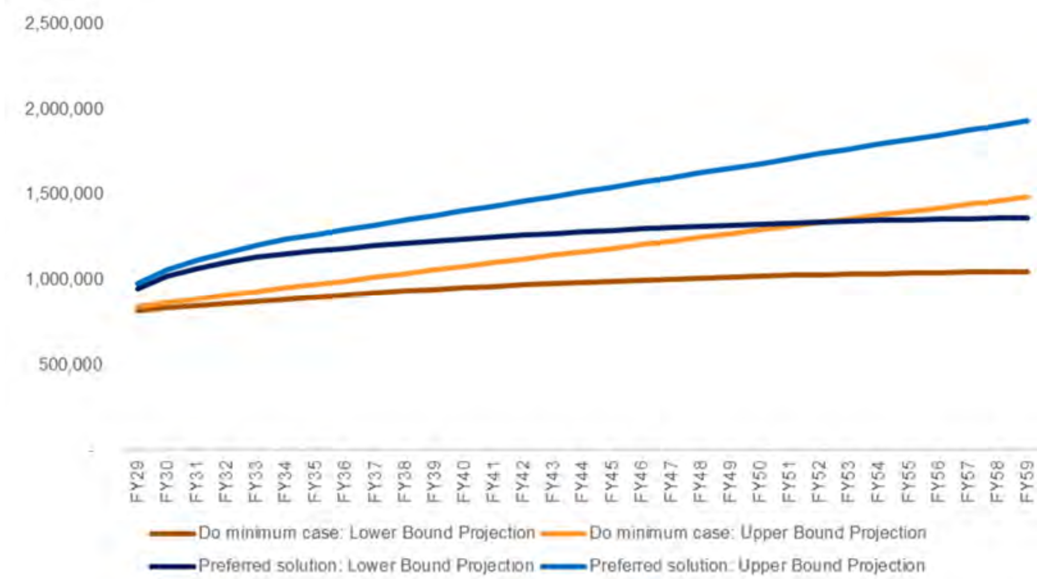
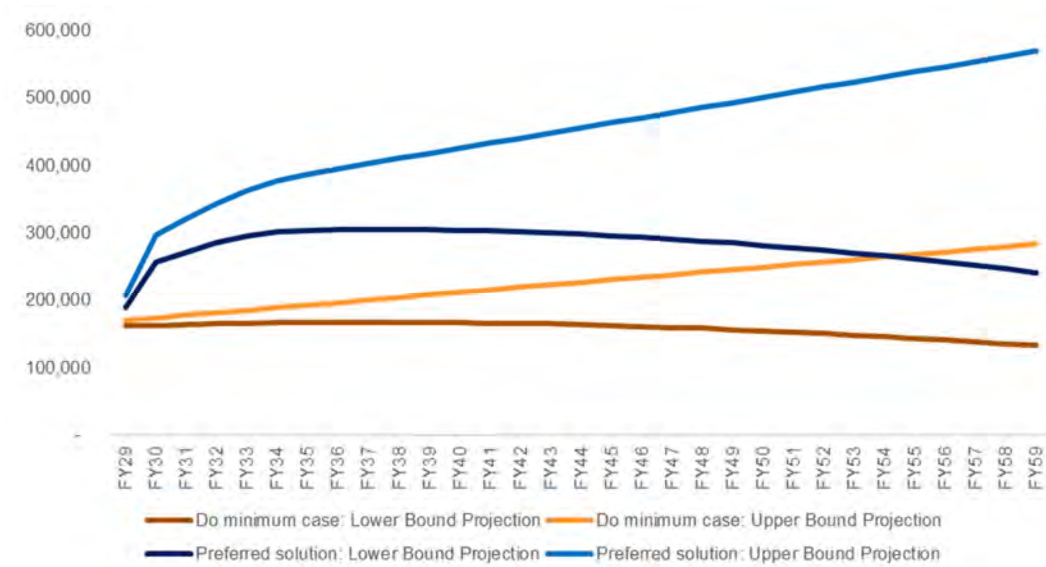


Figure 8-4 Manawatū patronage lower and upper bounds: preferred solution vs do minimum case, number of trips



The escalation rates for delivery and operations phase costs and revenue are assumed to be the same and were provided by GWRC by financial year (Table 8-3).

Table 8-3 Financial year escalation rates, provided by GWRC

Financial year	FY2021	FY2022	FY2023	FY2024	FY2025	FY2026	FY2027	FY2028	FY2029+
Escalation rate	1.6%	1.7%	1.7%	1.7%	1.6%	1.9%	2.0%	2.2%	2.3%

8.3 Assessment outcomes

This section summarises the outcomes of the financial modelling and outlines:

- the whole of life summary for the preferred solution and the do minimum case
- delivery phase costs
- operations phase costs
- revenue to be earned during the operations phase.

8.3.1 Whole of Life summary

Councils are responsible for providing a range of services to the community. These services are capital-intensive, have a significant fixed cost component and can incur significant ongoing maintenance and operating costs. Given the importance of financial sustainability in councils, considering whole-of-life (WOL) costs is critical when deciding on a new service or investment.

Therefore, it is critical that the financial implications of projects are assessed not only on the upfront capital cost today but also from a whole-of-life perspective. Whole-of life costs can include ongoing operating and maintenance, refurbishments, rehabilitation, disposal and other ongoing costs of ownership necessary to ensure service continuity.

The whole of life financial analysis was performed for the preferred solution in comparison to the do minimum case to:

- enable sound investment decisions
- assess the expected revenues, costs and risks associated with the investment
- understand the primary drivers of the asset’s ongoing costs
- evaluate the total costs when comparing replace (the preferred solution) versus refurbish (the do minimum case) options.

The tables below outline the net whole of life risk adjusted (P95) costs, of the preferred solution, and do minimum case, as well as the difference, in real, nominal and Present Value terms, respectively.

Table 8-4 shows a breakdown of the net whole of life cost in real terms, reflecting a cost that has no consideration for the effects of inflation. Table 8-5 summarises a breakdown of the net whole of life cost in nominal terms, which includes inflation and is normally used for the budgeting purposes. Table 8-4 shows:

- the net whole of life costs risk adjusted (P95) for the preferred solution is $1.3 billion in real terms and $1.7 billion in nominal terms
- the net whole of life costs risk adjusted for the do minimum case is $1.2 billion in real terms and $1.9 billion in nominal terms
- this amounts to a cost difference of $92.9 million in real terms but a savings of $166.4 million in nominal terms
- the committed funding of $193.6 million in real terms, or $203.4 million in nominal terms, for both the preferred solution and the do minimum case includes the costs for the existing train refurbishments and associated infrastructure upgrades that are already funded outside of the project.

Table 8-4 Net Whole of Life Cost Breakdown in real terms

Item ($NZD Millions)	Preferred Solution	Do Minimum Case	Difference
Delivery phase costs	690.2	173.6	516.5
Operating phase costs	1,293.0	1,536.1	(243.1)
Total Costs	**1,983.2**	**1,709.7**	**273.5**
Less Revenue	(709.3)	(528.7)	(180.6)
Net Whole of Life Cost	**1,273.9**	**1,181.0**	**92.9**
Committed funding	193.6	193.6	-
Total	**1,467.5**	**1,374.6**	**92.9**

Table 8-5 shows that while the initial delivery phase costs of the preferred solution are greater than the do-minimum case (by $572.6 million), the total whole of life cost of the preferred solution is smaller than the whole of life cost for the do minimum case by $166.4 million. This is explained by:

- the do minimum case's higher operating phase costs (by $431.6 million) due to the need to continuously refurbish and maintain the second-hand fleet
- the do minimum case's lower farebox revenue (by $307.4 million), as the do minimum case assumes current service frequencies compared to the preferred solution assuming increased service frequencies (see Chapter 4).

Table 8-5 Net Whole of Life Cost Breakdown in nominal terms

Item ($NZD Millions)	Preferred Solution	Do Minimum Case	Difference
Delivery phase costs	763.5	190.8	572.6
Operating phase costs	2,178.9	2,610.5	(431.6)
Total Costs	**2,942.4**	**2,801.3**	**141.0**
Less Revenue	(1,203.7)	(896.3)	(307.4)
Net Whole of Life Cost	**1,738.6**	**1,905.0**	**(166.4)**
Committed funding	203.4	203.4	-
Total	**1,942.0**	**2,108.4**	**(166.4)**

Figure 8-5 illustrates the difference in annual nominal net costs between the preferred solution and the do minimum case over the whole of life of the project:

- the incremental cost difference in the delivery phase peaks in FY2028 at $166.4 million, when most of the brand-new rollingstock is delivered for the preferred solution
- there are savings throughout the operating phase, however the most significant incremental savings are incurred every 10 years (periods of regular renewal and refurbishments of the do minimum case's second-hand fleet).

Figure 8-5 Net incremental risk adjusted annual cashflows in nominal terms

Figure 8-6 shows the cumulative net incremental risk adjusted annual cashflows in nominal terms, indicating that over the whole of life, the cost of the do minimum case would be increasing at a higher rate (steeper line) than for the preferred solution (flatter line after the delivery phase), exceeding it in FY2057.

Figure 8-6 Cumulative net incremental risk adjusted annual cashflows in nominal terms

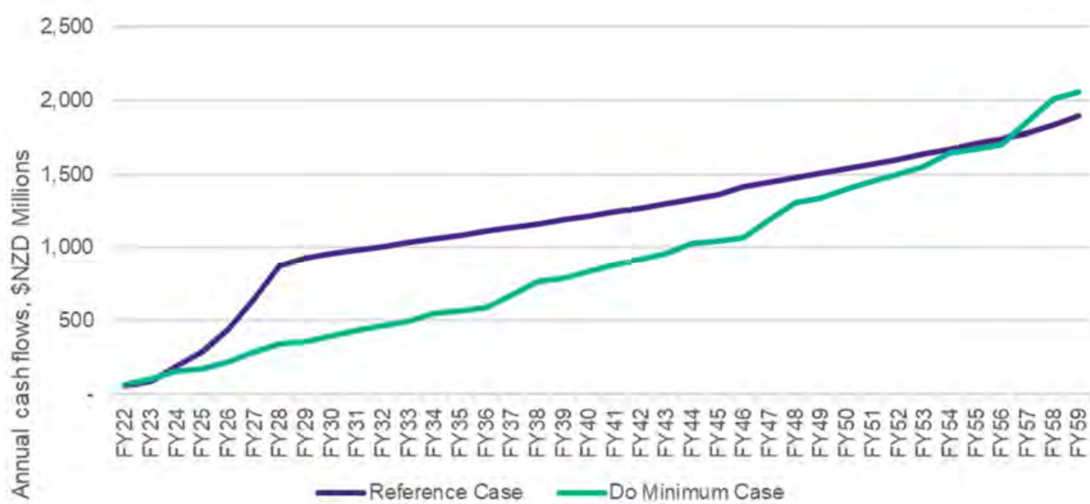


Table 8-6 shows a breakdown of the total net WOL cost in PV terms. Table 8-7 shows net WOL costs relative to the number of services provided over the assumed operations period.

The tables show that despite a higher net WOL PV of the preferred solution, compared to the do minimum case (by $181.8 million), the investment in the preferred solution will provide a higher value-for-money, demonstrated by providing about 151,000 more services[149] over the thirty-year period at a substantially lower cost per service. The per service WOL PV cost is lower by ~$3,800 per service measured on the whole of life PV basis. That means that for 143% more services, the preferred solution amounts to 50% less net WOL costs per service (PV).

In addition to increased services enabling increased mode shift, the communities would benefit from safety and environmental benefits associated with an investment in a modern brand-new fleet that would utilise electrified parts of the Manawatū and Wairarapa rail lines while also leveraging the opportunities for carbon reduction through batteries on the non-electrified parts of the network.

[149] Rounded

Table 8-6 Net Whole of Life cost breakdown in nominal PV terms

Item ($NZD Millions)	Preferred Solution	Do Minimum Case	Difference
Delivery phase costs	610.7	155.0	455.7
Operating phase costs	858.6	1,013.6	(155.1)
Total Costs	1,469.3	1,168.7	300.6
Less Revenue	(468.2)	(349.4)	(118.8)
Net Whole of Life Cost	**1,001.1**	**819.3**	**181.8**
Committed funding	181.4	181.4	-
Total	**1,182.5**	**1,000.7**	**181.8**

Table 8-7 Service frequencies[150] for do minimum case and preferred solution over the 30-year operations period, compared to net Whole of Life cost in nominal PV terms [151]

Service	Wairarapa Number of services	Manawatū Number of services	Total Number of services	Net WOL PV cost NZD Millions	$ PV cost per service
Do Minimum Case	90,304	15,252	105,556	819.3	7,762
Preferred Solution	158,334	83,282	256,868	1,001.1	3,897
Difference	68,030	68,030	151,312	181.8	(3,864)
% Difference	**75.3%**	**446.0%**	**143.3%**	**22.2%**	**(50.0%)**

8.3.2 Delivery phase costs

Overall, the delivery phase costs are higher for the preferred solution, compared to the do minimum case. This can be explained by the larger fleet being purchased to provide higher service frequencies based on the projected demand. Additionally, it reflects an investment in a brand-new modern environmentally friendly fleet, compared to the second-hand fleet equivalent to the existing rollingstock that would not contribute to carbon reduction.

Key observations:

- The risk adjusted (P95) delivery phase cost for the preferred solution, without the already committed funding, amounts to $690.2 million in real terms, $763.5 million in nominal terms and $610.7 million in PV terms.
- In comparison, the risk adjusted (P95) delivery phase cost for the do minimum case, without the already committed funding, amounts to $173.6 million in real terms, $190.8 million in nominal terms and $155.0 million in PV terms.

The additional committed funding, which includes the refurbishment of the existing fleet until FY2028 and track works, relevant for both the preferred solution and the do minimum case is estimated at $193.6 million in real terms, $203.4 million in nominal terms and $181.4 million in PV terms. Table 8-8 shows the committed funding items costs in real terms, which include existing train renewal and refurbishment and track works as part of NZUP.

[150] The service frequencies are estimated based on the number of working days, weekends and 11 public holiday days per year over the 30-year period

[151] The table excludes committed funding in both the preferred solution and do minimum case

Table 8-8 Breakdown of committed funding in real terms

Item ($NZD Millions)	Cost
Rollingstock	
Existing train renewal and refurbishments	25.2
Infrastructure	
NZUP Infrastructure Programme	168.4
Total	**193.6**

Table 8-9 shows a detailed breakdown of the delivery phase costs of the preferred solution compared to the do minimum case in real terms.

Table 8-9 Detailed breakdown of delivery phase costs in real terms

Item ($NZD Millions)	Preferred Solution	Do Minimum Case	Difference
Pre-implementation phase fees	[redacted]	[redacted]	[redacted]
Implementation Phase fees	[redacted]	[redacted]	[redacted]
Physical Works	[redacted]	[redacted]	[redacted]
Rollingstock	[redacted]	[redacted]	[redacted]
Rollingstock costs	[redacted]	[redacted]	[redacted]
Rollingstock related costs	[redacted]	[redacted]	[redacted]
Infrastructure	[redacted]	[redacted]	[redacted]
Property acquisition costs	[redacted]	[redacted]	[redacted]
Depots and maintenance facilities	[redacted]	[redacted]	[redacted]
Stations upgrades	[redacted]	[redacted]	[redacted]
Electrification costs	[redacted]	[redacted]	[redacted]
Other network upgrades	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]
Base estimate	**476.3**	**102.1**	**374.2**
Contingency	[redacted]	[redacted]	[redacted]
Funding risk contingency	[redacted]	[redacted]	[redacted]
Sub-total non-committed delivery phase	**690.2**	**173.6**	**516.5**
Committed funding	193.6	193.6	-
Total	**883.8**	**367.3**	**516.5**

The total cost for the delivery phase of the preferred solution is $690.2 million in real terms, excluding committed funding, which includes:

- the base estimate of $476.3 million
- risk adjustment of $213.8 million

The already committed funding amounts to $193.6 million (Table 8-8).

This is greater than the delivery phase costs of the do minimum case by $516.5 million in real terms.

Table 8-10 shows the delivery phase cost for the preferred solution and the do minimum case in nominal terms. The delivery phase costs in nominal terms are calculated using escalation rates provided by GWRC (refer Table 8-3 for detail):

- The preferred solution's base estimate cost for the delivery phase is $525.8 million and the risk-adjusted cost is $763.5 million in nominal terms, without the already committed funding. The committed funding amounts to $203.4 million in nominal terms, which when added to non-committed funding totals to $966.8 million.
- The total do minimum case's risk adjusted cost for the delivery phase is $394.2 million in nominal terms, including the committed funding of $203.4 million.

- The incremental cost difference amounted to $571.4 million in nominal terms.

Table 8-10 Detailed breakdown of delivery phase costs in nominal terms

Item ($NZD Millions)	Preferred Solution	Do Minimum Case	Difference
Pre-implementation phase fees	[redacted]	[redacted]	[redacted]
Implementation Phase fees	[redacted]	[redacted]	[redacted]
Physical Works	[redacted]	[redacted]	[redacted]
Rollingstock	[redacted]	[redacted]	[redacted]
Rollingstock costs	[redacted]	[redacted]	[redacted]
Rollingstock related costs	[redacted]	[redacted]	[redacted]
Infrastructure	[redacted]	[redacted]	[redacted]
Property acquisition costs	[redacted]	[redacted]	[redacted]
Depots and maintenance facilities	[redacted]	[redacted]	[redacted]
Stations upgrades	[redacted]	[redacted]	[redacted]
Electrification costs	[redacted]	[redacted]	[redacted]
Other network upgrades	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]
Base estimate	**527.0**	**112.3**	**414.7**
Contingency	[redacted]	[redacted]	[redacted]
Funding risk contingency	[redacted]	[redacted]	[redacted]
Sub-total non-committed delivery phase	**763.5**	**190.8**	**572.6**
Committed funding	203.4	203.4	-
Total	**966.8**	**394.2**	**572.6**

The delivery phase costs in PV terms are calculated by discounting the costs in nominal terms using a discount rate of 4% advised by Waka Kotahi. Table 8-11 shows the delivery phase cost for the preferred solution and the do minimum case in nominal PV terms:

- the preferred solution's base estimate cost for the delivery phase is $421.5 million and the risk-adjusted cost is $610.7 million
- the do minimum case's risk adjusted cost for the delivery phase is $155.0 million
- the incremental cost difference amounted to $455.7 million
- the committed funding amounts to $181.4 million.

Table 8-11 Detailed breakdown of delivery phase costs in nominal PV terms

Item ($NZD Millions)	Preferred Solution	Do Minimum Case	Difference
Pre-implementation phase fees	[redacted]	[redacted]	[redacted]
Implementation Phase fees	[redacted]	[redacted]	[redacted]
Physical Works	[redacted]	[redacted]	[redacted]
Rollingstock	[redacted]	[redacted]	[redacted]
Rollingstock costs	[redacted]	[redacted]	[redacted]
Rollingstock related costs	[redacted]	[redacted]	[redacted]
Infrastructure	[redacted]	[redacted]	[redacted]
Property acquisition costs	[redacted]	[redacted]	[redacted]
Depots and maintenance facilities	[redacted]	[redacted]	[redacted]
Stations upgrades	[redacted]	[redacted]	[redacted]
Electrification costs	[redacted]	[redacted]	[redacted]
Other network upgrades	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]

Base estimate	**421.5**	**91.2**	**330.3**
Contingency	[redacted]	[redacted]	[redacted]
Funding risk contingency	[redacted]	[redacted]	[redacted]
Sub-total non-committed delivery phase	**610.7**	**155.0**	**455.7**
Committed funding	181.4	181.4	-
Total	**792.1**	**336.4**	**455.7**

Figure 8-7 shows that the largest contributor to the preferred solution's delivery phase cost, without the committed funding, is the rollingstock costs, attributed to [redacted] of the total costs. Funding risk contingency and contingency are also significant contributors, [redacted] and [redacted] respectively. Depots and maintenance facilities contributed [redacted] of the total cost.

Figure 8-7 Preferred solution delivery phase costs, total out-turn nominal risk-adjusted P95, without committed funding

[redacted]

The comparative cashflow profile of the delivery phase between the preferred solution and do-minimum case illustrates similar costs in the first two years before the preferred solution costs grow significantly, peaking in FY2028 at $221 million. This reflects the periods of the delivery of the big part of the rollingstock fleet before it enters operations January 2029.

Figure 8-8 Preferred solution and do min delivery phase cashflow, total out-turn nominal risk-adjusted

8.3.3 Operations phase costs

The analysis considers only the operations phase operating expenditures for the two cases from when the new fleet starts operating under the preferred solution. The operations phase is assumed to be 30 financial years beginning from commissioning of the new fleet.

Compared to the preferred solution, the operations phase costs are higher for the do minimum case. This is explained by the need to continuously refurbish and maintain the second-hand fleet, compared to the operation and maintenance of a larger brand-new fleet.

The risk adjusted (P95) operating cost for the preferred solution amounts to $1.3 billion in real terms, $2.2 billion in nominal terms and $855.6 million in PV terms over a 30-year operating analysis period.

In comparison, the risk adjusted (P95) operating cost for the do minimum case amounts to $1.5 billion in real terms, $2.6 billion in nominal terms and $1.0 billion in PV terms over a 30-year operating analysis period.

Table 8-12 Detailed breakdown of operations phase costs in real terms

Item ($NZD Millions)	Preferred Solution	Do Minimum Case	Difference
Operating costs	[redacted]	[redacted]	[redacted]
Fleet maintenance costs	[redacted]	[redacted]	[redacted]
Renewal and refurbishment costs	[redacted]	[redacted]	[redacted]
Network maintenance	[redacted]	[redacted]	[redacted]
Client/ owners costs	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]
Project-related shared costs*	[redacted]	[redacted]	[redacted]
Base Estimate	**1,032.8**	**903.6**	**129.2**
Contingency	[redacted]	[redacted]	[redacted]
Funding risk contingency	[redacted]	[redacted]	[redacted]
Operating Phase Total	**1,293.0**	**1,536.1**	**(243.1)**

** Project-related shared costs comprise of costs incurred across both the Manawatū and Wairarapa lines and include depot, stabling and station maintenance costs.*

Table 8-12 provides a detailed breakdown of the delivery phase costs of the preferred solution compared to the do minimum case in real terms:

- The total risk adjusted cost for the operations phase of the preferred solution is $1.3 billion in real terms. This is comprised of the base estimate of $1.0 billion and risk adjustment of $260.3 million.
- The operating and maintenance costs of the preferred solution are significantly more expensive, which is expected due to extra train services that will be operating in comparison to the do minimum case. The preferred solution will provide nearly double the number of rail services.
- The total risk adjusted cost of the do minimum case is more expensive, amounting to $1.5 billion. The renewal and refurbishment costs of the do minimum are also expectedly to be higher due to the need to continuously renew and refurbish the second-hand fleet for it to operate longer. This is also captured in the project-related shared costs.
- The do minimum case's base estimate is $903.6 million, which is $129.2 million cheaper than the preferred solution, but the risk adjustments are significantly higher. The risk contingency is a deterministic estimate taking into consideration the uncertainty in costs for refurbishing and maintaining older rolling stock, including availability of spares, reduced reliability and increased unplanned maintenance.
- The incremental savings of the preferred solution compared to the do minimum case over the operating phase amount to $243.1 million in real terms.

Table 8-13 shows the operations phase cost for the do minimum case and preferred solution in nominal terms:

- The operations phase costs in nominal terms have been calculated using escalation rates provided by GWRC (refer Table 8-3 for detail). The analysis reflects most of the costs for the do minimum case are incurred in the operating phase, but relate to capital expenditure, including replacement of the rollingstock and significant refurbishment costs, including spares captured within the project-related shared costs.
- The preferred solution's base estimate cost for the operations phase is $1.7 billion and the risk-adjusted cost is $2.2 billion in nominal terms.
- The do minimum case's risk adjusted cost is $2.6 billion in nominal terms. The incremental cost savings amounts to $431.6 million in nominal terms.

Table 8-13 Detailed breakdown of operations phase costs in nominal terms

Item ($NZD Millions)	Preferred Solution	Do Minimum Case	Difference
Operating costs	[redacted]	[redacted]	[redacted]
Fleet maintenance costs	[redacted]	[redacted]	[redacted]
Renewal and refurbishment costs	[redacted]	[redacted]	[redacted]
Network maintenance	[redacted]	[redacted]	[redacted]
Client/ owners costs	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]
Project-related shared costs*	[redacted]	[redacted]	[redacted]
Base Estimate	**1,740.4**	**1,535.6**	**204.8**
Contingency	[redacted]	[redacted]	[redacted]
Funding risk contingency	[redacted]	[redacted]	[redacted]
Operating Phase Total	**2,178.9**	**2,610.5**	**(431.6)**

** Project-related shared costs comprise of costs incurred across both the Manawatū and Wairarapa lines and include depot, stabling and station maintenance costs.*

Table 8-14 shows the operating phase cost for the do minimum case and preferred solution in nominal PV terms:

- The preferred solution's base estimate cost for the operations phase is $685.8 million and the risk-adjusted cost is $858.6 million in nominal PV terms.
- The do minimum case's risk adjusted cost is $1.0 billion in nominal PV terms. The incremental cost savings amounts to $155.1 million in nominal PV terms.

Table 8-14 Detailed breakdown of operations phase costs in PV terms

Item ($NZD Millions)	Preferred Solution	Do Minimum Case	Difference
Operating costs	[redacted]	[redacted]	[redacted]
Fleet maintenance costs	[redacted]	[redacted]	[redacted]
Renewal and refurbishment costs	[redacted]	[redacted]	[redacted]
Network maintenance	[redacted]	[redacted]	[redacted]
Client/ owners costs	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]
Project-related shared costs*	[redacted]	[redacted]	[redacted]
Base Estimate	**685.8**	**596.3**	**89.5**
Contingency	[redacted]	[redacted]	[redacted]
Funding risk contingency	[redacted]	[redacted]	[redacted]
Operating Phase Total	**858.6**	**1,013.6**	**(155.1)**

** Project-related shared costs comprise of costs incurred across both the Manawatū and Wairarapa lines and include depot, stabling and station maintenance costs.*

Figure 8-9 shows that the largest contributor to the operations phase cost of the preferred solution is the operating costs, attributed to [redacted] of the total costs in nominal terms. Maintenance costs amounted to [redacted]. Funding risk contingency and contingency contributed [redacted] and [redacted] respectively.

Figure 8-9 Preferred solution operations phase costs, total out-turn nominal risk-adjusted P95

[redacted]

Figure 8-10 shows the real (non-inflated) cashflow profile of the operations phase of the preferred solution. It illustrates a steady growth in operating and maintenance costs for the entire period. There are significant renewal and refurbishment costs incurred in FY2046 and at the end of the operations phase in FY2058 and FY2059. The lower costs in the FY2029 are due to the operation only beginning partway through the year.

Figure 8-10 Preferred solution operating phase cash outflow, total real risk adjusted P95

[redacted]

Figure 8-11 Do minimum case operating phase cash outflow, total real risk adjusted P95

[redacted]

8.3.4 Revenue

The revenue considered in this financial analysis at this stage only includes farebox revenue. Other commercial opportunities may be explored further in future stages of the project.

The analysis considers only the operations phase farebox revenue and does not consider any revenue prior to the start of operations of the new fleet in the preferred solution.

The farebox revenue is based on an average fare that incorporates peak, off-peak and concession fares. A revenue leakage assumption of 5% was made to account for any revenue evasion due to those patrons who avoid paying the fare. As discussed in Section 8.2.3, the lower bound patronage projections were assumed for the revenue estimation, which is a conservative approach.

Table 8-15 provides breakdowns of the revenue forecast to be earned for the 30-year period (operations phase) by operating line from the commissioning of the new fleet (preferred solution) compared to the do minimum case in real, nominal and nominal PV terms, respectively. Key observations include:

- Overall, the preferred solution's farebox revenue is higher than for the do minimum case by $180.6 million in real terms, $307.4 million in nominal terms and $118.8 million in PV terms over the operations period. This is explained by the higher number of services provided and the attractiveness of the new fleet for commuters.
- Most of the revenue is expected to be generated by the Wairarapa line due to the significantly greater patronage in comparison to the Manawatū Line.

Table 8-15 Revenue in real, nominal and PV terms

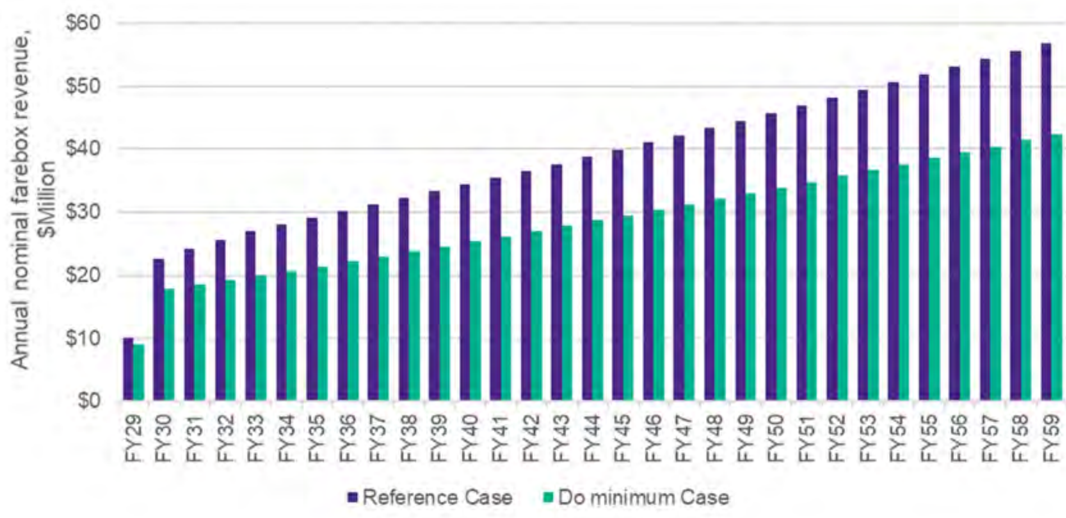
Item ($NZD Millions)	Preferred Solution	Do Minimum Case	Difference
Real revenue	709.3	528.7	180.6
Nominal revenue	1,203.7	896.3	307.4
PV nominal revenue	468.2	349.4	118.8

Table 8-15 shows that:

- in real terms, the preferred solution will generate $709.3 million, and the do minimum will create $528.7 million. This accounts for a difference of $180.6 million generated by the preferred solution.
- in nominal terms, the preferred solution will generate $1.2 billion, and the do minimum will create $896.3 million. This represents an increase of $307.4 million generated by the preferred solution over the 30-year operations period.
- in nominal PV terms, the preferred solution will generate $468.2 million, and the do minimum case will create $349.4 million. This accounts for a difference of $118.8 million generated by the preferred solution over the 30-year operations period.

Figure 8-12 shows the preferred solution and do minimum case's nominal farebox revenue cashflow profile. The lower revenue in the FY2029 is due to the operation only beginning partway through the year. The difference between the cases' farebox revenue reflects the increase in patronage multiplied by the nominal fare amount.

Figure 8-12 Preferred solution and do minimum case annual nominal revenue



** Section 8.2.3 provides more details on the assumptions of patronage projections underpinning the revenue estimation.*

8.3.5 Sensitivities and Scenarios

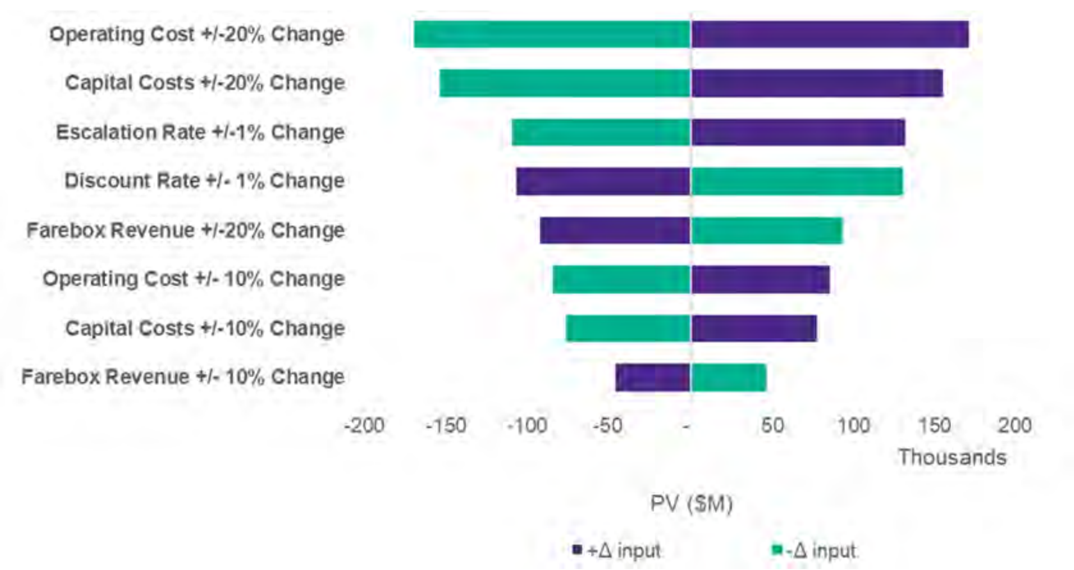
Table 8-16 outlines the sensitivities tested on the preferred solution and base net WOL PV costs, including committed funding.

Table 8-16 Sensitivities and Scenarios– net WOL PV costs

Sensitivity ($NZD Millions)	Preferred Solution	Do Minimum Case	Difference
Unsensitised case	1,182.5	1,000.7	181.8
10 per cent capital cost increase	1,259.6	1,032.1	227.5
20 per cent capital cost increase	1,338.7	1,065.7	273.0
10 per cent operating and maintenance cost increase	1,266.1	1,111.7	154.4
20 per cent operating and maintenance cost increase	1,351.7	1,212.8	138.9
20 per cent increase in farebox revenue	1,087.1	928.8	158.3
1 per cent discount rate increase	1,071.5	858.9	212.5
1 per cent discount rate decrease	1,312.8	1,176.6	136.2
1 per cent escalation rate increase	1,313.4	1,177.6	135.8
1 per cent escalation rate decrease	1,068.1	855.1	213.0
Additional 10 years of operation (40.5 years total)	1,262.0	1,152.9	109.0
No renewal and refurbishment in last years of operation	1,172.8	930.5	242.3

Figure 8-13 shows the preferred solution's net WOL PV costs sensitivity to changes in inputs. The strongest influencing sensitivity is the 20 per cent change to the Operating Costs, where a 20 percent increase will increase the preferred solution total cost by $171.1 million. A 20 per cent increase to capital cost will increase the cost by $158.2 million. A 1 per cent increase in the escalation rate over the life of the project will increase the total cost by $133.5 million.

Figure 8-13 Preferred solution Net WOL PV costs sensitivity to changes in inputs

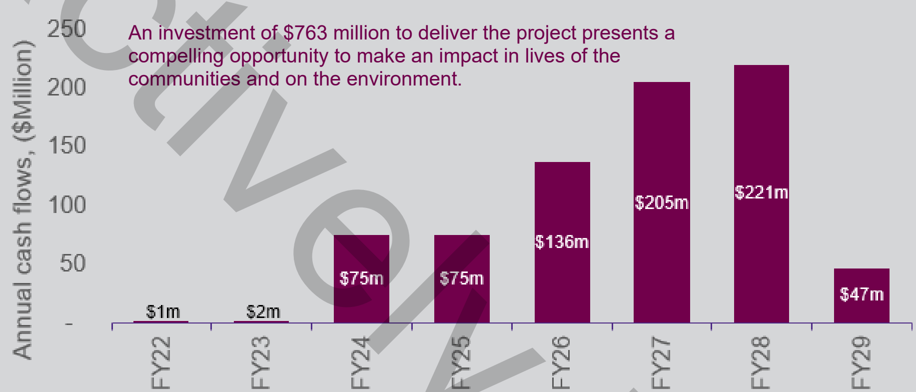


9 CHAPTER 9 – AFFORDABILITY ANALYSIS

CHAPTER SUMMARY AND CONCLUSIONS:

- The affordability analysis shows the funding required for the preferred solution, as defined in Chapter 5. The analysis shows that over the 38 years (3 years of pre-delivery, 4.5 years of delivery and 30.5 years of operations), the total investment is estimated at $1.7 billion in nominal terms.
- The Regional Councils (GWRC and Horizon) will contribute over $540 million (31.2% of the total whole of life cost, in nominal terms) to the project over its lifetime, with the remainder to be provided by the Central Government.
- The delivery phase funding requirement is $763 million, delivered over a period of 8 financial years as shown below.

Pre-delivery and delivery phase investment profile



- The analysis indicates that:
  - the pre-delivery and delivery phase costs will be shared, with the Central Government (Waka Kotahi and Crown) requested to fund a contribution of $699.0 million, and the balance of $64.3 million to be provided by the Regional Councils
  - the operational costs of $975.2 million in nominal terms are proposed to be funded at the current prevailing funding rate of 49% from the Regional Councils (GWRC and Horizon) and 51% from Waka Kotahi.
- An investment of $699.0 million by Central Government to deliver the project directly aligns with GPS2021 and other government strategies and presents a compelling opportunity to:
  - ensure regional communities have a reliable public transport option, currently the only alternative to road, to access social, health and economic opportunities
  - improve the corridors' capacity, safety and efficiency
  - contribute to carbon reduction through mode shift and new fleet
  - deliver a better value for money outcome with increased services and improved public transport attractiveness.
- Private sector financing is not considered to generate additional value for money for this project over and above traditional funding. However, alternative funding source opportunities such as value capture may be further considered to enhance project affordability.
- As described in Chapter 8, the current committed funding of $203.4 million in nominal terms includes the refurbishment of the existing fleet until FY2028, track works and station improvements and will be required for the preferred solution.

9.1 Purpose and overview

This chapter analyses future funding requirements and funding sources for the project as well as investigating further options to improve the overall project affordability. This chapter covers:

- funding assumptions
- a summary of funding requirements
- options to improve affordability.

The analysis focuses on the additional funding required to deliver the project over and above the current committed funding of $203.4 million for refurbishment of the existing fleet until FY2028, track works and station improvements, as described in Chapter 8.

9.2 Funding assumptions

GWRC proposed the funding split assumptions set out in Table 9-1 between Regional Councils (GWRC and Horizon) and Central Government (Waka Kotahi and/or Crown) for additional funding[152]. The split between GWRC and Horizon will be based on an approximate service kilometres basis. Contingency and funding risk contingency has been allocated based on the proportion of contribution to base estimate cost.

Table 9-1 Funding split percentage assumptions

Non-committed funding	Regional Councils	Central Government
Delivery Phase		
Pre-implementation phase fees	0%	100%
Implementation fees	10%	90%
Rolling Stock Capex	10%	90%
Maintenance depot	10%	90%
Stabling	0%	100%
Stations - above platform	10%	90%
Stations - below platform	0%	100%
Track Infrastructure	0%	100%
Contingency	8%*	92%*
Funding risk contingency	8%*	92%*
Operating Phase		
Net operations phase cost	49%	51%

** Contingency and funding risk contingency has been allocated proportionally to base estimate cost.*

9.2.1 Delivery phase funding

[redacted]

[152] The funding split negotiation is ongoing at the time of the submission of the DBC.

Table 9-2 Pre-delivery and delivery phase funding requirements, nominal

Non-committed funding ($Million)	Regional Councils	Central Government	Total, P95 nominal risk adjusted
Pre-implementation phase fees	[redacted]	[redacted]	[redacted]
Implementation fees	[redacted]	[redacted]	[redacted]
Rolling Stock Capex	[redacted]	[redacted]	[redacted]
Maintenance depot	[redacted]	[redacted]	[redacted]
Stabling	[redacted]	[redacted]	[redacted]
Stations - above platform	[redacted]	[redacted]	[redacted]
Stations - below platform	[redacted]	[redacted]	[redacted]
Track Infrastructure	[redacted]	[redacted]	[redacted]
Contingency	[redacted]	[redacted]	[redacted]
Funding risk contingency	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]

Figure 9-1 shows the cashflow profile of the additional funding requirements for the pre-delivery and delivery phase. The highest cash flows are observed in FY2027 and FY2028 when most of the rollingstock is estimated to be delivered.

Figure 9-1 Pre-delivery and delivery phase annual funding requirements, $ million

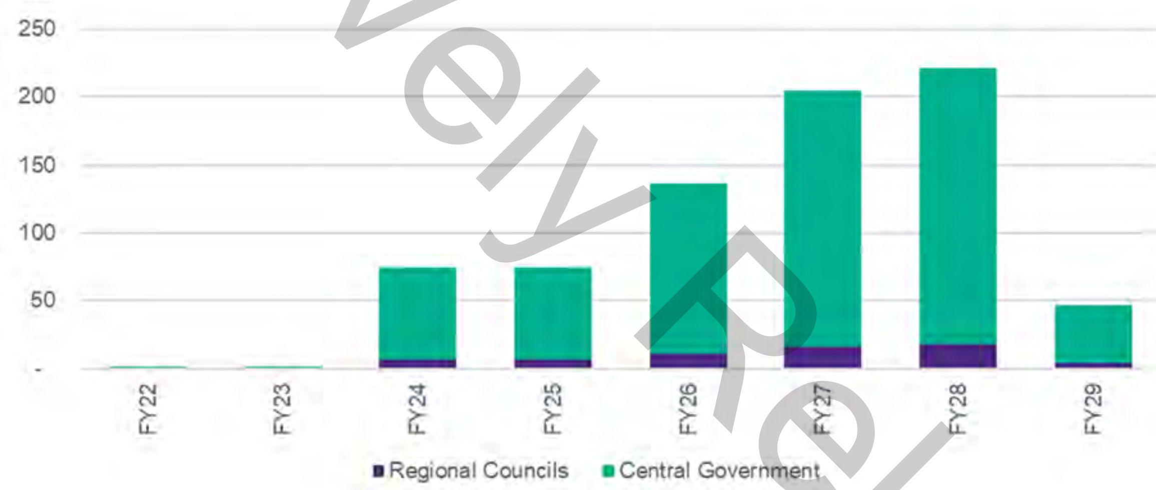


Table 9-3 Pre-delivery and delivery phase annual funding requirements, $ million

Financial year	FY21-22	FY22-23	FY23-24	FY24-25	FY25-26	FY26-27	FY27-28	FY28-29
Central Government	1.2	1.4	67.9	67.8	125.6	188.7	203.7	42.6
Regional Councils	0.1	0.1	7.1	7.1	11.1	16.6	17.8	4.5
Total	**1.2**	**1.5**	**75.0**	**74.9**	**136.7**	**205.3**	**221.5**	**47.1**

9.2.2 Operational cost funding

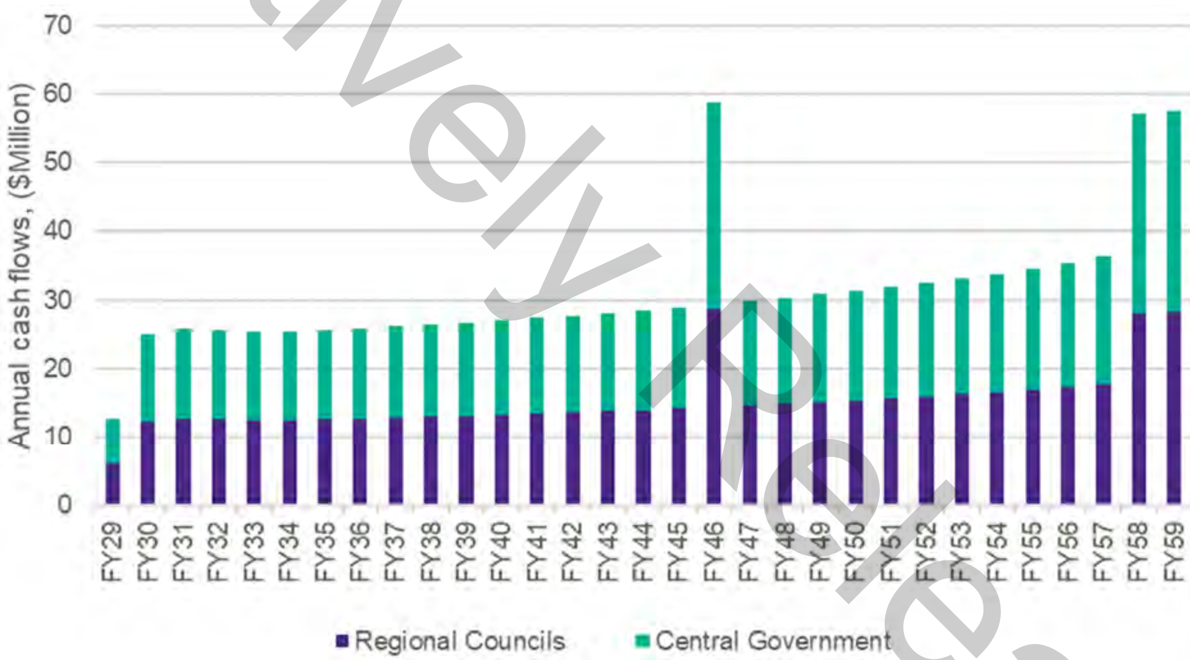
Table 9-4 shows the net operating phase cost funding requirements. The total of $477.8 million in nominal terms is assumed to be funded by the Regional Councils, while the Central Government will be required to fund $497.3 million, based on the current prevailing funding rate of 49% from the Regional Councils and 51% from Central Government (Waka Kotahi).

Table 9-4 Net operations phase cost funding requirements

Non-committed funding ($Million)	Regional Councils	Central Government	Total, P95 nominal risk adjusted
Operating Costs	852.8	887.6	1,740.4
Contingency	71.6	74.6	146.2
Funding risk contingency	143.3	149.1	292.4
Revenue[153]	(589.8)	(613.9)	(1,203.7)
Net Total	**477.8**	**497.3**	**975.2**

The cashflow profile of the funding requirements is illustrated in Figure 9-1. The higher funding in FY 2046, and FY2058 and FY 2059 related to periodic renewal and refurbishment costs.

Figure 9-2 Net annual operations phase funding requirements cashflow



[153] The revenue is assumed to be allocated between Regional Councils and Central Government proportionally to the operational cost funding split percentage.

9.3 Options to improve affordability

Options to improve affordability identified include:

- scope management
- value capture and alternative funding options.

Private sector financing was considered but was not considered to generate additional value for money compared to traditional funding.

9.3.1 Scope management

A number of scope management activities were identified, including:

- further testing of the cost estimates with the market
- staging of station upgrades
- optimising the design
- closely engaging the market
- better ongoing management and mitigation of risks
- exploring scaling the rollingstock solution to other regions to realise the economies of scale that can be achieved with larger fleet orders.

These options can be further explored during the implementation phase.

Deferring, staging, or scaling down the investment was considered in options analysis and all scenario considered indicated that replacing the fleet is the minimum viable option. Any delayed, partial or extended delivery leads to increased cost and reduced benefits. This situation arises because the asset management practice of refurbishing 1970s rolling stock relied upon in the past decades has brought the current fleet beyond the end of its reasonably expectable serviceable life. Consequent safety, operational and cost constraints mean that further delay in the replacement of the fleet by sufficient rolling stock to service the validated growth in the region will increase the cost of service, compound safety constraints, and reverse mode shift.

On the Manawatū line, the fleet is already life expired and with the limited number of services currently provided, scaling down the investment would create missed opportunities for economic growth and land development.

On the Wairarapa line, the services are currently running close to capacity and would restrict opportunities for mode shift and better climate outcomes, should there be a delay in investment.

Additionally, from the perspective of international suppliers, most of which responded in our market sounding exercise, the size of the fleet proposed in this investment is considered small. Reverse economies of scale mean that reducing our order would not attract a corresponding saving if any at all. Considered in perspective with New Zealand's historical under-estimation of rolling stock needs, deferring, staging, or scaling down the investment appears undefendable.

Another option the Central Government may further consider for improving affordability is value capture opportunities.

9.3.2 Value capture and alternative funding options

There are a number of value capture and alternative funding options which could potentially be implemented to defray the cost of the program.

Public transport projects often provide benefits to a broad range of beneficiaries beyond those that use the additional services provided. Examples include increases in local property prices (e.g., increase in local housing or retail property values because of additional transit amenity) and increases in local economic activity, productivity and profitability (e.g., increased profitability of local businesses due to increased accessibility or increased property development profitability due to increased transit amenity and planning changes which enable higher and better use). Value capture aims to share some of the increased value created by the project with government to defray the cost of the project.

Value capture is sometimes also coupled with changes in policy to affect desired changes in behavior (e.g., parking fee levy to defray the cost of the project but also to increase public transport and decrease private vehicle usage).

Table 9-5 provides an overview of potential value capture options.

Table 9-5 Value capture options

Mechanism	Description
Transport (public) transport infrastructure levy	• A broad-based levy (i.e., typically covering the whole of the local government area) used to fund a number of transport initiatives including the project. • Often collected via the local government rating system (although may be able to be collected by central government). • Mechanism does not have a direct nexus to project beneficiaries but rather all transport users in the region. • May require some exemptions. • Provides a relatively high, stable and potentially long-term funding source (albeit may be diluted as is normally justified to support a number of projects).
Benefit area levy	• A geographically focused levy (e.g., within walking distance to station) used to fund the project. • Often collected via local government rating system. • Mechanism does have a direct nexus via increase in property value and service level enjoyed by local property owners. • Can be focused upon certain property owners or all captured within the area (e.g., commercial properties only). • Revenue is stable and predictable and may be significant depending upon the application and the level of levy charged.
Developer contributions	• A geographically focused fee (e.g., within 400 metres of a station) used to fund the project. • Mechanism does have direct nexus via the increase in property development outcomes able to be achieved via the increase in transit amenity. • Recurring but potentially volatile revenue stream that relies on real estate development activity. • Potential to implement via existing infrastructure charging system, by a new regulated system or by commercial negotiation.
Parking fees	• A geographically focused parking fee (e.g., within walking distance to station) used to fund the project. • Can be applied to street or off-street parking facilities. • Mechanism does have a strong nexus to project however exemptions may need to be made (e.g., local residents and owners of commercial off-street parking facilities). • Revenue is stable and predictable.

Whilst there is potential merit in implementing these options, they are outside of the remit of the project.

There are a number of potential alternative funding options which could be implemented to defray the cost of the project other than rates and taxes.

Alternative funding options are non-traditional funding options, which typically include additional charges or fees to users (e.g., public transport fare increase due to the increase in service provision) and or use of assets created by the project to generate revenue as well as providing services (e.g., advertising or station precinct development). Table 9-6 provides an overview of potential alternative funding options.

Table 9-6 Alternative funding options

Mechanism	Description
Public transport fare increase	• Increase in public transport fares which may include increase in fares on this system, the broader rail system, the bus system and or other public transport systems. • Nexus is greater if the increase in fares is limited to the upgraded system. • Revenue is stable and predictable.
Fuel Tax	• Tax levied on the price of fuel (similar to what is levied in Auckland). The levy is use to fund public transport projects.

	• Will require exemptions • Revenue will fluctuate
Congestion Charging	• Targeted and incentivises mode shift • Will require exemptions • Revenue will fluctuate
Advertising	• Sale of advertising rights within carriages, outside of carriages, vehicle wraps, inside of stations, outside of stations and along corridor. • Direct nexus to project. • Revenue is stable and predictable.
Station and platform rents	• Rents to undertake commercial activities on platforms or at stations. • Direct nexus to project. • Revenue is stable and predictable.
Station precinct development	• Sale of surplus property and or development rights over and around station precinct, construction areas and surplus corridor property. • Direct nexus to project. • Quantum of revenue is not guaranteed and is dependent upon the dynamics of the property market at the time of sale.
Station car parking	• Implementation or increase in commuter parking charges at stations. • Direct nexus to project. • Revenue is stable and predictable.

Whilst there is potential merit in implementing these options they are generally outside of the remit of the project as they may impact the broader transport network and or require consideration of broader transport policy issues. For example:

- Public transport fare increase would require consideration of impacts on the broader transport network, (including interfacing rail and other networks) as well as precedent setting. For example, increasing fares may have a negative impact on mode shift objectives.
- Similarly, station car parking is often seen as an increase in the cost of public transport and would require broader consideration.
- Advertising and station and platform rents will require consideration of broader station look and feel, signage and way finding policies as well as current and future commercial, safety, asset ownership and asset management arrangements across the network. There may, for example, merit in letting a more wholistic advertising program across the whole network rather than just one corridor.
- Station precinct development may require additional consideration of current schemes, approvals, look and feel, signage and way finding policies, legislative change, asset ownership and management as well as precedent management.
- Fuel levy and congestion charging will require legislation from Central Government to enact. In addition, Congestion charging cannot be implemented until there is sufficient capacity and a suitability reliable and suitable public transport service to provide commuters– so the investment is required first, prior to the congestion charge to drive the behaviour change.

9.3.3 Further assessment of opportunities

There may however be merit in either central or local government undertaking a further assessment of value capture options or the Waka Kotahi – NZ Transport Agency undertaking a further assessment of alternative funding options including:

- Identification of additional options
- Detailed option definition
- Detailed assessment of options including consideration of:
  - Implementation issues such as beneficiary analysis, assessment of affected parties, implementation and operational resource requirements, legislative change, stakeholder engagement, machinery of government change
  - Powers to levy / implement, including current legal and legislative powers and potential changes that may be required
  - Financial outcomes including potential revenue raised, cost of implementation and efficiency of collection
  - Public interest issues such as capacity to pay, fairness, identification of beneficiaries, quantification of benefits, administrative costs, stakeholder support, impact on broader government policy objectives
- For preferred options - implementation planning including consideration of program, resource requirements, potential legislative changes and community and stakeholder engagement.

9.3.4 Private Sector funding

The potential for private sector funding to supplement government and council funding and provide short term cashflow relief from financing delivery phase costs has been considered.

9.3.4.1 Private Public Partnerships

A Private Public Partnership (PPP) is a recognised form of private sector financing used to finance a project.

The definition adopted by the New Zealand PPP Programme and the Standard Form PPP Project Agreement is:

A long-term contract for the delivery of a service, where the provision of the service requires the construction of a new asset, or the enhancement of an existing asset, that is financed from external (private) sources on a non-recourse basis, and where full legal ownership of the asset is retained by the Crown[154]*.*

A high-level qualitative value for money assessment was performed of the relative merit of a PPP compared to the preferred delivery model for the various works packages for the Project.

The value for money assessment was undertaken for Package One as it is of a size and scale to be attractive to be delivered as a PPP and includes Rollingstock and depot. Under the preferred delivery method, the package is to be delivered under a Design, Build, Maintain and [Operate] (DBM +[O]) contract.

For the assessment the following ranking were used:

✗	represents no scope for value generation
✓	represents some scope for value generation
✓✓	represents reasonable scope for value generation
✓✓✓	represents excellent scope for value generation.

[154] New Zealand Treasury. PPP Public Model and Policy. 2015. Accessed on: https://www.treasury.govt.nz/sites/default/files/2015-10/ppp-public-model-and-policy-sep15.pdf

Table 9-7 shows a high-level summary of the qualitative assessment of Package 1 delivery, compared to PPP and shows that the high-level qualitative assessment shows that DBM+ [O] would deliver better value for money.

Table 9-7 Package 1: high-level qualitative value for money assessment of traditional delivery vs PPP

Category	DBM +[O]	PPP	Explanation
Risk allocation	✓✓✓	✓	In PPP, a genuine risk transfer would not be possible as the risk allocation would not be relied upon in extreme circumstances, such as private sector finance default. The provision of the regional commuter rail services on Wairarapa and Manawatū lines is the only commuter alternative to roads and its closure due to financial failure would have a significant impact on communities. Meanwhile, DBM + [O] integrates design, construction and maintenance risk with a single point of accountability and offers maximum transfer of performance risk over whole of life without adding financial complexity
Whole-of-Life costing	✓✓	✓	DBM + [O] provides whole of life cost efficiencies and lower bid costs. While PPP's payment profile is relatively even, reflecting the level of service provision over the longer term of the contract, PPP would involve a higher total payment over the whole of life of the asset to service interest costs and shareholders return of not only the sub-contractors but also the investment vehicle.
Innovation	✓	✓	DBM + [O] and PPP provide potential for innovation, so it is not a differentiating factor.
Improved asset utilisation	✓	✓	It is unlikely that the private sector service provider will be able to generate additional third-party income from the asset or provide additional services to third parties, for example, through precincts, because of the regional nature of the services. However, some opportunities for additional commercial revenue could be further explored in both cases.
Economies of scale	✓✓	✓✓	Some economies of scale exist if the rollingstock platform is scaled to other areas in New Zealand. However, this is not a differentiating factor between the options.
Rating	**1**	**2**	**A PPP is not considered to be the optimal delivery model for this package.**

Based on the above assessment it has been determined that there is limited potential for a PPP delivery to generate additional value for money when compared to the preferred traditional delivery strategy.

10 CHAPTER 10 – DELIVERY OPTIONS

CHAPTER SUMMARY AND CONCLUSIONS:

- The recommended delivery strategy is to procure and deliver the scope of the preferred solution as three separate packages of work:
  - rollingstock and depot (Package 1)
  - station upgrades (Package 2)
  - stabling facilities and track upgrades (Package 3).
- GWRC will own the delivery of all three packages and manage their interface risks.
- The Rollingstock and depot package is to be delivered under a Design, Build, Maintain + Opperate (DBM +[O]) contract, and the Station upgrades package is to be delivered via a Managing Contractor arrangement.
- The Stabling facilities and track upgrades works (Package 3), included in the preferred solution and its costs, relate to the development of stabling and track facilities currently owned by Kiwi Rail. Package 3 will therefore be delivered via KiwiRail. GWRC will instruct, monitor and provide support for procurement and delivery of the works. GWRC will also manage the interface risks for Package 1 and 2 with Kiwi Rail's delivery of the stabling facilities and track upgrade works.
- Further refinement of the approach to packaging and delivery will need to be undertaken prior to any packages being taken to market.
  - Package 1 (Rollingstock and depot) – further work will be required to explore the interface between the preferred DBM+[O] Delivery Model and the existing operating arrangements to determine how best to mitigate interface issues.
  - Package 2 (Station upgrades) – refinement of the delivery model assessment will be required once the scope and key risks associated with that scope are better understood.
- This will involve further market sounding and further detailed work on package definition, delivery model option development, potentially alternative approaches to Project funding/financing, and procurement planning and scheduling. Refer to Chapter 11: Commercial Consideration for more detail on proposed readiness for market activities.

10.1 Purpose and overview of chapter

This chapter identifies, defines and assesses the options available for project delivery. This includes an assessment of how the various elements of project scope will be packaged for procurement and delivery, the delivery model for each package of work that will best drive achievement of the project's objectives and value for money. Market sounding outcomes are a key input to the delivery options assessment.

The purpose of this chapter is to identify, assess, and select a packaging option and delivery model option (together, the delivery strategy) that best achieves the procurement objectives for the Lower North Island Rail Integrated Mobility Project (LNIRIM, or the Project).

This chapter outlines the:

- methodology used to evaluate packaging and delivery model options
- project-specific circumstances relevant to the packaging and delivery model options assessment
- project scope elements and packaging options suitable for evaluation
- framework and evaluation criteria used to assess packaging options
- assessment of packaging options against the evaluation criteria
- preferred packaging option

- framework and evaluation criteria used to assess delivery model options
- delivery model options suitable for evaluation
- assessment of delivery model options against the evaluation criteria
- preferred delivery model for each project package.

10.2 Market sounding process and key findings

During March 2021, as part of the Project's development activities, a targeted market sounding process was undertaken by the project team to establish market views on key aspects of the Project. Participants were selected based on their institutional knowledge, being, rolling stock manufacturers and/or maintainers who are or have been involved in rolling stock projects of similar scope, including recent projects in New Zealand and Australia. Participants requested to provide written submissions only.

The key purpose of the market sounding was to establish the appetite and capability of the rolling stock market to supply a small fleet of regional style train sets to operate both under the 1600 V DC OHLE and on non-electrified routes, with the least possible dependence on diesel as a fuel for a prime mover.

Accordingly, GWRC received submissions from 8 market participants through this market consultation process to gauge the market's interest. Table 10-1 summarises key findings from the market sounding process that are most relevant to the delivery strategy assessment.

Table 10-1 Relevant market sounding findings

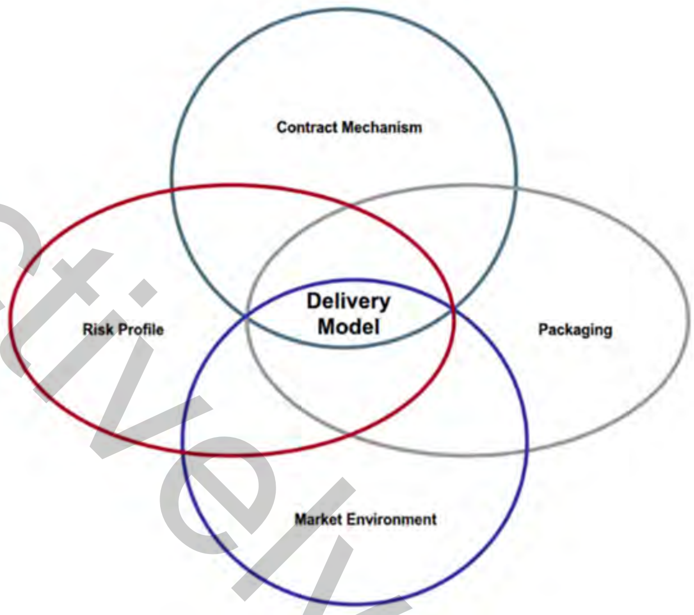
Category	Discussion Points	Key findings
Rolling stock: Contract Options	• Type of contract offered	• Contract and Term preference: Respondents generally prefer a supply and maintain arrangement with contract terms commencing at a minimum of 10-15 years.
Maintenance facility	• View on including design and construction/ refurbishment of a maintenance facility with rolling stock supply • View on maintenance of a maintenance facility • View on contract term length if maintenance facility maintenance is included	• Respondents mainly indicated at least supplier input into maintenance facility design and aligning maintenance contract with rolling stock maintenance contract term
Financing	• View on including financing of the new rolling stock and/or maintenance facility works in the tender process • View on type of financing considered likely to be available	• Generally, respondents did not see an issue with financing both the rolling stock and a maintenance facility.
Rolling stock technology review	• View on secondary propulsion	• Generally, there were no red flags.
Lead times	• Project timeframes and market's capacity to deliver within these.	• Based on the timelines, five years from contract award was the average for all units to be in revenue service.
Fleet size and risk	• Production and supply chain risks	• Generally, there were no red flags.
Reference projects	• Market capability	• All respondents can demonstrate previous project capability. There seems to be a change in attitude from use of super capacitors to batteries (which was global, not just restricted to a single respondent).

10.3 Delivery options assessment methodology

The delivery options analysis was conducted to determine the delivery strategy that best meets service needs and delivers the Project with the greatest potential to achieve value for money outcomes for GWRC, Horizons and Waka Kotahi.

Figure 10-1 shows key considerations in determining the preferred delivery strategy.

Figure 10-1 Delivery model considerations



The following methodology was adopted to consider and evaluate delivery strategy options for the LNIRIM (consistent with the delivery options assessment approach and compliments with the Waka Kotahi guidelines).

- **Step 1:** Project-specific circumstances such as project objectives, project risks, market analysis, technical characteristics and timing requirements that may influence the structuring of the packaging and delivery option solutions were outlined and considered.
- **Step 2:** Potential project packaging options were developed and assessed and a preferred packaging solution was identified, having regard to selected evaluation criteria and the project-specific circumstances.
- **Step 3:** Potential delivery model options were considered, considering their suitability for each project package and a short list of options was agreed.
- **Step 4:** Delivery model option evaluation criteria were agreed and a framework was developed for how the short-listed delivery model options would be analysed.
- **Step 5:** The short-listed delivery model options were assessed against the evaluation criteria.
- **Step 6:** A delivery model option for each project package was recommended based on the assessment undertaken in Steps 1 to 5.

10.4 Project specific characteristics relevant to analysis

10.4.1 Project objectives

The LNIRIM project objectives are outlined in Chapter 1: Introduction and Background. These objectives, or outcomes sought relate to key technical/performance requirements for the new rollingstock and associated assets and value for money objectives.

10.4.2 Delivery strategy objectives

The primary objectives of the delivery strategy assessment approach were to ensure that:

- the delivery strategy for LNIRIM presents a considered approach to maximise value for money to the GWRC through appropriate risk allocation and a fair and transparent process
- the delivery strategy appropriately considers the unique characteristics and key risks pertinent to the LNIRIM project
- project packages are appropriately scoped to enhance the likelihood of successful project outcomes
- the delivery strategy is reflective of market's appetite and capacity
- the delivery strategy is an outcome of a collaborative approach taking into account of concerns of key stakeholders.

The delivery options analysis undertaken for this LNIRIM report was designed as a high-level assessment with sufficient detail to inform readiness for market activities, where there will be an opportunity to further refine the delivery strategy.

10.4.3 Scope

As outlined in Chapter 5: Preferred Option, the LNIRIM scope consists of four key elements:

- rollingstock: 22 four-car tri-mode units (1600V DC & CI generator & battery), which will be owned by Greater Wellington Rail Limited (GWRL) and enter service in the 2029 financial year, and one simulator for training drivers
- a standalone maintenance facility for maintenance of the new rolling stock (in Masterton)
- station upgrades
- stabling facilities and track upgrades with up to three potential stabling locations (Palmerston North, Wellington and Masterton).

Key assumptions for each of these scope items that are relevant to the packaging and delivery options assessment are outlined in Table 10-2.

Table 10-2 Key scope assumptions

Scope element	Key assumptions
Rollingstock	• 22 four-car tri-mode units (1600V DC & CI generator & battery). • One simulator
Depot	• Standalone maintenance facility for maintenance of the new rollingstock. • Maintenance facility will be designed and built for new rollingstock only. • Track and track pedestals, overhead lines, and overhead isolation and depot protection system, including derailers, signals, etc to be owned by KiwiRail and funded via the Network Agreement.
Station upgrades	• Includes various station upgrade works. • Station buildings and related infrastructure (excluding platforms) owned by Greater Wellington Rail Limited (GWRL) on leased land. • Station platforms owned by KiwiRail with upgrades and maintenance funded via the Network Agreement. • Scope undefined at this stage.

Scope element	Key assumptions
Stabling facilities and track upgrades	• Scope of works are owned by Kiwi Rail and facilities will be accessed by GWRC via amendment of the existing Network Agreement. • Stabling locations to be confirmed but may include up to three (3) separate sites. • Locations will be a mix of brown and green field sites.

10.4.4 Timing

As demonstrated in Chapter 5: Preferred Option, timing of delivery for the new rolling stock is critical to meet operational requirements. Key timing considerations include the new rolling stock entering service in the 2029 financial year. Timing factors including duration of procurement processes and beat rates are critical for both the delivery options assessment.

10.4.5 Project risks

Key project risks during the development, procurement and delivery stages of the LNIRIM project have been identified and draft mitigation strategies developed (refer to Chapter 7: Risk Analysis). In Chapter 11: Commercial Considerations, initial consideration has also been given to whether risks may be better managed by the public or private sectors and whether these allocations would influence the selection of the most appropriate delivery strategy to cater for that risk allocation.

Table 10-3 outlines key risk areas that have the potential to impact on the preferred delivery strategy.

Table 10-3 Key risk areas

Risk area	Description
Proximity of works	Some elements of construction work will be in proximity of the live rail environment, may impact daily operations and may constrain delivery e.g., Station and track upgrades.
Fleet transition	Transition of operational and maintenance activities between fleets may have commercial and service implications.
Brownfield risk environment	Some elements of the project works are to be delivered in brownfield sites with exposure to high construction risks i.e., unknown site conditions, unknown services locations, live railways and electrical hazards.
Schedule	Delivery timeframes and interface risks, including rollingstock and associated infrastructure required to procure and maintain the new rolling stock.
Market engagement	A suitable packaging and commercial offering is critical for strong market engagement.
Customer experience	Customer experience will need to managed throughout development, commissioning and transition while maximising social benefits and managing social impacts.

10.5 Packaging options assessment

10.5.1 Overview of packaging options

As identified in Section 10.4.3, there are four distinguishable scope elements that comprise the preferred option for LNIRIM.

There are various packaging options that could be considered for delivering the Project (from a spectrum of smaller, individual packages to larger, integrated packages). However, based on an initial stakeholder briefing and clarity of the four project scope elements, four possible bundling options for the packages were selected for the packaging options assessment, as presented in Figure 10-2.

Figure 10-2 LNIRIM shortlisted packaging options

Package options				
Scope item	Option 1 Disaggregated	Option 2 Semi-aggregated	Option 2a Semi-aggregated	Option 3 Aggregated
Rollingstock	Package 1	Package 1	Package 1	Package 1
Depot	Package 2		Package 2	
Station upgrades	Package 3	Package 2		
Stabling facilities and track upgrades	Package 4	Package 3	Package 3	Package 2

10.5.2 Packaging evaluation criteria

Based on the project requirements and characteristics, evaluation criteria were determined for the packaging options assessment.

Table 10-4 outlines the criteria used for the packaging options assessment.

Table 10-4 Evaluation criteria for packaging options assessment

Criteria	Weighting	Description
Technical requirements	20%	Similarities in technical requirements, skills and capabilities needed to deliver the components of the package.
Timing	25%	The proposed package option aligns with operational timing requirements and considers planning approvals required for the project. All schedule impacts and planning approvals can be effectively managed and the required project works are completed as soon as possible.
Interface & integration with other packages	10%	The separation of the package creates a manageable point of interface with other packages/projects or creates unworkable interface risks.
Market appetite and capacity	20%	Alignment to market perception, appetite and capacity. Consideration of geographic proximity.
Value for money	25%	Packaging of the works maximises economies and value for money in project delivery. Proposed packaging solution drives appropriate risk transfer, such that cost efficiencies can be achieved.

10.5.3 Packaging options scoring

Table 10-5 outlines a four-point qualitative assessment rating was applied to each package criterion.

Table 10-5 Packaging option scoring guide

Score	Comment
3	The packaging option is highly suitable when assessed against this criterion
2	The packaging option is suitable when assessed against this criterion
1	The packaging option is somewhat suitable when assessed against this criterion
0	The packaging option is unsuitable when assessed against this criterion

Each score assigned in the assessment was then multiplied by the associated weighting and summed to provide a total weighted score.

10.5.4 Assessment of packaging options

The packaging option that will likely deliver the best value for money to GWRC was determined by the project team in a workshop on 11 August 2021 using the above assessment methodology.

Table 10-6 provides the details of the packaging options assessment undertaken to determine the preferred packaging option.

Table 10-6 Packaging options assessment

Criteria	Weighting	Option 1	Option 2	Option 2a	Option 3	Comments
Technical requirements • Similarities in technical requirements, skills and capabilities needed to deliver the components of the package	20%	3	2	3	1	• Option 1 separates all the unique scope requirements attracting specialists to deliver each package • Option 2a is like Option 1 but also groups 'technically-like' components. However, compared to Option 2, it reduces the ability of the rolling stock manufacturer and maintainer to influence depot design meaning a key input to depot technical requirements may be lacking • Option 2 is like Option 3 but less aggregated. Enables rolling stock manufacturer and maintainer to influence depot technical requirements and design • Option 3 aggregates the requirements which may result in a generalist being appointed who subcontracts components
Timing • Ability of the packaging option to align with operational timing requirements.	25%	2	3	2	3	• Option 2 and 3 combine the scope elements of rollingstock and depot. In doing this it drives an incentive for the depot to be completed in time for the arriving rolling stock, reducing the timing risks and the need for GWRC to bear interface risk in respect of delay to the design and construction of the depot. • Options 1 and 2a separate the major components of rolling stock and depot. This creates a timing interdependency and has impacted the scoring
Interface and integration with other packages and/or projects • The physical separation of the package creates a manageable point of interface with other packages or creates unworkable interface risks	10%	1	3	1	3	• Option 2 and 3, via aggregating the critical scope items reduce the interphase and integrations risks for the relevant procurements. • Option 1 and 2a, by either being disaggregated or grouping a major scope item with a less critical item increases the interface and integration risks.
Market appetite and capacity • Alignment to market perception, appetite and capacity • Consideration of geographic proximity	20%	3	2	2	1	• Option 1 disaggregates the scope items and attracts specialists focusing on unique services and mitigating participant risk. • Option 2 and 2a, have aggregated the scope items or introduced geographic considerations. These may potentially detract from the market interest although Option 2 is a tried and tested model in common use in the market and which should therefore be familiar and acceptable to potential tenderers.

Criteria	Weighting	Option 1	Option 2	Option 2a	Option 3	Comments
						• Option 3 aggregates the various scope items leading to consortiums who may not have the capability across all requirements. This in turn increases their risks from both delivery and commercial perspectives. • The market sounding activity suggested a separation of packaging was favourable but also an understanding and acceptance of aggregation.
Value for money • Packaging of the works maximises economies and value for money in project delivery • Proposed packaging solution drives appropriate risk transfer, such that cost efficiencies can be achieved	25%	1	2	1	2	• Option 2, 2a and 3 aggregate the scope items. This provides efficiencies and productivity gains that may be gained by combining various requirements. Additionally, GWRC may be able to mitigate delivery and operational risks via allocating risk to the best party to manage the risk. • Option 2 and 3 transfer integration risk transfer interface and integration risk between rolling stock and depot • Option 1 limits risk transfer and the potential for efficiencies and productivity gains.
TOTAL WEIGHTED SCORE	**100%**	**2.1**	**2.4**	**1.9**	**2.0**	

10.5.5 Preferred packaging option

Based on the packaging options assessment, the preferred packaging option is Option 2, which delivers the Project in three separate packages:

1. Package 1: Rollingstock and maintenance depot
2. Package 2: Station upgrades.
3. Package 3: Stabling facilities and track upgrades.

Delivery of the Project via this packaging arrangement provides the following advantages:

- transfer of construction completion risk for the maintenance depot in Package 1 to the rolling stock manufacturer
  - reducing interface risks associated with the design, manufacture and maintenance of the new rolling stock
  - whole of life value for money is enhanced through custom designed facilities for maintenance processes
  - aligning delivery timeframes to ensure the delivery of rolling stock manufacture and the construction of the maintenance facility areas align with the project timeframes.
- transfer of construction completion risk for station upgrades in Package 2 to an independent constructor who can support GWRC with the operational and transition risks associated with customer continuity and risks of working in proximity to daily operations.
- transfer of construction completion risk for the stabling facilities and track upgrades in Package 3 to an independent constructor uninhibited by interface risks associated with station upgrades.
- transfer of construction completion risk for stabling facilities and track upgrades in Package 3 to an independent specialist contractor familiar with undertaking corridor works in a brownfield rail environment.
- recognises that Package 3 will be driven by KiwiRail as network access provider rather than GWRC and that Package 3 may be likely to lend itself to a different delivery model (such as managing contractor or incentivised target cost) from the other Packages in view of the risks of corridor works in a brownfield rail environment being more difficult to price in advance.

Market appetite for this packaging arrangement is stronger than other options and it is expected that there will be sufficient interest from stronger contenders ensuring a competitive tender process.

10.6 Delivery model options assessment

The delivery model options assessment involved the following steps:

- shortlisting delivery model options
- assessing each shortlisted delivery model options based on a set of quantifiable, weighted criteria.

The delivery model options assessment was undertaken for each of the works packages identified through the packaging options assessment

10.6.1 Shortlisted delivery model options

Following a stakeholder briefing and the packaging workshop, a shortlist of delivery model options was developed. This considered the full suite of available delivery model options, the project-specific circumstances and the proposed project packaging solution. This process identified several options potentially suited but also removed unsuited models from the assessment process e.g. Private, Public Partnerships as described in Chapter 9 Affordability analysis. Table 10-7 summarises the short-listed delivery model options for each package.

Table 10-7 Shortlisted delivery options

z			
Delivery Model Option	**Description**	**Opportunities**	**Challenges**
Design & Build + Maintain + [Operate] **DB + M + [O]**	• A single group (consortium) manages the rollingstock manufacture and depot construction. The maintenance of the rollingstock and depot is procured separately and operations are retained under separate arrangements.	• Facilitates synergies between design and build obligations. • Facilitates the transition of existing operational activities. • Facilitates contestability of maintenance of new rollingstock.	• Additional procurements and negotiations required. • Limited obligations from manufacturer in the long-term maintenance of the rollingstock. • Operators and maintainers may have limited knowledge of the new rollingstock. • The commercial arrangements for operators will need to be managed and transitioned separately. • GWRC and KiwiRail (as current parties responsible for appointment of existing operator) will be exposed to the operating transition risks. • DB Contractor is not incentivised to consider whole of life costing and does not take long term performance risk
Design, Build & Maintain + [Operate] **DBM + [O]**	• A single group (consortium) manages the rollingstock manufacturing, responsible for depot construction and maintains the rollingstock and depot. The operations are retained under separate arrangements. • The DBM contract could be novated to or managed by the operator appointed by GWRC from time to time.	• Facilitates long term maintenance obligations in the design and manufacture of the rollingstock. • Facilitates the transition of existing operational activities. • Facilitates contestability of maintenance of new rollingstock. • Incentivises value for money on a whole of life basis • Integrates design, manufacture/construction and long-term performance risk	• Operators may have limited knowledge of the new rollingstock although this could be mitigated by the operator taking a novation of or being granted rights to manage the DBM contract. • The commercial arrangements for operators will need to be managed and transitioned separately. • GWRC and KiwiRail will be exposed to the operating transition risks, subject to the mitigating steps that could be taken as noted above.
Design & Build + Operate & Maintain **DB + [OM]**	• A single group (consortium) manages the rollingstock manufacture and depot construction. operations and maintenance for both the trains and depot are retained under separate arrangements. • As part of the D&B contract procurement, an option for either full maintenance or a technical support and spares supply agreement (TSSSA) could be sought which could then be taken up by GWRC or made available to the operator appointed by GWRC from time to time.	• Facilitates synergies between design and build obligations. • Facilitates long term maintenance and operations obligations. • Through the provision of a maintenance/TSSSA option, goes some way to incentivising value for money on a whole of life basis	• Additional procurements and negotiations required. • Limited obligations from manufacturer in the long-term maintenance of the rolling stock although this could be addressed by securing a maintenance or TSSSA option as part of the DB contract procurement. • Operators and maintainers may have limited knowledge of the new rollingstock and lack familiarity with the maintenance depot/infrastructure although this could be mitigated by securing a maintenance or TSSSA option as part of the DB contract procurement. • Lack of contestability in operation and maintenance activities although this could be mitigated by securing a maintenance or TSSSA option as part of the DB contract procurement.
Design, Build, Operate & Maintain	• This option was considered initially but subsequently discounted and excluded from assessment.		

DBOM	• The decision to exclude is premised on mitigating the commercial risks associated with terminating the existing operational and maintenance agreement early for convenience to implement these outcomes. The existing GWRC operating and maintenance agreement with TDW is due to expire in March 2025 but, by way of a performance incentive, includes a right for the existing operator to extend until March 2031 if it meets specified punctuality, reliability and performance outcomes. • In any event the same commercial outcome as this option could be achieved by pursuing the second option above and novating the DBM contract to the existing GWRC appointed operator so that the existing GWRC operator wraps the risk of the DBM contractor's performance.

Note – Depot: Track and track pedestals, overhead lines, and overhead isolation and depot protection system (including derailers, signals, etc) to be owned by KiwiRail and funded via the Network Agreement. KiwiRail will be responsible and accountable for the above across all delivery model options (like a nominated sub-contractor arrangement).

Package 2 - Station upgrades			
Delivery Model Option	**Description**	**Opportunities**	**Challenges**
Construct Only *(Could involve ETI)*	• Detailed design is developed by GWRC prior to procurement (e.g., 80% - 100%). • GWRC manages progression of design with Early Tenderer Involvement (ETI). • Procurement is for construction only. • Rail accredited contractor engaged.	• GWRC retains full control over all design outcomes.	• Platforms owned by KiwiRail, but station building owned by GWRL. Manage interface issues / approvals arising from GWRL procuring station building upgrades and KiwiRail procuring platform upgrades. This could be addressed by including the management of the platform scope in the contract and requiring the contractor to appoint KiwiRail as a nominated subcontractor. • Design may not be able to be fully scoped prior to construction. • GWRC retains design risk on the design although recent construct only railway station projects in Australia have transferred constructability risk to the contractor and it may be possible to achieve the same here. • Potentially longer lead time to procurement.
Managing Contractor	• Managing contractor engaged early by GWRC. • Level of design developed by GWRC prior to procurement (TBD). • Managing contractor manages design, procurement and construction. • Managing contractor engages subcontractors to carry out the works. • Rail accredited contractor engaged.	• Managing contractor manages various subcontractors on behalf of GWRC. • GWRC retains control over design outcomes. • May best facilitate different contracting models for individual stations based on scope of works (i.e., may be a mix of Contract Only, D&C etc.).	• Platforms owned by KiwiRail, but station building owned by GWRL. Manage interface issues/ approvals arising from GWRL procuring station building upgrades and KiwiRail procuring platform upgrades. This could be addressed by including the management of the platform scope in the contract and requiring the managing contractor to appoint KiwiRail as a nominated subcontractor. • Subcontracts are back to GWRC and may include elements of cost and time risk being retained.
Design & Construct *(Could involve ECI)*	• Lower level of design is developed by GWRC prior to procurement (e.g., 20-40%). • Early Contractor Involvement (ECI) phase to further develop design. • Rail accredited D&C contractor engaged for preparation of detailed design followed by construction.	• GWRC retains control over high level design outcomes • Contractors input into design as part of ECI phase to assist in GWRC outcomes being met without GWRC retaining design risk. • Facilitates innovation and competitive tension in design and construction solutions. • Maximises efficiency between management and interplay of design risk and construction risk.	• Platforms owned by KiwiRail, but station building owned by GWRL. Manage interface issues/ approvals arising from GWRL procuring station building upgrades and KiwiRail procuring platform upgrades. This could be addressed by including the management of the platform scope in the contract and requiring the contractor to appoint KiwiRail as a nominated subcontractor. • Need to ensure contract documentation adequately covers design obligations.

Package 3 - Stabling facilities and track upgrades	
Delivery Model Option	**Description**
KiwiRail	• The stabling and track facilities are owned by Kiwi Rail. • The works associated with this package are not detailed in this delivery strategy as the planning, investigation, design and physical works delivery of the assets will be determined by KiwiRail under GWRC's instruction as detailed in Chapter 12. • The works in this package will be procured and delivered via KiwiRail (subject to the Crown funding provided to deliver this package), following which it will be accessed (and paid for) by GWRC via the Network Agreement. • GWRC will monitor and provide support of procurement and delivery of the works via either the Network Agreement or a separate support agreement • GWRC will also manage the interface risks for Package 1 and 2 with KiwiRail's delivery of Package 3.

10.6.2 Delivery model options evaluation criteria

The delivery model option assessment adopted similar evaluation criterion to the packaging options assessment, with some refinements to ensure the suitability of the assessment to delivery model options. Table 10-8 outlines the criteria used for the delivery options assessment.

Table 10-8 Evaluation criteria for the delivery model options assessment

Criteria	Weighting	Description
Delivery strategy objectives	**20 %**	Ability of the delivery model to assist with meeting the project objectives.
Manufacturing, construction and interface risk	**15 %**	The proposed delivery model can effectively manage manufacturing, construction and interface risk ensuring continuance of operations during manufacture, construction and that any customer and operational impacts are minimised. The delivery model should also provide the means to sufficiently manage construction access.
Timing and complexity	**15 %**	Ability of the delivery model option to deliver the project in the required timeframes and appropriately deal with the complexity of the project's implementation requirements.
Market appetite and capacity	**10 %**	The extent to which the delivery model option assists in maximising market interest amongst the appropriate players with the relevant skills, expertise and capacity to deliver the project.
Customer experience	**15 %**	The proposed delivery model maximises customer experience both during the project's development and implementation, and post commissioning.
Value for money and budget certainty	**25 %**	The extent to which each option assists in maximising the Greater Wellington Regional Council's value for money from implementing the project through; innovation, whole-of-life cost considerations, Greater Wellington Regional Council development costs and resources and private sector tender costs. The extent to which the delivery option assists in providing earlier budget certainty to the Greater Wellington Regional Council.

10.6.3 Delivery model option scoring

A four-point qualitative assessment rating detailed in Table 10-9 was applied to each criterion for each delivery model option.

Table 10-9 Delivery model option scoring guide

Score	Comment
3	The delivery model option is highly suitable when assessed against this criterion
2	The delivery model option is suitable when assessed against this criterion
1	The delivery model option is somewhat suitable when assessed against this criterion
0	The delivery model option is unsuitable when assessed against this criterion

Each score assigned in the assessment was then multiplied by the associated weighting and summed to provide a total weighted score.

10.6.4 Assessment of delivery model options

The delivery model options that will likely deliver the best value for money to GWRC was determined by the project team in a workshop on 18 August 2021 using the above assessment methodology.

Table 10-10 and Table 10-11 provide the details of the delivery model options assessment undertaken to determine the preferred delivery model by package.

Table 10-10 Package 1 Rollingstock and depot

Criteria	Weighting	DB + M + [O]	DBM + [O]	DB + [OM]	Comments
Delivery strategy objectives • Ability of the delivery model to assist with meeting the project objectives.	**20%**	1	3	2	• Number of separate procurements increases the risk to the project program • Disaggregation of operations and/or maintenance from the design and build components potentially increases interface risk, reduces value for money on a whole of life basis, adds complexity and results in sub-optimal risk allocation
Manufacturing, construction and interface risk • Effectively manages manufacturing, construction and interface risk.	**15%**	1	3	1	• Interface risk is increased with the greater number of interfaces
Timing and complexity • Ability of the delivery model to deliver the project in the required timeframes and	**15%**	1	2	2	• The more interface risk will increase the timing and complexity risk, potentially resulting in protracted negotiations between GWRC and the contractor to address those interface risks

Criteria	Weighting	DB + M + [O]	DBM + [O]	DB + [OM]	Comments
deal with the complexity of the project.					
Market appetite and capacity • The extent to which the delivery model maximises market interest with the relevant skills, expertise and capacity.	10%	2	3	2	• No significant differentiating factors. DBM model scores slightly better as it is well accepted and has been used in many of the recent rollingstock projects in the region. • The market engagement exercise identified a preference for the aggregation of DBM with the respondents mainly indicating, at least, supplier input into maintenance facility design and aligning maintenance contract with rolling stock maintenance contract term.
Customer experience • The proposed delivery model maximises customer experience.	15%	1	2	2	• Customer experience arrangements are available during transition but increased disaggregation of either maintenance and/or operations may increase the customer experience interaction risks.
Value for money and budget certainty • Maximising value for money. The extent to which the delivery option provides budget certainty.	25%	1	3	1	• The greater level of aggregation will facilitate greater ownership, incentivise whole of life costing and subsequently innovation and the potential for increased economies of scale. • Less interfaces may result in increased cost certainty
TOTAL WEIGHTED SCORE	**100%**	**1.1**	**2.7**	**1.6**	

The assessment identified the DBM + [O] delivery model as the one most likely to deliver best value for money for GWRC for this package. Delivery of the package via this model provides the following advantages over the other delivery model options:

- integrates design, construction and maintenance risk with a single point of accountability and offers maximum transfer of performance risk over whole of life
- reduces the number of key procurement and contractual interfaces
- mitigates some of the commercial risk associated with operations
- less complex procurement process
- well established model that is accepted by the market, as demonstrated through the market sounding outcomes
- whole of life cost efficiencies and potential for innovation
- lower bid costs.

Table 10-11 Package 2 Station upgrades

Criteria	Weighting	Construct Only	Managing Contractor	Design & Construct	Comments
Delivery strategy objectives • Ability of the delivery model to assist with meeting the project objectives.	**20%**	1	3	1	• There is an uncertain nature of the scopes of work. This will evolve over time. • The current GWRC team will not be able to manage the scale of these works.
Manufacturing, construction and interface risk • Effectively manages manufacturing, construction and interface risk.	**15%**	2	3	1	• Uncertain nature of works increases the design risk. • The number and diversity of the package elements increase the interface risk. • A managing contractor may coordinate and create programs of work based on either construct only or design and construct, or other models.
Timing and complexity • Ability of the delivery model to deliver the project in the required timeframes and deal with the complexity of the project.	**15%**	1	3	2	• The number and diversity of the package elements increase the timing and complexity risks. • A managing contractor may coordinate and reduce the management complexity for GWRC.
Market appetite and capacity • The extent to which the delivery model maximises market interest with the relevant skills, expertise and capacity.	**10%**	2	2	1	• Based on the unknown nature of the works, transfer of full design risk, may reduce the interest of design and construct contractors.
Customer experience • The proposed delivery model maximises customer experience.	**15%**	2	2	2	• The customer interface is isolated to construction activities which are generally consistent across the delivery options.
Value for money • Maximising value for money.	**15%**	2	2	1	• Design risk is uncertain and optimum allocation of it is difficult to ascertain currently. Given this uncertainty, at this time, subject to further assessment once the scope is better defined, it is best assumed that the combined stations scope would include a mix of construct only or design and construct contracts, on a case-by-case basis. At this stage, this

Criteria	Weighting	Construct Only	Managing Contractor	Design & Construct	Comments
					uncertainty may favour a managing contractor model.
Budget certainty • The extent to which the option provides budget certainty.	**10%**	2	1	3	• A design and construct contract may have a fixed fee which promotes budget certainty as the contractor will carry the design and construction risks. • A managing contractor arrangement is a mix of the above and budget certainty is reduced with GWRC carrying design and construction risk outcomes.
TOTAL WEIGHTED SCORE	**100%**	**1.7**	**2.4**	**1.5**	

The assessment identified the Managing Contractor delivery model as the one most likely to deliver best value for money for GWRC for this package. Delivery of the package via this model provides the following advantages over the other delivery model options:

- The uncertain nature and scope of works currently results in design risk and construction risk being uncertain. Optimum allocation of these risks is difficult to ascertain currently. Given this uncertainty, at this time and subject to further assessment once the scope is better defined, it is best assumed that the combined stations scope would include a mix of construct only or design and construct contracts, on a case-by-case basis.
- Based on the above likely mix of contracting models, and given likely internal resourcing constraints, a Managing Contractor model would help alleviate the internal resourcing of administering multiple contracts. The number and diversity of the package elements increase the timing and complexity risks. A Managing Contractor would coordinate and reduce the management complexity for GWRC.

10.6.5 Summary and conclusions

The recommended delivery strategy is to procure and deliver the Project scope as three separate packages of work:

I. Rollingstock and depot

II. Station upgrades

III. Stabling facilities and track upgrades.

GWRC will own the delivery of all three packages and manage their interface risks.

The Rollingstock and depot package (Package 1) is to be delivered under a DBM +[O] contract, and the Station upgrades package (Package 2) is, subject to further assessment once the scope is better defined, to be delivered via a Managing Contractor arrangement.

The Stabling facilities and track upgrades works (Package 3), included in the preferred solution and its costs, relate to the development of stabling and track facilities currently owned by Kiwi Rail, located in the rail corridor or on rail designated land.

Package 3 will therefore be advantageously delivered via KiwiRail. GWRC will instruct, monitor and provide support for procurement and delivery of the works. GWRC will also manage the interface risks for Package 1 and 2 with Kiwi Rail's delivery of the stabling facilities and track upgrade works.

Further refinement of the approach to packaging and delivery will need to be undertaken prior to any packages being taken to market.

- Package 1 (Rollingstock and depot) – further work will be required to explore the interface between the preferred DBM+[O] Delivery Model and the existing operating arrangements to determine how best to mitigate interface issues.
- Package 2 (Station upgrades) – refinement of the delivery model assessment will be required once the scope and key risks associated with that scope are better understood.

This will involve further market sounding and further detailed work on package definition, delivery model option development, potentially alternative approaches to Project funding/financing, and procurement planning and scheduling. Refer to Chapter 11: Commercial Consideration for more detail on proposed readiness for market activities.

11 CHAPTER 11 – COMMERCIAL CONSIDERATIONS

CHAPTER SUMMARY AND CONCLUSIONS:

- Based on the delivery strategy proposed in Chapter 10, a high-level procurement program has been developed for Packages 1 and 2, which accommodates the full new fleet in revenue service by Q4 2028. Following completion of the DBC, a detailed procurement program will be developed in line with the development of a comprehensive procurement plan for the Project.
- The procurement program includes three packages, two of which will be delivered by GWRC:
  - Package 1, a single design, build and maintain (DBM) agreement for the successful Tenderer to deliver the rollingstock and depot (maintenance) facility, and
  - Package 2, a managing contractor arrangement for the station upgrades. These are at an early stage of planning and yet to have a defined scope but are likely to include a mix of contracting models, including Construct Only and Design & Construct models.
- Package 3 (Stabling facilities and track upgrades) will be delivered by KiwiRail, who in turn will determine its delivery strategy as part of the wider WMUP programmes of work.
- An initial assessment of procurement risks associated with the procurement of Packages 1 and 2 has been completed. It is intended that this assessment will be monitored and updated with the Project Team following completion of the DBC and throughout the procurement process.
- A draft risk allocation table and summary of the key commercial issues in relation to each of Packages 1 and 2 has been developed and is included in this chapter. These are based on the proposed delivery strategy in Chapter 10: Delivery options and the risk analysis in Chapter 7: Risk analysis. It is intended that this section will be further developed with the Project Team following completion of the DBC. At that stage, a commercial principles document will be produced for each of Packages 1 and 2, using the contents of this Chapter 11 as a basis and this will be used to inform the contract drafting.

11.1 Purpose and overview of chapter

This chapter outlines:

- the proposed procurement arrangements for the preferred delivery strategy, based on the option selected in Chapter 10: Delivery options, with consideration for statutory constraints, existing GWRC and HRC Waka Kotahi NLTP approved procurement Strategies, and the existing contractual arrangements in place
- consideration of approvals and property requirements
- an overview of commercial issues and draft risk allocation for Packages 1 and 2.

11.2 Approval requirements and consent processes

11.2.1 Depot

The location of the maintenance depot will be confirmed by investigations and analysis to be carried out after the completion of the DBC. The selection of the Masterton site, currently owned by KiwiRail, will provide the advantages of being a brownfield rail environment, including limited Resource Consent requirements on designated rail land.

Initial feedback and endorsement gained through consultation with KiwiRail during the analysis presented in Chapter 5: Preferred Option, indicates that several stabling / depot options are feasible on this site. A formal approval will be gained from KiwiRail, including land leasing agreement, and reflected in the risk allocation of Package 1 prior to procurement.

Building Consent processes for the depot will follow the standard approach and its risk transferred to the supplier of Package 1.

11.2.2 Stabling

The location of the stabling facilities identified as a requirement for the LNIRIM project will be confirmed after the completion of the DBC. Stabling facility concept options selected in Chapter 5: Preferred Option, can be established on a variety of sites within designated rail land. Resource Consent requirement will be limited to null and the associated risk will be placed in Package 3.

11.2.3 Stations

Existing railway stations on the Manawatū Line, north of Waikanae, will require substantial upgrades to meet the standard required for the implementation of the preferred solution. Initial engagement with ownership organisations will lead to approval being sought during the market readiness period for Package 2. In summary these are:

- Ōtaki and Levin – The Ōtaki and Levin stations are currently listed on the LINZ Treaty Settlement Land Bank and are subject to future Te Tiriti o Waitangi claims. Essentially there are two scopes of work where the stations require upgrades
  - The station buildings, of heritage value, are significantly deteriorated and require significant work, including seismic strengthening, to be appropriate for use. GWRC will have to seek ministerial approval to alter these assets. While this process may be long and uncertain, it is simply required to enable an opportunity to deliver further benefits to the community.
  - The platform upgrades to accommodate the new fleet of rollingstock require minimal works to facilitate the preferred solution.
- Shannon – Upgrades at Shannon station will require approval from the Horowhenua District Council.
- Palmerston North – Upgrades at Palmerston North station require approval from KiwiRail.

Considerations for building consents and approvals related to buildings of historical significance will be integrated into the contractual model for Package 2.

11.3 Property requirements

11.3.1 Land acquisition

No property acquisition requirement is identified as required to enable the implementation of the preferred solution.

11.3.2 Lease agreement

Lease agreements are likely to be considered for:

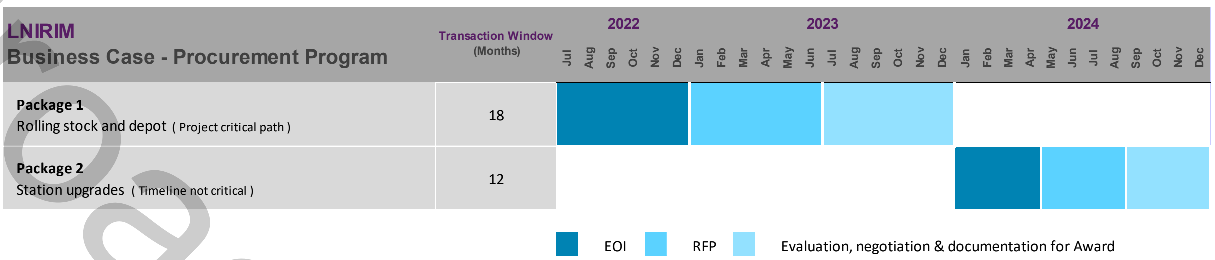
- the KiwiRail land required for Depot and Stabling facilities.
- the Station land related to the Ōtaki and Levin stations.

Lease agreements will remain the responsibility of GWRC and will be negotiated and managed in the market readiness phase and reflected appropriately in Packages 1,2 and 3.

11.4 Procurement program

Based on the delivery strategy proposed in Chapter 10: Delivery options, a high-level procurement program has been developed and is shown in Figure 11-1. The timing of delivery for Package 3 is less relevant to this commercial consideration analysis and presented in Chapter 12: Management Considerations.

Figure 11-1 High Level Procurement Program



11.4.1 Detailed procurement program

Following completion of the DBC, a detailed procurement program will be developed in line with the high-level procurement program in Figure 11-1, the delivery options detailed in Chapter 10 and the commercial considerations in this Chapter. This detailed procurement program will form part of the procurement plan to be developed for the Project.

The detailed procurement program will include all relevant details of each procurement (Package 1 and Package 2), including critical interdependencies and interfaces between transactions.

The procurement program typically takes several iterations to develop, as critical contributing milestones are incorporated, and a final schedule is agreed. The procurement program will then be the master baseline time management tool for procurement. The procurement program will be tracked in terms of major milestones linked to key deliverables. It will define the full scope and all steps required to deliver the procurement of each package.

The objectives of the procurement program will be to ensure:

- a baseline work breakdown structure is planned and scheduled
- package procurement can be controlled against a baseline
- dependencies are defined and co-ordinated
- task durations are accurately forecasted
- standard milestones and approvals are defined
- adequate contingencies are incorporated.

A summary of the key phases of the procurement stages for each package is contained in the following sections.

11.4.2 Package 1 Rollingstock and depot

The procurement of Package 1 will commence in July 2022 and consist of the rollingstock and the maintenance depot. The transaction nominally has an 18-month duration.

The key features of the preferred delivery option for Package 1 are illustrated in Table 11-1.

Table 11-1 Package 1 - Delivery option

Rollingstock and depot			
Delivery Option	**General Description**	**Opportunities**	**Challenges**
Design, Build & Maintain + [Operate] **DBM + [O]**	• A single group (consortium) manages the rollingstock manufacturing, responsible for depot construction and maintains the rollingstock. The operations are retained under separate arrangements. • The DBM contract could be novated to or managed by the operator appointed by GWRC from time to time.	• Facilitates long-term maintenance obligations in the design and manufacture of the rollingstock. • Facilitates the transition of existing operational activities. • Facilitates contestability of maintenance of new rollingstock. • Incentivises value for money on a whole of life basis. • Integrates design, manufacture/construction and long-term performance risk • Integrates options for supply of additional units for future national requirements.	• Operators may have limited knowledge of the new rollingstock, although this could be mitigated by the operator taking a novation of or being granted rights to manage the DBM contract. • The commercial arrangements for operators will need to be managed and transitioned separately. • GWRC and KiwiRail will be exposed to the operating transition risks, subject to the mitigating steps that could be taken as noted above. • The scope of future national opportunities requiring further units will have to be managed early with relevant stakeholders.

The procurement program for Package 1 includes an Expression of Interest, an Interactive Request for Tender phase and an Evaluation, negotiation and award phase. These are summarised below.

Expression of Interest (EOI)

In parallel with the finalisation of the procurement plan and procurement program, an Invitation for EOI will be developed for Package 1 – Rolling Stock and Depot by the second quarter of 2022, with issue to the market in the third quarter 2022.

The timeframes between shortlisting from the EOI process and issue of RFT will be as short as practical. This will allow full and continued engagement with the market and optimise market confidence in the procurement process.

The procurement program allows for an offset of 18 months between the commencement of procurement of Package 1 and the commencement of the EOI process for Package 2.

- This enables the use of the EOI and RFT documentation developed and resources for Package 1 to benefit Package 2 (where applicable)
- This aligns the award date of Package 1 with the commencement of procurement for Package 2 to allow for a contract and scope alignment process (where applicable) to be undertaken.

Request for Tenders (RFT)

RFT document development

In parallel with the EOI process, the suite of RFT documentation will be developed in readiness for the RFT process. The objective of the RFT process is to conduct a competitive and thorough tender process identifying the Tenderer who:

- Is best placed to successfully deliver the package.
- Can best achieve the LNIRIM project/procurement objectives, and
- Represents the greatest value for money for GWRC.

At the commencement of the RFT phase, it is important to hold a set of structured pre-start workshops across the entire integrated project team. These workshops will help by clearly articulating the key elements of the RFT documents for all authors and stakeholders. As part of this process, an RFT document roadmap will be developed articulating the full suite of RFT documents to be developed.

RFT development includes pre-planning, aligning team members and stakeholders, timely production of procurement documentation, and interface management. Approaches to be adopted to ensure these objectives are met will include:

- Maintaining a team approach with GWRC, relying on consistent two-way information sharing with the broader project team including external advisors and experts nominated by GWRC. This will ensure a coherent set of documentation which contains all required objectives.
- Formalised decision-making process to ensure that timeframes allowed for tendering are consistent with GWRC's approach across Package 1 and the other package, are appropriate for each procurement package and are in line with the overall LNIRIM delivery program.
- Incorporation of lessons learnt assessments from other tender processes and recent work being transacted by similar projects to ensure best practices are incorporated.
- Development and implementation of RFT procurement processes consistent with GWRC's framework.
- Ongoing critical assessment of returnable information being requested from Tenderers, with the aim of reducing size, complexity and costs.

Interactive RFT process

The RFT will be supported by an interactive process providing an opportunity for Tenderers to reach technical, legal and commercial alignment with GWRC's objectives. This will prevent non-productive work being carried out by the Tenderer and improve the efficiency and cost-effectiveness of the process. Interactive workshops, led by GWRC, will ensure clarity between GWRC's team and the Tenderers. Feedback to Tenderers will be provided whilst competitive tension remains on matters relating to the technical requirements, commercial model, as well as contractual issues, structure, responsibilities and accountabilities to enable Tenderers to better develop their Tenders.

Evaluation, negotiation and award

Evaluation

Prior to the closing of Tender submissions, in collaboration with the relevant stakeholders, a Tender evaluation plan (consistent with the NZTA Procurement Manual) will be prepared and approved detailing the methodology of the Tender evaluation process to be followed. The tender evaluation plan will detail elements such as:

- detailed evaluation procedures
- evaluation guidelines and methodology
- assessment criteria
- processes for issue and evaluation management
- roles, responsibilities and processes associated with the evaluation of Tenders
- a clear link between the required information in Tenders and the evaluation criteria developed in the RFT phase
- management and organisation of evaluation / clarification meetings during the Tender evaluation period
- outlining approval processes and announcement protocols to be followed to achieve full compliance for all activities undertaken
- requirements for the preparation of Tender evaluation reports.

The Tender evaluation process will be coordinated with GWRC in accordance with the tender evaluation plan to ensure that:

- full probity and confidentiality requirements are satisfied
- a fair, objective and optimum value for money outcome is achieved, and importantly that the decision-making process and the reasoned outcomes reached at each step are comprehensively documented and evidenced
- the overall timelines and objectives of GWRC in relation to the procurement are met.

Negotiation and contract award

Following the evaluation process, the focus will be to reach commercial alignment, through negotiation and settlement of contract documentation with the preferred Tenderer(s) to enable contract award. The negotiation process will be guided by the development of a tender negotiation plan, setting out GWRC's preferred and fall-back positions, which will be approved by GWRC at the same time as selection of the preferred Tenderer(s) and prior to the commencement of negotiations.

11.4.3 Package 2 Station upgrades

The procurement of Package 2 will commence in 2024 and consists of various station upgrades to support the introduction of the new rollingstock. The detailed scoping of what is involved in these works will be clarified further following the completion of the DBC The transaction nominally has a 12-month duration.

The key features of the preferred delivery option for Package 2 are illustrated in Table 11-.

Table 11-2 Package 2 - Delivery option

Station upgrades			
Delivery Option	**Description**	**Opportunities**	**Challenges**
Managing Contractor	• Managing contractor engaged early by GWRC. • Level of design developed by GWRC prior to procurement (TBD). • Managing contractor manages design, procurement and construction. • Managing contractor engages subcontractors to carry out the works. • Rail accredited contractor engaged.	• Managing contractor manages various subcontractors on behalf of GWRC. • GWRC retains control over design outcomes. • May best facilitate different contracting models for individual stations based on scope of works (e.g., may be a mix of Contract Only, D&C etc).	• Platforms owned by KiwiRail, but station building owned by GWRL. Manage interface issues/ approvals arising from GWRL procuring station building upgrades and KiwiRail procuring platform upgrades. This could be addressed by including the management of the platform scope in the contract and requiring the managing contractor to appoint KiwiRail as a nominated subcontractor. • Subcontracts are back to GWRC and may include elements of cost and time risk being retained.

Procurement of Managing Contractor

The procurement program for Package 2 will include an Expression of Interest, Request for Tender for the initial appointment of the Managing Contractor.

The procurement method for a Managing Contractor involves the appointment of a head contractor (the Managing Contractor) who may provide or engage sub-contractors to deliver the works. A fixed lump sum management fee would generally be negotiated with the Managing Contractor, but depending on the model to be adopted, the Managing Contractor may also receive incentive payments for achieving cost and schedule targets.

For the procurement of the Managing Contractor, a brief, documentation and specifications would typically be prepared as a basis for the tender documentation to be issued to competing Managing Contractors. This procurement of the Managing Contractor would likely be conducted via a two-stage process, using an EOI and RFT process. Further detail on the structure of this procurement will be developed following the completion of the DBC.

Procurement of Subcontracts

Following completion of the DBC, it is recommended that work continues to scope the various required station upgrades and confirm the likely contracting models that may be applicable. Once the Managing Contractor is appointed, it will prepare tender documentation and facilitate procurement of the subcontracts based on the various contracting models.

11.4.4 Close out and transition

As the procurement of Package 1 and then Package 2 conclude and move into delivery, several procurement phase close out and transition processes will occur:

- GWRC stakeholders, including external parties (incl. existing operators) where applicable, will be debriefed.
- Unsuccessful Tenderers will be debriefed.
- Procurement records and information will be collated and stored, hard copy and electronic versions of all relevant documentation and data will be gathered. This will ensure full access and traceability of this information is available for future packages and projects.
- Procurement material will be collated to assist in any project / procurement reporting requirements.

11.4.5 Procurement risks

This section provides a draft of the key procurement risks associated with the procurement of Packages 1 and 2. It is intended that this assessment will be updated with the Project Team following completion of the DBC and kept under review throughout the procurement phase.

Table 11-3 Key procurement risks

Category	Risk	Risk Description	Risk Rating	Treatment	Risk Owner
Legal	Legal process	The legal steps required to implement the project are not identified or are not correctly followed, leading to delay and the risk of challenge	**Low**	• The legal steps required to implement the project have already been identified, including: – establishment of a CCTO – community consultation – changes to GWRC's and Horizons Regional Council's Long-Term Plans, Regional Land Transport Plans and Regional Public Transport Plans – Order in Council under the LTMA to de-register the Capital Connection as an exempt service – Amendments to the existing Wellington Network Agreement and Rail Partnering Contract • Both Horizons Regional Council and GWRC have already commenced the community consultation process signalling, in their Regional Public Transport Plans and Regional Land Transport Plans, the importance of the LNIRIM project in increasing service frequency and capacity and improving community connectivity across the lower North Island through the Wairarapa and Manawatū lines	**GWRC and Horizons Regional Council**
Interface	Stakeholder agreement	It is not possible to secure the cooperation of other key stakeholders that will be required because of legislative constraints or existing contractual arrangements	**Medium**	• Cross-participation in governance frameworks • Stakeholder management plan • Active engagement with KiwiRail and TDW throughout the business case, RFT development, evaluation and negotiation phases • Development of negotiation plan identifying preferred and fall-back plans for required contract amendments	**GWRC**
Interface	Interface risk with operations and associated commercial agreements (i.e. KiwiRail and TDW)	Risk that insufficient detail is provided to Tenderers on the operational interfaces with Kiwi Rail and TDW. This may place GWRC at risk in relation to operational and cost exposure in relation to integration risk and scope change.	**High**	• Cross-participation in governance frameworks • Active engagement with KiwiRail and TDW throughout RFT development, evaluation and negotiation • Kiwi Rail and TDW participation (in some form) in interactive tender processes • Potential novation of rolling stock and depot DBM contract to TDW for the remaining duration of the Rail Partnering Contract • Clarity of technical definition of requirements regarding key operational elements	**GWRC**

Category	Risk	Risk Description	Risk Rating	Treatment	Risk Owner
Interface	Interface risks with other projects or Infrastructure	There is a risk that interfaces between packages are not appropriately identified and managed (e.g., Package 1 to Package 2, or Package 1 to Package 3 (Stabling and track upgrades). This places GWRC at risk in relation to cost exposure for integration risk and scope change.	**Moderate**	• Cross-participation in design and delivery functions • Provision of design documentation across packages • Participation in interactive processes • Clarity of technical definition of requirements	**GWRC**
Project Management	Tenderer's existing relationships	Risk that entities that are part of Tenderers, have existing relationships (including existing operators) and have unfair perceived advantages in the procurement process.	**Moderate**	• Competitive procurement process • Probity deeds poll/tender participation terms and conditions	**Project Team**
Scope	Approach to depot	Risk that insufficient information or clarity is provided to Tenderers on requirements in relation to the Depot and interfaces resulting in significant risk premium.	**Moderate**	• Site investigations to be conducted by GWRC and information provided to Tenderers • Procurement seeking only "concept" design to be refined through negotiation • Bundling depot with rolling stock transfers interface risk between them to the DBM contractor • Stakeholder engagement with KiwiRail • Interactive procurement process	**GWRC**
Schedule	Resolving land tenure issues, including approvals	Risk that land tenure issues are not dealt with to enable Depot and stabling sites to be acquired and made available to Tenderers in a timely manner.	**Moderate**	• Engagement with KiwiRail • Engagement with the stabling team(s) • Engagement with landowners	**GWRC**

Category	Risk	Risk Description	Risk Rating	Treatment	Risk Owner
Project Management	Risk that project does not demonstrate fair and robust processes - probity	Risk that an ineffective procurement process benefits some bidding parties over others. Risk that there is misconduct (e.g., collusion) and/or poor public perception of the Project	**Moderate**	• Independent project probity advisors • Robust procurement documentation and rules of engagement • Secure communication channels • Consistency of comms and instructions • Evaluation plans • Probity codes of practice • Internal and external processes • Alignment with GWRC probity process and requirements • Develop plan for managing the involvement of existing contract parties (i.e. KiwiRail and TDW) to minimise risk of transfer of information relating to one tenderer's proposal to another	**All**
Project Management	Confidentiality is not adhered to	Risk that confidential information is leaked leading to the Project being compromised and adverse media attention.	**Moderate**	• Confidentiality deeds poll • Secure communication channels • Document protection • Secure bid storage/assessment • Controlled consultant access provisions • Separate secure office space for procurement evaluation	**All**
Scope	Risk of lack of scope clarity on critical elements during development of the Project	Risk that insufficient information or clarity is provided to the Tenderers on key project objectives, scope of project works and project requirements.	**Low**	• Governance structure and appointment of experienced consultants • Capture in key issues/assumptions log • Stakeholder consultation outside of advisory groups	**Project Team**
Schedule	Evaluation / negotiations phase protraction	Protracted evaluation and negotiation phases due to complexity of options scope, project interfaces and delays to subsequent approvals.	**Low**	• Robust procurement documentation and rules of engagement • Interactive tender processes • Clarity of technical definition of requirements • High quality and fully developed Project Deed and supporting agreements • Key stakeholder engagement in all aspects of process where appropriate	**Project Team**
Schedule	COVID Risk causing procurement delays	An outbreak of COVID may lead to meetings and negotiations not being able to take place.	**Low**	• Use of electronic data rooms • Ability to distribute all communications and documents remotely • Use of virtual conferencing	**Project Team**
Schedule	Unforeseen delays to accreditation	Risk that regulatory accreditation requirements (including safety case	**Low**	• Engagement with relevant rail participants and Waka Kotahi • Effective use of governance framework	**GWRC**

Category	Risk	Risk Description	Risk Rating	Treatment	Risk Owner
		variation to test new rolling stock and type approval for the new fleet) cause a delay in the Project schedule.			
Project Management	Risk of loss of project knowledge as project proceeds	Risk that a key person leaves the LNIRIM team or prior work and reports done are not utilised at future stages of the project leading to rework, loss of momentum or delays.	**Low**	• Accurate record keeping • Information sharing • Robust procurement management plan • Appropriate resourcing and succession planning • Team approach with some knowledge and skill overlap	**Project team**
Project Management	Governance unclear and not sufficient for timely decision making	Risk that governance/approval structure is unclear or ineffective leading to delays in decision making.	**Low**	• A robust procurement management plan in accordance with established GWRC guidance • Effective use of governance - signoff of responsibilities	**GWRC**
Project Management	Inadequate coordination and communication between workstreams	Risk that work streams operate in silos and work stream activities are uncoordinated. This can lead to poor decision-making and project delays.	**Low**	• Weekly reporting and weekly meetings • Single points of control • Appropriate resourcing	**Project team**
Project Management	Evaluation process failure - does not achieve value for GWRC	Risk that the evaluation process has not been well developed and does not align with the project objectives in sub-standard outcomes.	**Low**	• Governance structure and appointment of experienced consultants • Use of a proven major project evaluation approach • Capture in key issues log • Stakeholder consultation outside of advisory groups	**Project team**
Project Management	RFT documents (and Q&A) are of poor quality and do not provide clear guidance to Tenderers	Risk that the quality of the Q&A process and the RFT documents does not provide adequate clarity to Tenderers. This could lead to solutions and final bids that fail to meet GWRC requirements.	**Low**	• Effective use of governance framework • Establishment of data room • Peer review • Document control protocols • Appropriate resourcing • Cross pollination of consultant team • Legal review • High quality and will developed draft Project Agreements • Key stakeholder engagement in all aspects of process where appropriate	**Project team**

Category	Risk	Risk Description	Risk Rating	Treatment	Risk Owner
Project Management	Loss of Tenderers leading to uncompetitive process	Risk that Tenderers drop out (or consolidate) of the competitive bid process, leading to a lack of competitive tension and lower value for money being achieved by GWRC	**Low**	• EOI process and shortlisting • Commercially attractive process, drawing on lessons learned and market developments from similar recent international rolling stock, depot and station upgrade procurements • Timeframes for evaluation and clear procurement documentation • Potential partial reimbursement of bid costs	**Project Team + GWRC**
Political Risk	Stakeholders feel disenfranchised from the project processes and decisions	Risk that key stakeholders feel disenfranchised from the process, leading to a negative opinion of the procurement process and a poor working relationship between GWRC and other key stakeholders.	**Low**	• Stakeholder management plan • Effective use of governance framework • Due diligence and consultation • Regular meetings with key stakeholders	**Project Team**
Project Management	Value for Money	Risk that the delivery strategy and procurement does not create value for money.	**Low**	• Conduct a peer review of delivery strategy and proposed procurement processes	**Project Team**
Project Management	Market interest and capability	Risk that the procurement is unable to attract enough market interest and capability.	**Low**	• Following the completion of the DBC, undertake further market sounding to confirm interest • Conduct regular industry engagement • Develop risk allocation drawing on similar recent international rolling stock, depot and station upgrade procurements	**Project Team**
Political Risk	The community feels disenfranchised from the project processes and decisions	Risk that community groups and the community feel disenfranchised from the process, leading to a negative media and public opinion of the procurement process.	**Low**	• Communications plan • Expectations management • Regular communication • Investigate use of community reference group in evaluation where appropriate • Clear and consistent agreed messaging with relevant government agencies	**GWRC**

11.5 Draft risk allocation and commercial issues

11.5.1 Overview

The procurement program will include two packages:

4. Package 1, a single design, build and maintain (DBM) for the successful Tenderer to deliver the rollingstock and depot facility, and
5. Package 2, a managing contractor arrangement for the station upgrades. These are at an early stage of planning and yet to have a defined scope but are likely to include a mix of contracting models, including Construct Only and D&C models.

Package 3 (Stabling facilities and track upgrades) will be managed by KiwiRail, who in turn will determine the delivery strategy and commercial framework as part of the wider WMUP programmes of work.

This section contains a draft risk allocation table providing a draft of the key areas of risk allocation based on the proposed delivery strategy in Chapter 10: Delivery options and the risk analysis in Chapter 7: Risk analysis, as well as high-level summary of key commercial issues associated with each of Packages 1 and 2.

It is intended that this section will be further developed with the Project Team following completion of the DBC. At that stage, a commercial principles document will be produced for each of Packages 1 and 2, using the contents of this Chapter 11 as a basis and this will be used to inform the contract drafting.

11.5.2 Package 1 Rollingstock and depot

11.5.2.1 Draft risk allocation table

	Type of Risk	Description	Draft Risk Allocation		
			GWRC	Private Sector	Shared
1	**Supply Activities**				
1.1	Design risk	Risk that the design of the fleet, simulators, spares, and other assets do not meet contracted operational and technical specifications requirements or are not otherwise fit for purpose.		✓	
1.2	Appropriateness of the performance specification to meet GWRC requirements	Responsibility that performance requirements and service levels specified in the performance specification are appropriate and sufficient to meet GWRC's requirements.	✓		
1.3	Feasibility of and ability to meet the Technical Performance Specification	The Tenderer takes the risk of the feasibility of the performance specification and the ability to meet the Specification with respect to the design, manufacture, supply, testing, commissioning and delivery of the rollingstock fleet.		✓	
1.4	Construction / manufacturing risk	Risk that construction / manufacture of the fleet cannot be completed on time and / or to budget (other than specific qualifying causes of delay).		✓	
1.5	Integration with the network	Responsibility for integration of the fleet with the network and associated infrastructure during testing and commissioning.		✓	
1.6	Commissioning and testing	Responsibility for commissioning and testing in accordance with the testing requirements and the commissioning and testing plan.		✓	
1.7	Infrastructure information	Risk of specified information provided by GWRC regarding existing operations, existing rail infrastructure and existing rail fleet not being correct.		✓	
1.8	Driver assistance and test running	GWRC will be required to provide driver assistance and test running in accordance with the agreed plans. The Tenderer takes the risk of unavailability of track access and / or driver crews due to act or omission of the Tenderer.	✓		
1.9	Storage / movement of rollingstock	Responsibility for providing transport and storage until acceptance of the rollingstock units within any facility controlled by the Tenderer.		✓	
1.10	Network conditions	GWRC gives no warranty as to the condition of the network.		✓	
1.11	Changes to Wellington Network Agreement and Rail Partnering Contract	Variations are required to existing agreements	✓		
1.12	Design risk	Risk that the design of the fleet, simulators, spares, and other assets do not meet contracted operational and technical specifications requirements or are not otherwise fit for purpose.		✓	

2	**Maintenance Depot**				
2.1	Land acquisition (including development approval)	Land (including development approval) for the maintenance facility cannot be acquired in a timely manner, costs of procurement of land are greater than anticipated or resource consent is delayed or refused.	✓		
2.2	Approvals	Responsibility for obtaining the required approvals within the required timeframes (other than the resource consent) and complying with all approvals to build the maintenance facility.		✓	
2.3	Access to Maintenance Facility site	Risk relating to, gaining access to and egress from the maintenance facility		✓	
2.4	Design risk	Risk that the design does not meet project scope and technical requirements or is not fit for purpose.		✓	
2.5	Program/timing risk	Failure to develop and deliver the maintenance facility within the required timescale as set out in the agreed program (for the commissioning and operations phases) (other than qualifying causes of delay).		✓	
2.6	Heritage and artefacts	Risk of discovery of items of heritage and artefacts at the site. The Tenderer may be entitled to time and cost relief in some circumstances.			✓
2.7	Site conditions and contamination during construction of the maintenance facility	Shared based on known and unknown risks.			✓
2.8	Rail safety accreditation – delivery phase	Responsibility for obtaining and maintaining type approval required (if any) for the rollingstock.		✓	
3	**Maintenance Services**				
3.1	Required availability and maintenance	Making the rollingstock and simulators available for rail operations in accordance with required availability requirements, the performance specification and any accreditation requirements.		✓	
3.2	Maintenance cycles	Sufficient availability of new rolling stock at maintenance facility to undertake required maintenance at required intervals. Private sector risk unless the Operator fails to cycle the relevant multiple unit through the maintenance facility in accordance with pre-agreed Train Plan Parameters			✓
3.3	Lifecycle maintenance	Risk that a component of Project assets requires replacement earlier than anticipated or an overhaul of the fleet is required earlier than anticipated.		✓	
3.4	Defects / Fault risk	Risk that defects or faults are identified following delivery of the rollingstock units and responsibility for rectification.		✓	
3.5	Residual life and end of term handover	Satisfying the residual design life requirements for the rollingstock units at the end of the maintenance phase.		✓	
3.6	Rail safety accreditation – maintenance phase	Obtaining accreditation as necessary for use of the fleet for the operation of passenger services on the network.		✓	
3.7	Construction / assembly noise, pollution etc.	Third party claims relating to construction / assembly / maintenance activities (e.g., noise pollution, loss of amenity on adjacent properties etc.) at the maintenance facility.		✓	

3.8	Environmental impact	Responsibility for any adverse environment impacts due to project activities at the maintenance facility, including risk of any costs associated with remedying.		✓	
3.9	Workplace health and safety	Responsibility for the workplace health and safety obligations for employees at the maintenance facility.		✓	
3.10	Rail safety accreditation	Responsibility for obtaining and maintaining rail safety accreditation required for the rollingstock, including movement of rollingstock within the maintenance facility during the maintenance phase.		✓	
3.11	Energy usage	Risk that the fleet consumes more energy than specified in the performance specification (resulting in potential additional energy costs)		✓	
4	**Financial / Performance**				
4.1	Tax and duties	Risk that actual tax or duties payable by the Tenderer differs from the base case financial model.		✓	
4.2	Foreign Exchange	GWRC will be responsible for changes in foreign exchange rates between the time of RFT response submission and the time of contract award. The Tenderer will be responsible for changes in foreign exchange rates after the time of contract award with respect to the base bid.			✓
4.3	Insurance	Responsibility for effecting insurances for the Project.		✓	
4.4	Performance regime	The Tenderer fails to meet the specified performance regime and bears the risk of being abated for failing to meet the required performance levels.		✓	
4.5	Inflation	The Tenderer’s costs (including labour costs) increase due to inflation at a faster rate than that provided for in the agreed indexation mechanism.			✓
4.6	Distance travelled	Risk that performance or maintenance requirements are adversely affected due to the distance travelled as required by GWRC being different from that initially estimated. The Tenderer will be compensated based on an agreed mechanism.			✓
5	**Industrial Relations**				
5.1	Industrial relations risk	GWRC takes the risk on industrial action within New Zealand that directly affects the Project and that results directly from an act or omission of government. All other industrial actions are the risk of the Tenderer.			✓
6	**Change**				
6.1	Project specific change in law	Risk of additional cost or delay resulting from changes in government policy or law which expressly and exclusively applies to the Project.	✓		
6.2	General change in law	Risk of a general change in law prior to the date of provisional acceptance of the first rollingstock unit that is not specifically related to the Project.		✓	
6.3	General change in law	Risk of a general change in law during after the date of provisional acceptance of the first unit that is not specifically related to the Project.			✓
6.4	Force majeure	Risk that force majeure events cause a delay to the delivery of the rollingstock or the ability of the Tenderer to perform maintenance services.			✓
6.5	Variations	The Tenderer will take the risk in any change in requirements of the Tenderer and/or changes required by the Tenderer leading to additional costs or delay. Where GWRC requires changes to the fleet, or the maintenance facility, simulators or to the services provided by the Tenderer, GWRC will be responsible for any increase in costs.			✓

7	**Termination**			
7.1	Early termination for convenience	Flexibility for GWRC to terminate all or part of Project for convenience subject to payment of unavoidable costs.		✓
7.2	Early termination for default	Termination for non-performance of Tenderer.	✓	
7.3	Early termination for force majeure	Termination by government due to force majeure.		✓

11.5.2.2 Commercial issues

Delivery model

- A single consortium will be engaged to manage the rollingstock design, manufacture and commissioning, as well as depot construction and rollingstock and depot maintenance.
- The design, manufacture and commissioning of the rollingstock would be paid for via milestone payments linked to key milestones such as preliminary, provisional and final acceptance of each unit, as well as a payment being made for the final acceptance of all units, once all units are in revenue service. A design, manufacture and commissioning review process will be adopted.
- The design, construction and commissioning of the depot would be paid for via milestone or progress payments (or a combination of the two). A design, construction and commissioning review process will be adopted. Completion of the depot will be linked to commencing maintenance of the units, as the units are brought into revenue service.
- During the maintenance term, the contractor would be paid an availability payment, linked to abatement under a performance regime (based around achievement of availability and reliability targets). The availability payment would nominally be based on kilometres travelled by each unit during the payment period.
- Acquisition of land required for the depot would be the responsibility of GWRC. Resource consents for the purpose of using the site as a depot, would be the responsibility of GWRC. All other consents would be the responsibility of the contractor. Responsibility for compliance with consents would be transferred to the contractor.

Asset ownership

- Greater Wellington's current rolling stock fleet and all Metro rail assets (including the Matangi EMU maintenance depot and all station buildings, except for Wellington Station) are owned by Greater Wellington Rail Limited (GWRL). GWRL is wholly owned by GWRC and is classified as a council-controlled organisation (CCO) and a council-controlled trading organisation (CCTO), as defined in section 6 of the Local Government Act 2002 (LGA). Section 27 of the Land Transport Management Act 2003 (LTMA) currently requires regional councils that are funded via the National Land Transport Fund to hold any interest in a public transport service or any public transport infrastructure in a CCTO, whether in conjunction with another local authority. As a result, section 27 prevents GWRC and Horizons Regional Council from directly owning the new trains, the new maintenance depot or any of the related infrastructure assets.
- Unless section 27 of the LTMA is amended, further development of the commercial delivery model after completion of the DBC is subject to an assessment of the following ownership options, which in turn may have an impact on how the funding is structured. The shortlisted potential ownership options identified are:
  - Option 1 (GWRL): GWRL owning the assets (with GWRC remaining the sole shareholder in GWRL)
  - Option 2: (GWRL JV): GWRL owning the assets (funded via GWRC and Horizons Regional Council) with Horizons Regional Council becoming a minority shareholder
  - Option 3 (New CCTO JV): A new CCTO being established to own the assets (funded via GWRC and Horizons Regional Council), with the shareholding held in proportion to the regional council funding provided
  - Option 4 (New inter-governmental JV): A new publicly owned company established to own the assets (controlled by the regional councils as to 50% or more of the shares so that it is a CCTO but including one of more of KiwiRail, Waka Kotahi or Ministry of Transport as shareholders)
- Following completion of the DBC, a multi-criteria assessment be conducted on the options above to determine the preferred asset ownership model.

Operations and maintenance

Background

- Passenger services on the Wairarapa line are provided by Transdev Wellington Ltd (TDW) under the performance-based Rail Partnering Contract signed on 10 March 2016. However, unlike services on the other metropolitan lines covered by the Rail Partnering Contract, the Wairarapa line services are powered using freight locomotives provided and operated by KiwiRail under a "hook and tow" arrangement. To the extent that KiwiRail fails to provide locomotive services or shunts in accordance with this arrangement, TDW is relieved from the application of the performance regime under the Partnering Contract, which is a sub-optimal outcome for passengers.
- The Manawatū Line is currently served by the Capital Connection, a weekday commuter train operated by KiwiRail using locomotive-hauled rolling stock. This is largely funded by NZTA Transitional Rail Funding with contributions from GWRC and Horizons Regional Council under arrangements which, unlike the Rail Partnering Contract with TDW, do not include any performance incentives for the operator to achieve passenger focused outcomes.
- As the two lines are currently run as separate operations, there is no ability to manage operations between the two lines, nor is there the ability to manage rolling stock fleet allocation and maintenance in an effective way. Accordingly, it is proposed to combine responsibility for operation of the two lines. The Rail Partnering Contract with TDW gives TDW the right to operate the metropolitan rail service, including the Wairarapa line, until March 2025. In addition, TDW has the right (if TDW achieves specified punctuality, reliability and performance outcomes in years 4 to 7 of the contract) to extend the Rail Partnering Contract for a further 6 years to March 2031.
- Terminating TDW's Rail Partnering Contract for convenience to allow for a transfer of responsibility for operation of the Wairarapa line to KiwiRail would be likely to significantly undermine the future contestability of New Zealand rail operations at a time when Auckland Transport has only recently announced the successful conclusion of its rail franchise procurement process, finally bringing a second private passenger rail operator (the ComfortDelGro Transit/UGL Rail joint venture) into the New Zealand market and thereby enhancing future contestability. Furthermore, the cost (including compensation to TDW for lost profit) of such a termination would be prohibitive and, accordingly, it is not considered to be a viable option.
- The alternative approach of negotiating a contract variation with TDW is to remove the Wairarapa line from its scope to allow for the transfer of responsibility for operation of the Wairarapa line to KiwiRail would also be expensive and result in inflexibility and operational inefficiencies between the Manawatū and Wairarapa operations on the one hand and the remaining metropolitan rail services on the other hand.
- Accordingly, the preferred approach is to combine operation of the Manawatū line with the operation of the remainder of the metropolitan rail network under the Rail Partnering Contract. This will enhance passenger benefits by maximising the ability of a single operator to manage rolling stock fleet allocation and maintenance effectively. It will also avoid any adverse impact on the future contestability of rail operations in the New Zealand market and the cost of any early termination for convenience. Furthermore, it will mean that the current provisions of the Rail Partnering Contract giving relief from the performance regime where KiwiRail fails to provide locomotive services or shunts in accordance with the "hook and tow" arrangement will cease to apply and all services across the network will be governed by a performance-based contract which will increase the incentivisation of passenger focused outcomes across the lower North Island. Further discussions are required with KiwiRail, and TDW, along with seeking ultimately approval from Waka Kotahi.
- Further work in the following key areas is required:
  - Work with Transdev and KiwiRail to establish an agreed transition from the current operational arrangements to the new operating arrangements
  - Work with KiwiRail to vary and /or terminate the locomotive and shunt 'hook and tow' agreement
  - Horizons Regional Council to enter into an agreement with GWRC for the management of the service between the GWRC boundary and Palmerston North (including GWRC expanding its current Rail PTOM Unit and Horizons establishing a new PTOM Rail Unit)
  - GWRC to vary its rail network access agreement to include the Manawatū line from Waikanae to Palmerston North

- GWRC and Horizons Regional Council to appropriately amend their Regional Public Transport Plans to recognise a Palmerston North-Wellington passenger rail service as 'integral to the public transport network' that each regional council proposes to provide in accordance with the LTMA and establish / expand the PTOM Units as noted above
    - confirm Waka Kotahi's share of ongoing funding is provided through the National Land Transport Fund in accordance with the LTMA for a public transport network that crosses regional boundaries
- Other considerations in relation to the above include the following:
    - The introduction into revenue service of the new rollingstock will occur progressively between Q2 2027 and Q4 2028. As such, there will be a transition period in the extended agreement between operating and maintaining the existing fleet, a decrease of the existing carriage fleet and ramp up of the new fleet, to full operation and maintenance of the new fleet.
    - Noting the expiry of the current TDW Rail Partnering Contract for operating and maintenance agreement in March 2025, negotiations in relation to the 6 year extension will need to commence nominally by mid-2024

11.5.3 Package 2 Station upgrades

11.5.3.1 Draft risk allocation table

	Type of Risk	Description	Draft Risk Allocation		
			GWRC	Private Sector	Shared
1	**Design and Construction Activities**				
1.1	Design risk	Risk that the design of the station upgrades does not meet contracted operational and technical specifications and requirements and are not otherwise fit for purpose.	✓ Construct only	✓ Design & Construct	
1.2	Appropriateness of the technical specification to meet GWRC requirements	Responsibility that the technical specification is appropriate and sufficient to meet GWRC's requirements.	✓		
1.3	Feasibility of and ability to meet the technical specification	Responsibility for the ability to meet the technical specification with respect to the design and construction of the station upgrades.	✓ Construct only	✓ Design & Construct	
1.4	Construction risk	Risk that construction of station upgrades cannot be completed on time and / or to budget.		✓	
1.5	Infrastructure information	Risk of specified information provided by GWRC regarding existing operations, existing rail infrastructure, station upgrades and existing rail fleet not being correct.	✓ Construct only	✓ Design & Construct	
1.6	Constructability risk	Risk that an in issue in the design documentation results in the construction not being technically feasible or constructible in a safe manner	✓ Construct only	✓ Design & Construct	
1.7	Infrastructure ownership and interface management	Platforms are owned by KiwiRail, but station buildings are owned by GWRL. The potential for interface issues / approvals arising from GWRL procuring station building upgrades and KiwiRail procuring platform upgrades will need to be addressed.			✓
2	**Financial / Performance**				
2.1	Tax and duties	Risk that actual tax or duties payable by the Tenderer differs from the contracted pricing.		✓	
2.2	Insurance	Responsibility for effecting insurances for the Project.		✓	
2.3	Inflation	The Tenderer's costs (including labour costs) increase due to inflation at a faster rate than that provided for in the agreed indexation mechanism.		✓	
3	**Industrial relations**				
3.1	Industrial relations risk	GWRC takes the risk on industrial action within New Zealand that directly affects the Project and that results directly from an act or omission of government. All other industrial actions are the risk of the Tenderer.			✓

4	**Change**				
4.1	Project specific change in law	Risk of additional cost or delay resulting from changes in government policy or law which expressly and exclusively applies to the Project.	✓		
4.2	General change in law	Risk of a general change in law prior to the date of practical completion of the station upgrade works.	✓ Construct only where the general change in law necessitates design change	✓ Design & Construct	
4.3	General change in law	Risk of a general change in law after the date of practical completion of the station upgrade works that is not specifically related to the works.			✓
4.4	Force majeure	Risk that force majeure events cause a delay to the delivery of the station upgrade works.			✓
4.5	Variations	The Tenderer will take the risk in any change in requirements of the Tenderer and/or changes required by the Tenderer leading to additional costs or delay. Where GWRC requires changes to the scope of the station upgrade works, GWRC will be responsible for any increase in costs.			✓
4.6					
5	**Termination**				
5.1	Early termination for convenience	Flexibility for GWRC to terminate all or part of the contract for convenience, subject to payment of unavoidable costs.			✓
5.2	Early termination for default	Termination for non-performance of Tenderer.		✓	
5.3	Early termination for force majeure	Termination by government due to force majeure.			✓

11.5.3.2 Commercial issues

- A Managing Contractor will be engaged to then engage sub-contractors to deliver the works. GWRC and the Managing Contractor would negotiate a fixed lump sum management fee. Depending on the model to be adopted, the Managing Contractor may also receive incentive payments and a 'pain share' for achieving or failing to achieve cost and schedule targets. It is intended to further assess the above following completion of the DBC.
- Once further clarity is ascertained around the scope of works required at each station, and a preferred sub-contracting model then determined, the level of design developed by GWRC (or a design consultant engaged through the Managing Contractor) prior to the procurement of each subcontract can be determined.
- At this stage, and subject to the scoping of the station upgrade works, it assumed that the subcontracts may result in a range of contracting models, including Contract Only, D&C, Supply Only etc.).
- All subcontractors will be required to be rail accredited.
- Platforms are owned by KiwiRail, but station buildings are owned by GWRL. The potential for interface issues / approvals arising from GWRL procuring station building upgrades and KiwiRail procuring platform upgrades will need to be addressed. One option for addressing this would be to include the management of the platform scope in the respective subcontracts and require the Managing Contractor to appoint KiwiRail as a nominated subcontractor, under the respective subcontracts.
- GWRC will retain the risk of ensuring the station upgrades are completed to suit the introduction of the new fleet in Package 1.

12 CHAPTER 12 – MANAGEMENT CONSIDERATIONS

CHAPTER SUMMARY AND CONCLUSIONS:

- A governance structure for the delivery of the LNIRIM Project has been developed from an analysis of institutional capabilities and recommends modifying the existing LNIRIM Phase 1 Governance Group and establishing appropriate Governance Working Groups to lead the implementation of discrete packages of work and initiatives.
- The Project Governance Group will be led by GWRC. GWRC will have overarching responsibility for all activities of the three packages. GWRC, as rolling stock and service owner, will lead the delivery of Package 1 and 2 with its own teams and instruct KiwiRail, as network owner, to deliver Package 3 with its specialist teams, under the leadership of the Governance Group Steering Group.
- The preliminary implementation schedule includes commencing the procurement of Rolling Stock expression of interest (EOI) stage in Q3 2022 and the request for tender (RFT) stage in Q1 2023. The timing of certain activities will be refined in a detailed procurement strategy during the market readiness phase preceding the procurement phase. This will allow opportunities to accelerate the programme if it can advantageously mitigate the risks related to delayed service start.
- Achieving the timing of activities and milestones proposed by the current schedule will be critical to the delivery of the benefits sought by the proposed investment. It will be essential to secure agreement with all levels of government regarding funding. The procurement phase should not commence unless this occurs to provide certainty of process and funding to the market.
- The current LNIRIM Governance Group will have to oversee the completion of significant tasks during the market readiness phase. These will include:
  - validating of the preferred ownership and operation models
  - validating the implementation plan
  - securing funding commitments
  - securing land lease agreements with relevant stakeholders
  - confirming financial models with all stakeholders
  - developing a detailed procurement and packaging plan (including technical specifications and further consideration of interface risks)
  - initiating value engineering processes.
- A preliminary benefits management plan has been developed in accordance with Waka Kotahi's Benefits Management Framework, including Indicative key performance indicators. This plan articulates the key steps in defining, planning, and reviewing project benefits throughout the project development lifecycle. This will be further developed during the procurement, delivery, and operation phases, with a focus on implementing opportunities to enhance the level of benefit derived from the project.
- GWRC will require appropriate resources to implement the LNIRIM Project. Initial budgets and resource requirements have been developed across each of the three packages. This initial budget will be subject to review and refinement as the LNIRIM Project progresses. However, for this business case, the current budget is considered to be appropriate and sufficient (within the bounds of reasonableness) for the tasks and activities identified for the implementation plan.

12.1 Purpose and overview of chapter

The purpose of this chapter is to outline the implementation plan for the LNIRIM Project. This chapter is based on information currently available, as well as the body of knowledge developed during this and previous business cases. This chapter outlines the:

- proposed governance framework for the implementation of the LNIRIM Project
- key activities and milestones for the LNIRIM Project across the various phases of the implementation schedule
- key activities of the 'readiness for market' phase that will help enable the procurement phase to commence by the targeted date
- key activities for the procurement phase (Phase 2), together with the proposed approach to procurement of each of the works packages
- key activities to be undertaken during the delivery phase (Phase 3)
- key activities to be undertaken during the benefit realisation period, including a proposed benefits management plan to ensure the expected benefits from the LNIRIM Project are realised
- budget and resourcing requirements to implement the LNIRIM Project across each of the three phases
- key operational readiness activities to be undertaken.

12.2 Management strategy and framework

The management strategy and framework details how the preferred solution can be delivered to maximise the benefits sought from the investment. It provides the level of detail required at a DBC stage on the project planning, governance structure, risk management, communications and stakeholder management, benefits realisation, and assurance.

The primary objective of the management strategy is to provide a clear and agreed understanding of what needs to be done, why, when, and how, with measures in place to identify and manage any risks. It sets out a framework under which various plans will be detailed in the upcoming phases of the project.

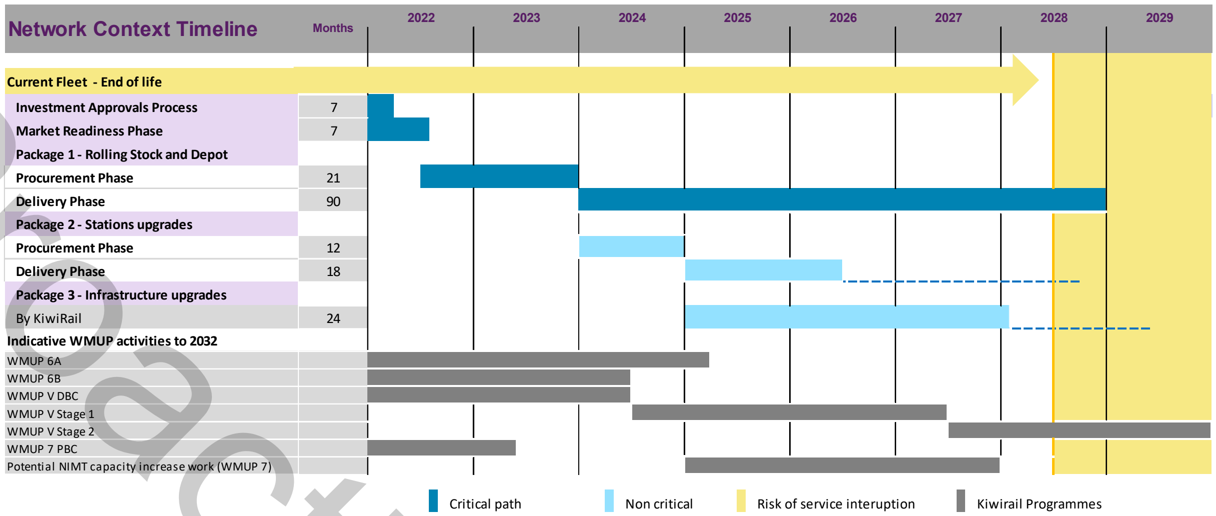
12.2.1 Delivery context and relationship with other programmes

The key strategic threat to the delivery of the benefits sought by investing in the preferred solution is that regional rail services reduce or stop because the new fleet cannot achieve its expected role before the existing fleet must be retired. The causes and consequences of this risk are detailed in previous parts of the this DBC. In summary, to avoid the consequences of delay, the LNIRIM project must:

- procure new rolling stock in time
- build a maintenance depot and stabling facilities in time to host the new fleet
- ensure regional station infrastructure is upgraded it time to support the new service
- ensure the rail network capacity required is achieved in time to allow all new timetables to be implemented.

Consequently, the key roles and responsibilities underpinning the governance model required for the successful delivery of LNIRIM must be understood within the context of other key programmes and projects. The timeliness of a number of Wellington Metro Upgrade Programmes (WMUP) included in the Rail Network Investment Programme (RNIP) and delivered by KiwiRail points to a strong need for a close collaboration between GWRC, Horizons and KiwiRail in the delivery of LNIRIM.

Figure 12-1 LNIRIM activities and WMUP activities to 2032



12.2.2 Short- and long-term benefit delivery

GWRC and HRC, as the primary benefit owners for the Wellington metro, the Capital Connection, and the Wairarapa service, are accountable to the public for the operational outcomes and benefits of the regional public transport system.

Key benefits from the LNIRIM investment will be delivered through more than three decades of service. The governance structure set up for the implementation of the project will have key responsibilities in the design of the assets and their consequences on the long-term realisation of benefits. To maximise these benefits, it must achieve:

- The design and delivery of rolling stock, stations upgrades and service levels that meets the current and future requirements of the sought patrons and the wider community.
- The sustainable management of assets (including a strong customer focused brand) and services that will foster new patronage shifting from road transport.

Accordingly, the current institutional capability of potential participants in the Governance Group is relevant to the responsibility they are best placed to hold for the whole of life success of LNIRIM, as summarised in Table 12-1. Considering the magnitude of the investment and its potential for establishing a National Regional Rail platform, a national perspective is also useful to identify if institutional knowledge from other jurisdictions can inform LNIRIM.

Table 12-1 Capability alignment to project scope

Capability	GWRC	KiwiRail	Other or New entity
Experience in design and delivery of new passenger rolling stock.	Yes, recent, through the Matangi programme	Limited to design of refurbishment projects, and design reviews and acceptance of Matangi programme and AT Metro EMUs.	Strong, through the current custodianship of the AT Metro fleet.
Experience in design and delivery of station upgrades for regional passenger rail.	Extensive, through the current custodianship of the Wellington Metro and Wairarapa regional lines.	Limited to low patronage stations through Capital Connection and Great Journeys	Strong, through the AT Metro network and the H2A corridor stations.
Experience in the design and delivery of rail network improvement	Limited, through KiwiRail	Extensive, through the current RNIP / WMUP programmes of work.	Limited, through KiwiRail

Capability	GWRC	KiwiRail	Other or New entity
Experience in the compliance management of rolling stock and station assets	Strong, through the current custodianship of the Wellington Metro and Wairarapa regional lines.	Extensive, through the RSS (Rail Safety System) process and current custodianship of the Capital Connection and other services in New Zealand.	Strong, through the current custodianship of the AT Metro fleet.
Experience in delivery of Regional Passenger Rail Service in the region	Extensive, through the current Wairarapa regional lines.	Limited to low service level through Capital Connection and involvement in the H2A Te Huia service.	Limited, through the H2A Te Huia service.
Experience in managing a mobility brand	Strong, through Metlink	Limited to low patronage, infrequent services.	Strong, through Auckland Transport management of the AT Metro brand.
Experience in public transport decarbonisation programmes.	Growing, through the Metlink public Transport's initiatives.	Limited so far.	Growing, through the Auckland Transports initiatives.

Accordingly, and in alignment with the delivery options detailed in Chapter 10 and the Commercial Considerations documented in Chapter 11:

- GWRC is advantageously positioned to deliver the LNIRIM investment proposed in this DBC, as project sponsor and by leading its Governance Group steering committee.
- GWRC is advantageously positioned to deliver the packages of work related to the rolling stock and station upgrades.
- KiwiRail is ideally positioned, as owner and custodian of the rail network, to be a member of the Governance Group and to deliver the package of works related to required network improvement and stabling facilities.
- GWRC is ideally positioned to prepare for the delivery of the extended regional service enabled by the investment and manage the fleet and the service as owner and custodian for the foreseeable future.

12.3 Governance framework

As the LNIRIM Phase 1 Governance Group included the members required for future phases, the governance framework preferred for the successful delivery of LNIRIM is very similar to the Governance Group currently in place for the delivery of this DBC. This advantageous situation will allow a seamless transition to a new management structure. The proposed key changes to the existing Governance Group, represented in figure 12-2 below, are:

- KiwiRail, through a new representative of its network owner capacity, will become a decision-making member of the Governance Group.
- KiwiRail, through the current representative of its operator capacity, and as current operator of the Manawatū line, will remain advisors only, and will be managed to avoid any future conflict of interests as to future operation contracts.
- Transdev, as current operators of the Wairarapa service, will remain advisors only, and will also be managed to avoid any future conflict of interests as to future operation contracts.
- The Ministry of Transport could become a decision-making member or remain an advisor, depending on funding model decisions to be taken after this DBC is approved.

The Governance Framework, and therefore the members of the Governance Group, in their leadership of the project, will:

- maximise the effectiveness of the Governance Group by fostering and maintaining a strong strategic collaborative approach between GWRC and KiwiRail.
- maximise the input from parties with the most institutional knowledge in the subject matter.

- seek and integrate insights and institutional knowledge from other participants in the project and outsiders with relevant institutional knowledge.
- share Rail Transport Decarbonisation knowledge gained by LNIRIM to benefit other communities.

12.3.1 Key responsibilities

Key responsibilities within the Governance Group Steering Committee will be:

- GWRC as the overall project owner is accountable for the project's overall delivery.
- Final decisions on committing funds and accepting risk to all three Packages will be taken by GWRC, as Project Sponsor, in accordance with funding and management requirements prescribed by funding authorities, its internal investment framework, and statutory requirements.
- Horizons Regional Council, Waka Kotahi, KiwiRail (through the representative of its network owner capacity) and potentially The Ministry of Transport, as members, will participate in the decision-making process in the steering group.
- Transdev, and KiwiRail through the representative of its operator capacity, as operators of the current regional services, will be part of governance conversations as advisors only. They will not be part of the decision-making group and may be excluded of commercially sensitive conversations related to operation contracts that may create potential perceived conflicts of interests.

The current members of the Phase 1 Governance Group Steering Group have the relevant skills and experience to carry out these key responsibilities.

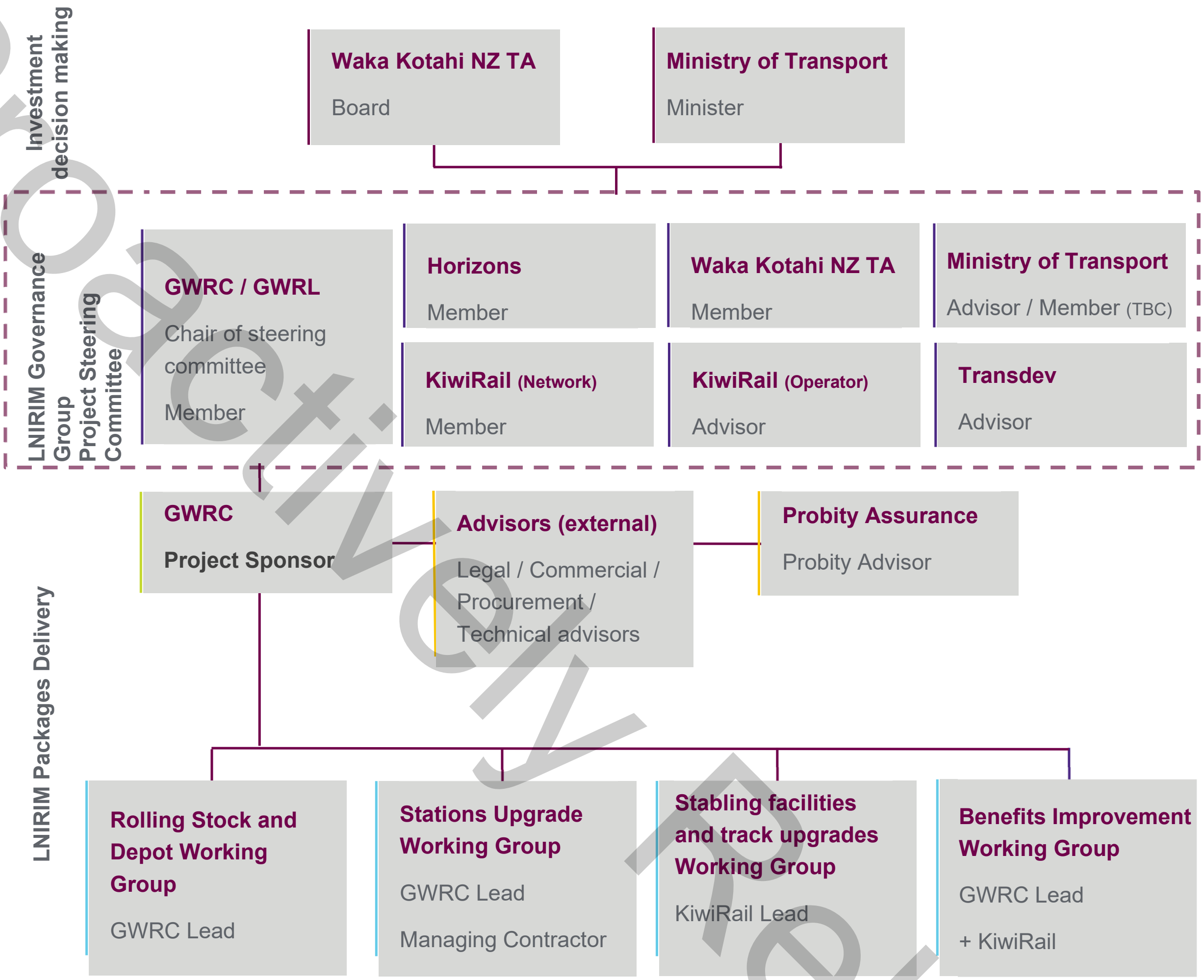
12.3.2 Governance Working Groups

In addition to its steering committee, the governance group will establish appropriate Governance Working Groups to lead the implementation of discrete packages of work and initiatives with appropriate focus and resources.

Subject to confirmation of the approach to packaging and delivery proposed in this DBC, four working group will be created to manage discrete parts of the scope of work and progress required opportunities to improve the benefits sought by the proposed investment:

- The Rollingstock and Depot Working Group, to deliver Package 1 under a DBM (Design Build & Maintain) +[O] contract. This group will be led by GWRC and include KiwiRail in its capacity of rolling stock specification and standards authority. As lead of this working group, GWRC will own and manage the interface risks for Package 1 and 2 with KiwiRail's delivery of Package 3.
- The Station Upgrades Working Group, to deliver Package 2 via a Managing Contractor arrangement. This group will be led by GWRC and include KiwiRail in its capacity of owner of station assets (below platform). It may be delivered through existing GWRC public transport facilities delivery teams if deemed advantageous to the LNIRIM project by the steering group.
- The Stabling facilities and track upgrades Working Group, to deliver Package 3. This group will be led by KiwiRail, as owner of the network, and include GWRC as future owner and operator of the fleet. It will lead the identification and design of all stabling facilities and manage the realisation of the network capacity improvements required by LNIRIM through the wider KiwiRail programme.
- The Benefits Improvement Working Group will be created to manage the interface between the LNIRIM project and other Stakeholders to identify and deliver initiatives that can enhance the benefits delivered by the investment. It will be led by GWRC, and will engage and coordinate the other Working Groups, as required to carry out task including but not limited to:
  - assessment and scoping of potential opportunities of scales through the design of a National Platform for Regional Passenger Rail services. This will inform the RFT and allow options for the supply of additional units to be integrated in the scope of Package 1
  - investigation of supply chains and technologies to identify further opportunities related to energy economy, storage, and generation, like batteries, biofuels, energy management systems.

Figure 12-2 Governance structure for LNIRIM phase 2 and 3



12.4 Management structure

The management structure, outlined in figure 12-3, will be confirmed in line with the differing contract arrangements sought for each of the packages. It will include project teams with skills and resources commensurate to the scope of the package.

At a high level, the management structure proposed below will see Package 3 delivered by the KiwiRail organisation, as part of other Network Capacity Improvement programmes. By its membership to the LNIRIM Governance group, KiwiRail will have a duty to manage Package 3 to the best advantage of LNIRIM. Reporting will be done through the Stabling facilities and track upgrades Working Group.

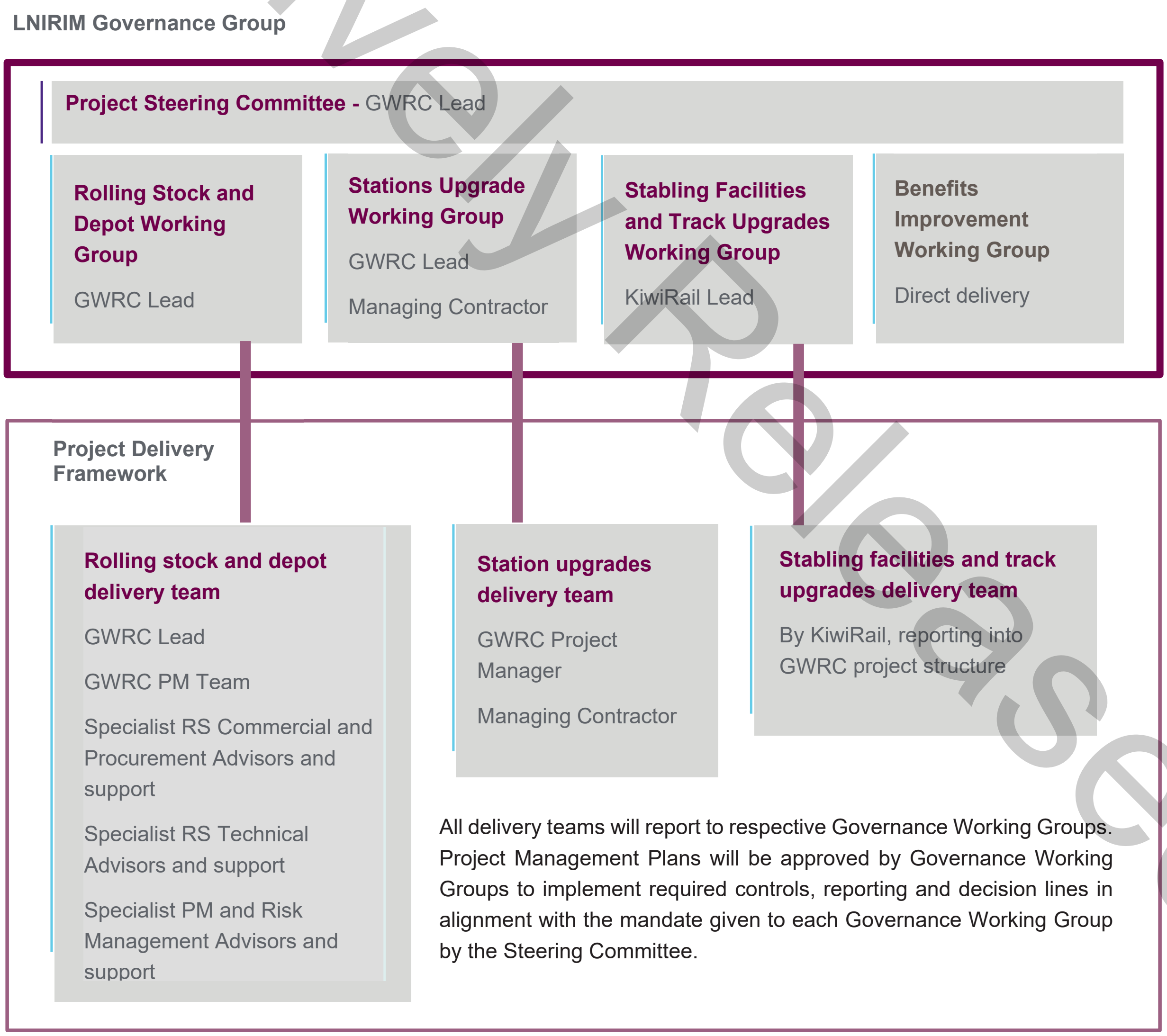
Packages 1 and 2 will be delivered within the GWRC organisation.

Package 1 will require a bespoke team delivery structure to be put in place with appropriate external advisors and suppliers.

Package 2, proposed to use a Managing Contractor model, will require less bespoke resources, and may be delivered by existing GWRC teams already dedicated to station assets renewal and upgrade works.

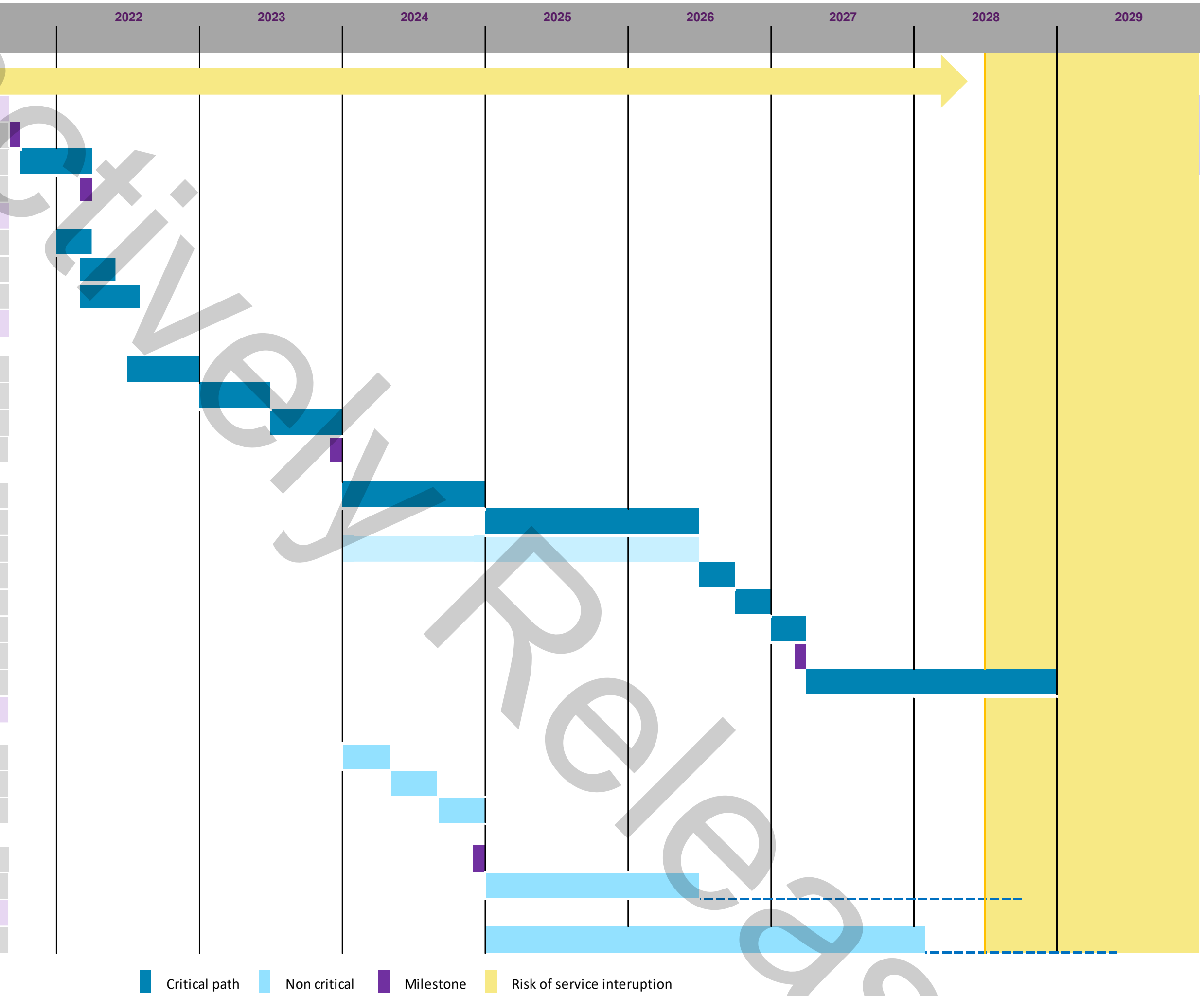
Package 3, will be delivered by existing KiwiRail teams dedicated to network development, renewal and upgrade works, instructed by GWRC through the Stabling Facilities and Track Upgrades Working Group of the Governance Group.

Figure 12-3 Management structure for LNIRIM phase 2 and 3



12.5 Indicative Delivery Programme

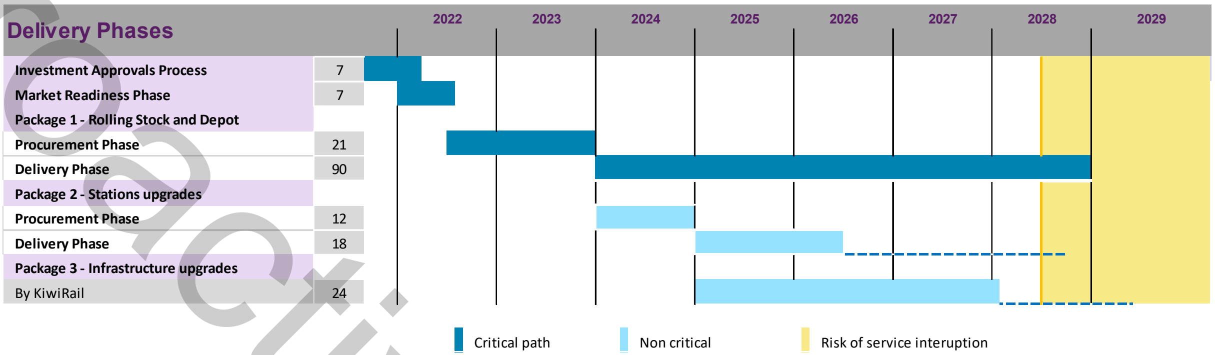
Indicative Delivery Programme	Months
Current Fleet - End of life	
Approvals Process	
DBC submission	M
Investment approval	6
Funding commitment	M
Market Readiness Phase	
Governance transition	3
Strategy and Models validation	3
Project esatablishment	5
Package 1 - Rolling Stock and Depot	
Procurement Phase	
Mobilise procurement team, prepare and issue EOI	6
EOI in the market and select shortlist	6
Issue RFP and appoint preferred tenderer	9
Supply agreement	M
Delivery Phase	
Design of the rollingstock	12
Manufacture of the rollingstock (first unit)	18
Design and Delivery of Maintenance depot	30
Testing at manufacturing facility	3
Shipping time	3
Commissioning and testing in NZ	3
First Unit in revenue service	M
All Units produced commissioned and accepted	21
Package 2 - Stations upgrades	
Procurement Phase	
EOI	4
RFP	4
Evaluation, negotiation & documentation for Award	4
Delivery Phase	
Managing Contractor agreement	M
Design and Delivery of upgrades	18
Package 3 - Infrastructure upgrades	
By KiwiRail	24



12.6 Readiness for market’ phase

The ‘readiness for market’ phase is a transitional phase that spans from the formal submission of this DBC to funding authorities to the formal start of the Procurement Phase for Packages. Accordingly, the readiness for market phase spans the first half of 2022 and precedes the start of the three packages of work, as represented in figure 12-4 below.

Figure 12-4 Key phases of delivery



Key decisions required from the Governance Group and the wider delivery team during the readiness to market phase include but are not limited to:

- Terms of Reference of Phase 2 Governance Group.
- Terms of Reference, including mandate and delegations to working groups.
- Timeframe and budgets allocation of each package, including clear allocation of contingencies and funding risk contingencies.
- Detailed funding, financial and ownership models for delivery and operation phases.
- Detailed procurement strategy for Package 1, including:
  - potential for further market sounding,
  - potential acceleration of the RFT process to mitigate the gap between old fleet retiring and new fleets end of life,
  - use of potential options for additional units on a National Platform concept to leverage better terms.
- Commercial model for Rolling Stock DBM+O contracts.
- Stakeholder engagement and communication plan.
- Approach to Otaki and Levin stations upgrades, including Tangata Whenua engagement, Te Arawhiti engagement, and potentially Ministerial and cabinet intervention.
- Maintenance and stabling depot location, including land lease agreements between KiwiRail and GWRC, acceptance of site risks and costs.
- Network capacity improvements proposed by KiwiRail to enable reliable increased passenger rail services on both lines before the new fleet is in service, including the management of competing needs with freight services to minimise the need for new assets to be built.

Additional tasks will be started as identified by the Governance and Newly formed Working Groups beyond the list above. Notably, any conditions attached to the funding and financial management processes prescribed by funding authorities may require implementation in this phase.

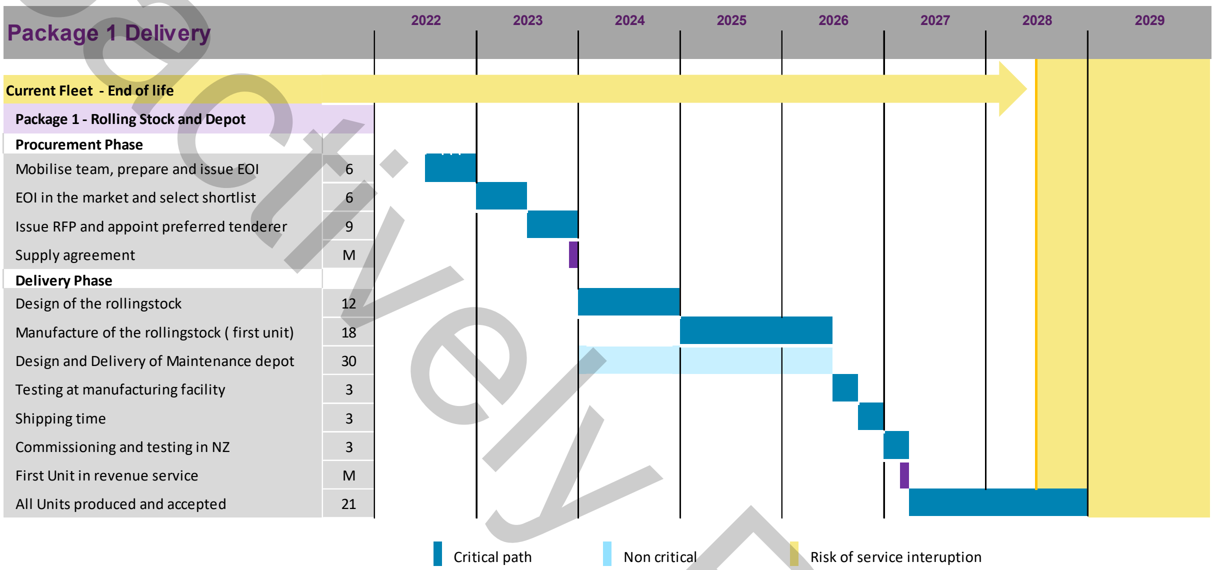
12.7 Delivery of Rolling stock and depot (Package 1)

Package 1 is described in detail in Chapter 10 and includes Rolling Stock and Depot facilities. It is to be delivered by a DBM+O model and will require significant procurement process to be managed.

12.7.1 Timeline

Package 1 represents the critical path in the delivery of LNIRIM. Accordingly, and as shown on figure 12-5 below, any delivery time improvement to package 1 will positively impact the project by minimising the gap between the end of life of the current fleet and the new fleet's entry in service. It will also be accelerating the delivery of benefits derived from the increased service enable by the new fleet.

Figure 12-5 Package 1 Key activities and timeline.



12.7.2 Strategic objectives

Beyond project management activities expected for the delivery of this package, the Rolling Stock and Depot Governance Working Group and the delivery team will strategically focus on:

- delivering a fleet that is fit for purpose,
- accelerating delivery to reduce the potential service gap and increase early benefits realisation,
- minimise the cost of Rolling Stock by leveraging on the potential for a larger order, and
- minimise the whole of life cost by optimising the design of the rolling stock and depot.

In particular, the Rolling Stock and Depot Governance Working Group will implement the accelerated procurement process aimed at closing the potential 6-month gap between the retirement of the existing fleet and the commencement of operations for the full new fleet. Activities, planned in the market readiness phase, will potentially include:

- an early mobilisation of the procurement team, saving up to 2 months on the critical path,
- a shorter EOI process capitalising on the market sounding conducted in 2021, saving up to 3 months on the critical path,
- a subsequent RFT process reduced to 6 months, saving another 3 months on the critical path.
- a potential staged introduction of the new fleet from early 2027.

Table 12-2 Key activities mitigating Rolling Stock end of life risk

Activity		Indicative timeline	Potential improvement
Procurement	EOI to market	Dec 2022	Oct 2022
	Shortlist of suppliers	Jun 2023	Feb 2023
	Supply DBM agreement	Mar 2024	Sep 2023
Delivery	57 Months		
	All units accepted	Dec 2028	Jun 2028

Further to the accelerated procurement process discussed above, the Rolling Stock and Depot Governance Working Group will be exploring the possibility to further close the potential gap of services between old and new fleet by developing a detailed plan for the introduction of the new fleet to service.

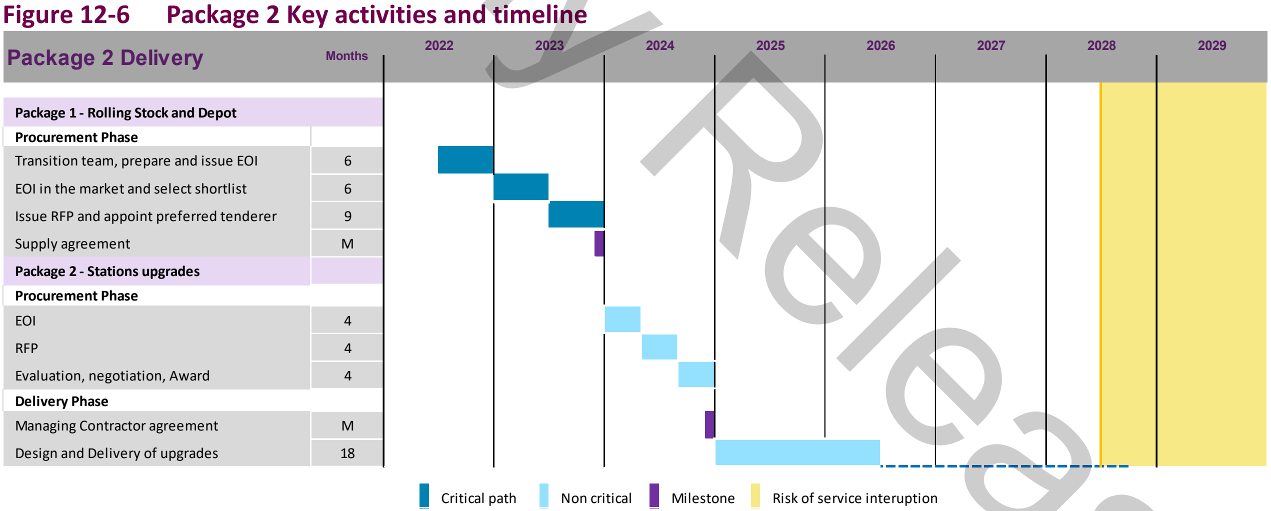
12.8 Delivery of Stations Upgrade (Package 2)

Package 2 is described in chapter 10 and includes station upgrades. Refinement of the delivery model assessment will be required once the scope and key risks associated with that package are better understood. Package 2 will be delivered by using a Managing Contractor model.

12.8.1 Timeline

Package 2 is not on the critical path to the overall delivery of LNIRIM. The estimated duration of the planning, investigations, design and delivery of the station upgrades will fit comfortably within the envelope of Package 1. As an indicative timeline, Figure 12-6 shows a potential advantageous start of the Package 2 procurement activities in January 2024, that follows on the end of the Package 1 procurement activities. This may allow the rationalisation of resources and will be considered in the procurement strategy to be completed during the 'readiness to market' phase.

Figure 12-6 Package 2 Key activities and timeline



A stand-alone programme of work, requiring liaison and agreement with KiwiRail regarding the KiwiRail owned station assets will be undertaken. Similarly, GWRC may elect to deliver these station upgrades along other planned upgrades to leverage on its current facility delivery team.

12.8.2 Strategic objectives

Beyond project management activities expected for the delivery of this package, the Station Upgrades Governance Working Group and the delivery team will strategically focus on:

- delivering upgrades that make stations fit for purpose,
- optimise delivery to reduce impact on existing services,
- minimise the cost of upgrades by leveraging on other stations upgrade work, and
- minimise the whole of life cost by optimising the design of the stations.
- improve customer experience by creating a 'national' standard for regional stations by extending the metro 'standard' into the regional stations.

12.9 Delivery of Stabling and Network Upgrade (Package 3)

Package 3 will be delivered by KiwiRail as part of other network activities. While it is advantageous to deliver Stabling facilities and Network upgrade through KiwiRail, GWRC will own and manage the interface risks between Package 1, 2 and 3.

12.9.1 Timeline

Package 3 is not on the critical path to the overall delivery of LNIRIM. The estimated duration of the planning, investigations, design, and delivery of the stabling facilities required will fit comfortably within the envelope of Package 1. The delivery of the network improvements of the Manawatu line can also comfortably fit within the envelope of Package 1. As indicated in the Indicative Delivery Programme above, a delivery of Package 3 starting in 2025 allows three years for the appropriate assets to be delivered.

12.9.2 Strategic objectives

Beyond project management activities expected for the delivery of this package, the Stabling and Network Upgrade Working Group and the delivery team will strategically focus on:

- identify locations and design stabling facilities that contribute to the efficiency of the fleet.
- deliver stabling facilities that accommodate the needs of the new fleet in time for its reception.
- optimise delivery to reduce impact on existing services.
- minimise the cost of upgrades by leveraging on other stabling and track upgrade work.
- deliver upgrades that contribute to make rail infrastructure fit for purpose and resilient.

12.10 Delivery of Benefits

The development of a benefits management plan is an important step in articulating, monitoring and realising the benefits of the LNIRIM Project during delivery and operation.

The benefits management plan, being developed at the business case stage, is built on the anticipated project benefits. The plan therefore is designed assist the project owner in tracking and delivering on these benefits throughout construction and operation.

12.10.1 Strategic objectives

The draft benefits management plan has been developed in accordance with Waka Kotahi's Benefits Management Framework. Its prescribed approach was used as part of the LNIRIM Business Case to further identify, define, and confirm the potential benefits of the proposed investment.

The benefits management plan will be further developed during the establishment of Phase 2 and will allow Waka Kotahi, GWRC and the other members of the Project Governance Group to implement a continuous monitoring of benefit realisation against key decisions, to ensure a complete understanding of their impact on the benefits sought.

The governance Group will lead its Working Groups and delivery teams to focus efforts on implementing opportunities to maximise benefits beyond those quantified for the justification of the investment. In particular to:

- Deliver the new fleet to service earlier to:
  - minimise the potential disbenefits, cost and reverse mode shift, associated with the potential gap in service after the end of life of the existing fleet.
  - Improve, operational cashflow and carbon emissions by retiring the expensive existing fleet earlier.
- Deliver a rolling stock design that:
  - maximises the opportunities to fully decarbonise its operation earlier.
  - enable the delivery of wider passenger rail requirements by providing New Zealand with a template for decarbonised regional passenger rail framework.
- Deliver a coordinated approach to network capacity improvement to minimise the need for built assets by optimising the coordination between passenger and freight service, thus saving capital, and reducing construction carbon emissions.

12.10.2 Benefit Realisation Plan

Benefits were defined in Chapter 3 – Need For Investment, from the analysis of problems and investment objectives. Benefits, Investment Objectives and Problems therefore align to provide a clear understanding of the way in which value is delivered from the investment. The benefit measures described in Table 12-3, are proposed as an indicative list sufficient to manage the likely measurable benefits derived by the project. These do not cover all the benefits delivered, as other non-measurable benefits exist.

As detailed in section 12-3 and 12-4 above, GWRC will be responsible for the ultimate realisation of the benefits. The tracking, monitoring, reporting, and optimisation of benefit delivery will be central to the Project Management Plan to be produced by the Working Groups for each of the three Packages and endorsed by the Governance Group Steering Committee.

Table 12-3 is therefore to be understood as conservative starting summary of the total potential benefit delivered by LNIRIM. The Governance Group will be further developing it during the establishment of Phase 2, as the start of an ongoing benefit realisation process.

Table 12-3 Summary of the likely quantifiable benefits provided by the LNIRIM Project[155]

#	Problem	Investment Objectives	Benefits sought	Outcomes sought	Measures	Current baseline	Target	Responsibility	When measured and reported	Where reported	Target date
1	The current fleets are approaching the end of useful life and do not align with modern standards	• Improve connectivity and access to opportunities	• Reduced service vulnerability due to unplanned maintenance • Access to economic centres	Inclusive access and improved mobility to unlock associated economic benefits	• service availability (ensuring timetabled passenger services are completed)	99.4%	99.5%	Metlink Operator	Monthly	Monthly Operational Report	2029
					• network reliability (public performance measure) • Overall Customer satisfaction score	To be confirmed	>96%	Metlink Strategy and Customer	Annual	Customer satisfaction report	2030
					• frequency of services (availability of travel options) • Customer satisfaction survey: satisfaction level with how ofter service runs	45% (Nov 2020)	75%	Metlink Strategy and Customer	Annual	Customer satisfaction report	2030
					• Percentage of passengers who are satisfied with the condition of the vehicle fleet	94%	>96%	Metlink Assets and Infrastructure	Annual	Customer satisfaction report	2030
					• Delay time caused by vehicle defects	55 mins (3MMA Indirect)	<10mins Improving trend	Metlink Assets and Infrastructure	Monthly	Monthly Vehicle Service Report	2029
					• availability of a viable alternative to high-risk and high-impact route	To be confirmed	To be confirmed	To be confirmed	Annual	To be confirmed	To be confirmed
2	The existing regional rail services are unattractive to commuters	• Improve corridor capacity • Improve public transport attractiveness	• Increased connectivity between centres, across towns and associated urban planning benefits • Improved commuter safety • Improved amenity benefits	Increased transport network resilience, safety and reliability	• impact on user experience of the transport system • Passenger satisfaction with convenience of paying for Metlink public transport		>90%	Metlink Strategy and Customer	Annual	Customer satisfaction report	2030
					• impact on user experience of the transport system • Passenger satisfaction with Metlink public transport being on time	<80%	>90%	Metlink Strategy and Customer	Annual	Customer satisfaction report	2030
					• Delays caused by Network • Level of Temporary Speed Restrictions	>5min delay	To be confirmed	Metlink Assets and Infrastructure	Monthly	Monthly Network Performance Report	2026
					• impact on user experience of the transport system • number of public transport boardings	To be confirmed	To be confirmed	Metlink Operations	Monthly	Monthly Operations Report	2028
					• collective risk (average annual fatal and serious injury crashes per kilometre of parallel roads) • number of deaths and serious injuries on roads	New measure	5% reduction YoY	Metlink Operations	Annual	Metlink annual Report	2030
					• travel time reliability – motor vehicles[156] (travel time savings)	New measure	To be confirmed	Metlink Strategy and Customer	Annual	Metlink Annual report	2028
					• Amenities – Customer satisfaction • on board noise • on board temperature • cleanliness and condition	New measure		Metlink Strategy and Customer	Annual	Customer Satisfaction Report	2028
					• station condition, furniture, cleanliness and graffiti • Customer satisfaction	To be confirmed	To be confirmed	Metlink Assets and Infrastructure	Annual	Customer Satisfaction Report	2028
3	The current regional passenger services do not contribute to achieving the government's objectives on decarbonisation	• Reduce carbon emissions	• Increased public transport patronage • Reduced carbon emissions from mode shift to rail • Reduced carbon emissions of current fleets	Impact on mode choice and enable associated decongestion of the road network	• mode shift from private vehicles • 40 percent increase in regional mode share for public transport and active modes by 2030	New measure	40% increase in mode share	Metlink Strategy and Customer	Annual	Metlink Annual report	2030
					• Annual Public Transport boardings per capita	63 per capita	88 per capita	Metlink Strategy and Customer	Annual		2030
					• increased public transport patronage • YoY Patronage growth by line (WRL, PNL)	New measure	To be confirmed	Metlink Operations	Monthly	Monthly Operations Report	2028
					• CO_2 emissions from fleet (tonnes) • Gross emissions for Metlink's public transport fleet will be minimised, reducing the offsets required to reach net carbon neutrality	22kT (total Metlink fleet)	5.5kT (total Metlink fleet)	Metlink Assets and Infrastructure	Annual	GWRC Carbon footprint report	2030

[155] The measures have been directly sourced from technical work undertaken for the DBC and will be reviewed and updated as the project progresses through subsequent phases.

[156] Coefficient of variation; standard deviation of travel time divided by average minutes travel time (as per Austroads)

4	The existing regional train operations are inflexible and inefficient	• Increase value for money • Increase reliability	• Reduced operating risk • Reduced whole-of-life costs (opex and capex) • Improved punctuality • Improved interface with increasing freight	Optimised operations and costs	• service reliability (ensuring on-time performance of services)[157] - Punctuality	64.3%	95%	Metlink Operator	Monthly	Monthly Operations Report	2030
					• cost per passenger-km	$0.27/km	TBD	Metlink Operations	Annual	Metlink Annual Report	2028
					• Cost recovery (revenue/cost)	42%	TBD	Metlink Operations	Annual	Metlink Annual Report	2028
					• Vehicle availability (vehicle is available for service)	99%	100%	Metlink Assets and Infrastructure	Monthly	Monthly Vehicle Services Report	2028
					• Vehicle reliability (potential for a failure of the rolling stock element) Mean Distance Between Failures (MDBF) • *NB: LHCS inherent reliability due to simplicity	250,000km*	>80,000km	Metlink Assets and Infrastructure	Monthly	Monthly Vehicle Services Report	2029

[157] Percentage of scheduled service trips between 59 seconds before and 4 minutes 59 seconds after the scheduled departure time of selected point

12.11 Resources and Budget

GWRC will assemble a suitably experienced and skilled team to deliver the package and bring into service suitable rolling stock and depot in line with the DBC recommendations.

Given the size and complexity of package 1 and the significant complexity associated with procuring multiple packages largely in parallel, it will be critical for the GWRC delivery team to have sufficient resources and decision-making autonomy to progress activities and ensure that the procurement phase timeline and target dates for improvement are achieved.

An initial, high-level budget, outlined in Table 12-4, has been developed having regard to the key activities to be undertaken during the delivery of LNIRIM. It indicates a total of [redacted] (excluding contingencies) allocated in the Preferred Solution estimate to cover the costs of in-house and external professional services related to the management of the project. This amount represents 5% of the base implementation estimate and aligns with expected costs for projects of this nature, noting that the commercial details of the DBM+O model proposed for the delivery of Package 1 can impact significantly the share of management tasks laying with the client organisations.

Table 12-4 Management and Professional Services Costs summary

Budget estimate (excl Contingencies)	$ Million (real)
Package 1 and 2	
Pre implementation inc. procurement	[redacted]
Package 1	
Implementation (post procurement) – Rolling stock and Depot	[redacted]
Package 2	
Implementation (post procurement) – Stations upgrades	[redacted]
Package 3	
Implementation (post procurement) – Stabling facilities (x3)	[redacted]
Implementation (post procurement) - Passing loops (allowance)	[redacted]
Total	[redacted]

12.12 Management systems

During the implementation phase, GWRC will adopt an approach that is responsive to the unique requirements and risks associated with the delivery methods chosen for each package. Both the DBM+O and the Managing Contractor models enable many of the execution risks associated with construction to be borne by suppliers. However, even with detailed risk transfer arrangements, some risks will remain directly or indirectly with GWRC or KiwiRail, requiring oversight by the Governance Group and its constituting organisation.

Accordingly, GWRC will be taking lead responsibility for contract management for Package 1 and 2, while responsibility for any work related to Package 3 will be held by KiwiRail. To perform this responsibility GWRC will need to develop, from its current framework, robust contract management processes adapted to the scope and magnitude of the LNIRIM project.

12.13 Project assurance

Both internal and external assurance activities will be implemented to deliver the project.

Using the existing organisational quality framework of GWRC, the Governance Group will confirm the schedule of assurance activities to be undertaken by GWRC or KiwiRail in accordance with the risk management plans to be detailed and confirmed in the readiness to market phase.

All audits and reviews will be reported to the Working Groups and their results responded to or escalated to the project Sponsor and Governance Group Steering committee according to the triggers establish in the project management plans to be detailed and confirmed in the readiness to market phase.

Table 12-5 list proposed minimum project assurance deliverables for the pre-implementation and implementation stages.

Table 12-5 Proposed minimum project assurance deliverables

Item	Component	Description
DBC Peer Review (Started in Aug 2021)	Detailed Business Case	Peer review according to Waka Kotahi guidelines on the 5 cases during the approval phase.
Probity (Started in Feb 2021)	Entirety of project	Independent external Probity Assurance related to planning, implementation and outcome of all procurement activities.
Organisational readiness	Management structure	Internal + External audit of organisational readiness to perform its role in implementation and operation. Including client organisations and operator.
Cost Reviews	Cost estimates of discrete elements of scope	External cost review of discrete element of scope (Depot, Stations, Stabling…etc.) when and as appropriate with regards to their delivery model.
Quality Assurance	All organisational processes relevant to scope.	Independent QA reviews during project implementation and operation at regular intervals.
Compliance System Assurance Audits	Rolling stock & Depot	Independent audit of compliance against compliance management plan related to the scope of the DBM+O contract for Package 1.
Post Delivery Benefit Assessments	Benefit Realisation Framework	Internal + Independent review of benefits realised at regular intervals during implementation and operation lifecycle.

13 CHAPTER 13 – RECOMMENDATIONS

It is recommended that local and central governments endorse this detailed business case and note:

- Investing in a new fleet and associated infrastructure for the Wairarapa and Manawatū commuter rail services will fulfill investment objectives of improving connectivity and access to opportunities in the region, improving corridor capacity, improving the attractiveness of public transport, reducing carbon emissions relating to commuter travel and enhancing value for money through increased network productivity and efficiency of operations.
- Failure to intervene exposes an increasing risk of ceasing operating services on the corridors due to an inability to meet minimum safety requirements.
- The scope of the preferred solution includes a new fleet of 22 four-car tri-mode (electric, combustion ignition and battery) trains, a simulator to support crew training, a maintenance depot located at Masterton, stabling facilities located at Wellington, Masterton and Palmerston North, station upgrades north of Upper Hutt and Waikanae and allowance for additional passing loops and other track infrastructure.
- Delivery of the preferred solution will enable a significant uplift in rail services to meet forecast demand.
- Other benefits generated from the delivery of the preferred solution include inclusive access and improved mobility, increased transport network resilience, safety and reliability, improved operational efficiency, improved attractiveness of the public transport network resulting in increased mode shift and positive environmental outcomes through reduced carbon emissions.
- The positive economic merit of the preferred solution, which has a benefit cost ratio of 1.83 and an economic NPV of $218 million.
- The preferred solution will be delivered as three separate works packages:
  - The Rollingstock and depot package (Package 1) is to be delivered under a Design, Build, Maintain and [Operate] (DBM +[O]) contract. The commercial arrangements for operators will need to be managed and transitioned separately from the DBM due to commercial risks associated with terminating the existing operational and maintenance agreement.
  - The Station upgrades package (Package 2) is to be delivered via a Managing Contractor arrangement.
  - The stabling and track facilities package (Package 3) is to be procured and delivered by the Rail Network owner (KiwiRail), with access to GWRC provided via amendment to the Network Agreement.
- Total whole of life cost for the preferred solution is $1,0 billion without the committed funding, or $1.2 billion with committed funding (NPV, P95), which is only an incremental increase of $182 million over the do-minimum case despite more than doubling the total number of services provided to commuters.
- The delivery phase funding requirement is $763 million (non-committed, nominal, P95) delivered over a period of 8 years from FY22 to FY29, with funding to be shared between Central Government and Regional Councils (GWRC and Horizon).
- The key risks of the project, to be further mitigated in subsequent phases, include:
  - risks of delay in delivery of the project due to late funding commitment or exceptional international supply chain disruption
  - risks of technical incompatibility between modern trains and the local rail network
  - risks related to foreign exchange volatility between the estimate date and the supply agreement.
- The full new fleet is forecast to be in revenue service by Q4 2028.
- Ōtaki and Levin railway stations, currently listed on the Treaty Settlement land bank, will only be upgraded to the benefits of relevant Māori groups and the wider community insofar as an agreement with relevant parties, including Te Arawhiti, can progress to be endorsed by Ministerial decision or Cabinet approval.

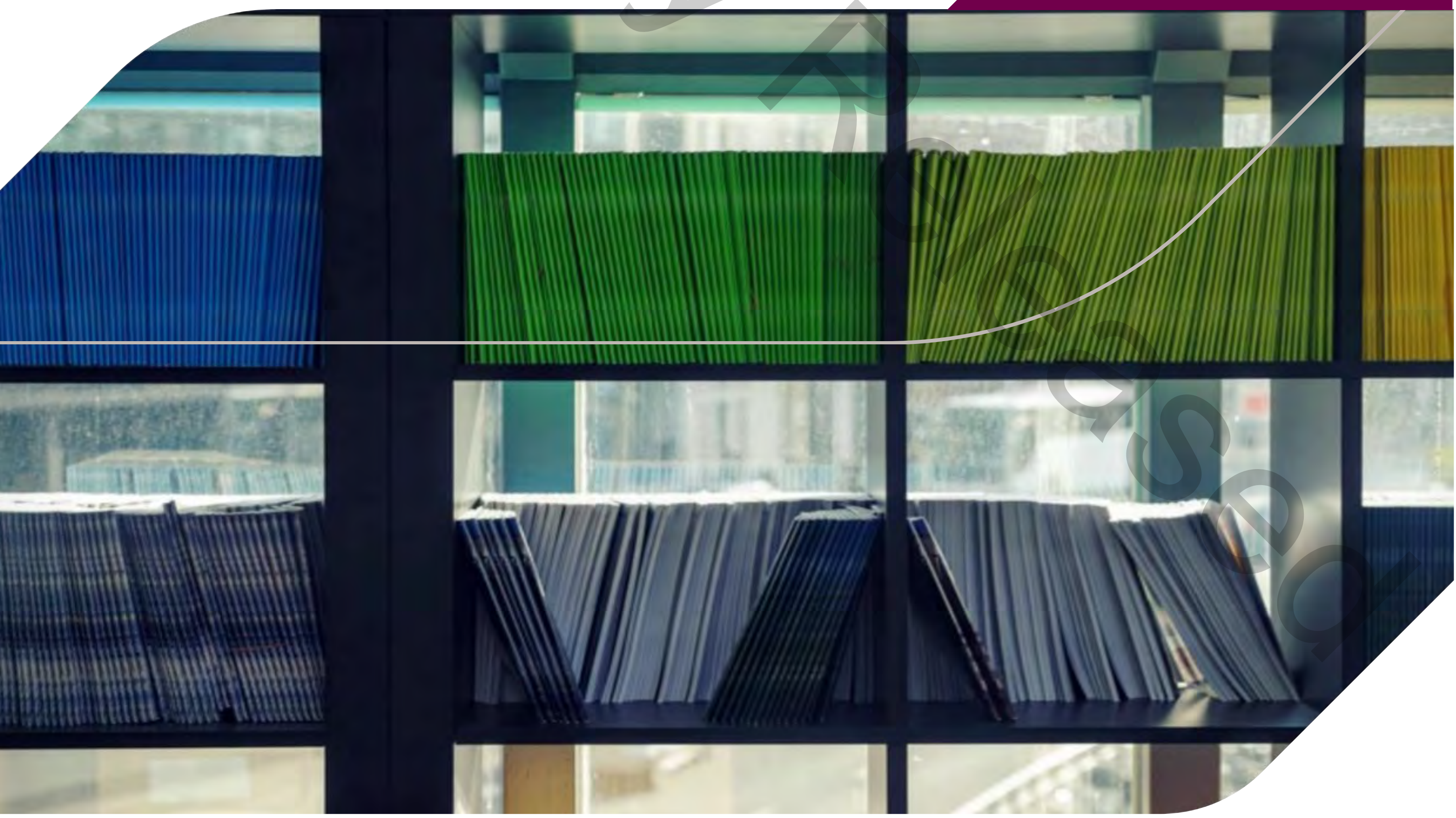
- Mitigation measures are planned to address the gap between existing fleet retirement and new fleet in service, as well as other key risks and opportunities.
- Members of the governance steering group set up to deliver the project will include The Ministry of Transport, Waka Kotahi, KiwiRail, Horizons Regional Council and Greater Wellington Regional Council, ensuring a concerted approach to maximise benefit delivery.
- The preliminary implementation schedule defines the critical path to the implementations of LNIRIM as the delivery of Package 1 - Rollingstock and depot. It currently includes commencing the procurement of Rolling Stock expression of interest (EOI) stage in Q3 2022 and the request for proposal (RFP) stage in Q1 2023.
- Achieving the timing of activities and milestones proposed by the current schedule will be critical to the delivery of the benefits sought by the proposed investment. It will be essential to secure agreement with all levels of government regarding funding. The procurement phase should not commence unless this occurs to provide certainty of process and funding to the market.

GLOSSARY

Acronym	Full name and description, when relevant
AC	Alternating current
ACNZ	Accessing Central New Zealand
ARIMA	Autoregressive integrated moving average
B	Batteries
BCR	Benefit Cost Ratio
B-DMU	Battery-diesel multiple unit – a hybrid diesel multiple unit with mechanical drive with a motor, connected to a battery, mounted between the engine and gearbox. The motor can use battery power to either provide additional power or be used stand-alone for a short range. The motor is used as a generator in braking to capture regenerative braking.
B-EMU	Battery-electric multiple unit - an electric multiple unit with an additional battery power source to provide self-power capability
BMU	Bi-mode 1 multiple unit – an electric multiple unit with self-power provided with a diesel generator
CBA	Cost Benefit Analysis
CCO	Council Controlled Organisation
CCTV	Close Circuit Television
CET	Controlled Emission Toilet
CI	Compression ignition
COVID-19	Coronavirus disease 2019
CRLL	City Rail Link Limited
DBC	Detailed Business Case – this business case
DC	Direct Current
DMU	Diesel Multiple Unit – diesel multiple unit with either mechanical or hydraulic drive (sometimes separated into DMMU and DHMU)
DPS	Depot Protection System
EMU	Electric Multiple Unit – a fixed formation train taking traction power from overhead wires
FOREX	Foreign exchange
GPS 2021	Government Policy Statement on land transport 2021-2031
GST	goods and services tax
GTL	Gas to liquid fuel – a diesel substitute
GWRC	Greater Wellington Regional Council
GWRL	Greater Wellington Rail Limited
HMU	Hydrogen multiple unit – a Battery-EMU which utilises a hydrogen fuel cell to provide a self-power electricity supply
Horizons	Horizons Regional Council
HVO	Hydrogenated vegetable oil – a diesel substitute
IBC	Initial Business Case – the 2019 310200204 191202 Lower North Island Longer-Distance Rolling Stock Business Case - Final
IEP	Intercity Express Programme
ILM	Investment Logic Map
LGWM	Let's Get Wellington Moving
LHCS	Locomotive hauled coaching stock – carriages fitted with drawgear to enable operation with a head end traction source.
LINZ	Land Information New Zealand
LNIRIM	Lower North Island Integrated Mobility
LRU	Line Replaceable Items
LTMA	Land Transport Management Act 2003
MBCM	Monetised Benefits and Costs Manual
MCA	Multi-Criteria Analysis
MSA	Manufacture and Supply Agreement
MTIN	Miles per Technical Incident Number
MU	Multiple unit – a semi-permanently coupled number of vehicles with a driving cab at each end which together form a unit. A single multiple unit, or several multiple units coupled together, form a train.

Acronym	Full name and description, when relevant
NIMT	North Island Main Trunk – the mainline railway between Wellington and Auckland
NLTF	National Land Transport Fund
NLTP	National Land Transport Plan
NPV	Net Present Value
NSW	New South Wales
NZUP	New Zealand Upgrade Program
ODRC	Optimised Depreciated Replacement Costs
OEM	Original Equipment Manaufacturer
OHLE	Overhead Line Electricification
ORC	Optimised Replacement Cost
PBC	Preliminary Business Case
PPP	Private Public Partnership
PSC	Project Steering Committee
PV	Present Value
PV	Present Value
PWA	Public Works Act 1981
QRA	Quantitative Risk Assessment
RLTP	Regional Land Transport Plan
RMA	Resource Management Act 1991
RNIP	Rail Network Investment Programme
RPTP	Regional Passenger Transport Plan
RRP	Regional Rail Plan
SDO	Selective Door Operation
SMART	Specific Measurable Achievable Realistic Time-bound
TMU	Tri-mode multiple unit – electric + battery + diesel multiple unit
TOF	Transport Outcomes Framework
TSR	Temporary Speed Restrictions
TTS	Train Technical Specifications
V	Volt
VCB	Vacuum Circuit Breaker
Waka Kotahi	Waka Kotahi New Zealand Transport Agency
WC	Waste Closet
WMUP	Wellington Metro Upgrade Programme
WOL	Whole of life

Appendix A
Service level modelling



MEMO

Version 1.1
Date 24/10/2021
To Organisation (RPS, GWRC)
Author Lynxx (Beau Bellamy)

Executive Summary

Do Minimum

The "Do Minimum" stage provides the expected patronage demand forecast under the current operational conditions of train frequency, capacity, journey time, and available amenities.

Wairarapa

The population in the Wairarapa sub-region is projected to increase until 2032, then plateau and reverse after 2038, and Wellington-bound train passengers in this sub-region have experienced disproportionately higher fare increases compared to others on the Wairarapa line.

The capped scenario visualises patronage projections once trains have reached full standing and seating capacity and assumes no more growth beyond what is physically permitted on the carriages. This scenario is unrealistic in that:

- demand will still exist and grow despite capacity limitations due to external factors (which may be represented in future substitution effects (e.g. driving, driving to alternative stations, switching to less busy trains).
- crowding will affect demand, particularly once the remaining capacity is standing only.

Wairarapa is expected to see annual patronage growth between 0.9% and 2.0% over the forecast period, which is likely to reach capacity by circa 2025.

Manawatu

The Manawatu line runs one return service per day, and capacity is limited to seating capacity due to the long-distance nature of the journey. Although monthly aggregate demand is not exceeding monthly aggregate seating capacity, individual trains are likely to be experiencing capacity close to maximum already. The capacity is likely to be reached circa 2030 with people expected to shift to alternate modes when their individual experience approaches capacity, which is likely to be sooner.

Manawatu is expected to see annual patronage growth between -0.7% and 1.8% over the forecast period, which is likely to reach seating capacity by circa 2030.

Improved Services

The "Improved Service" stage provides a means of testing several alternative service options by varying key features of operational services. I.e. improving journey time, frequency of services, and available capacity. These inherently describe the passenger experience, and thus can be used as a measure of benefit to the rail patron. We present the results of the preferred options for each line.

Additional patronage growth is expected to occur shortly after implementation of improved services, with the assumption that new patrons are sourced via mode shift from cars to trains. This initial additional growth will stabilise to a regular rate as future growth continues to be driven mostly by population growth.

The lower bound and upper bound projections for each line diverge significantly in later years. The initial divergence captures the uncertainty in predictions due to the variations and seasonality in the historical data available. The later years is predominantly driven by the relatively long prediction window.

Wairarapa

The first 5 years will see the largest growth with an expected average annual growth rate of between 6.5% and 7.2%. This will likely average out to between 1.5% and 2.5% over the full forecast period.

Manawatu

Additional data with higher granularity was available for Manawatu which allowed us to consider the different experiences from each individual at different stations. This improves the effect of journey time and frequency improvements, which increase the expected patronage over similar modelling to Wairarapa.

The first 5 years will see the largest growth with an expected average annual growth rate of between 13.6% and 17.7%, which will likely average out to between 0.7% and 3.5% over the full forecast period.

Overview

An iterative process between Lynxx, RPS, Greater Wellington regional Council (GWRC) and KiwiRail (hereafter stakeholders) identified several data sources, both public and private, to project expected patronage growth for a baseline "do minimum" scenario for the Manawatu and Wairarapa rail lines. Additional historical data and empirical research on rail demand elasticity was identified to establish benefits from various changes in the services and infrastructure. Modelling potential growth used this historical information as well as an iterative process of scenario generation between the stakeholders to identify the best options to test.

Stakeholders agreed on a preferred option for each line that would balance capacity (primarily frequency and train consist size) and demand (made up of exogenous and endogenous factors) to ensure sufficient capacity in the future.

Data

The StatsNZ population forecasts for both Manawatu and Wairarapa regions were used to identify the expected growth due to population growth. Both the subregions within Manawatu and Wairarapa and the wider region projections were considered.

Fare data for the Wairarapa line describing the changes in fares between 2006 and 2021 were used to identify any shocks to the network that would impact patronage. This fare information was not available for the Manawatu line.

Patronage data for both lines were available at different granularities, as such, Manawatu and Wairarapa were modelled with different granularities. The results were aggregated to the monthly totals to provide consistency for comparison purposes. The historical patronage figures on both lines fluctuate significantly due to external factors such as the Kapiti line extension to Waikanai and introduction of the new Matangi fleet.

Methodology Overview

The modelling methodology employs two main stages to predict the potential patronage demand for both Manawatu and Wairarapa lines. The "do minimum" stage identifies the baseline expected growth without any intervention. The "improved service" stage incorporates several key features of operations, to identify up to 19 different service offerings that could drive patronage demand.

Each stage is modelled using different methodologies that suit the available data. The details of the methodology will be discussed in each stage.

The modelling initially forecasts the scenarios to 2040 for evaluation, with the final selected options modelled to 2068. Evaluation at 2040 is considered to be sufficient time to allow for any growth to stabilise and form a consistent trend for future forecasts.

Do Minimum

This stage of modelling is used to understand the expected patronage forecast if nothing was to change with the current operations i.e., retain the same service frequency, vehicle capacity, journey times, and amenities. This inherently means that the current vehicles would be maintained to the required operational standards and would thus require some investment to maintain. We present the expected patronage demand going forward without consideration for this cost.

Methodology

The basis of our modelling are autoregressive integrated moving average (ARIMA) models that project future monthly patronage based on historical seasonality and overall trends. Historical patronage shifts through multiple trend patterns due to external factors, such as line electrification and fleet replacements. These external factors are removed by modelling the data from the more stable and recent subsets of the data depending on the line. This provides a significantly more stable pattern and improves the model's statistical robustness.

The uncertainty in the projections is encapsulated using a lower bound and upper bound estimate for each option.

Wairarapa Results

Modelling was performed on data after the introduction of the SE fleet and subsequent crowding alleviations in 2013. This inherently removed any significant change in the system and ensures the most recent patronage trends inform the forecasts. Additional exogenous factors that informed the "do minimum" modelling are:

- Population in the Wairarapa sub-region is projected to grow until 2032, plateau, and then decrease after 2043.
- Projected growth for the wider catchment region remains positive but decreasing over time.

Peak considerations included:

- Fare costs for the line have increased over time with no major shocks, but the fare increases for full-line journeys (i.e., those between Wellington and the ends of the line) have increased slightly more relatively to medium length journeys. From 2006 to 2021, shorter zone tickets experienced higher price increases – a monthly ticket for one zone increased 45% compared to the 10-zone ticket increasing 30%. However, this trend reverses for 11-14 zone tickets, which experienced an average price growth of 35%. We assume passengers travelling the full length of the line experience the small but disproportionate increase in fares relative to those travelling from the middle of the line.
- These combined factors are likely to reduce demand growth from regional Wairarapa passengers who travel into Wellington from the end of the line. This reduction over time has a significant impact on the lower bound projections.
- We have no external data to suggest a notable accelerant in demand, so the upper bound is only informed by the historical growth patterns.

Off-Peak considerations included

- Fare costs and ticket types for off-peak travel shifted in 2018 with the removal of the cash ticket and the introduction of the 10-trip ticket. This is marked by a light grey line in Figure 2. Demand decreases after this change, compared to the steady demand between mid-2013 and 2018. Additionally, a significant proportion of off-peak travelers are elderly patrons using the free off-peak "Supergold Card" introduced in 2006.
- Train delays and bus replacements due to track work undertaken in the interpeak is likely to have affected customer experience and contributed to reduced patronage.
- Given the positive (but plateauing) population growth and unsteady demand trends, our projections assume two potential scenarios. Our lower bound assumes post-2018 demand patterns continue, and demand will slowly continue decreasing. Our upper bound assumes a less aggressive decrease, given that historical patronage was much higher and has potential to return to previous levels.
- We do not expect seating capacity to influence demand elasticity, as demand is well within capacity limits.

Peak

Our peak projections are broadly in line with those presented in the Indicative Business Case (IBC) – both expect crowding and capacity problems within a few years. The IBC presents three flat annual growth rates based on population growth (1.3% p.a.), recent patronage growth (3.3% p.a.), and a previous patronage forecast based on older data. Our projections incorporate population growth, historical & recent patronage growth, and fare trends and are more nuanced over time, but not inconsistent with the existing views.

Figure 1 shows our monthly patronage projections (black line) with the upper and lower bounds widening towards the end of the prediction period. The light and dark grey segments represent the seating and seating+standing monthly capacity of the services respectively. Currently monthly demand is already exceeding monthly seating capacity, so individual trains are already experiencing crowding. The peak capacity under the "do minimum" scenario will see capacity hit in circa 2025/2026.

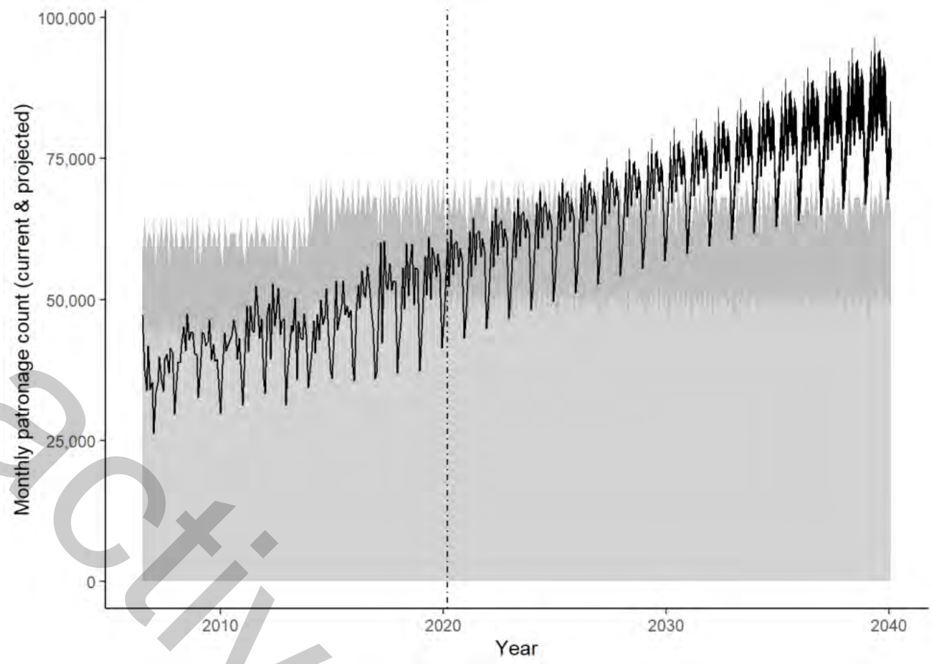


Figure 1. Historical and projected Wairarapa Line monthly peak patronage

Off-Peak

Figure 2 shows our monthly patronage projections (black line) with the upper and lower bounds widening towards the end of the forecast period. Service capacity has not been overlaid, as neither historical nor predicted patronage is expected to reach capacity limits (average monthly off-peak capacity is 43,000 seated). Monthly off-peak demand is expected to plateau or decrease, given the strong trends of decreasing patronage from 2010 to 2020. This is likely to be partially caused by delays and bus replacement services due to significant track work undertaken in the interpeak.

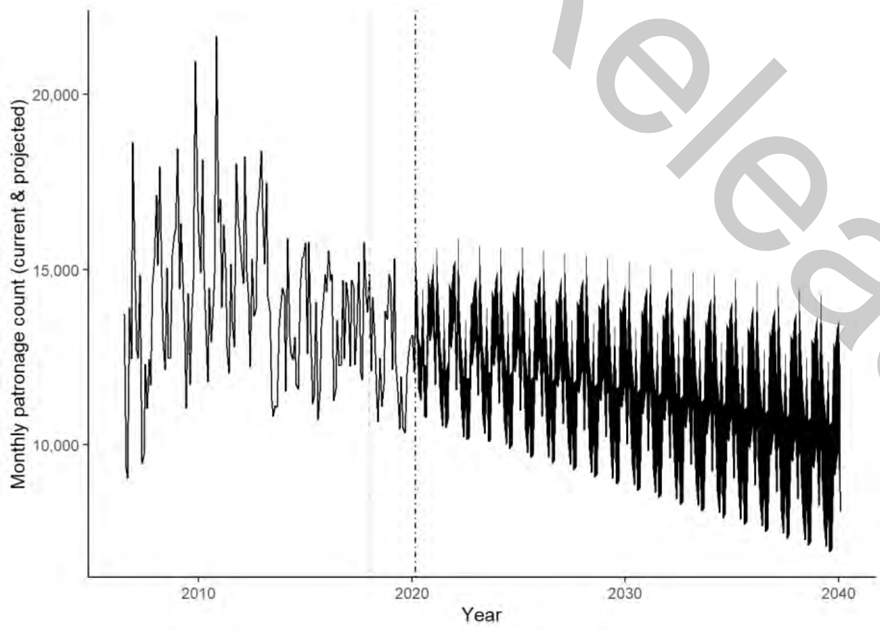


Figure 2. Historical and projected Wairarapa Line monthly off-peak patronage

Manawatu Results

The extension of the Metlink services and the subsequent fare increases for the Capital Connection line introduced turbulant patronage trends between 2011 and 2015. For this reason, data from 2015 data onwards was used for the Manawatu modelling. The additional exogenous factors that informed the "do minimum" modelling are:

- StatsNZ population projections for the Manawatu region (Kapiti Coast district, Manawatu district, Horowhenua district, and Porirua City) show steady but slowly plateauing growth by 2040.
- Given the long-distance nature of the line and the single peak period daily service, we assume customers are likely to be more sensitive to crowding and the maximum seating capacity of the services.
- State Highway 1, the road providing the only car alternative, is currently undergoing multiple improvement projects to increase capacity and reduce travel times. Although congestion is currently an issue, these projects are scheduled to be completed by 2025.
- As capacity starts to hit maximum and as the car alternatives continue improving, we expect a slow plateau of railway demand by 2030 as travellers consistently choose to rely on improved car alternatives over potentially unavailable train seats. This plateau over time, combined with the plateau of population growth, drives our lower bound projection.
- We have no external data to suggest a notable acceleration in demand, so our upper bound forecast is informed by historical growth patterns only.
- Our projections are initially in line with those presented in the IBC and both expect capacity problems by 2030, but our projections diverge later in the forecast period as we expect a plateauing of demand growth due to these capacity problems.

The IBC presents three flat annual growth rates based on population growth (1.1% p.a.), recent patronage growth (3.1% p.a.), and a previous Wairarapa Line patronage forecast. Our projections incorporate population growth, car alternatives, and seat availability. However, anecdotally, many people living along the Manawatu corridor drive to Waikanai to access the metro service due to the limited frequency of the current Manawatu service.

Figure 3 shows our monthly patronage projections (black) with the upper and lower bounds widening towards the end of the forecast period. The light grey segments represent current seating monthly capacity of the services, although historically this capacity has been higher. Standing capacity was not considered given the long-distance nature of the line. Although monthly aggregate demand is not exceeding monthly aggregate seating capacity, individual trains are likely to be experiencing capacity close to maximum already. This provides some support of a view that already suppression of demand (which is likely to happen on account of a limited set of service options).

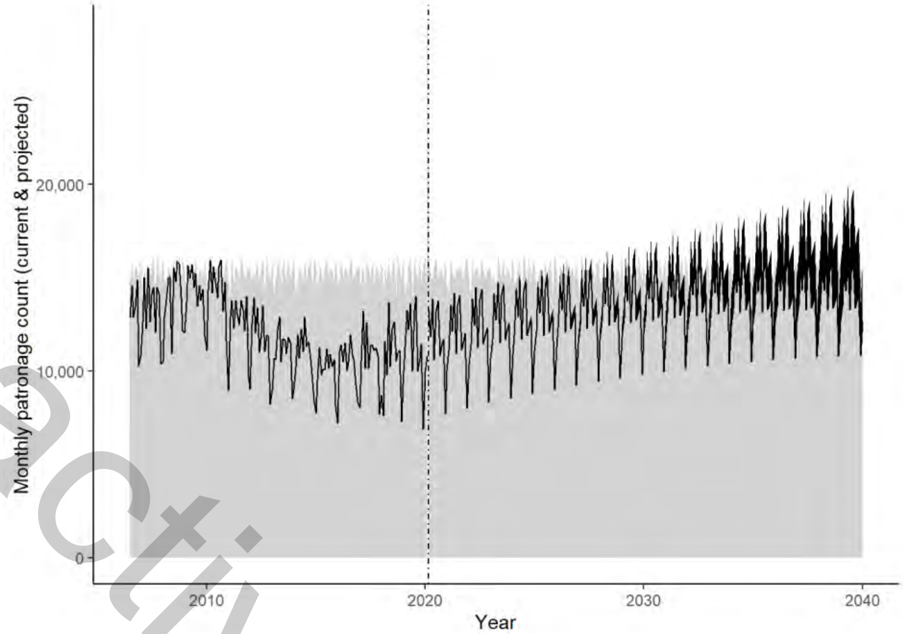


Figure 3. Historical and projected Manawatu Line monthly patronage

Improved Service

This stage of modelling is intended to compare several potential options that would likely lead to high patronage demand with minimal investment. Evaluation of each option is based on the expected patronage demand at 2040, with stakeholders considering the likely investment impact of each option.

Only the peak period is considered for comparison of patronage demand, where patronage influencers such as service frequency, capacity, and journey time will have a larger impact. There is also more opportunity to improve peak services due to the patronage expectations.

Methodology

The evaluation methodology proposed was a generalised journey time model (where all elements of a trip are 'converted' into a weighted "generalised" journey time and measured for attractiveness). This model is based on the Institute of Transport Studies' (Leeds University, UK) and the UK's Association of Train Operating Companies' Passenger Demand Forecasting Council methodology, which is the world's most empirically tested rail demand forecasting methodology. The generalised journey time is constructed from the journey time and service frequency. These factors were driven by the following operational factors that could reasonably be achieved:

- Line Speed: The maximum line speed can be improved through infrastructure investment, with the current line speed at 90km/h. Current technology allows trains to travel up to 160 km/h in a similar environment, thus the proposed options considered a realistic 110 km/h and an optimistic 160km/h for line speed.
- Temporary Speed Restrictions (TSRs): The individual TSRs are not examined in detail to understand the potential benefit from removing them, rather we assume that some TSRs will be improved over the short to medium term, resulting in a small journey time improvement. We extend this to assume a higher benefit from removing all TSRs to show the benefit of longer-term infrastructure improvements.

- Frequency: The service frequency is also considered, as a high frequency service has a higher potential to achieve patronage growth. The improved service options consider more services within the same peak period.
- Stopping Pattern: As currently both lines only operate all stops trains, improved service options consider the introduction of an express train within the service. This is inherently linked to the service frequency, so the suggested scenario was varied depending on the line being modelled. The specific express service is not defined so we assume there is a 10 min saving in journey time associated with an express service.
- Consist Configuration: Variations in the consist configuration were considered to adjust the potential capacity of each trip. The current peak operations typically use six or eight carriages per train - this could be decreased to reduce investment or increased with consideration for platform lengths.

The line speed and TSR improvements (Table 1) both impact the journey time, which is a direct input into the modelling. The improvements to the journey time, based on the increased line speed or improvements in TSRs, was based on results from modelling done in Open Track by stakeholders (see Appendix 3 and Appendix 4). The frequency and stopping pattern influence the perceived journey time and is modelled using an elasticity factor that was derived from research done on a similar network (using the empirical research base from the UK Passenger Demand Forecasting Council's handbook). The variation in the elasticity factor was increased or decreased according to the level of improvement described.

TSRs	Journey Time Saving (min)
All existing	0
Some removed	5
None	15

Table 1. Journey time impact from removing TSRs

Data from the relevant stakeholders and empirical research on demand elasticity identified the likely benefits for the various changes in each of these factors. Historical patronage data going back 8 years was combined with variations of the factors described above to generate a variety of reasonable/achievable and aspirational scenarios.

Wairarapa

The data available provided the total historical patronage for the full corridor, which is based on the passenger count crossing the Remutaka range (through the Remutaka tunnel) between Wairarapa and Hutt Valley. Based on this, we inherently assume all passengers travel between Wellington and Masterton. We believe this to be reasonable as the majority of the passengers are likely to travel to Wellington for work, rather than work locally. We are also unable to ascertain the proportion of people at each station. Further assumptions could be made to try to acount for this, but we believed this would introduce further uncertainty in the projections.

This uncertainty is encapsulated using the lower and upper bounds of the estimates. For all scenarios, both lower and upper bounds of the "do minimum" option are multiplied by the patronage demand growth caused by the generalised journey time impacts of the scenario.

For scenarios with express services, given the uncertainty of the patronage split between express and non-express services, the upper bound for the scenario is further modified to represent the maximum likely demand growth from the additional express-specific service improvements. This results in a slightly wider band of projections as compared with non-express services.

Scenarios

The Wairarapa line currently runs three services each direction during the peak. Services run all stops between Masterton and Wellington. Improvements are modelled through improving one or more of the five charactersitics described above, increased speeds, improving the infrastructure via removal of TSRs, increasing the service frequency, adding express services and consist configuration. Table 2 below specifies each option considered and how each operational characteristic is modified, with the current operations represented as the baseline of all characteristics. The resulting patronage estimates for 2040 can be seen in Appendix 1.

Option	Line Speed (km/hr)	TSRs	Frequency (# services per day each direction)	Stopping Pattern	Consist Configuration
Current	90	All existing	3 (1 every 30 mins)	All stops	3x8 car train
1	90	All existing	4 (1 every 25 mins)	All stops + 2 express	4x8 car train
2	90	All existing	5 (1 every 20 mins)	All stops + 2 express	5x8 car train
3	90	All existing	8 (1 every 15 mins)	All stops + 4 express	8x8 car train
4	90	Some removed	3 (1 every 30 mins)	All stops	3x8 car train
5	90	Some removed	5 (1 every 20 mins)	All stops + 2 express	5x8 car train
6	90	Some removed	8 (1 every 15 mins)	All stops + 4 express	8x8 car train
7	90	None	3 (1 every 30 mins)	All stops	3x8 car train
8	90	None	4 (1 every 25 mins)	All stops + 2 express	4x8 car train
9	90	None	5 (1 every 20 mins)	All stops + 2 express	5x8 car train
10	90	None	6 (1 every 15 mins)	All stops	6x8 car train
10a	90	None	7 (1 every 15 mins)	All stops	(6x8, 1x4) car train
11	90	None	7 (1 every 15 mins)	All stops	7x8 car train
12	110	Some removed	4 (1 every 25 mins)	All stops + 2 express	4x8 car train
13	110	None	4 (1 every 25 mins)	All stops + 2 express	4x8 car train
14	110	None	5 (1 every 20 mins)	All stops + 2 express	5x8 car train
15	110	None	8 (1 every 15 mins)	All stops + 4 express	8x8 car train
16	160	None	4 (1 every 25 mins)	All stops + 2 express	4x8 car train
17	160	None	5 (1 every 20 mins)	All stops + 2 express	5x8 car train
18	160	None	8 (1 every 15 mins)	All stops + 4 express	8x8 car train

Table 2. Wairarapa Line option list, detailing what factors were changed for each option under consideration

Note: Option 10a was added after intial modelling and consultation with stakeholders, to identify the sensitivty around the consist length of trains betwen option 10 and option 11.

Additional modelling on the options that were considered to be realistic was also conducted with the addition of 2 extra cars for each train consist to increase the potential capacity. This however did not increase the likely patronage demand, becasue many of the options were not capacity limited. The options that were capacity limiited would not achieve sufficient capacity to overcome this limit.

Preferred Option

A guided decison was made by the stakeholders, where Lynxx provided the framework and modelling implications and the stakeholders chose the prefered options for each line. The Stakeholders identified option 10a as the prefered option which expects to run 7 trains (six trains in an eight car configuration and one train in a four car configuration) at a 15 min headway during the peak period. This option is also expected to achieve 15 minutes of savings in the journey time by removing TSR's.

Figure 4 shows the monthly patronage projections for both the current operations (black line) and those of option 10a (blue line). The red line indicates the average trend line for the projected demand for the improved service option chosen, 10a. The vertical line at 2020 represent the point where the projections begin, and the vertical line at 2040 represents the point where the estimates were evaluated compared to the other options.

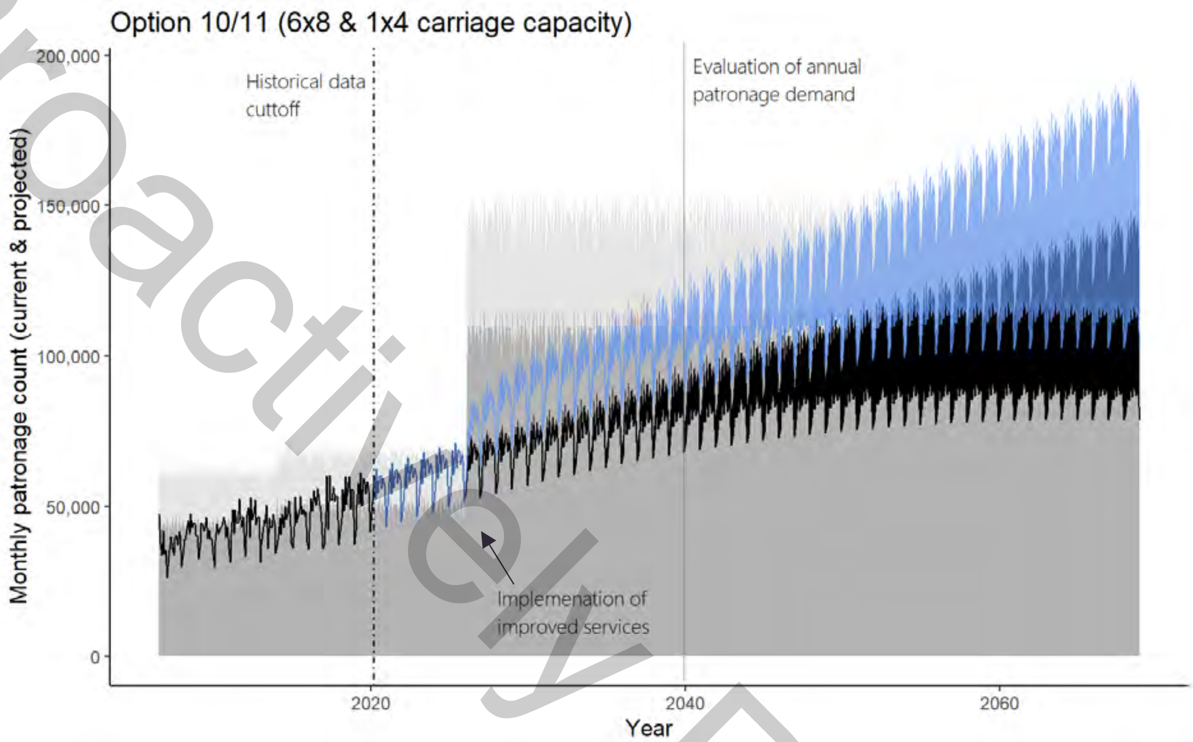


Figure 4. Monthly projected patronage demand for Wairarapa preferred service option. The seated capacity is shown in dark grey shading with additional standing capacity shaded in light grey. Projections for current operations are in black, with projections for the preferred option in blue.

The figure shows the capacity limitations of the current operations that were seen in the "do minimum" modelling. The improved services are assumed to be implemented in 2029, where there is a step change in capacity. The patronage is expected to significantly increase initially with the growth rate settling down after 4-5 years.

The projections for both the current operations and the preferred option start to diverge significantly in the later years, with the initial divergence encapsulating the uncertainty in predictions due to variances and seasonality in the historical data. The uncertainty in the later years is predominantly driven by the long prediction windows relative to the historical data (forecasting 40 years ahead with 8 years of historical data).

Over the first 5 years of improved services, the average annual growth rate is expected to be between 6.5% and 7.2% averaging out to between 1.5% and 2.5% over the 40 years forecast period.

Manawatu

Additional data available for Manawatu sumarised the number of patrons embarking at each station allowing for more detailed incorporation of where people get on the train. Our key assumption remains that patrons will travel to and from Wellington for each journey. However, a higher demand elasticity for patrons embarking closer to Wellington is incorporated to account for the different patronage patterns associated with local/city services and regional services. Thus, we can account for the different experiences from each patron at different stations.

We find that the aggregated patronage demand projections are higher under this approach, due to the greater effect of improvements on shorter journeys.

Also given that frequency is a large driver of demand and the existing service is a single train each way, each day, any improvements in the service are more aligned with creating a new service. Therefore, the assumptions are shifted towards the benefit of modelling a new train service, rather than incremental improvements to the existing service, which further increases demand projections.

Scenarios

Alternate services are modelled through improving one or more of the five charactersitics described above, increased speeds, improving the infrastructure via removal of TSRs, increasing the service frequency, adding express services, and consist configuration. Table 3 below specifies each option considered and how each operational characteristic is modified, with the current operations represented as the baseline of all characteristics. The resulting patronage estimates for 2040 can be seen in Appendix 2.

Option	Line Speed (km/hr)	TSRs	Frequency (# services per day each direction)	Stopping Pattern	Consist Configuration
Current	90	All existing	1	All stops	1x8 car train
1	90	All existing	2 (1 every 90 mins)	All stops + 1 express	2x8 car train
2	90	All existing	4 (1 every 40 mins)	All stops + 2 express	4x8 car train
3	90	Some removed	1	All stops	1x8 car train
4	90	Some removed	4 (1 every 40 mins)	All stops + 1 express	(2x8, 2x4) car train
5	90	None	1	All stops	1x8 car train
6	110	All existing	2 (1 every 90 mins)	All stops + 1 express	2x8 car train
7	110	All existing	4 (1 every 40 mins)	All stops + 2 express	4x8 car train
8	110	Some removed	2 (1 every 90 mins)	All stops + 1 express	2x8 car train
9	110	None	2 (1 every 90 mins)	All stops + 1 express	2x8 car train
10	110	None	4 (1 every 40 mins)	All stops + 2 express	4x8 car train
11	160	None	2 (1 every 90 mins)	All stops + 1 express	2x8 car train
12	160	None	4 (1 every 40 mins)	All stops + 2 express	4x8 car train
13	90	All existing	3 (1 every 60 mins)	All stops	3x8 car train

Table 3. Manawatu Line options list

Preferred Option

A guided decison was made by the stakeholders, where Lynxx provided the framework and modelling implications and the stakeholders chose the prefered options. The Stakeholders identified option 4 as the prefered option which expects to run 4 trains (two trains in an eight car configuration and two trains in a four car configuration), one service will be an express service, with a headway of 40 minutes. This option is also expected to achieve an additional 5 minutes of savings in journey time by removing some TSR's.

Figure 5 shows the monthly patronage projections for both the current operations (black line) and those of option 4 (blue line). The red line indicates the average trend line for the projected demand for the alternate service option chosen. The vertical line at 2020 represents the point where the projections begin, and the vertical line at 2040 represents the point where the estimates were evaluated with the other options.

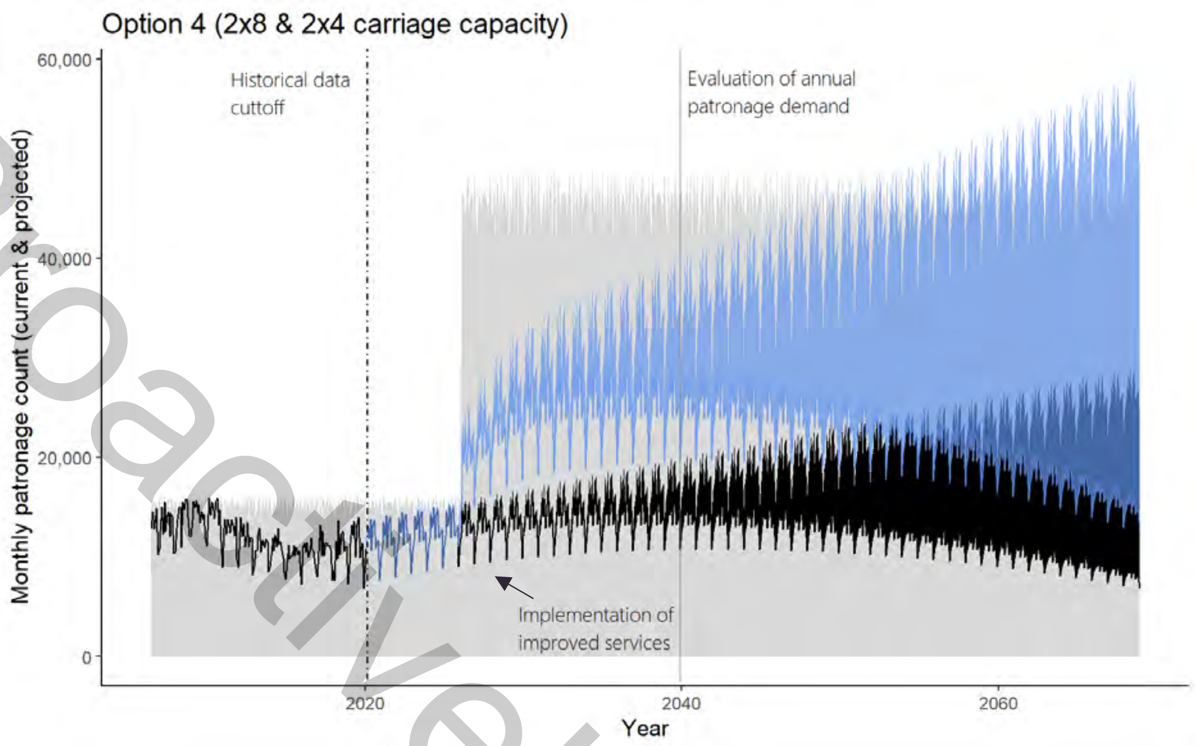


Figure 5. Monthly projected patronage demand for Manawatu preferred service option. The seated capacity is shown in dark grey shading. Projections for current operations are in black, with projections for the preferred option in blue.

The figure shows the capacity limitations of the current operations that are likely to be met circa 2025. The improved services are assumed to be implemented in 2029, where there is a step change in capacity. The patronage is expected to significantly increase initially with the growth rate settling down after 4-5 years.

The projections for both the current operations and the preferred option start to diverge significantly in the later years, with the initial divergence encapsulating the uncertainty in predictions due to variances and seasonality in the historical data. Additional patronage growth is expected to occur shortly after implementation of improved services, with the assumption that new patrons are sourced via mode shift from cars to trains. This initial additional growth will stabilise to a regular rate as future growth continues to be driven mostly by population growth The uncertainty in the later years is predominantly driven by the long prediction windows relative to the historical data (forecasting 40 years ahead with 6 years of historical data).

Over the first 5 years of the alternative service, the average yearly growth rate is expected to be between 13.6% and 17.7% averaging out to between 0.7% and 3.5% over the 40 year forecast period.

We note that, due to the frequency increase of the preferred option, total seating capacity is significantly more than required for the projected patronage demand for the initial decade of service. A consist configuration of 2x8 and 2x4 car trains per day was selected, but reduced capacity configurations for the first decade of service (such as 4x4 car trains) would suffice to minimise operating costs and early investment while retaining the required frequency.

Results

The preferred Wairarapa option varies three of the five key features from the current operations, which include:

- The removal of temporary speed restrictions (TSR's), which is expected to result in a 15 minute benefit to the overall journey time.
- The frequency of services has been increased to seven (7) services during the peak period, with a headway of one service every 15 minutes.
- The consist configuration is varied from the standard in that one of the peak services is assumed to be a single four car train, with the remaining services all assuming a standard eight car train.

The annual peak demand of the Wairarapa preferred option is expected to reach 1,400,000 by 2040.

The preferred Manawatu option varies four of the five key features from the current operations, which include:

- The removal of some Temporary speed restrictions (TSR's), which is expected to result in a 5 minute benefit to the overall journey time.
- The frequency of services has been increased to four services during the peak period, with a headway of one service every 40 minutes.
- The stopping pattern is varied to include one of the four peak hour services as an express train. This specific service is not defined, however it assumed to save an additional 10 minutes of journey time.
- The consist configuration is varied from the standard in that two of the peak hour services is assumed to be a single four car train, with the remaining two services a standard eight car train.

The annual peak demand of the Manawatu preferred option is expected to reach 430,000 by 2040.

Disclaimer

Lynxx has been engaged by RPS to provide professional advice and modelling of patronage demand for the Lower North Island Rail Integrated Mobility project (LNIRIM) for Greater Wellington Regional Council. These results have been prepared on the basis of the data, assumptions and other inputs provided as part of the LNIRIM. It represents Lynxx's professional view given the inputs and the specified constraints in delivering the work. Lynxx is not licenced to provide financial or investment advice. This report cannot therefore be 'relied upon' for financial, operational performance or investment purposes.

Appendix 1

Wairarapa Improved service options and resulting Annual peak demand for 2040, with the preferred option (10a) highlighted.

Option	Line Speed (km/hr)	TSRs	Frequency (# peak hour services)	Stopping Pattern	Consist Configuration	2040 Peak Demand (Lower)	2040 Peak Demand (Upper)
current	90	All existing	3 (1 every 30 mins)	All stops	3x8 car train	955,721	1,089,162
1	90	All existing	4 (1 every 25 mins)	All stops + 2 express	4x8 car train	982,541	1,259,052
2	90	All existing	5 (1 every 20 mins)	All stops + 2 express	5x8 car train	1,010,747	1,298,852
3	90	All existing	8 (1 every 15 mins)	All stops + 4 express	8x8 car train	1,061,130	1,370,447
4	90	Some removed	3 (1 every 30 mins)	All stops	3x8 car train	1,001,185	1,140,974
5	90	Some removed	5 (1 every 20 mins)	All stops + 2 express	5x8 car train	1,061,130	1,370,447
6	90	Some removed	8 (1 every 15 mins)	All stops + 4 express	8x8 car train	1,116,221	1,449,473
7	90	None	3 (1 every 30 mins)	All stops	3x8 car train	1,104,796	1,259,052
8	90	None	4 (1 every 25 mins)	All stops + 2 express	4x8 car train	1,139,720	1,483,418
9	90	None	5 (1 every 20 mins)	All stops + 2 express	5x8 car train	1,176,682	1,537,098
10	90	None	6 (1 every 15 mins)	All stops	6x8 car train	1,243,306	1,416,901
10a	90	None	7 (1 every 15 mins)	All stops	(6x8, 1x4) car train	1,243,306	1,416,901
11	90	None	7 (1 every 15 mins)	All stops	7x8 car train	1,243,306	1,416,901
12	110	Some removed	4 (1 every 25 mins)	All stops + 2 express	4x8 car train	1,104,796	1,401,105
13	110	None	4 (1 every 25 mins)	All stops + 2 express	4x8 car train	1,229,445	1,574,864
14	110	None	5 (1 every 20 mins)	All stops + 2 express	5x8 car train	1,271,887	1,634,742
15	110	None	8 (1 every 15 mins)	All stops + 4 express	8x8 car train	1,348,777	1,744,149
16	160	None	4 (1 every 25 mins)	All stops + 2 express	4x8 car train	1,301,673	1,676,983
17	160	None	5 (1 every 20 mins)	All stops + 2 express	5x8 car train	1,348,777	1,744,149
18	160	None	8 (1 every 15 mins)	All stops + 4 express	8x8 car train	1,348,777	1,744,149

MEMO

Appendix 2

Manawatu Improved service options and resulting Annual peak demand for 2040, with the preferred option (4) highlighted.

Option	Line Speed (km/hr)	TSRs	Frequency (# services per day each direction)	Stopping Pattern	Consist Configuration	2040 Peak Demand (Lower)	2040 Peak Demand (Upper)
Current	90	All existing	1	All stops	1x8 car train	166,859	213,950
1	90	All existing	2 (1 every 90 mins)	All stops + 1 express	2x8 car train	239,714	333,692
2	90	All existing	4 (1 every 40 mins)	All stops + 2 express	4x8 car train	292,399	412,484
3	90	Some removed	1	All stops	1x8 car train	171,031	219,301
4	90	Some removed	4 (1 every 40 mins)	All stops + 1 express	(2x8, 2x4) car train	303,517	429,465
5	90	None	1	All stops	1x8 car train	179,984	230,780
6	110	All existing	2 (1 every 90 mins)	All stops + 1 express	2x8 car train	247,560	344,196
7	110	All existing	4 (1 every 40 mins)	All stops + 2 express	4x8 car train	303,517	427,710
8	110	Some removed	2 (1 every 90 mins)	All stops + 1 express	2x8 car train	255,887	356,596
9	110	None	2 (1 every 90 mins)	All stops + 1 express	2x8 car train	274,164	384,005
10	110	None	4 (1 every 40 mins)	All stops + 2 express	4x8 car train	341,934	486,655
11	160	None	2 (1 every 90 mins)	All stops + 1 express	2x8 car train	281,644	394,142
12	160	None	4 (1 every 40 mins)	All stops + 2 express	4x8 car train	352,937	501,981
13	90	All existing	3 (1 every 60 mins)	All stops	3x8 car train	270,325	346,618
13A	90	All existing	3 (1 every 60 mins)	All stops	3x8 car train	378,455	485,265
13B	90	All existing	3 (1 every 60 mins)	All stops	3x8 car train	702,845	901,206

MEMO

Appendix 3

Modelling performed by KiwiRail of a train from the Upper Hutt to Masterton on the Wairarapa line provided expected travel times at each station for various scenarios with higher speed and no TSRs. Each scenario is compared to the current schedule (1606) which inherently includes small amounts of time that account for TSRs to remain on time.

UP		Current schedule 1606	Simulation at Line Spd 90Km/h	Simulation at Line Spd 110Km/h	Simulation at Line Spd 160Km/h
UPPER HUTT	Dep.	17:03:00	17:03:00	17:03:00	17:03:00
Maymorn	Arr.	17:11:00	17:09:00	17:09:00	17:09:00
Maymorn	Dep.	17:12:00	17:10:00	17:10:00	17:10:00
Featherston	Arr.	17:32:00	17:24:08	17:23:01	17:22:32
Featherston	Dep.	17:33:00	17:25:08	17:24:01	17:23:32
Woodside	Arr.	17:41:00	17:31:35	17:29:54	17:29:20
Woodside	Dep.	17:42:00	17:32:35	17:30:54	17:30:20
Matarawa	Arr.	17:46:00	17:36:37	17:34:48	17:34:02
Matarawa	Dep.	17:47:00	17:37:37	17:35:48	17:35:02
Dalefield IB	Pass	...	17:39:53	17:37:49	17:37:00
Carterton	Arr.	17:55:00	17:43:19	17:40:57	17:39:53
Carterton	Dep.	17:56:00	17:44:19	17:41:57	17:40:53
Belvedere IB	Pass	...	17:44:32	17:42:10	17:41:06
Clareville IB	Pass	...	17:47:18	17:44:37	17:43:34
Waingawa	Pass	...	17:50:32	17:47:15	17:45:41
Judds Road IB	Pass	...	17:52:13	17:48:41	17:46:58
Solway	Arr.	18:06:00	17:53:14	17:49:42	17:47:51
Solway	Dep.	18:07:00	17:54:14	17:50:42	17:48:51
Renall St	Arr.	18:10:00	17:55:55	17:52:23	17:50:28
Renall St	Dep.	18:11:00	17:56:55	17:53:23	17:51:28
MASTERTON	Arr.	18:13:00	17:58:53	17:55:20	17:53:23
Run time		**01:10:00**	**00:55:53**	**00:52:20**	**00:50:23**
Gain over 1606 sched [mm:ss]		00:00	14:07	17:40	19:37

MEMO

Appendix 4

Modelling performed by KiwiRail of a train from Masterton to the Upper Hutt on the Wairarapa line provided expected travel times at each station for various scenarios with higher speed and no TSRs. Each scenario is compared to the current schedule (1606) which inherently includes small amounts of time that account for TSRs to remain on time.

DOWN		Current schedule 1603	Simulation at Line Spd 90Km/h	Simulation at Line Spd 110Km/h	Simulation at Line Spd 160Km/h
MASTERTON	Dep.	06:20:00	06:20:00	06:20:00	06:20:00
Renall St	Arr.	06:22:00	06:21:53	06:21:53	06:21:52
Renall St	Dep.	06:23:00	06:22:53	06:22:53	06:22:52
Solway	Arr.	06:26:00	06:24:29	06:24:29	06:24:28
Solway	Dep.	06:27:00	06:25:29	06:25:29	06:25:28
Judds Road IB	Pass	...	06:26:07	06:26:07	06:26:09
Waingawa	Pass	...	06:27:48	06:27:34	06:27:34
Clareville IB	Pass	...	06:31:01	06:30:12	06:29:34
Belvedere IB	Pass	...	06:33:45	06:32:36	06:31:38
Carterton	Arr.	06:37:00	06:34:23	06:33:14	06:32:11
Carterton	Dep.	06:38:00	06:35:23	06:34:14	06:33:11
Dalefield IB	Pass	...	06:38:30	06:37:05	06:35:59
Matarawa	Arr.	06:47:00	06:41:03	06:39:21	06:37:57
Matarawa	Dep.	06:48:00	06:42:03	06:40:21	06:38:57
Woodside	Arr.	06:52:00	06:45:58	06:44:06	06:42:44
Woodside	Dep.	06:53:00	06:46:58	06:45:06	06:43:44
Featherston	Arr.	07:01:00	06:53:25	06:50:59	06:49:31
Featherston	Dep.	07:02:00	06:54:25	06:51:59	06:50:31
Maymorn	Arr.	07:22:00	07:08:36	07:05:05	07:03:08
Maymorn	Dep.	07:23:00	07:09:36	07:06:05	07:04:08
UPPER HUTT	Arr.	07:31:00	07:15:39	07:12:08	07:10:07
Run time		**01:11:00**	**00:55:39**	**00:52:08**	**00:50:07**
Gain over 1603 sched [mm:ss]		00:00	15:21	18:52	20:53

Appendix B
Do-minimum base case

Do-minimum base case

<table>
<tr><th>Category</th><th>Wairarapa</th><th>Manawatu</th></tr>
<tr><td>Fleet</td><td>Existing fleet
• Complete the light refurbishment of the SW and SE fleet started in early 2020 by January 2023, extending the carriages' service life to FY2028.
• Maintain the existing fleet of 12 SW, 4 SE, 3 SWS, 3 SWG, 1 SES, 1 SEG and 1 AG van until the end of the service life.
• The fleet is normally operated with between five and nine carriages, providing a seated capacity of between 266 and 599 passengers per train.
• Two SWs, one SWS and one SWG are typically held as spares to facilitate maintenance.
• New second-hand fleet.
• Purchase a second-hand LHCS fleet in quantity sufficient to provide services of equivalent capacity and frequency and spares to facilitate maintenance by FY2029.
• The ageing locomotives are assumed to be significantly overhauled or replaced with second-hand locomotives.
• The fleet will require regular subsequent light refurbishments every 5 years of operation.
• The fleet will require regular subsequent purchase and refurbishments every 10 years of operation over 30-40 years of operations.
• It is assumed that the new second-hand fleet is refurbished to include the same features as for the current fleet, without increasing or reducing the perceived quality.</td><td>Existing fleet
• Complete the $26 million refurbishment of the S fleet covered within the NZUP[1], with a start in 2021 and completion by late 2022, extending the carriages' service life to FY2027-FY2028.
• Complete a light refurbishment of the fleet in FY2026, extending the carriages' service life to FY2031.
• Maintain the existing fleet of 7 S, 1 S servery and 1 AG van until the end of the service life.
• The train normally operates in an eight-car configuration between Friday afternoon and Tuesday morning to provide a seated capacity of 388.
• It operates with one less standard car at other times to allow for maintenance, providing a seated capacity of 328.
• New second-hand fleet.
• Purchase a second-hand LHCS fleet in quantity sufficient to provide services of equivalent capacity and frequency and equivalent spares to facilitate maintenance by FY2031.
• The ageing locomotives are assumed to be significantly overhauled or replaced with second-hand locomotives.
• The fleet will require regular subsequent light refurbishments every 5 years of operation.
• The fleet will require regular subsequent purchase and refurbishments every 10 years of operation over 30-40 years of operations.
• It is assumed that the new second-hand fleet is refurbished to include the same features as for the current fleet, without increasing or reducing the perceived quality.</td></tr>
<tr><td>Maintenance</td><td>Maintenance is assumed based on the current arrangements and the need to sufficiently maintain the same reliability, speed, timetable and travel time of current services.</td><td>Maintenance is assumed based on the current arrangements and the need to sufficiently maintain the same reliability, speed, timetable and travel time of current services.</td></tr>
<tr><td>Infrastructure</td><td colspan="2">Station upgrades
• A second platform at Featherston will support improved passenger services by enabling two passenger trains to pass, and being offset from the existing platform, it will allow for future freight-related improvements (NZUP commitment).
• Wairarapa line stations will be modified to raise their platform to the carriages levels for accessibility purpose.
Stabling facilities and maintenance depots
• One new storage facilities for train carriages will be built to provide extra capacity during peak train services and support anticipated growth as well as to allow for maintenance (NZUP commitment).
Other upgrades, including funded as part of the Wellington Metro Upgrade Programme (WMUP)
• New passing infrastructure at Carterton and Maymorn will enable express freight and commuter trains to operate with greater efficiency on the Wairarapa line (NZUP commitment).</td></tr>
</table>

[1] Rail Network Investment Programme (RNIP). 2021. KiwiRail. Accessed on: https://www.kiwirail.co.nz/what-we-do/projects/rail-network-investment-programme/

- WMUP III = catch-up track renewals formation upgrade and drainage upgrade, primarily on the Wairarapa Line, Remutaka and Tawa tunnels catch up track renewal, re-sleepering twelve short tunnels, slope stabilisation and bridge replacement.
- WMUP IV = Network improvement for increased capacity.
- WMUP V = signalling improvements and automated train protection.
- WMUP VIa = Entrance into Wellington Station to enable increased frequency.
- WMUP VIb = Wairarapa Line capacity upgrades to support a planned increased service frequency, including the Featherston, Maymorn and Masterton related NZUP work described above.

Appendix C
Long list of options

Long list of options

#	Option description	Decision	Comment	Intervention types sourced from intervention hierarchy: Integrated planning	Manage demand	Best use of existing system	New infrastructure
1	Change land use policy + reduce demand and need for longer distance transportation	Discontinue	This option does not align with strategic objectives and future land use plans.	✔			
2	Increase fares + reduce demand and need for longer distance transportation	Discontinue	This option does not align with strategic objectives.		✔		
3	Discontinue longer distance rail service + encourage commuters using cars	Discontinue	This assumes people using private cars, additional park & ride facilities and an improved road network. This option does not align with strategic objectives.			✔	
4	Discontinue longer distance rail service + provide full replacement with subsidised bus services on Wairarapa and Manawatu	Discontinue	This option will contribute to further road congestion, reliance on an improved road network and does not align with strategic objectives.				✔
5	Discontinue longer distance rail service + encourage a commercial bus service to connect to electrified network	Discontinue	Similar option assessed as part of Palmerston North-Wellington Rail Passenger Business Case and determined not to be viable.			✔	
6	Maintain the existing Wairarapa Line services with new LHCS + allow Manawatu Line services fleet to cease operating	Discontinue	This is a modified version of the IBC's 'do-minimum' option. However, this option is discontinued for the purposes of this DBC as it offers lower service levels than this DBC's 'do-minimum' option.				✔
7	Use existing EMU capacity on the electrified part + provide shuttle services on non-electrified network in peak	Discontinue	Does not provide increased capacity within the electrified area, which is already approaching capacity.				✔
8	Use existing EMU capacity on the electrified part + provide shuttle services on non-electrified network in off peak	Discontinue	While possible, it does not provide as good of a customer experience, as requires people to change services.				✔

#	Option description	Decision	Comment	Intervention types sourced from intervention hierarchy			
				Integrated planning	Manage demand	Best use of existing system	New infrastructure
9	Use existing EMU capacity on the electrified part + provide shuttle services on non-electrified network in peak and off peak	Discontinue	Does not provide increased capacity within the electrified area, which is already approaching capacity				✔
10	Refurbish existing Manawatu and Wairarapa fleets + keep current service pattern	Discontinue	Fleet refurbishment would be closer to a rebuild due to the current deterioration of the assets due to age. No carbon reduction. This option will neither address growth nor facilitate mode shift.			✔	
11	Second-hand CI generator locomotive & LHCS + keep current service pattern	**Progress (DBC 'base case')**	Cost effective but not aligned to carbon reduction. Does not utilise available infrastructure. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS				✔
12	Second-hand DMUs + keep current service pattern	Discontinue	Cost effective but not aligned to carbon reduction. Does not utilise available infrastructure.				✔
13	Second-hand CI generator locomotive & LHCS + increased services	Discontinue	Cost effective but not aligned to carbon reduction. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS				✔
14	Second hand DMUs + increased services	Discontinue	Cost effective but not aligned to carbon reduction. Does not utilise available infrastructure.				✔
15	New CI generator locomotive & LHCS + increased services	Discontinue	Lack of acceleration for interrunning with other fleets. Slight carbon reduction. Does not utilise available infrastructure.				✔
16	New DMUs + increased services	Discontinue	Cost effective but not aligned to carbon reduction. Does not utilise available infrastructure. This option was shortlisted in the IBC but has been replaced with #17 as discussed in Section 4.5.4.				✔
17	B-DMU + increased services	**Progress (Option 2)**	Cost effective but not fully aligned to carbon reduction. Does not utilise available infrastructure.				✔
18	CI generator locomotive with battery + increased services	Discontinue	Cost effective but not fully aligned to carbon reduction. Does not utilise available infrastructure. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS.				✔

#	Option description	Decision	Comment	Intervention types sourced from intervention hierarchy			
				Integrated planning	Manage demand	Best use of existing system	New infrastructure
19	Bi-mode multiple unit (1600V DC & CI generator) + increased services	Discontinue	Does not capture regenerative braking energy when on non-electrified running line. This option was shortlisted in the IBC but has been replaced with #27 and #31 as discussed in Section 4.5.4.				✔
20	Bi-mode locomotive (1600V DC & CI generator) + increased services	Discontinue	Does not capture regenerative braking energy when on non-electrified running line Refer to Section 4.5 for all TMU advantages vs. BMUs.				✔
21	Bi-mode multiple unit (1600V DC & CI generator) + partial 1600V DC electrification + increased services	Discontinue	Does not capture regenerative braking energy when on non-electrified running line.				✔
22	Bi-mode locomotive (1600V DC & CI generator) + partial 1600V DC electrification + increased services	Discontinue	Does not capture regenerative braking energy when on non-electrified running line. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS. Refer to Section 4.5 for all TMU advantages vs. BMUs.				✔
23	Bi-mode multiple unit (25kV AC & CI generator) + partial 25kV AC electrification + increased services	Discontinue	Does not capture regenerative braking energy when on non-electrified running line. Systems would not take advantage of existing infrastructure (1,600 V DC) and would use diesel which could be avoided.				✔
24	Bi-mode locomotive (25kV AC & CI generator) + partial 25kV AC electrification + increased services	Discontinue	Does not capture regenerative braking energy when on non-electrified running line. Systems would not take advantage of existing infrastructure (1,600 V DC) and would use diesel which could be avoided. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS. Refer to Section 4.5 for all TMU advantages vs. BMUs.				✔
25	Bi-mode multiple unit (DV & CI generator) + partial 25kV AC electrification + increased services	Discontinue	No known off the shelf configuration to suit the New Zealand market. Does not capture regenerative braking energy when on the non-electrified running line.				✔
26	Bi-mode locomotive (DV & CI generator) + partial 25kV AC electrification	Discontinue	No known off the shelf configuration to suit the New Zealand market. Does not capture regenerative braking energy when on the non-electrified running line. Refer to Section 4.3.1 for multiple unit				✔

#	Option description	Decision	Comment	Intervention types sourced from intervention hierarchy			
				Integrated planning	Manage demand	Best use of existing system	New infrastructure
	+ increased services		advantages vs. locomotives & LHCS. Refer to Section 4.5 for all TMU advantages vs. BMUs.				
27	Tri-mode multiple unit (1600V DC & CI generator & battery) + increased services	**Progress (Option 4.1)**	An option for short timescales and carbon reduction.				✔
28	Tri-mode locomotive (1600V DC & CI generator) + increased services	Discontinue	The locomotive tri-mode is a non-standard product compared to the multiple unit variant. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS.				✔
29	Tri-mode multiple unit (1600V DC & CI generator & battery) + partial 1600V DC electrification + increased services	Discontinue	Benefit of further 1600V DC electrification could be provided more easily by the on-board battery power.				✔
30	Tri-mode locomotive (1600V DC & CI generator & battery) + partial 1600V DC electrification + increased services	Discontinue	The locomotive tri-mode is a non-standard product compared to the multiple unit variant. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS.				✔
31	Tri-mode multiple unit (1600V DC & 25kV provision & CI generator & battery) + increased services	**Progress (Option 4.2)**	Allows full benefits of option 4.1 with mode shift to 25kV embedded earlier in the product life cycle for ease of conversion.				✔
32	Tri-mode locomotive (1600V DC & 25kV provision & CI generator & battery) + increased services	Discontinue	A non-standard product that would require appropriate design time to fully appreciate limitations. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS				✔
33	Tri-mode multiple unit (25kV AC & CI generator & battery) + partial 25kV AC electrification + increased services	Discontinue	Systems would not take advantage of existing infrastructure (1,600 V DC) and would use diesel which could be avoided.				✔
34	Tri-mode locomotive (25kV AC & CI generator & battery) + partial 25kV AC electrification + increased services	Discontinue	Systems would not take advantage of existing infrastructure (1,600 V DC) and would use diesel which could be avoided. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS				✔

#	Option description	Decision	Comment	Intervention types sourced from intervention hierarchy			
				Integrated planning	Manage demand	Best use of existing system	New infrastructure
35	Tri-mode multiple unit (DV & CI generator & battery) + partial 25kV AC electrification + increased services	Discontinue	Non-standard product, none in production, carbon reduction				✔
36	Tri-mode locomotive (DV & CI generator & battery) + partial 25kV AC electrification + increased services	Discontinue	Non-standard product, none in production, carbon reduction. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS				✔
37	B-EMU (1600V DC) + increased services	**Progress (Option 3.1)**	The larger battery capacity is not practical in line with current technology.				✔
38	Electric locomotive (1600V DC & battery) + increased services	Discontinue	The larger battery capacity is not practical in line with current technology. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS				✔
39	B-EMU (1600V DC) + partial 1600V DC electrification + increased services	**Progress (Option 3.3)**	Increased partial electrification and carbon elimination, analysis of number of charging points to be conducted to understand balance to tri-mode option.				✔
40	Electric locomotive (1600V DC & battery) + partial 1600V DC electrification + increased services	Discontinue	Increased partial electrification and carbon elimination, analysis of number of charging points to be conducted to understand balance to tri-mode option. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS				✔
41	B-EMU (DV) + partial 25kV AC electrification + increased services	**Progress (Option 3.2)**	Increased partial electrification aligned to 25kV expansion and carbon elimination, analysis of number of charging points to be conducted to understand balance to tri-mode option.				✔
42	Electric locomotive (DV & battery) + partial 25kV AC electrification + increased services	Discontinue	Increased partial electrification aligned to 25kV expansion and carbon elimination, analysis of number of charging points to be conducted to understand balance to tri-mode option. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS				✔
43	EMU (1600V DC) + full 1600V DC electrification on current non electrified route	Discontinue	Full electrification, potential unnecessary costs that a battery could remove and carbon elimination.				✔

#	Option description	Decision	Comment	Intervention types sourced from intervention hierarchy			
				Integrated planning	Manage demand	Best use of existing system	New infrastructure
	+ increased services		Electrifying tunnel is likely unfeasible relative to adding battery capacity.				
44	Electric locomotive (1600V DC) + full 1600V DC electrification on current non electrified route + increased services	Discontinue	Full electrification, potential unnecessary costs that a battery could remove and carbon elimination. Electrifying tunnel is likely unfeasible relative to adding battery capacity. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS				✔
45	EMU (1600V DC) + 1600V DC electrification up to Featherston/ Ōtaki + bus from Featherston/ Ōtaki + increased services	**Progress (Option 1)**	Contributes to road traffic congestion and does not maximise existing network capacity. Option derived from IBC.				✔
46	Electric locomotive (1600V DC) + 1600V DC electrification up to Featherston/ Ōtaki + bus from Featherston/ Ōtaki + increased services	Discontinue	Contributes to road traffic congestion and does not maximise existing network capacity. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS				✔
47	EMU (25kV AC) + full 25kV AC electrification on route + increased services	Discontinue	Full electrification aligned to 25kV expansion, potential unnecessary costs that a battery could remove, impact on Wellington Commuter network and carbon elimination				✔
48	Electric locomotive (25kV AC) + full 25kV AC electrification on route + increased services	Discontinue	Full electrification aligned to 25kV expansion, potential unnecessary costs that a battery could remove, impact on Wellington Commuter network and carbon elimination. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS				✔
49	EMU (DV) + full 25kV AC electrification on current non electrified route + increased services	**Progress (Option 5)**	Full electrification aligned to 25kV expansion, potential unnecessary costs that a battery could remove and carbon elimination. Electrifying tunnel is likely unfeasible relative to adding battery capacity. This option was shortlisted in the IBC.				✔
50	Electric locomotive (DV) + full 25kV AC electrification on current non electrified route + increased services	Discontinue	Full electrification aligned to 25kV expansion, potential unnecessary costs that a battery could remove and carbon elimination. Electrifying tunnel is likely unfeasible relative to adding battery				✔

#	Option description	Decision	Comment	Intervention types sourced from intervention hierarchy			
				Integrated planning	Manage demand	Best use of existing system	New infrastructure
			capacity. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS				
51	High-speed trains	Discontinue	Not included as perceived to be cost prohibitive, and technically challenging for New Zealand rail environment				✔
52	Light Rail Trains (LRT) vehicles	Discontinue	LRT are not able to co-operate on the rail network with heavy rail (freight trains), so would require significant investment in creating a parallel light rail network.				✔
53	Hydrogen fuel cell + battery multiple unit	Discontinue	Developing technology that requires associated infrastructure. Timeline for delivery may be longer than other technologies.				✔
54	Hydrogen fuel cell + battery locomotive	Discontinue	Developing technology that requires associated infrastructure. Timeline for delivery may be longer than other technologies. Refer to Section 4.3.1 for multiple unit advantages vs. locomotives & LHCS				✔
55	Solar	Discontinue	Technology not developed for rolling stock with no successful trials.				✔

Appendix D
Secondary propulsion modes

IPEX

A2 – Secondary Propulsion Modes

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A2 – Secondary Propulsion Modes

Issue Number: v2.0

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Greater Wellington Regional Council

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Contents

1 Executive summary

The market sounding has clarified the following with respect to rolling stock secondary propulsion:

- There will be sufficient competition for a procurement exercise by GWRC to be successful.
- Full electrification, which results in an electric multiple unit, (single or dual voltage), is likely to be an expensive option indicating secondary propulsion modes are required.
- Hydrogen fuel may well be a compelling option for the NIMT or South Island in a few years' time should electrification not progress, but has been rejected from this study due to:
  - the timescales involved in providing supporting infrastructure;
  - the maturity of green hydrogen production in New Zealand;
  - the immaturity of the technology for trains; and
  - the lack of competition in the market.

Therefore, IPEX continues to consider the baseline option as a tri-mode (TMU) using 1,600 V DC + battery + compression ignition (CI) generator using the existing infrastructure, as per version 1.0 of this report. Further analysis is due to take part in conjunction with finalised work packages for A3 – whole life costings, A5 – maintenance strategy and A6 – electrification analysis. Initial investigations included all five options below and full electrification. The options assessment as follows in terms of feasibility:

More feasible:

- Option 1 Tri-mode (1,600 V DC + battery + CI generator) with no further electrification
- Option 4 B-EMU (1,600 V DC + battery) with partial electrification at 1,600 V DC

Less feasible

- Option 2 Tri-mode (1,600 V DC + battery + CI generator) with partial electrification at 1,600 V DC
- Option 3 Tri-mode (25 kV + battery + CI generator) with partial electrification at 25 kV AC (no use of current electrification in 1,600 V DC configuration)
- Option 5 B-EMU (dual voltage + battery) with partial electrification at 25 kV AC

Final validation of the preferred option is dependent on the high-level strategy and cost assessment of any further electrification.

The technical information in this report provides a progress update from IPEX Technical Note *0369 - A2 - Secondary Propulsion Modes v1.0*. This technical information will feed into the Detailed Business Case (DBC) where it will be collated with analyses of other transport modes and other workstreams, such as A3 whole life costings. The DBC will provide a full step by step elimination of long list options to provide the preferred option whilst considering all workstream outputs.

2 Introduction

This deliverable assesses options for multi-mode rolling stock for work package A2: Secondary Propulsion Options. This follows the IPEX Technical Note *0369 - A2 - Secondary Propulsion Modes v1.0,* which was an initial qualitative assessment which provided focus in the market sounding exercise.

The decision on secondary propulsion mode(s) was dependent on the outcome of the detailed business case (DBC), of which this workstream, A2, is a contributing part.

Definitions are provided in Appendix 1.

The Initial Business Case (IBC) and the High-Level Specification used the acronym "DMMU" to mean dual-mode multiple units. However, the generally accepted term for rolling stock with two modes of propulsion is bi-mode multiple unit or "BMU". The term DMMU has been used since the early 1960s to mean diesel mechanical multiple unit (to differentiate from a diesel hydraulic multiple unit "DHMU", and diesel electric multiple unit "DEMU"). Although the term DMMU is becoming legacy, with both diesel mechanical and diesel hydraulic multiple units being categorised together as "DMU", use of DMMU to a manufacturer may cause confusion so this report retains the industry standard term bi-mode multiple unit or BMU.

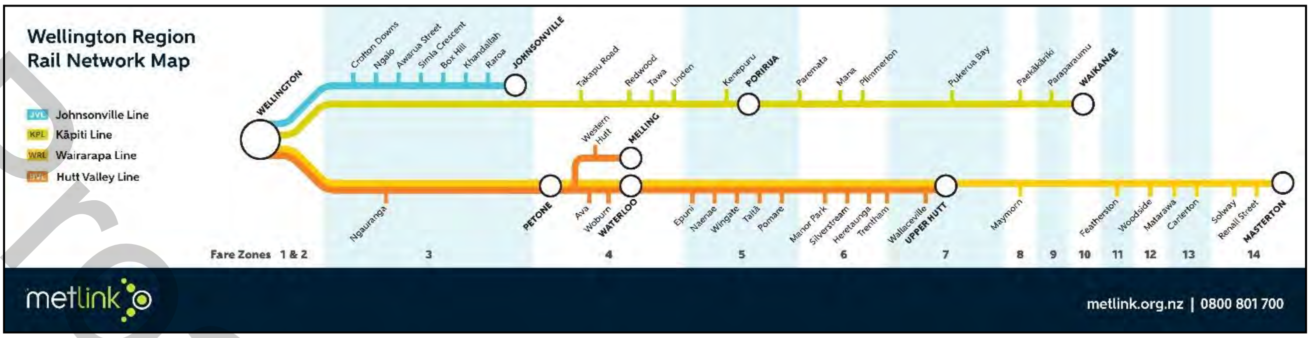
2.1 Background

Between Wellington and Masterton on the North Island of New Zealand a regional rail service is run, known as the Wairarapa Connection. This is operated by Metlink, Greater Wellington Regional Council's (GWRC) concession operator, that also operates the Wellington commuter electric multiple unit (EMU) services. The Wairarapa Connection is serviced using locomotive hauled carriage sets consisting of second-hand British Rail Mk2 carriages rebuilt for narrow gauge operation. These carriages are life expired.

Similarly, the Capital Connection, operated by KiwiRail, is a regional rail service from Wellington to Palmerston North, running along the North Island Main Trunk (NIMT) linking Wellington to Auckland. This operates with a similar fleet of ex-British Rail Mk2 carriages though these have not had such extensive refurbishment and are also life expired.

Both routes run on the Wellington electrified commuter network for the first stage of the journey, the Wairarapa running under the wires from Wellington to Upper Hutt (32 km) and the Capital Connection from Wellington to Waikanae (55 km), before working over non-electrified sections (Upper Hutt to Masterton at 59 km and Waikanae to Palmerston North at 81 km).

Figure 1. Wellington rail network



Both these services use diesel locomotives for traction power that predate emissions standards. There is therefore an opportunity to replace both these services with new, sustainable, rolling stock which can utilise overhead line where available and continue off-wire where required.

3 Rolling stock options assessment

As indicated in the initial business case (IBC), the New Zealand government has a strong environmental focus. As such, IPEX has considered how the existing infrastructure can be utilised or supported to maximise decarbonisation and emissions reduction, and considers the baseline case for new rolling stock as a tri-mode 1,600V DC + battery + CI generator multiple unit (TMU).

The assessment evaluates further enhancements against this baseline, considering:

- total expenditure (the overall value for money will be addressed for the preferred options within the DBC);
- total project timescales;
- impact on any future infrastructure enhancements;
- contribution to reducing the carbon emissions;
- complexity of technology required (supplier capacity to deliver will be explored in the market sounding activities); and
- whether the approach fits in with the wider vision for the Wellington region.

The options assessment is primarily based on IPEX industry knowledge and experience. Emissions for electricity generation are not considered in the assessment.

Full results of the options analysis are presented in Appendix 4.

3.1 Full electrification

Electrification is an established technology which is emissions free at point of use and can be generated using sustainable resources. It provides rolling stock with an unlimited practical range. Trains using electrification are typically quieter and more powerful over their total speed range while electrified routes provide the capability for both high speed passenger and freight operations. However, electrification installation is invasive and expensive, and it may not always provide good value for money on certain parts of the railway, especially those with lower traffic flows.

Only 12% of New Zealand's rail network currently has electrification[1]; approximately 3,622 km is not yet electrified. A study in 2008 estimated the cost of electrification in New Zealand as $2.5m per single track kilometre (stk) and $4m per double track km[2]. Additionally, the timescales for an electrification scheme are not insignificant; IPEX estimates that the time required from original concept to full operation could be 5 to 10 years.

IPEX is currently working with KiwiRail to better understand electrification in New Zealand and will include further information in Deliverable A6: Electrification. This work package will cover key aspects such as capital costs, operating costs, route-specific challenges, and the wider requirements of running on the North Island Main Trunk (NIMT).

There are no technological barriers to the introduction of EMUs to Manawutu and Wairarapa lines which would provide a zero-carbon solution. The main barriers to full electrification are the timescales to design, build and commission the system, completing this before the delivery of the rolling stock and the overall cost, with potential additional costs on other operations on the same lines.

3.1.1 Electrification types

The Wellington commuter network is electrified at 1,600 V DC. It is relatively simple to extend the use of the DC source for any further electrification. However, such electrification requires a significant expenditure on substations every few kilometres.

Particularly on the North Island Main Trunk, it may be more attractive to electrify to 25 kV AC, which would align with the electrification in Auckland and align to a potential future upgrade of the entire North Island. This also only requires substations approximately every 40 km so would increase the options for hub locations and length. However, this requires dual voltage rolling stock until a time where it may be feasible to re-electrify Wellington to 25 kV DC.

3.1.2 1,600 V DC

1,600 V DC EMU or electric locomotive – not feasible (cost and timescales)

Extending the 1,600 V DC electrification to complete the routes allowing for 1,600 V DC rolling stock is a simple solution in terms of technology but would require multiple substations to be constructed, and still requires surveys into clearances to be undertaken. Prohibiting factors are the cost involved and timescales for the electrification programme, which is unlikely to be completed before the rolling stock is required.

[1] The World Factbook. 2018. https://www.cia.gov/the-world-factbook/countries/new-zealand/#transportation Accessed 20 Apr 21.
[2] King, M. 2008. Extension of electrification: Benefits and costs. Report for prepared for ONTRACK by Murray King & Francis Small Consultancy Limited. Wellington.

3.1.3 1,600 V DC + 25 kV AC

Dual voltage EMU or electric locomotive – not feasible (cost and timescales)

This option involves keeping the 1,600 V DC existing infrastructure and electrifying the remaining route to 25 kV AC. This allows for a dual voltage EMU or locomotive, and also aligns with any potential future upgrade of the Wellington commuter network to 25 kV AC. However, the costs involved, the complexity of the installation, particularly in the Rimutaka tunnel, and the timescales required, are likely to make this option unfeasible.

3.1.4 25 kV AC

25 kV AC EMU or electric locomotive – not feasible (cost and timescales)

Electrification with 25 kV AC has become the industry standard due to the reduced energy losses when compared to 1,600 V DC and the reduction in number of substations required along the route.

The full electrification of 25 kV AC, allowing for a 25 kV AC EMU or locomotive, would require the removal of the existing 1,600 V DC network. In turn, this would require the replacement or modification of the Matangi fleets running on the Wellington commuter network.

Additionally, this solution would require electrification through tunnels, bridges, and other restrictive assets along the route. It is likely these reduced clearance sections would undoubtedly require isolated wire sections, or bespoke electrification solutions, which may result in requiring a battery to be installed on the unit. It is unlikely any electrification programme would complete before the rolling stock is required in service.

The costs involved, the complexity of the existing electrified network, and the timescales required, are likely to make this option unfeasible.

3.2 Partial electrification

IPEX expects that new electrification schemes may consider partial electrification where infrastructure complexity is prohibitively expensive relying instead on rolling stock with onboard energy storage to bridge any gaps (such as diesel, battery, or hydrogen).

The size and capability of the onboard energy storage solution and electrification is derived from analysing specific route geography, timetable requirements, and train specification.

There are two types of partial electrification; discontinuous where the electrification is paused under bridges and tunnels, and "hub" or "smart" electrification where reliance on on-board energy storage minimises the amount of electrification to hubs from which services can run on non-electrified sections.

3.2.1 Discontinuous electrification

One of the major costs in electrification is the cost of enabling adequate infrastructure clearance for the overhead line equipment (OLE). This often can only be achieved by demolishing and rebuilding structures with higher clearances or lowering the track. One version of discontinuous electrification is to install equipment on the majority of the line but with breaks where the infrastructure clearance is too limited or at junctions where the electrification itself becomes complex and expensive. Where multiple gaps are necessary in quick succession, these could be merged into fewer, longer gaps, to reduce the costs incurred in terminating the OLE before and after gaps, and to reduce the number of times the train requires to transition between power sources.

In this approach, rolling stock would require a short-range onboard energy storage solution. It requires less investment in infrastructure than full electrification while still retaining most of its benefits. However, compatible rolling stock would need to be procured or existing rolling stock converted. Further analysis is required to assess multi-mode rolling stock whole life cost against the savings in electrification brought about by the discontinuous solution.

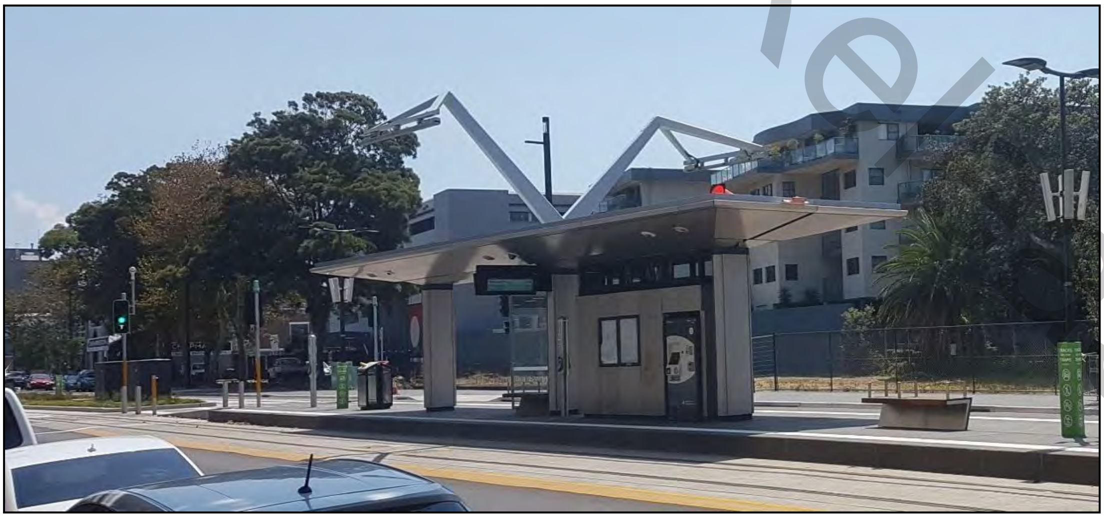
More background detail on this solution is in Appendix 2.

3.2.2 Smart electrification

With smart electrification schemes, wired sections serve as a hub from which the operation on unwired sections would be supported by rolling stock with on-board energy storage, with capacity to travel greater distances under self-power, with the storage recharged while running through the electrified hub.

This approach has been used effectively for a light rail system in Newcastle, Australia, which uses CAF Urbos units with contact charging at stations as shown in Figure 2.

Figure 2. Light rail system in Newcastle, Australia, with bar contact charging point at station



Stations may already have some form of national electricity grid connection nearby, which could be adaptable to providing charging solutions. Additionally, the station approaches could be electrified so that the energy required for accelerating away from the station is drawn from the overhead rather than being a heavy drain on the energy storage. A key objective of the electrification scheme would be to provide charging of batteries as the unit decelerated to a stop and during dwell time, and the removal of reliance on batteries for acceleration away from the station stop.

Terminus stations could supplement hubs with short bar section overhead making use of the dwell time to charge batteries and reduce the length of overhead line sections extending from the hub. This approach would minimise the OLE footprint to that required to feed a longer-range rolling stock battery, reducing the level of investment in infrastructure required. For this to be successfully implemented, analysis would need to be carried out on whether a predominantly battery train could deliver the desired services for a specific route in terms of journey times and capacity, and how the battery charging concept would be delivered.

Given that the cost and timescales for delivery of discontinuous electrification to the Wairarapa Connection and Capital Connection is likely to be as prohibitive as full electrification, and that the Rimutaka tunnel would require significant battery capacity, IPEX considers "hub" electrification as the more appropriate.

More background detail on this solution is in Appendix 3.

3.3 Battery

3.3.1 Background

Battery technology is developing rapidly; energy storage capacity is increasing, and weight and cost are reducing. The continuous development of battery technology over the last decade has meant an inherent annual growth rate of between 5 and 8% in gravimetric energy density – power-to-weight ratio – providing more power from smaller scale units. Figure 3 shows the evolution of key battery performance criteria, against an example requirement of 50 km "off-wire" range.

Figure 3. Evolution of key battery performance criteria

Battery traction technology is relatively new for heavy rail, though it has been used commonly on light rail for decades. Most major rolling stock manufacturers offer light rail vehicles which are able to operate "off-wire" through the provision of traction batteries and charging technology.

Manufacturers including Alstom, CAF, Hitachi, Siemens, and Stadler, have transferred the mature learning from the light rail industry to their heavy rail products, enabling a much sharper learning curve.

IPEX has considered the developments in recent years, the solutions currently in progress, and those being offered on the market today.

In the UK in 2015, Bombardier trialled the Independently Powered EMU (IPEMU), fitting batteries to a Class 379 Electrostar[3]. The IPEMU was designed with a target range of 30 km, followed by sustained running under OLE to recharge the batteries for a distance of approximately 50 km.

In Japan, Hitachi has developed a heavy rail battery-electric train for use in passenger service[4]. The JR Kyushu Series BEC819 can run on non-electrified sections of track, for up to 50 km.

Hitachi has also recently signed an agreement with Hyperdrive Innovation to develop battery packs for rolling stock[5]. Hitachi believes the batteries could be installed on its fleets in the UK, and has signed an agreement with train operator Great Western Railway (GWR) to introduce batteries to its Class 802 fleet[6]. Hitachi claims trains could operate for up to 90 km on battery power.

In 2019, Stadler won an order to supply battery-powered trains to Germany[7], claiming an off-wire range of up to 150 km, and has since proven capability of up to 185 km during testing[8]. In the UK, Stadler is supplying Transport for Wales Rail with battery-electric tram-trains and tri-mode multiple units with diesel, electric, and battery traction technology[9].

Battery rolling stock is not currently operated in New Zealand. In 2017, Auckland Council approved an order for 15 battery EMUs (B-EMU) due to replace DMUs on suburban services to Pukekohe. However, an

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[3] Rail Technology Magazine. "Prototype battery-powered 'IPEMU' carries passengers for first time". 13 Jan 2015. https://www.railtechnologymagazine.com/Rail-News/prototype-battery-powered-ipemu-carries-passengers-for-first-time Accessed Feb 2021.

[4] Modern Railways Insight. "Building better battery trains". 29 Jan 2018. https://www.modernrailwaysinsight.com/view_article.asp?ID=3848 Accessed Feb 2021.

[5] Hyperdrive. "Hitachi Rail and Hyperdrive agreement opens way for battery trains across Britain". 6 Jul 2020. https://hyperdriveinnovation.com/insights/news/hitachi-rail-and-hyperdrive-agreement-opens-way-for-battery-trains-across-britain/ Accessed Feb 2021.

[6] Hitachi. "Hitachi and Eversholt Rail to develop GWR intercity battery hybrid train - offering fuel savings of more than 20%". 15 Dec 2020. http://www.hitachi.com/New/cnews/month/2020/12/201216b.html Accessed Feb 2021.

[7] Stadler. "Stadler supplies 55 battery-operated FLIRT trains for the Schleswig-Holstein local transport association". 2 Jul 2019. https://www.stadlerrail.com/en/media/article/stadler-supplies-55-battery-operated-flirt-trains-for-theschleswig-holstein-local-transport-association/522/ Accessed Feb 2021.

[8] Stadler. "185-Kilometre Range: Stadler Successfully Concludes "Battery Technology" Research Project with the FLIRT Akku". 30 Mar 21. https://www.stadlerrail.com/media/pdf/2021_03_30_media_release_stadler%20concludes%20flirt%20akku%20battery%20research%20projetc%20with%20proven%20range%20of%20185%20km.pdf Accessed 20 Apr 21.

[9] RailTech. "Stadler will supply battery-powered tram-trains to Wales". 1 Mar 2019. https://www.railtech.com/rolling-stock/2019/03/01/stadler-will-supply-battery-powered-tram-trains-to-wales/ Accessed Feb 2021.

agreement was reached between city administration and national government to instead electrify the line, and the order of rolling stock changed to pure EMUs[10].

The use of batteries in rail has been proven, and both new and converted battery trains are available on the market. The range capabilities vary from 30 to 185 km, and are likely to increase as battery technology develops further.

At present a B-EMU would be suited to discontinuous electrification or routes where diesel trains currently spend considerable time under the OLE, enabling a low-carbon alternative to current bi-mode multiple units with diesel engines. This approach could be taken in the Wellington region where the Wairarapa Connection runs under the wires from Wellington to Upper Hutt (32 km) and the Capital Connection from Wellington to Waikanae (55 km), before working over non-electrified sections (Upper Hutt to Masterton at 59 km and Waikanae to Palmerston North at 81 km). Given the off-wire range capabilities claimed by manufacturers in recent developments, it is possible that batteries could provide emissions-free operation on these routes, possibly supported by appropriately located infrastructure charging points.

However, there are some challenges with this solution. For a route without OLE, investment would be required to construct electrification, be that majority or hub. The whole life cost of batteries and their renewal have not yet been fully validated through real-world application in passenger service across a 35-year train life. Procuring new rolling stock would require investment although conversion of an existing EMU may require sacrifice of saloon space if the batteries could not be fitted to the underframe. Additionally, a detailed assessment of battery charging, including the method and impacts, would need to be considered. For a B-EMU, it is possible that this could be carried out while running under OLE, however, the time available to draw power from the wires would vary depending on the route and level of electrification. A full picture of how this would work in practice is not yet clear.

3.3.2 Rolling stock options

Tri-mode (1,600V DC + battery + CI generator)

This option constitutes the baseline tri-mode 1,600V DC + battery + CI generator multiple unit (TMU) where the rolling stock utilises the existing wires and then uses battery and a combustion ignition (CI) generator for the rest of the journey, requiring no infrastructure changes. Modern diesel emissions standards are significantly lower than those of the existing fleet which pre-date any standards. The Euro Stage V emissions standards become mandatory this year (2021) so any new rolling stock will utilise compliant engines. Emissions from the non-electrified section could be further improved with the use of alternative fuels.

The rolling stock options for this infrastructure solution could also include second hand DMUs, new DMUs, and Battery-DMUs although none of these would benefit from using the existing overhead wires. However, some manufacturers have removed diesel engine vehicles from their portfolios. As these have a greater emissions impact, these are not considered feasible.

[10] Railway Gazette. "Auckland awards P2P electrification contract". 7 Oct 2020. https://www.railwaygazette.com/infrastructure/auckland-awards-p2p-electrification-contract/57529.article Accessed April 2021.

Tri-mode 1600 V DC (electric traction + battery + CI generator)

This option is similar to the baseline case, but will utilise the additional electrification so the requirements of battery and CI generator as secondary and tertiary power sources to bridge gaps in electrification will not be as significant. This should result in cheaper rolling stock with less space taken up by traction equipment. The tri-mode capability will provide the highest resilience, but is not emissions-free.

Tri-mode 25 kV (electric traction + battery + CI generator)

This option is also similar to the baseline case, and like the above option will utilise the additional electrification so the requirements of battery and CI generator as secondary and tertiary power sources will not be as significant. The difference being that the hub electrification is supplied with 25 kV AC instead of 1600 V DC.

B-EMU 1600 V DC (electric traction + battery)

This option would utilise the additional electrification and remove the CI generator engine for a zero-carbon solution, relying solely on battery to provide off-wire capability. This is optimal for reducing emissions if sufficient recharging capability can be achieved.

B-EMU dual voltage (electric traction + battery)

This zero-carbon option would offer the capability of operating under both 1600 V DC and 25 kV AC electrification, with a battery to provide off-wire capability. In the initial assessment it was unknown whether manufacturers could offer dual voltage and a secondary traction source, and was included as part of the market sounding exercise.

3.4 Hydrogen

Hydrogen multiple unit Hydrogen locomotive and LHCS

The application of hydrogen in industry is growing, as is the ambition and innovation to implement it as a sustainable energy solution. In rail there have been a number of notable developments in recent years.

In the UK, rolling stock leasing company Porterbrook and the University of Birmingham have produced the "HydroFLEX" – a converted Class 319 dual voltage train fitted with a hydrogen fuel cell enabling it to run purely on hydrogen on non-electrified routes. In 2020, the unit began operational mainline testing following two years of development[11].

[11] Porterbrook. "UK's First Hydrogen Train takes to the Mainline". 30 Sep 2020. https://www.porterbrook.co.uk/news/uks-first-hydrogen-train-takes-to-the-mainline Accessed Feb 2021.

This success followed developments in mainland Europe, where the hydrogen fuel cell powered Alstom Coradia iLint entered passenger service in Austria[12]. In comparison to the HydroFLEX, the iLint is a relatively experienced product, as it has been trialled in passenger service in Germany for two years, serving a 100 km route and operating 180,000 km in total. Alstom claims the iLint is capable of travelling at 140 km/h and operating 1,000 km on one tank of fuel.

Alstom has also partnered with rolling stock leasing company Eversholt Rail in the UK to develop the Class 600 "Breeze" hydrogen train[13]. The Breeze is a converted Class 321 EMU fitted with hydrogen fuel cells which enable it to operate under self-power. Alstom is confident with the progress of the project, offering the Breeze for immediate orders, and claims to be in discussions with several operators and stakeholders to secure fleet deployments. However, the Breeze currently has some limitations in that the necessary equipment for hydrogen traction requires a large amount of space, occupying the first third of each driving vehicle. Additionally, any orders would require an accompanying supply of hydrogen and investment in associated infrastructure.

In addition to the successful trials, several operators and manufacturers have recently made announcements supporting a hydrogen future. In Italy, Alstom is to supply operator Ferrovie Nord Milano with six hydrogen fuel cell powered multiple-units from 2023[14]. In Germany, Deutsche Bahn and Siemens Mobility are to trial a hydrogen train in passenger service, along with a green hydrogen fuelling plant, from 2024[15]. Spanish manufacturers Talgo and CAF have both separately announced plans to construct hydrogen powered trains, with Talgo aiming for its product to be ready by 2023[16], and CAF leading a consortium of parties to develop a train by 2025[17].

New Zealand is taking steps towards hydrogen use. In 2019, the New Zealand Government's *a vision for hydrogen in New Zealand* green paper[18] set out the ambition to become a national and international green hydrogen producer. In line with this, there are production facilities at Taranaki; a production and refuelling facility is to be built by Ports of Auckland, while also developing hydrogen fuel cell vehicles with Auckland Transport and KiwiRail; and the Tuaropaki Trust is constructing a geothermal hydrogen production facility with Obayashi Corporation of Japan. Outside of rail, Auckland Transport unveiled New Zealand's first hydrogen bus in March 2021, in line with the organisation's transition to an emissions-free fleet[19]. The bus

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[12] Alstom. "Alstom's hydrogen train enters regular passenger service in Austria". 11 Sep 2020. https://www.alstom.com/press-releases-news/2020/9/alstoms-hydrogen-train-enters-regular-passenger-service-austria Accessed Feb 2021.
[13] Alstom. "Alstom and Eversholt Rail unveil a new hydrogen train design for the UK". 7 Jan 2019. https://www.alstom.com/press-releases-news/2019/1/alstom-and-eversholt-rail-unveil-new-hydrogen-train-design-uk Accessed Feb 2021.
[14] Railway Gazette. "Italian operator orders hydrogen fuel cell trains". 26 Nov 2020. https://www.railwaygazette.com/traction-and-rolling-stock/italian-operator-orders-hydrogen-fuel-cell-trains/57888.article Accessed Feb 2021.
[15] Deutsche Welle. "Deutsche Bahn, Siemens launch hydrogen trains trial". 24 Nov 2020. https://www.dw.com/en/deutsche-bahn-siemens-launch-hydrogen-trains-trial/a-55716107 Accessed Feb 2021.
[16] Talgo. "Talgo will have its hydrogen train ready in 2023". 19 Nov 2020. https://www.talgo.com/es/-/talgo-tendra-listo-su-tren-de-hidrogeno-en-2023/ Accessed Feb 2021.
[17] Railway Gazette. "Hydrogen fuel cell train to be developed with EU funding". 4 Nov 2020. https://www.railwaygazette.com/technology/hydrogen-fuel-cell-train-to-be-developed-with-eu-funding/57731.article Accessed Feb 2021.
[18] *a vision for hydrogen in New Zealand* green paper, New Zealand Government, Wellington, Sept 2019, accessed 19 Feb 2021 from https://www.beehive.govt.nz/sites/default/files/2019-09/Hydrogen%20Discussion%20Paper.pdf
[19] Auckland Transport. "New Zealand's first hydrogen fuel cell bus unveiled" 30 Mar 2021. https://at.govt.nz/about-us/news-events/new-zealand-s-first-hydrogen-fuel-cell-bus-unveiled/ Accessed 19 Apr 2021

will be used to trial operational performance and understand operating costs compared to diesel and electric buses of similar configurations.

In the green paper, the Government envisages that the use of hydrogen trains, in conjunction with partial electrification, is an option to replace non-electrified operations. The Wellington region is an area with potential for this with routes of 59-81 km of non-electrified railway where self-power is required. Rolling stock manufacturers claim that hydrogen trains are capable of operating up to 1,000 km under self-power which would likely be sufficient for a typical daily diagram of services.

Hydrogen trains have potential to bring many benefits to the railway, however, there are challenges in their application. According to a study by UK rail infrastructure manager, Network Rail, for a specified range, hydrogen trains require approximately eight times the storage volume of fuel, using 350 bar storage equipment, compared to diesel. This means that saloon space is likely to be compromised, especially for longer ranges. Increasing storage pressure beyond 350 bar is possible but extremely complex because current systems are designed for 350 bar and increasing pressure does not proportionally increase the amount of hydrogen capacity (as pressure increases the volumetric density decreases).

Currently, there are no plans for hydrogen trains powerful enough for use in freight or capable of 200 km/h speeds. The maximum speed offered on the market today is 145 km/h. This is likely to prevent hydrogen from helping to decarbonise freight or high speed services in its current state.

For successful fleet deployment, a suitable source of hydrogen must be identified or constructed, and an appropriate method, system and plan for refuelling developed. This is likely to require new infrastructure to be built across the area of operation, including at rolling stock depots.

IPEX considers that hydrogen is not currently a feasible option for the Wairarapa Connection and Capital Connection due to the immaturity of the technology and the challenges of implementation:

- The multiple units currently operating are built to the wider Bern (European) loading gauge.
- The technology is currently insufficiently miniaturised to enable it to be mounted underfloor for New Zealand gauged rolling stock, which then requires the equipment to take up valuable passenger space.
- However much the equipment is miniaturised, the hydrogen storage volume is unlikely to change as to do so requires increasing the pressure in the tank.
- Although hydrogen production is being installed in New Zealand, new rolling stock charging facilities would be needed, with potential for additional legislative requirements for storing hydrogen on railway sites.
- A new supply chain would need to be established to deliver the hydrogen to the charging site(s).
- New safety cases would be required demonstrating safe operation and also covering public perceived safety concerns, particularly for sections such as the Rimutaka tunnel.

However, it is highly likely that hydrogen technology will be deployed onto the railways in the future, particularly to decarbonise the long non-electrified sections of the NIMT and South Island, but the technology, its distribution, and economies of scale for rail use are not mature enough yet for this project, and hydrogen development may be better focussed currently on the higher polluting transport modes such as roads and shipping.

It is expected, that when the current AK carriages or the locomotive traction requires replacement in approximately 10-15 years, hydrogen technology will have matured to a stage where this becomes a compelling option.

3.5 Multi-mode locomotives and carriages

3.5.1 Refurbished existing rolling stock

The current Wairarapa Connection and Capital Connection is served with locomotives and carriages (locomotive hauled coaching stock, or LHCS).

The carriages were constructed by British Rail in the 1970s where they were categorised as Mk2D, Mk2E, and Mk2F. Following withdrawal in the late 1990s and early 2000s, they were exported to New Zealand where they underwent varying levels of overhaul before being placed into service. The S carriages had little done to the body or structural members and are considered as life expired. The SW carriages were significantly rebuilt with a new window ladder design, new doors, a new body skin, and on some vehicles, new structural members. However, they are now life expired and show significant signs of wear and corrosion. Any refurbishment would need to be so extensive that the life extension would not outweigh the cost, and new rolling stock would undoubtedly have a higher cost benefit ratio.

The services use DFB locomotives, the superstructure of which dates from the 1970s and the engines from the early 1990s. In 2007 they were fitted with the Brightstar engine management system. These locomotives are therefore 50 years old, with 30-year-old engines pre-dating emissions standards, and with locomotive hauling of passenger trains often being inefficient, these locomotives have passed their useful life for regional commuter passenger services.

Refurbishing of these fleets would be costly with extended timescales and would still not result in useful life of 35-year life attainable with new build.

3.5.2 New locomotives and locomotive-hauled coaching stock (LHCS)

3.5.2.1 New locomotives

Multi-mode locomotives are relatively common with two and more electrical systems, and in some cases diesel. However, locomotives fitted with batteries, although common in shunting, is an uncommon solution for mainline operations and has only recently been contractualised in the procurement of a fleet of 25 kV AC + battery + diesel tri-mode Class 93 locomotives by Rail Operations Group (ROG) in the UK. These locomotives utilise the overhead line for mainline, higher speed, working, the diesel engine for the trip working along branch lines to the freight terminal, and “last mile” battery for movements in the terminals. Any consideration of tri-mode locomotives for the operations envisaged would be a step further than this recent procurement, with the usual additional pressures of first in class extended timescales.

In general, the use of locomotives has been discarded due to:

- inefficient operation unless multiple working locomotives are procured with driving trailers;

- fuel consumption can be higher than multiple units; and
- track wear costs are higher than multiple units.

However, it is known that the New Zealand Government made funding commitments of $1.2 billion in its 2020 budget which includes the procurement of new locomotives for KiwiRail.

> *Enables KiwiRail to continue its locomotive replacement programme and is expected to cover:*
>
> *10 new main line locomotives for the North Island*
>
> *The first tranche (25) of new mainline locos for the South Island – replacing 48-year-old locos*
>
> *10 electric/battery powered shunting vehicles for rail depots – new green technology replacing old diesels*
>
> *The first tranche of 20 short haul locos*
>
> *The first locos are expected to arrive in New Zealand in late 2022/early 2023.*[20]

It is understood that in addition to the battery shunters, investigations are being made into bi-mode and tri-mode locomotives. Should KiwiRail propose to procure new low emission locomotives, it may be beneficial to use this opportunity to procure additional locomotive hauled coaching stock for a lower investment cost than multiple units.

Diesel locomotives

The use of diesel locomotives, even with more modern locomotives, such as the DL class, is particularly inefficient and results in higher emissions than could be achieved with any other option.

1600 V DC Tri-mode or Bi-mode locomotives

In both cases, it is likely the use of diesel would be significantly higher with locomotives than would be the case with multiple units as the battery would be smaller for the resultant traction demand, resulting in higher emissions.

Dual voltage Tri-mode or Bi-mode locomotives

[20] *How KiwiRail will spend its $1.2b rail investment*, Infrastructure News New Zealand, 18 May 2020, accessed April 2021, https://www.infrastructurenews.co.nz/kiwirail-will-spend-1-2b-rail-investment/

In both cases, it is likely the use of diesel would be significantly higher with locomotives than would be the case with multiple units as the battery would be smaller for the resultant traction demand, resulting in higher emissions.

25 kV AC Tri-mode or Bi-mode locomotives

These options either result in the locomotive using diesel under the extant 1600 V DC or re-electrifying the 1600 V DC to 25 kV AC. In both cases, the use of diesel would be significantly higher with locomotives than would be the case with multiple units, resulting in higher emissions.

3.5.2.2 New locomotive hauled coaching stock (LHCS)

Procurement of new carriages would almost certainly need to be a bespoke build. The last carriages built for New Zealand, the AK class for the Great Journeys of New Zealand, were built at the Hillside Workshops in Dunedin, on the South Island. This workshop has just been through almost complete closure before being rescued by Crown investment so may need further works before being in a position to offer such large-scale engineering services It is possible that further of these carriages could be built and may be the most efficient way to procure now LHCS, although the external market may also show interest. Further British rolling stock is not available as all the carriages built after the Mk2s are 23m long, rather than 20m, and will not fit the New Zealand kinematic envelope.

3.6 Alternative fuels

The use of alternative fuels is an effective way to reduce the emissions from diesel engines. This is an option which could be used in the Wellington region if the rolling stock relies on a diesel engine in some way. IPEX has considered a number of options available on the market today.

3.6.1 Gas to liquid (GTL)

Gas to liquid (GTL) fuel is a diesel substitute derived from natural gas and can be used with existing diesel infrastructure with no modification. Infrastructure can be returned to diesel use if required with no modification.

Table 1. GTL emissions reduction

Emissions type	Average reduction	Reduction at idling
NOx	6%	22%
Hydro-carbons	11%	21%
Carbon monoxide	14%	32%
Particulate matter	28%	-
Smoke number	Up to 54%	-

Tests on a locomotive in Germany conducted according to ISO 8178-4 produced the results as shown in Table 1[21]. The reduction in idling is key as it is when idling, such as in stations and maintenance depots, that the emissions come into most contact with people.

GTL has a higher energy per kg compared to diesel fuel but is less dense, so the energy per litre equates with that for diesel. It is hydrophobic so generally is unlikely to have bacterial problems experienced with other fuels. It has been approved for use in MTU and Caterpillar engines. It is currently more expensive than diesel fuel, but this could reduce with higher volume purchases.

3.6.2 Dual-fuel

In the UK, through the Rail Safety and Standards Board (RSSB) Powertrain research funding, G-Volution has proposed a solution for a dual-fuel modification to diesel multiple units[22]. The modification requires the installation of additional fuel tanks and control technology which enables the engine to be fuelled both with diesel and natural gas.

The control system determines the fuel mix for greatest economy and lowest emissions. G-Volution has a design for dual-fuel railway vehicles and has fitted locomotives successfully in the USA.

G-Volution believes the technology can be fitted to any multiple unit or locomotive, and is collaborating with UK train operator Grand Central and UK ROSCO Angel Trains to trial the system on a Class 180 DMU. The system does require infrastructure modifications to provide fuel supply tanks at maintenance facilities and will require type approval to enable the units to run with gas tanks added to the underframe. G-Volution has done sufficient research to believe these hurdles can be overcome and approval will be granted.

3.6.3 Hydro-treated vegetable oil (HVO)

HVO is a more recent development in alternative fuels. DB Cargo UK has successfully trialled the use of HVO to fuel Class 60, 66 and 77 diesel locomotives[23]. DB Cargo UK estimates that replacing diesel with 100% renewable HVO can reduce a train's carbon emissions by as much as 90%, and believes that HVO made through the hydro-treatment of vegetable oils or animal fats can be a viable alternative to diesel. See section 4 for further details on emissions.

While this has successfully been proven as a trial, it is currently unclear how the use of HVO would work in practice. Further consideration would need to be given to any infrastructure requirements, rolling stock modification requirements, operational impacts, and the cost implications of using HVO over diesel.

3.7 Other options

Other alternative traction options not considered sufficiently mature are summarised in Appendix 4.

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[21] Tests conducted according to ISO 8178-4 Reciprocating internal combustion engines -- Exhaust emission measurement -- Part 4: Steady-state test cycles for different engine applications Engine dynamometer tests and operational trial of Shell GTL fuel, Deutsche Bahn & Shell Global Solutions, April 2015

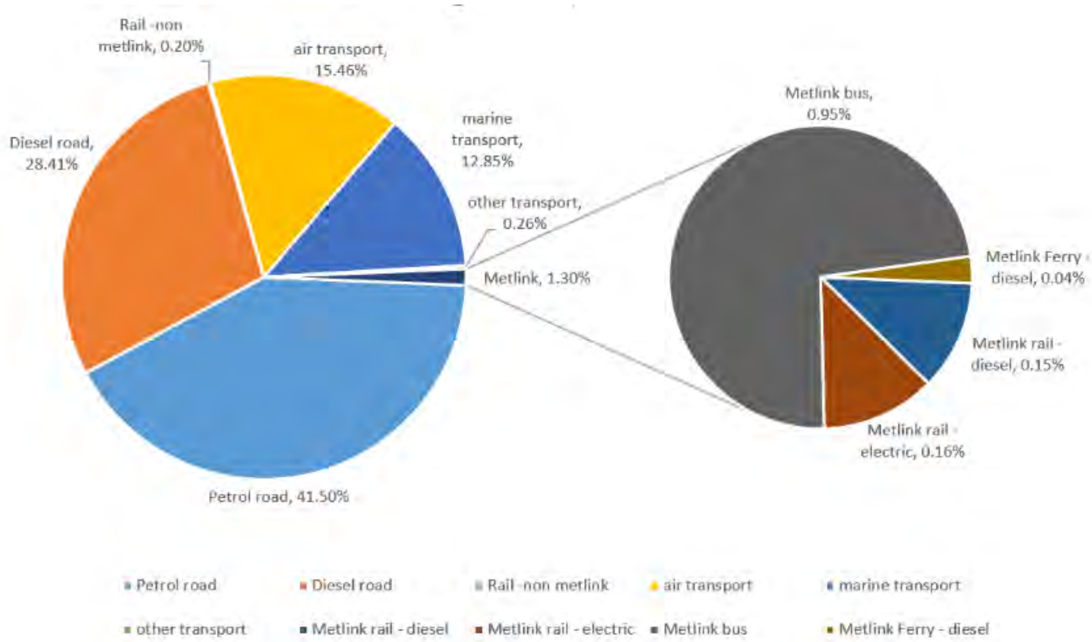
[22] RSSB. Powertrain: Dual fuel technology for improving operating costs and emissions from DMU (SC04-POT-17).

[23] DB Cargo UK. "DB Cargo UK and Tata Steel collaborate on decarbonisation". https://uk.dbcargo.com/rail-uk-en/metaNavi/news/DB-Cargo-UK-and-Tata-Steel-collaborate-on-decarbonisation-5952504 Accessed Feb 2021.

4 Emissions

GWRC provided historical emissions data which highlights that road transport is the highest emitting activity within the Wellington area. Wellington transport emissions in 2019 equate to 1,635kt CO_2e / year. Wairarapa and Capital Connect emissions in 2019 account for 2.9kt CO_2e / year. Therefore, modal shift from road to rail regardless of the train's propulsion mode would greatly reduce emissions per passenger km travelled.

Figure 4 Wellington CO2 transport emissions: percentages attributed to each sector



IPEX has conducted an initial analysis of predicted CO_2 emissions at point of use for the most likely and suitable rolling stock options, along with comparators, based on diesel engine emissions data, Greater Wellington region routes and services information, and assumptions around alternative traction capability. The analysis breakdown has been documented in the IPEX A3 report as part of the whole of life cost modelling for the proposed rolling stock options.

The traction source split for the rolling stock options is summarised below.

Table 2 Traction source splits per option

Description	Legacy diesel	B-DMU	Trimode	B-EMU + partial electrification 25kV	EMU + electrification 25kV
OLE	0%	0%	38%	43%	100%

Description	Legacy diesel	B-DMU	Trimode	B-EMU + partial electrification 25kV	EMU + electrification 25kV
Diesel	100%	65%	26%	0%	0%
Battery	0%	35%	35%	57%	0%

2.85 kg of CO_2 is emitted per mile travelled in a standard DMU. To calculate the CO_2 per year from diesel for each option, the emission is scaled by the proportion of the total annual miles utilising diesel. The second component is the CO_2 from the production of the electricity for the overhead lines. 0.0074 kg of CO_2 is emitted for every kWh of electricity generated. This is from the carbon footprint 2019 data source[24].

However, there is the New Zealand target of total renewable energy by 2035. This is assumed to be CO_2 no emissions from electricity generation. Therefore, the emission value from the grid has been progressively reduced to 0 kg of CO_2 / kWh in 2035 in the whole life cost modelling. The representative year value of electricity emissions is scaled to the proportion of annual miles utilising the overhead lines for each option,

By providing the cumulative total over the 35-year life of the assets, a total is provided which provides the comparison between the options.

Table 3 Carbon emissions based on whole life cost model

Carbon emissions based on V4 timetable aspirations	Legacy diesel	B-DMU	Trimode	B-EMU + partial electrification 25kV	EMU + electrification 25kV
Mt CO_2 e / 35 year	1.935	0.222	0.067	0	0

5 Other emissions

In addition to CO2, there are other pollutants which contribute to the air quality in the Wellington region, including greenhouse gases such as carbon monoxide (CO) and nitrous oxide (NOx), as well as particulate matter (PM).

Many rail engine manufacturers build their products to comply with emissions regulations currently enforced by European Commission Directive 97/68/EC *(emission of gaseous and particulate pollutants from internal*

[24] Grid Electricity Emissions Factors v1.0 – June 2019, https://www.carbonfootprint.com/docs/2019_06_emissions_factors_sources_for_2019_electricity.pdf

combustion engines to be installed in non-road mobile machinery). This directive sets out the current diesel emissions category for “railcars” (diesel trains) as Stage V, enforced from 2021. In this directive, Stage V standard limits are placed on CO, NOx, and PM, as detailed in Table 8.

Table 4 Emissions limits for Stage V Railcar diesel engines

Category	CO (g/kWh)	NOx (g/kWh)	PM (g/kWh)
RLR-v/c-1 (Railcars)	3.50	2.00	0.015

Currently, legacy diesel trains do not have to comply to strict limits on these pollutants, especially regarding particulate matter, where Stage V enforces filtration down to microns. The introduction of new trains with Stage V compliant engines would realise benefits of a reduction in not only CO2 but also these pollutants, and in turn a subsequent improvement in air quality.

6 Market sounding

IPEX and RPS invited a number of rolling stock manufacturers to participate in a market sounding process. 13 manufacturers were contacted. One declined, four did not reply, and eight submitted responses. Detailed responses are in Appendix 6, with the key findings being as outlined below.

- The consensus solution was for a battery-EMU (B-EMU).
- Responses varied regarding the off-wire range capability although a range of 70-80 km was stated as being achievable by most manufacturers using batteries.
- Hydrogen range was stated as sufficient to complete at least a day’s service before refuelling. However, only Alston and Stadler offered hydrogen products, and CAF are starting a 5-10 year development programme for hydrogen trains
- Manufacturers indicated an average of 35 months for the first unit and a total of 53 months for the full fleet delivery from contract award based on a fleet of 15-20 units.
- All manufacturers have prior experience of low-emission or emission free rolling stock although only Alstom have a production hydrogen train, and CAF’s experience to date is limited to light rail vehicles (although they did bid B-EMUs for Auckland).
- The commentary did highlight the current KiwiRail tender for locomotives for a potential national platform standard to be produced across New Zealand.

The market sounding has provided useful data in demonstrating that any B-EMU solution will need charging overhead at the Masterton and Palmerston North

It has also demonstrated that hydrogen cannot be considered currently as there is insufficient technology maturity to ensure a competitive tendering process.

An additional question was posed to the market in relation to providing provision for 25kV use in the initial design of the baseline tri-mode (1600V DC + battery + CI generator). Responses indicated that there is currently no proven method of fitting all the necessary equipment for dual voltage on top of engines and battery equipment on a 4-car narrow gauge consist. Whilst this option does plan for a transition should 25kV electrification be installed in future years, the weak argument in the overall cost benefit has been further explored in the options assessment of DBC.

7 Conclusions

There will be sufficient competition for a procurement exercise by GWRC to be successful.

Full electrification, which results in an electric multiple unit, (single or dual voltage), is likely to be an expensive option.

Hydrogen fuel may well be a compelling option for the NIMT or South Island in a few years' time should electrification not progressed, but has been rejected from this study due to:

- the timescales involved in providing supporting infrastructure;
- the maturity of green hydrogen production in New Zealand;
- the immaturity of the technology on trains; and
- the lack of competition in the market.

IPEX considers the baseline option as a tri-mode (TMU) using 1,600 V DC + battery + CI generator using the existing infrastructure, but further analysis should be carried out on the battery-EMU (B-EMU) option, particularly as all manufacturers will offer such a solution.

The B-EMU case is compelling if it can be demonstrated that the range of such a unit would enable charging only at Masterton and Palmerston North. Electrification costing, performance modelling, charging time, timetable modelling, and the detailed business case is required to determine the preference for a tri-mode which can be converted to a B-EMU or to erect electrification and procure a B-EMU.

The preferred rolling stock solution is likely to be a multiple unit. Distributed traction is preferred for modern passenger rolling stock, particularly where it mixes with commuter and suburban services where higher acceleration and deceleration rates are required. It also results in lower track forces, thus reducing track wear and maintenance costs. It does not require either running round or a driving trailer at the other end as required with locomotives that either results in operational inefficiency or a bespoke vehicle.

However, the locomotive options (battery diesel hybrid or battery-diesel-electric tri mode) discussed by Stadler could be advantageous if procured as part of a national platform for KiwiRail and discussions with KiwiRail are recommended to determine if a more economically attractive solution can be derived from a combined national locomotive and carriage procurement exercise. The assumption has been taken that the benefits of multiple unit usage as outlined in this report coupled with the project timescales for delivering the new fleet to the Manawatu and Wairarapa would deem this option an unlikely avenue to pursue.

Appendix 1. Definitions, abbreviations, and acronyms

Acronym	Definition	Meaning
AC	Alternating current	
B-DMU	Battery-diesel multiple unit	A hybrid diesel multiple unit with mechanical drive with a motor, connected to a battery, mounted between the engine and gearbox. The motor can use battery power to either provide additional power or be used stand-alone for a short range. The motor is used as a generator in braking to capture regenerative braking.
B-EMU	Battery-electric multiple unit	An electric multiple unit with an additional battery power source to provide self-power capability
BMU	Bi-mode[25] multiple unit	An electric multiple unit with self-power provided with a diesel generator
DBC	Detailed business case	The scope of this project
DC	Direct current	
DMU	Diesel multiple unit	Diesel multiple unit with either mechanical or hydraulic drive (sometimes separated into DMMU and DHMU)
EMU	Electric multiple unit	A fixed formation train taking traction power from overhead wires
GTL	Gas to liquid fuel	A diesel substitute
GWRC	Greater Wellington Regional Council	The Client
HMU	Hydrogen multiple unit	A Battery-EMU which utilises a hydrogen fuel cell to provide a self-power electricity supply
HVO	Hydrogenated vegetable oil	A diesel substitute
IBC	Initial business case	The 2019 *310200204 191202 Lower North Island Longer-Distance Rolling Stock Business Case - Final*
LHCS	Locomotive hauled coaching stock	Carriages fitted with drawgear to enable operation with a head end traction source.
MU	Multiple unit	A semi-permanently coupled number of vehicles with a driving cab at each end which together form a unit. A single multiple unit, or several multiple units coupled together, form a train.
NIMT	North Island Main Trunk	The mainline railway between Wellington and Auckland
NZTA	New Zealand Transport Authority	The transport regulator of New Zealand
TMU	Tri-mode multiple unit	Electric + battery + diesel multiple unit

[25] The IBC uses the acronym "DMMU" to mean dual mode multiple unit. However, the generally accepted term for such rolling stock is a bi-mode multiple unit (BMU). The term DMMU has been used since the early 1960s to mean diesel mechanical multiple unit (to differentiate from DHMU diesel hydraulic, and DEMU diesel electric). Use of DMMU to a manufacturer may cause confusion.

Appendix 2. IPEX Industry Insight Discontinuous electrification

The recent cull in electrification projects in the UK has seen a rise in the exploration of alternatives, particularly alternative fuels. Although this is an attractive option, types of discontinuous electrification may be a better, and longer term, solution. IPEX has recently run several projects working to develop strategies for long term alternatives. In the next two IPEX Industry Insights, we aim to discuss two types of discontinuous electrification, examining the cases for: majority electrification with gaps only employed where infrastructure issues are costly or insurmountable; and electrification hubs with considerable distances without electrification using battery power to bridge the gaps.

Reducing railway electrification costs

Electric trains have several significant advantages over diesel trains.

In particular, the size, weight, complexity and maintenance costs of an electric train's on-board power equipment is typically much less than that of a diesel train with comparable performance. Their impact on the environment and the travelling public is also kinder.

The National Grid enables appropriate technologies and processes to be used to minimise the cost of electricity in both economic and environmental terms, and railway electrification passes these benefits on to the trains that use it. However, the investment needed to install the necessary railway electrification infrastructure is huge, and this reality continues to prevent the majority of the UK network from being electrified.

Much-needed electrification schemes can be rendered unviable because of the disproportionate cost of infrastructure clearance work. For example, if a bridge is below a certain height and the track cannot be lowered, it may need to be demolished and completely rebuilt.

One way to reduce infrastructure clearance costs is to leave gaps in the overhead line equipment (OLE) where non-compliant structures exist, and use on-board energy storage systems to power trains across these gaps. This concept is known as 'discontinuous electrification'.

Examples of discontinuous electrification schemes

The diagrams below provide three examples of discontinuous electrification schemes. The scenario is a branch line off an electrified part of the main rail network, such as the Windermere branch. In this hypothetical example, there are two low bridges over the line, which would require difficult and expensive work to enable electrification. The '£' symbols represent the money spent installing the electrification.

In the first solution, the electricity is carried all the way to the end of the route, but the OLE is absent through and between the bridges and replaced by a buried cable. This approach is only viable if the trains have sufficient battery autonomy to run the length of the gap.

It would be possible to install OLE between the bridges but, in this example, it is assumed that the distance between them is too short for this to be appropriate.

The second scheme shows an alternative approach. In this, the high cost of rebuilding one bridge is justified because it enables the OLE to be run all the way to the second bridge, at which point it ends completely, thus saving the cost of any further OLE and buried cable. This approach is only viable if the trains have sufficient battery autonomy to run the twice the length of the gap (there and back) and run their auxiliary loads for the whole time, including the station dwell time.

The third scheme shows another alternative. In this, the rebuilding of the first bridge has been avoided by running a neutral section through it. As explained later in this article, this option is typically only feasible for small proportion of structures.

Prior research

In 2009-2010 RSSB (the UK Rail Safety and Standards Board) commissioned a suite of research projects.

- Project T777 concluded that OLE featuring gaps is a feasible proposition that could significantly reduce the cost of electrification.
- Project T778 found no fundamental reason why pantographs cannot be routinely raised at speeds up to 100 mph or more.
- Project T779 concluded that one of the problems with OLE featuring gaps was that the entire fleet of trains would need to be fitted with storage devices, introducing severe constraint on operation. However, it suggested that future technologies may hold a key to make this application possible.

On-board energy storage solutions

Batteries

A suitably sized battery is able to store sufficient energy and produce sufficient power to propel a road or rail vehicle at reasonable speeds over reasonable distances. It can also absorb power (during charging) at a similar rate.

A good example of this application is the electric sightseeing bus produced by the innovative propulsion system developer

Magtec, which is now operating in the city of York, running all day long without charging, with a range of over 70 miles. The new electric drive train with two battery packs easily fits within the space vacated by the diesel engine, transmission and cooling system.

Alternatives

Capacitors are able to charge and discharge at high power levels due to low internal resistance giving them the capability to absorb and redeliver energy very quickly. They are therefore well suited to capturing energy generated during braking, as well as short-term boosting of traction power. Their inherent disadvantage is that they can only store a fraction of the energy that can be stored by a battery of a similar size and weight.

Hydrogen fuel cells could provide a good future solution for diesel replacement on long, lightly used routes. Other emerging energy technologies also present promising prospects. However, on heavily used routes (such as Trans-Pennine) and short non-electrified branches connected to electrified routes (such as the Windermere branch), electrification provides a robust solution that is already available. Such schemes are viable today and will remain viable in the future.

Electrified railways will always benefit from improvements in energy generation and storage technologies as they continuously improve the affordability and sustainability of the electricity supplied by the National Grid.

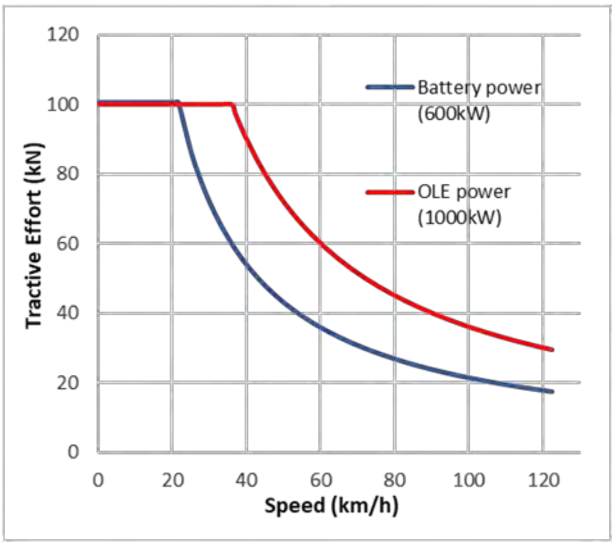
Can it really work?

Power and energy principles

A typical 3-car electric train might weigh in the region of 100 tonnes and accelerate from rest at ca. 1m/s2. To achieve this acceleration, it would require 100kN of tractive effort (TE).

At low speed, power consumption is low because energy is a function of force multiplied by distance, which is only covered slowly at low speed. As speed increases, the rate of delivery of energy (power) to the wheels increases. Once the power limit is reached, the rate of delivery of energy to the wheels cannot increase any further, so the TE has to fall as the speed continues to increase.

The graph illustrates this principle. Two lines are plotted as examples for a hypothetical train that can drive on either battery power or power from the overhead electrified line (OLE). The example train has a lower power rating in battery mode (600kW) than in OLE mode (1000kW).



With 600kW available, the train can accelerate as fast in battery mode as it can in OLE mode up to 6m/s (22km/h). Above that speed, the TE falls in inverse proportion to speed. In OLE mode, the TE only starts to reduce after 10m/s (36km/h).

The energy used per km for acceleration is TE x distance. Therefore, while the TE is at its highest (100kN), the energy usage per kilometre is 100MJ (100kN x 1,000m) or 28kWh. Once the TE starts to reduce, so the energy per km also falls as a result.

Realistic assumption for typical operation

Peak power would only be used for a small proportion of a typical journey. Information obtained from various train manufacturers indicates that a unit weighing in the region of 100 tonnes would typically be expected to use between 6kWh and 10kWh per km in normal service.

Battery capability

Battery manufacturers typically consider a battery to have reached the end of its useful life once its capacity has deteriorated to 80% of its as-new capacity. They recommend that a battery should not be discharged below ca. 10% and caution that the rate at which a battery can accept charge tends to become very low as the charge level approaches 100%. This means that the amount of energy available from a fully charged battery on a train might only be 64% (80% x 80%) of its quoted as-new capacity. On this basis, to ensure that 100kWh of energy would actually be available, the battery specification would need to be 156kWh.

Battery technology is becoming increasingly able to provide well over 100kWh on a 100t train: for example, the electric sightseeing bus mentioned above has a 133kWh battery.

Optimising battery life by managing duty cycle

Another recommendation from battery manufacturers is that the useful life of a battery is significantly reduced if its duty cycle involves repeatedly varying its level of charge by more than ca. 35% of its nominal capacity (for example, from 90% to 55%).

A battery can be recharged at a similar rate (power) to the rate at which it can discharge power. This means that, if a train runs in a non-electrified gap for a period of time, the energy discharged from the battery during that period can be replaced in a similar time period once it returns to the OLE.

For optimization of whole-life cost and performance, the above principles would need to be reflected in the design of a discontinuous electrification system.

Operational Resilience

Trains must be able to operate near-normally in disruption/emergency scenarios, and battery-powered trains are no exception. This means that the battery must have sufficient capacity to get out of any foreseeable adverse scenario, such as the following.

Consider a 100t unit trying to propel a failed unit up a 1 in 40 gradient. Each unit might be laden with 300 people adding 24t per unit. The total weight of the consist would be just under 250t. With 100kN of TE, the acceleration would be 0.4 m/s2 on level track. On a 1 in 40 gradient, the loss of acceleration due to gravity would be one fortieth of the gravitational constant (9.8m/s2), which equates to 0.25m/s2. On a 1 in 40 gradient, the train would therefore accelerate at only 0.15m/s2.

If (for example) the battery power rating were 600kW, the tractive effort of 100kN would be available up to 6m/s, after which it would decline in inverse proportion to speed. At an acceleration rate of 0.15m/s2, 6m/s would be achieved after 40s, during which time the consist would cover 120m.

As explained above, with maximum TE being applied, the energy consumption would be 28kWh per km up to 6m/s, after which it would start to decline in proportion to the declining TE. At 12m/s (43km/h) the TE would be half of 100kN and the rate of energy consumption would therefore be only half of 28kWh/km.

This analysis indicates that, although the energy usage per km would be 28KWh/km initially, it would start to reduce after only 120m, and could be expected to settle at a rate of no more than ca. 15kWh/km.

As explained above, if the battery capacity were 100kWh, a prudent estimate of the energy available would be 64kWh. In this case, the battery would be able to power the consist for at least 3km.

Optimising the system

Rolling stock

Energy storage capability significantly increases the cost of a train and can be difficult to achieve due to space and weight constraints. Therefore, if the number and lengths of gaps in the electrification system is as low as practicable, this helps to reduce the capital and maintenance costs of the trains.

Infrastructure

It is reasonable to assume that the cost per mile of a gap is much less than half of the cost of electrified plain line. However, this is not a good reason to incorporate long gaps in a discontinuous electrification system. The most efficient way to achieve good train performance (acceleration and recovery of braking energy) is to provide as much OLE as is feasible.

As a general rule, gaps should therefore only be used to avoid structure clearance work, but where multiple gaps are necessary, consideration should be given to merging two or more small gaps into fewer, longer gaps, for two reasons:

1. Additional costs are incurred in terminating the OLE before and after gaps.
2. A train requires several seconds to go through the process of separating itself from the conductor and then reconnecting, noting that a pantograph cannot be hurried because of the need to finely control contact force.

Neutral sections can enable OLE to be installed under structures with limited clearance. However, even if the OLE is not energised, significant clearances must be maintained to prevent the OLE or the pantograph from contacting the structure. Allowances must be made for installation tolerances (of both OLE and track), as well as movement of the wire due to pantograph interactions, ice and wind, and of the track due to settlement and tamping. This option is therefore typically only feasible for small proportion of structures.

Compatibility

The scenario discussed above under 'Operational Resilience' illustrates how the basic requirements for the trains and the infrastructure could start to be worked out. For example:

- the battery capacity could be specified in terms of enabling the train to run for a certain distance at maximum tractive effort; and
- the infrastructure could be specified so as to enable such a train to be able to reach an electrified section or a station from any point.

Future-proofing

A train designed to routinely, safely and reliably traverse gaps of, for example, 3-4km today is likely to be able to be upgraded in 5-10 years' time to be able to traverse longer gaps, simply by replacing the battery system with improved technology that is likely to become available in the intervening years.

This realisation should enable manufacturers and electrification planners to focus on specific systems (such as the Trans-Pennine route) in the secure knowledge that, once they have installed a system that today's trains can operate on, they can be sure that it will be more than suitable for tomorrow's trains.

Appendix 3. IPEX Industry Insight – Hub electrification

On 12 February 2018, the Rt. Honourable Jo Johnson, then Minister of State at the Department for Transport, announced a new ambition to "take all diesel-only trains off the track by 2040". This statement, coming after the Government's recent cancellation of several electrification schemes, has encouraged the industry to examine other on-train sources of energy. These have included batteries and super-capacitors, alternative-fuel engines, hydrogen fuel cells, and solar panels, often in combination to form hybrid units. Today, battery energy storage on a two-car DMU could be equivalent to 120 kWh capacity which would provide diesel-free operation of a 100 t (2-car) unit over distances of between 5.5 km and 10 km. Battery storage on a three-car EMU could be sufficient to provide in excess of 40km catenary free running.

Extending electrification is relatively expensive, disruptive to operations and, being fixed infrastructure, reliant to a large extent upon Government funding. This paper explores the opportunity to reduce electrification to a bare minimum, using the rolling stock capability to provide the long-term solution, which can then be funded through means other than the Treasury.

The case against electrification

Electrification enables high-capacity, high-efficiency, high-reliability and low-carbon railway system operation over the long term, with less equipment, complexity and weight on the train. It uses electricity that can be drawn from a variety of sources remote from the railway and optimised separately for available technology, environmental, and capacity requirements. However, the capital cost of electrification works is sufficiently high to be prohibitive in some cases and difficult to justify in business case return timescales.

For a decade or so, the rule of thumb cost of electrification was £1 million per route mile, or £0.6 million per route km. However, the recent electrification of the Great Western Mainline, with the necessary works for clearances, has led to the cost of electrification rising sharply to around £3 million per route km.

Electrification installation is invasive and disruptive, and may even be subject to architectural or aesthetic restrictions (e.g., at Sydney Gardens in Bath). The disruption during electrification works can continue for many years, even when electrification "factory" trains are used, causing disruption to passengers and also to users of other fixed infrastructure such as bridges, which may need to be modified or rebuilt.

Rolling stock hybridisation

The rise in the use of the bi-mode trains (fitted with both electric and diesel traction sources) has been facilitated, in part, by the Government using the Intercity Express Programme (IEP) to reduce electrification schemes in favour of greater reliance on the bi mode capability. Since the ambition stated by Jo Johnson MP to remove diesel-only trains from the GB network by 2040, greater focus has been given to methods to hybridise diesel trains with other energy sources.

The most popular hybridisation is through the use of batteries and it led to MTU developing a power pack comprising a diesel engine and gearbox and an additional generator / motor providing electric traction through the existing drivetrain and battery charging through energy capture from regenerative braking. Both CAF and Stadler now have units available with hybridisation either fitted from new or designed (to a varying degree) to be fitted at a later date. However, if the desire is to reduce pollution through the removal of diesel engines, then a DMU with batteries, or an electro-diesel bi-mode train is arguably a sub-optimal diesel-centric solution.

An alternative approach, where non-electrified line sections can be kept in relative proximity to electrified sections, may be to start with an EMU fitted with energy storage to enable it to bridge gaps in electrification. In 2015 Bombardier trialled the independently powered electric multiple unit (IPEMU) Electrostar over the relatively flat land in East Anglia. The trial, using a 425kWh battery, determined that a range (or gap) of 30 miles (48km) was achievable. Significantly, in 2017, CAF tendered to Auckland Transport a Civity EMU that would operate there and back over an 18.5km branch line (37km total), the line rising 88m in elevation over the 18.5km. Although installed power figures are not available, it was to use SAFT battery modules which come in 212 and 238 kWh modules and the batteries would be fitted on a single vehicle as was done in the case of the Electrostar. What was particularly significant about this milestone was it was a commercially tendered solution, with a manufacturer performance guarantee of 5 years.

Both these examples used batteries to provide the on board energy storage. However, hydrogen is also being offered as a viable solution.

EMU fitted with hydrogen fuel cell

There are various schemes for the use of hydrogen fuel cells on rolling stock. Hydrogen, like electrical batteries, use or store energy created elsewhere. Challenges with hydrogen include the relatively low energy density – some quarter that of diesel when stored under pressure at 700 bar, compounded by the need to store it in cylindrical pressure vessels, which is an inefficient use of space compared to a diesel tank, which can be a space-efficient cuboid, if not shaped to fit the available space envelope on the rolling stock (including the loading gauge). However, like all innovation, such issues are there to be resolved and following the introduction of the fleet of Alstom Coradia iLint EMUs in Germany, Alstom has teamed with Eversholt to create a hydrogen fuel cell powered Class 321 unit as a trial.

EMU fitted with electrical storage

As argued earlier, battery technology development is more advanced, with a range of 40+km already available and this distance will only increase over time with further development. However, the IPEMU trial also demonstrated the criticality of the recharge rate, and sustained running on the electrified line for around 40 minutes was required to recharge the batteries.

More recent work by manufacturers such as CAF and CRRC has seen a rise in super-capacitor use, particularly in light rail and metro applications. These devices can withstand much faster charging than batteries and so could be part of a solution for routes where fast charging is necessary.

The electrification hub

Expanding on the concept, encountered above, of electrification with gaps, the wired section could serve as a 'hub' from which operation on unwired sections could be supported by batteries, charged whilst at the hub. Stations would make good hubs since they are where the train will spend a maximum amount of time (for charging batteries) for a given amount of wired section, and the energy-hungry acceleration away from the station could be on a wired section, turning what would otherwise be a heavy drain on battery charge into extended battery charging instead. Additionally, stations could potentially be "hubs" from which more than one line radiates.

The new electrification would cover the station approaches and the station itself. So, the objective of the electrification scheme would become providing charging of batteries and the removal of reliance on batteries for acceleration away from the station stop.

As the unit enters the wired zone, a passive balise would signal the unit to raise its pantograph, shut off battery power and then close the vacuum circuit breaker (VCB) to draw power from the wire. This could also be achieved manually as is the case with the IEP units but a passive balise is a low cost solution to maximise effective time under the wires. The unit then starts replenishing its batteries, and as it starts braking, the regenerated kinetic energy would also be diverted to the battery recharging circuit. The unit then continues to recharge from the wire whilst at the station stop and as power is retaken for traction to accelerate the train away from the station. As the unit approaches the end of the electrified section, a second passive balise opens the VCB, switches the unit to battery power, and then lowers the pantograph.

In addition, unless the non-electrified section to the terminus is short, it may be necessary also to electrify the terminus station. This could be managed differently, by fitting an auto-coupler arrangement to the buffer stop, enabling the unit to recharge through a special power plug, by "coupling up" in the same manner as coupling to another unit.

The electrification scheme

The electrification would, in general terms, start at the station home signal and continue through to the advance starter, or to the end of the block section in advance of the advance starter.

One of the aspects that has increased electrification costs so significantly is the requirement for increased clearances and the need to raise structures to clear the catenary. Since stations are generally areas that can include a large population of overhead infrastructure, such as footbridges and road bridges, bar contact could be utilised in place of wire and catenary in order to minimise the clearances required from the fixed infrastructure, and remove some of the requirement for invasive modification to such structures.

IPEX is currently in the early stages of developing mapping of the existing electrification, and the potential distances that could be covered by an EMU with battery power (IPEMU). This will provide a map of those routes that can be hub-electrified and so can be considered part of the DMU-free infrastructure. This mapping will then enable the highlighting of those stations at which electrification would provide the most benefit.

Battery technology

Batteries are currently expected to last in the region of around seven years. If a pessimistic view is taken that batteries only last 6 years, then a multiple unit with a 35 year design life would need its batteries replacing five times during its life.

Not only would a manufacturer or owner have to consider the life and technology of the battery, the disposal would also need to be analysed. However, if the battery manufacturers entered the market as battery leasing companies, possibly employing the rolling stock financiers for funding, or attracting new funding from other sources, the burden of battery renewal, as well as migration to future improved battery technology, could be lifted from the operators of the units and wrapped up within lease pricing.

In terms of the batteries themselves, a concept could be developed whereby the battery module is a thin skin, similar to that used in mobile phones, laptops and some battery cars, and distributed down the length of the vehicle between the floor and the carpet, thus spreading the mass while also reducing the space requirements on the underframe.

Benefits

A number of potential benefits are foreseeable or worthy of consideration:

- Reduced electrification, to a minimum;
- Electrification investment requirements are reduced to a 'parcel' level that may attract private funding (such as from energy supply companies);
- Electrification deployment, in parcels, may be less disruptive;
- Electrification 'distributed' at stations removes the need for providing Grid supply at remote locations – stations may have a good power supply infrastructure already and are usually near habitation with large levels of existing supply;
- Reduced reliance on DMUs for non-electrified areas of the network;
- Most of the energy requirements are moved onto the rolling stock, which can utilise mechanisms already in place to be funded privately;
- Batteries become the new commercial asset in addition to the EMU itself being the commercially attractive asset. This helps drive a full 35-year life from the EMU asset as the battery technology can be upgraded whenever required to enable the unit to remain attractive commercially;
- With electrification limited to stations, risk of objection to electrifying sensitive areas is potentially minimised;
- Battery leasing becomes the norm to preventing outdated battery technology remaining in use;
- As battery technology improves and off-wire range increases, so the map of DMU-free infrastructure increases without the need for more fixed infrastructure.

Appendix 4. Options analysis

	Rolling stock options	Summary and rating		Costing		Timescales		Infrastructure		Environment		RS technology		Future considerations	
1	Tri-mode (1600 V DC + battery + CI generator) - **Baseline**	Baseline option for short timescales and carbon reduction.	++	Moderate - No electrification cost. Complexity of tri-mode results in additional cost	+	Only rolling stock procurement timescales	+	Infrastructure as is	++	Moderate - Partial reduction of carbon footprint	+	Available - Supplier appetite to be tested in market sounding activities	+	Allows carbon emissions to be reduced from current. Diesel can be replaced as battery capacity develops, or electrification plans are developed.	+
2	Tri-mode (1600 V DC + battery + CI generator) Partial 1600 V DC electrification	Partial electrification required but improved carbon reduction	+	High - High electrification cost. Complexity of tri-mode results in additional cost	-	Moderate - Partial electrification of the route for end state. There is the opportunity for the rolling stock be delivered and use diesel, whilst the electrification is still being delivered.	-	High - At least one charging point required to reduce reliance on diesel compared to Option 1	-	Good - Partial reduction of carbon footprint. Diesel emission kept to a minimum. Vehicles will be heavier than equivalent EMUs and will therefore require more energy to travel over the same distance	+	Available - Supplier appetite to be tested in market sounding activities	+	Allows carbon emissions to be reduced from current. Diesel can be replaced as battery capacity develops, or electrification plans are developed.	+
3	Tri-mode (dual voltage + battery + CI generator) Partial 25 kV AC electrification	Partial electrification aligned to 25kV expansion required but improved carbon reduction	+	High - High electrification cost for 25kV sections. Complexity of tri-mode results in additional cost	-	Moderate - Partial electrification of the route for end state. There is the opportunity for the rolling stock be delivered and use diesel, whilst the electrification is still being delivered.	-	High - At least one charging point required to reduce reliance on diesel compared to Option 1	-	Good - Partial reduction of carbon footprint. Diesel emission kept to a minimum. Vehicles will be heavier than equivalent EMUs and will therefore require more energy to travel over the same distance	+	Market sounding required to determine appetite for dual voltage tri-mode	=	Allows carbon emissions to be reduced from current. Supports 25kV expansion and diesel can be replaced as battery capacity develops	+
4	B-EMU (1600 V DC)	Increased partial electrification and carbon elimination, analysis of number of charging points to be conducted to understand balance to tri-mode option	+	High - High electrification cost for 1,600V sections. Moderate cost of rolling stock.	-	Extensive - Increased partial electrification of the route	--	High - Charging points required approximately every 50km maximum (perhaps between Levin and Shannon, and at Palmerston North station on NIMT; at Featherston and Masterton on Wairarapa)	--	Very good - Carbon - zero (excluding battery production and any non-sustainable grid production)	++	Available - Supplier appetite to be tested in market sounding activities	+	This option would decarbonise the railway but extension of 1600 V DC requires analysis	=
5	B-EMU (dual voltage)	Increased partial electrification aligned to 25kV expansion and carbon elimination, analysis of number of charging points to be conducted to understand balance to tri-mode option	+	High - High electrification cost for 25kV sections. Moderate cost of rolling stock.	-	Extensive - Increased partial electrification of the route	--	High - Charging points required approximately every 50km (perhaps between Levin and Shannon, and at Palmerston North station on NIMT; at Featherston and Masterton on Wairarapa)	--	Very good - Carbon - zero (excluding battery production and any non-sustainable grid production)	++	Market sounding required to determine appetite for dual voltage battery EMU	=	Allows carbon emissions to be eliminated. Supports 25kV expansion in the future.	+
6	EMU / Electric Loco (1600 V DC) Full electrification of unelectrified sections to 1600 V DC with extant electrification retained	Full electrification, potential unnecessary costs that a battery could remove and carbon elimination. Electrifying tunnel is likely unfeasible relative to adding battery capacity.	--	High - High electrification cost for 1,600V section. Moderate cost of rolling stock.	--	Extensive - Full electrification of the route	--	High - Full electrification of the route, including restrictive civil assets e.g. tunnel and bridges	--	Very good - Carbon - zero (excluding any non-sustainable grid production)	++	Available - Common product	++	This option would decarbonise the railway but extension of 1600 V DC requires analysis	=
7	EMU / Electric Loco (dual voltage) Full electrification of unelectrified sections to	Full electrification aligned to 25kV expansion, potential unnecessary costs that a battery could remove and carbon elimination.	--	High - High electrification cost for 25kV section. Moderate cost of rolling stock.	--	Extensive - Full electrification of the route	--	High - Full electrification of the route, including restrictive civil assets e.g. tunnel and bridges	--	Very good - Carbon - zero (excluding any non-sustainable grid production)	++	Market sounding required to determine appetite for dual voltage EMU	=	Allows carbon emissions to be eliminated. Supports 25kV expansion in the future.	+

	Rolling stock options	Summary and rating		Costing		Timescales		Infrastructure		Environment		RS technology		Future considerations	
	25 kV AC with extant 1600 V DC retained	Electrifying tunnel is likely unfeasible relative to adding battery capacity.													
8	EMU / Electric Loco (25 kV AC) Full electrification of unelectrified sections to 25 kV AC with extant 1600 V DC replaced with 25 kV AC	Full electrification aligned to 25kV expansion, potential unnecessary costs that a battery could remove, impact on Wellington Commuter network and carbon elimination	- -	High - High electrification cost for 25kV section and removal of 1,600V. Moderate cost of rolling stock.	- -	Extensive - Full electrification of the route	- -	High - Full electrification of the route, including restrictive civil assets e.g. tunnel and bridges	- -	Very good - Carbon - zero (excluding any non-sustainable grid production)	+ +	Available - Common product	+ +	Allows carbon emissions to be eliminated. Aligns to Auckland and other electrification standards	+ +
9	Refurbish existing stock	Fleet refurbishment would be closer to a rebuild due to the current deterioration of the assets due to age. No carbon reduction.	- -	High - fleet life expired (whole life cost)	-	Refurbishment timescales extensive due to life expired state	-	Infrastructure as is	+ +	Very poor - Continued use of diesel for full operation	- -	Available - existing rolling stock only	+ +	No alignment to decarbonisation strategies.	- -
10	Diesel locomotive and LHCS	Lack of acceleration for inter-running with other fleets. Slight carbon reduction. No infrastructure requirements	- -	Low - No electrification cost. High cost of locomotive. Low cost of LHCS	+ +	Only rolling stock procurement timescales	+	Infrastructure as is	+ +	Very poor - Continued use of diesel for full operation	- -	Available - Common product	+ +	No alignment to decarbonisation strategies.	- -
11	Bi-mode 1600 V DC + diesel locomotive and LHCS	Standard product, carbon reduction but loco acceleration limited for inter-running with other operations.	- -	Moderate - No electrification cost.	+	Only rolling stock procurement timescales	+	Infrastructure as is	+ +	Average - Continued use of diesel for full operation "off wire" with no energy saving capability	-	Available - Common product	+ +	This option would decarbonise the railway but any further extension of 1600 V DC requires analysis. Locomotives are more damaging to the track than multiple units and may not align to longer term strategy.	=
12	Tri-mode 1600 V DC + battery + diesel locomotive and LHCS	Non-standard product, none in production, carbon reduction but loco acceleration limited for inter-running with other operations.	- -	Moderate - No electrification cost. Complexity of tri-mode results in additional cost	+	Only rolling stock procurement timescales	+	High - At least one charging point required to reduce reliance on diesel compared to Option 1	-	Moderate - Partial reduction of carbon footprint	+	Developing product - Supplier timescales for development to move into production to be tested in market sounding activities	-	Allows carbon emissions to be reduced from current. Diesel can be replaced as battery capacity develops, or electrification plans are developed. Locomotives are more damaging to the track than multiple units and may not align to longer term strategy.	=
13	Bi-mode Dual voltage + diesel locomotive and LHCS	Carbon reduction with high electrification costs but loco acceleration limited for inter-running with other operations.	- -	High - High electrification cost for 25kV sections. High cost of rolling stock.	-	Extensive - Partial electrification of the route	-	High - Partial electrification of the route	-	Moderate - Partial reduction of carbon footprint	+	Available - Supplier appetite to be tested in market sounding activities	+	Allows carbon emissions to be reduced from current. Supports 25kV expansion in the future. Locomotives are more damaging to the track than multiple units and may not align to longer term strategy.	=
14	Tri-mode Dual voltage + battery + diesel locomotive and LHCS	Non-standard product, none in production, carbon reduction but loco acceleration limited for inter-running with other operations.	- -	High - High electrification cost. Complexity of tri-mode results in additional cost	-	Extensive - Partial electrification of the route	-	High - At least one charging point required to reduce reliance on diesel compared to Option 1	-	Moderate - Partial reduction of carbon footprint	+	Non-existent - No current trials in the market. Supplier development timescales to be tested in market sounding activities	- -	Allows carbon emissions to be reduced from current. Supports 25kV expansion and diesel can be replaced as battery capacity develops. Locomotives are more damaging to the track than multiple units and may not	=

	Rolling stock options	Summary and rating		Costing		Timescales		Infrastructure		Environment		RS technology		Future considerations	
														align to longer term strategy.	
15	Bi-mode 25 kV AC + diesel locomotive and LHCS	Standard product, carbon reduction but loco acceleration limited for inter-running with other operations.	--	High - High electrification cost for 25kV sections. High cost of rolling stock.	--	Extensive - Partial electrification of the route	-	High - Partial electrification of the route	-	Moderate - Partial reduction of carbon footprint. However, does not utilise existing infrastructure and diesel must be used under 1,600 V DC	-	Available - Common product	++	Allows carbon emissions to be reduced from current. Supports 25kV expansion in the future. Locomotives are more damaging to the track than multiple units and may not align to longer term strategy.	=
16	Tri-mode 25 kV AC + battery + diesel locomotive and LHCS	Systems would not take advantage of existing infrastructure (1,600 V DC) and would use diesel which could be avoided.	--	High - High electrification cost. Complexity of tri-mode results in additional cost	--	Extensive - Partial electrification of the route	-	High - At least one charging point required to reduce reliance on diesel compared to Option 1	-	Moderate - Partial reduction of carbon footprint. However, does not utilise existing infrastructure and diesel must be used under 1,600 V DC	-	Developing product - Supplier timescales for development to move into production to be tested in market sounding activities	-	Allows carbon emissions to be reduced from current. Supports 25kV expansion and diesel can be replaced as battery capacity develops. Locomotives are more damaging to the track than multiple units and may not align to longer term strategy.	=
17	Hydrogen fuel cell + battery multiple unit	Developing technology that requires associated infrastructure. Timeline for delivery may be longer than other technologies.	--	High - No electrification cost. High cost of rolling stock.	+	Market sounding required to determine development of hydrogen products	=	High - Hydrogen infrastructure required for re-fuelling and storage	--	Very good - Carbon - zero (excluding battery production and any non-sustainable hydrogen production)	++	Developed product - Supplier timescales for fleet production to be tested in market sounding activities. Narrow gauge may cause difficulties of underframe equipment envelope. May need "power car" for hydrogen equipment.	-	Allows carbon emissions to be eliminated. Hydrogen infrastructure development requires further analysis.	=
18	Hydrogen fuel cell + battery locomotive	Developing technology that requires associated infrastructure. Timeline for delivery may be longer than other technologies.	--	High - No electrification cost. High cost of rolling stock.	+	Market sounding required to determine development of hydrogen products	=	High - Hydrogen infrastructure required for re-fuelling and storage	--	Very good - Carbon - zero (excluding battery production and any non-sustainable hydrogen production)	++	Non-existent - No current trials in the market. Supplier development timescales to be tested in market sounding activities	--	Allows carbon emissions to be eliminated. Hydrogen infrastructure development requires further analysis.	=
19	Tri-mode (25 kV AC + battery + diesel) Partial 25 kV AC electrification	Partial electrification aligned to 25kV expansion, potential unnecessary costs that a battery could remove, does not utilise existing infrastructure	--	High - High electrification cost for 25kV sections. Complexity of tri-mode results in additional cost	-	Extensive - Partial electrification of the route	-	High - At least one charging point required to reduce reliance on diesel compared to Option 1	-	Good - Partial reduction of carbon footprint. Diesel emission kept to a minimum. However, does not utilise existing infrastructure and diesel must be used under 1,600 V DC	-	Available - Supplier appetite to be tested in market sounding activities	+	Allows carbon emissions to be reduced from current. Supports 25kV expansion and diesel can be replaced as battery capacity develops	+
20	Battery-EMUs with no infrastructure enhancement	Battery capacity not large enough with current technology.	--	Moderate - No electrification cost. Low cost of rolling stock with added battery	++	Only rolling stock procurement timescales	+	Infrastructure as is	++	Very good - Carbon - zero (excluding battery production and any non-sustainable grid production)	++	Available - Supplier appetite to be tested in market sounding activities	+	Allows carbon emissions to be eliminated. Efficiencies can be improved as battery capacity develops	+
21	Battery-DMUs (B-DMU)	Cost effective but not aligned to carbon reduction. Does not utilise available infrastructure.	--	Moderate - No electrification cost. Low cost of rolling stock with added battery	+	Only rolling stock procurement timescales	+	Infrastructure as is	++	Very poor - Continued use of diesel for full operation	--	Available - Supplier appetite to be tested in market sounding activities	+	No alignment to carbon reduction strategies.	--
22	New DMUs	Cost effective but not aligned to carbon reduction. Does not utilise available infrastructure.	--	Low - No electrification cost. Low cost of rolling stock	+	Only rolling stock procurement timescales	+	Infrastructure as is	++	Very poor - Continued use of diesel for full operation	--	Market sounding required to determine appetite for DMUs. Manufacturers moving away from DMUs	=	No alignment to carbon reduction strategies.	--

Rolling stock options		Summary and rating		Costing		Timescales		Infrastructure		Environment		RS technology		Future considerations	
23	Second hand DMUs	Cost effective but not aligned to carbon reduction. Does not utilise available infrastructure.	- -	Low - No electrification cost. Low cost of rolling stock	+ +	Only existing rolling stock acquisition and delivery timescales	+ +	Infrastructure as is	+ +	Very poor - Continued use of diesel for full operation	- -	Market dependent, may not meet current emissions standards.	=	No alignment to carbon reduction strategies.	- -
24	Solar	Technology not developed enough for significant rolling stock use with no meaningful trials.	- -	Low - No electrification cost. High cost of under developed technology	-	Market sounding required to determine development of solar products	+	Infrastructure as is	+ +	Very good - Carbon - zero (excluding solar panel production)	+ +	Only one successful rolling stock trial to date for short, low power, tourist line use. Limited market application for mainline railway.	- -	Allows carbon emissions to be eliminated. No successful trials to date but if technology worked, it would be carbon-zero.	+
25	Steam	Modern emissions-free technology not yet developed for rolling stock with no successful trials.	- -	Low - No electrification cost. High cost of under developed technology	-	Market sounding required to determine development of steam products	+	Infrastructure as is	+ +	Very good - Carbon - zero	+ +	No successful rolling stock trial to date. Limited market application.	- -	Allows carbon emissions to be eliminated. No successful trials to date but if technology worked, it would be carbon-zero.	

Appendix 5. Other alternative traction options

Solar

The use of solar power is a low-carbon, renewable technology, which converts energy from sunlight into electricity using solar panels with photovoltaic cells. Initially solar power was used for small and medium-sized applications, but the use has increased in commercial and industry settings as the cost of the technology has reduced, leading to the construction of solar power stations with large networks of connected panels around the world. In recent years, the use of solar power has made some initial introductions in rail, though it is not yet a common practice.

In India, Indian Railways has placed into service trains with rooftop solar panels that power the lights, fans, and information display systems inside passenger coaches[26]. Although the trains' source of traction is a diesel-engine locomotive, a set of 16 solar panels on each of the six coaches replaces the diesel generators that usually power these auxiliary appliances. Indian Railways estimates that this application of solar power could save approximately 21,000 litres of diesel per year.

In Australia, Byron Bay Railroad Company has restored and converted a two-car heritage train into a battery train which runs purely on solar power[27]. Energy is generated from solar panels on the train roof which feed the onboard batteries to power the train. Solar panels on the train shed roof are also used for battery charging. All the equipment on the train is powered from Lithium-ion batteries including traction power, lighting, air compressors and control circuits.

This is a remarkable application of solar power, but should be caveated with the fact that the train runs on an isolated section of railway between two stations, covering a distance of 3 km in 10 minutes, an average speed of 18 km/h, in a part of the world which consistently receives a great deal of sunlight. Scaling up this operation to mainline passenger services would likely prove challenging.

In the UK, Riding Sunbeams, a social enterprise founded by charity 10:10 Climate Action, has installed a lineside 30 kWp solar power test unit with approximately 100 panels on Network Rail's third rail-electrified Wessex Route, directly supplying electricity to the railway to power signalling and lighting[28]. Riding Sunbeams has estimated that power produced using community-owned solar farms could one day provide up to 10% of the traction energy needed for the UK's 750 V DC third rail network.

Applications of this nature are a welcome contribution to rail on its journey towards decarbonisation, however, the implementation of solar power in rolling stock will face challenges.

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[26] Quartz India. "India is rolling out trains with solar-powered coaches that'll save thousands of litres of diesel". 17 July 2017. https://qz.com/india/1030696/india-is-rolling-out-trains-with-solar-powered-coaches-thatll-save-thousands-of-litres-of-diesel/ Accessed Feb 2021.
[27] Byron Bay Railroad Company. https://byronbaytrain.com.au/sustainability/ Accessed Feb 2021.
[28] Railway Gazette. "Riding Sunbeams deploys solar array". 6 Sep 2019. https://www.railwaygazette.com/uk/riding-sunbeams-deploys-solar-array/54504.article Accessed Feb 2021.

The use of solar technology in rail is currently in its infancy. Currently, solar power is likely only capable of supplying support functions in rail, not acting as a primary traction power source. It is unclear how this will progress and whether it will be able to develop to full-scale operations.

The quantity of solar power which would be required to supply a railway or fleet of trains consistently and fully for normal operation would be significant. Geography is a factor, and it is likely that many parts of the world would not be able to collect enough sunlight per year for this application (particularly during winter).

Steam

Traditionally, steam power was used to power locomotives from the early 19th century until electric and diesel locomotives superseded them in the early 20th century. Classic steam locomotives were fuelled by burning combustible materials such coal, wood, and oil.

Steamology is a specialist company in the UK which has developed a zero-emission steam generator for use in rolling stock. The company has received UK government funding through its 'First of a Kind' 2020 Rail Decarbonisation programme to develop a 600kW turbine for trial on a Class 66 locomotive[29].

Steam is generated using energy stored as compressed hydrogen and oxygen gas in tanks. High pressure superheated steam is used to drive a turbine to do useful work by generating electricity, which could charge battery packs onboard trains. Renewable energy is used to power electrolysis to generate the hydrogen and oxygen gas and to compress the gas into storage tanks. The closed cycle process is emission free producing no carbon or NOX emissions in a repeatable cycle without charging losses.

The company has suggested developing the technology as part of a bi-modal solution due to the technology's infancy. Pairing steam technology with discontinuous electrification could allow rolling stock to operate on steam power for the last mile, where noise and pollution are higher priorities.

Steamology is targeting a static demonstration of the technology on a Class 66 locomotive in 2021, though there is currently no committed timeline for an operational model.

[29] 'Can freight locos run on steam?', Webinar, RFG. Accessed at: http://www.rfg.org.uk/can-freight-locos-run-steam/

Appendix 6. Market Sounding Summary

Propulsion modes summary

Organisation	EMU	B-EMU	B-E Loco	Hydrogen	H-EMU	B-DMU	B-D Loco	B-D-E Loco	B-D-E TMU
Alstom		Yes			Yes				
CAF		Yes		Yes					
CRRC		Yes							
Hitachi		Yes				Yes			Yes
Hyundai-Rotem		Yes							
Talgo		Yes							
UGL		Yes							
Stadler	Yes	Yes	Yes	Yes		Yes	Yes	Yes	

Estimated battery range

Organisation	Range
Alstom	80-100 km
CAF	50-70 km
CRRC	75-82 km
Hitachi Group	50 km
Hyundai-Rotem	90 km
Talgo	80-90 km
UGL	80-160 km
Stadler	60-80 km

Estimated hydrogen fuel cell range

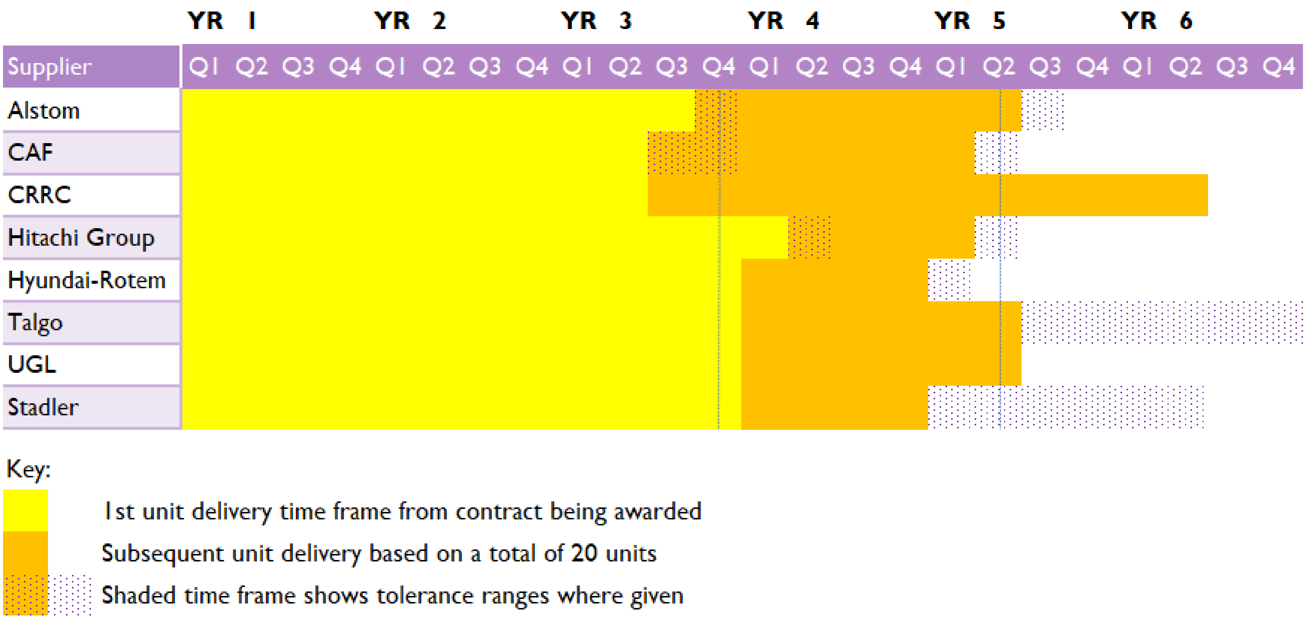
Organisation	Range
Alstom	600-1000 km
CAF	300 km
Stadler	400-600 km

Propulsion modes

Organisation	Response
Alstom	1. Hydrogen: For a H2 (hybrid) application, there would be no need for "top up" overhead charging locations as the on-board Lithium-Ion batteries would be recharged from the hydrogen fuel cells and from regenerative braking. A centralized H2 supply site is needed which could also support other H2 transportation to amortize the cost of development and maintaining the re-fuelling site. 2. Battery: BMEU's are limited in range, and carry extra weight due to the number of batteries that need to be carried for associated autonomy. Consideration would then need to be made for appropriate re-charging facilities (and dwell times) at the termination stations.
CAF	1. Hydrogen: CAF states it will take 5-10 years to achieve the same technological maturity as battery power. 2. Battery: Operational data analysis is required for CAF to comment further other than mentioning further developments in energy storage and battery life span seem to be promising in terms of life cycle costs as well as performance and capabilities.
CRRC	CRCC anticipates the train battery will be charged when operating under the catenary, as the train travels from Wellington to Upper Hutt and from Wellington to Waikanae, in this case it is two sets of charging equipment at Palmerston North and Masterton stations will be required with an approximate charge time of 10 minutes. It is estimated that a lithium battery capacity of 650kwh needs to be configured. Considering heavier weight, improved performance and other factors of the new vehicle, the energy consumption will increase. However, the battery energy (950kWh) configured in their existing platform solution can fully meet one-way operation of the train between Waikanae and Palmerston North.
Hitachi Group	HRL states it is worth noting up-to-date developments in battery range when the final solution is established. HRL notes that the volume of vehicles is relatively small compared to normal global project volumes, therefore where possible, suggest minimising unique project technical or delivery requirements and conforming to a more broadly accepted European standard will enable more involvement and competition in the market
Hyundai-Rotem	10 mins charging time anticipated, with further work required on terminal stations needing electrification as re charging points for battery power to cover return trip back to any OLE running line.
Talgo	Talgo states the solution is innovative and experience in the market limited however development work is currently underway within Talgo on utilising hydrogen power.
UGL	UGL propose both the Upper Hutt to Masterton Journey, and the Waikanae to Palmerston North Journey have a single charge point at the terminus station. To ensure operational service performance, consideration should be given to adding a charging station at the midway point to negate any concerns with battery operation (e.g., extreme conditions, excess passenger loads, emergency recovery, tractive effort issues). A top up charge at these facilities would be in the region of 60 to 120 seconds.
Stadler	B-EMU with a partial electrification or EMU with full electrification has proven to be significantly more economical than HEMU

Organisation	Response
	Both battery and hydrogen technologies have reached a certain maturity level, which permits to use them in a regular daily train operation. Nevertheless, there are limited long term experiences available, which is expressed especially in the expected lifetime of the energy storage systems. Lifetimes beyond 8-10 years typically can't be guaranteed, but only for very narrowly defined load-cases/patterns. Larger batteries on B-EMU would be replaced 3 or 4 times in the 30-year life, as would fuel cells and puffer batteries on the HEMU 1. Battery: Stadler suggests to use the OLE for recharge the battery rather than having only stationary "top up" locations at stations. Charging under the OLE has 2 main benefits: (i) Train traction power is directly and most efficiently drawn from the OLE in these sections, (ii) Charging time is actual running time of the train, no time loss 2. Hydrogen: For the refilling of hydrogen appropriate infrastructure is required and refuelling of 45 min durations. Additional time lost might arise for the transfer from station to the re-filling point 3. Locomotives: Stadler would like to draw the attention of GWRC to a potential alternative option, which at least at present is considered by Stadler as "Commercially Sensitive". Stadler is one of the pre-qualified, shortlisted bidders for the KiwiRail new mainline locomotive tender for freight and passenger rail service. Decision on this tender is expected within the next few months. Should Stadler be successful, they would supply at least 65 latest state of the art diesel technology, stage V emission standard compliant locomotives to New Zealand. KiwiRail intends to purchase pure diesel locomotives, yet based on the same locomotive platform a Dual-mode (Diesel and 1600VDC) or Tri-mode (Diesel, 1600VDC and battery) solution from Stadler could add substantial benefit and synergies to GWRC and KiwiRail

Lead times (average times shown as vertical lines)



Fleet size

Organisation	Response
Alstom	Order size is important to pricing, the larger order allows additional economies of scale in terms of development cost over a larger value, more competitive quotations from suppliers for fuel cells, H2 tanks, brakes, doors, HVAC etc. is achieved.
CAF	The size of the order is directly related to the appetite to participate in the tender.
CRRC	Order size impacts price and appetite.
Hitachi Group	Hitachi participation plan will be reviewed once project details become clear and procurement strategy is decided. That is, Hitachi may look to participate at a rolling stock supply level or simply as a key technology supplier to another rolling stock OEM for an order of this size.
Hyundai-Rotem	Hyundai will have a larger appetite to participate in tendering process if order size is larger e.g., 20 unit of 4 cars rather than 15 units, so that economies of scale can be achieved.
Talgo	Talgo would envisage a procurement contract of more than 120M Euros
UGL	UGL states they offer greater flexibility in developing a solution compared to the traditional globally oriented competitors but note that a small order-size can have a negative effect on the per-car price.
Stadler	An order size of 20 x 4-car trainsets would be adequate and permit the required customization and create appetite at Stadler. In case GWRC could further commit with a binding frame contract for a larger quantity, this would help to distribute the non-recurring cost onto a larger number of vehicles and therefore reduce the price.

Supplier experience

Organisation	Response
Alstom	The Coradia LINT is an articulated railcar manufactured by Alstom since 1999, offered in diesel and hydrogen fuel models. The Coradia I-Lint, Alstom's Hydrogen powered train with zero carbon emissions has now been in passenger service since 2018. SNCF, France has recently placed an order for 12 dual mode electric-hydrogen Polyvalent Coradia trains. It can be operated at a maximum speed of 160 km/h in electric or bi-mode at voltages of 25 kV, 15kV or 1,500 V
CAF	CAF have several light rail project experiences using super capacitors or battery strings and Electrical Locomotives: CAF have also worked on a locomotive project in which the OESS is used to feed the traction system for "Last Mile" applications, namely Electrical Locomotives Dual-mode for RATP (France). RENFE'S 3-car commuter unit prototype belongs to the Civia series based on the hybridization of hydrogen fuel cells and LTO batteries
CRRC	CRCC have worked on a Beijing Subway Line B-EMU and new subway B-EMU presented in InnoTrans 2018. CRRC has also developed and manufactured 2 types of hybrid locomotive: (i) 2200kW hybrid locomotive and the power of power battery is 1100kW, (ii) 1000kw hybrid locomotive and the power of power battery is 500kW CRRC has developed and manufactured 250kW battery railcar.

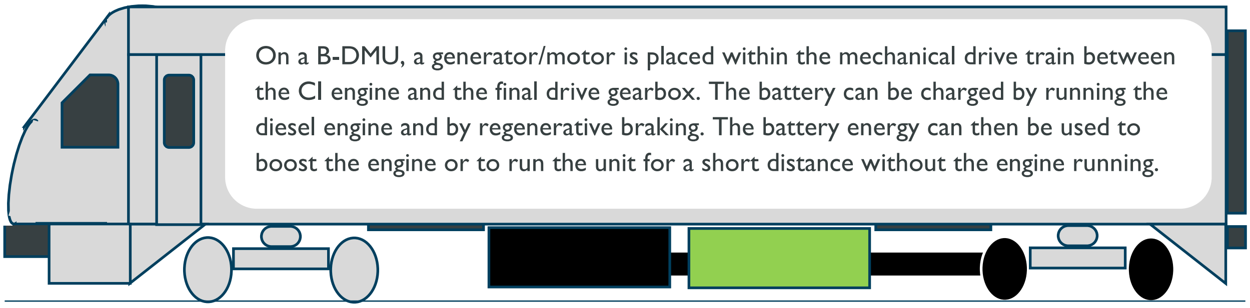
Organisation	Response
Hitachi Group	B-EMU, B-DMU and Tri-modes are within Hitachi's range/experience HRL has partnered with the Kyushu Railway Company (JR Kyushu) to develop a Bi-mode EMU that can run off-wire using batteries. This was adopted in the Series BEC819 BEMU introduced in 2016. HRL selected the batteries from the automotive/industrial- lithium-ion batteries developed by the Hitachi Group. Hitachi has also delivered similar BEMU, of the EV-E801 series to East Japan Railway Company (JR East). The Hayabusa test train (or V-Train2) project in 2003 modified the Network Rail New Measurement Train with battery technology positioned under the floor of the trailer vehicles. During the train's regular service, it completed over 100,000km, experienced zero hybrid traction system failures causing train delay. The result was a 15% fuel saving. In 2019, HRL received a first order for 135 "Masaccio" Tri-Mode (electric, diesel and battery) trains from Trenitalia in Italy. The units will be capable of running in EMU (3kVDC), Bi-modal (EMU/DEMU) or Hybrid (DEMU + Power Batteries). The contract also has a 15-year maintenance agreement. HRL have worked on the Sirio Battery Tram, Florence Italy, HRL also have experience on eBus projects
Hyundai-Rotem	Hyundai Rotem are working on development work of a H-EMU tram train.
Talgo	Talgo Vittal-One hydrogen train is being developed, based on a modular design to take into account any future diesel to hydrogen conversions.
UGL	OBES systems in light rail vehicles regenerative energy solutions passenger vehicles, battery and hydrogen solutions in heavy haul locomotives
Stadler	Based on the FLIRT BMU, Stadler's Power Pack and Power Head concepts allow the installation of a diesel engine with electrical traction. Once operation on fully electrified lines commences, the installed power pack may be dispensed. The FLIRTUK fleet for Keolis Amey for Wales & Borders features a tri-mode solution that allows the passenger train to run under overhead wire, on diesel and batteries. The order for 52 new Metro trains for Merseyrail and 42 for Tyne and Wear Metro both feature a traction battery option to extend the service off-wire. Stadler is currently in negotiation to supply a fleet of hydrogen narrow gauge passenger trains for the operator Zillertalbahn in Austria and has a contract for SBTCA in California. Stadler has established a range of Dual Mode (diesel / electric) locomotives and is investigating the use of traction batteries for a tri-mode locomotive. The Citylink tram-train fleet for Keolis Amey for Wales & Borders is able to use 25 kV AC overhead catenary as well as battery power to allow continues operation off-wire

Appendix 7. Train architecture diagrams

Key

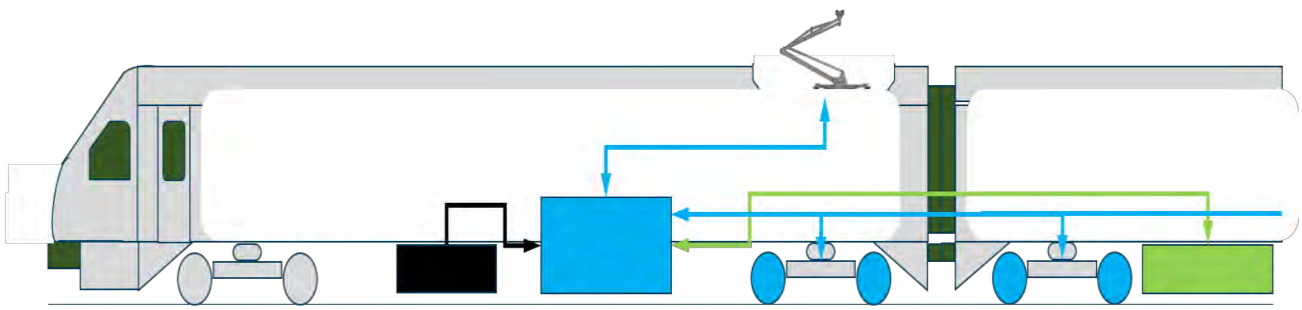
- Engine
- 1600V equipment
- 25kV equipment
- Battery pack

B-DMU



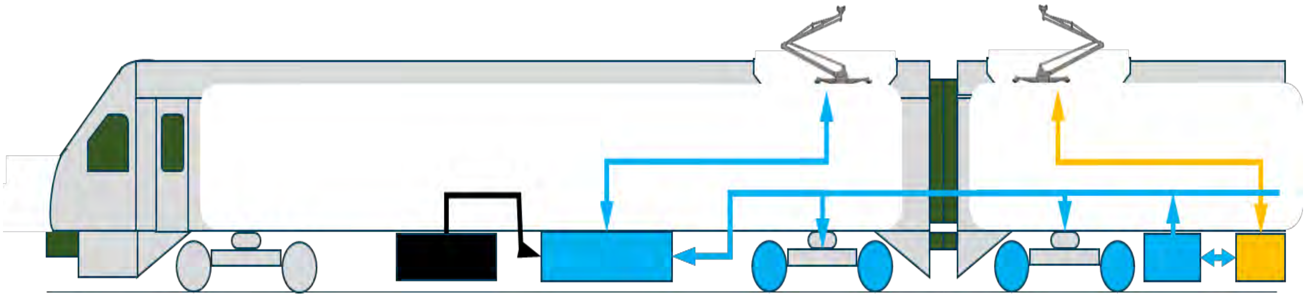
TMU

On a TMU, the CI engine has no mechanical drive and is connected to a generator. When in electric mode, the power is taken from the overhead line for both traction and to recharge the battery. Energy from regenerative braking is used to charge the battery until the battery is fully charged when the energy is returned to the overhead line. In self-power mode, traction power is taken from the battery or a combination of the battery and the engine. Energy from regenerative braking is used to rechange the battery. Further, the engine can be used to charge the battery.

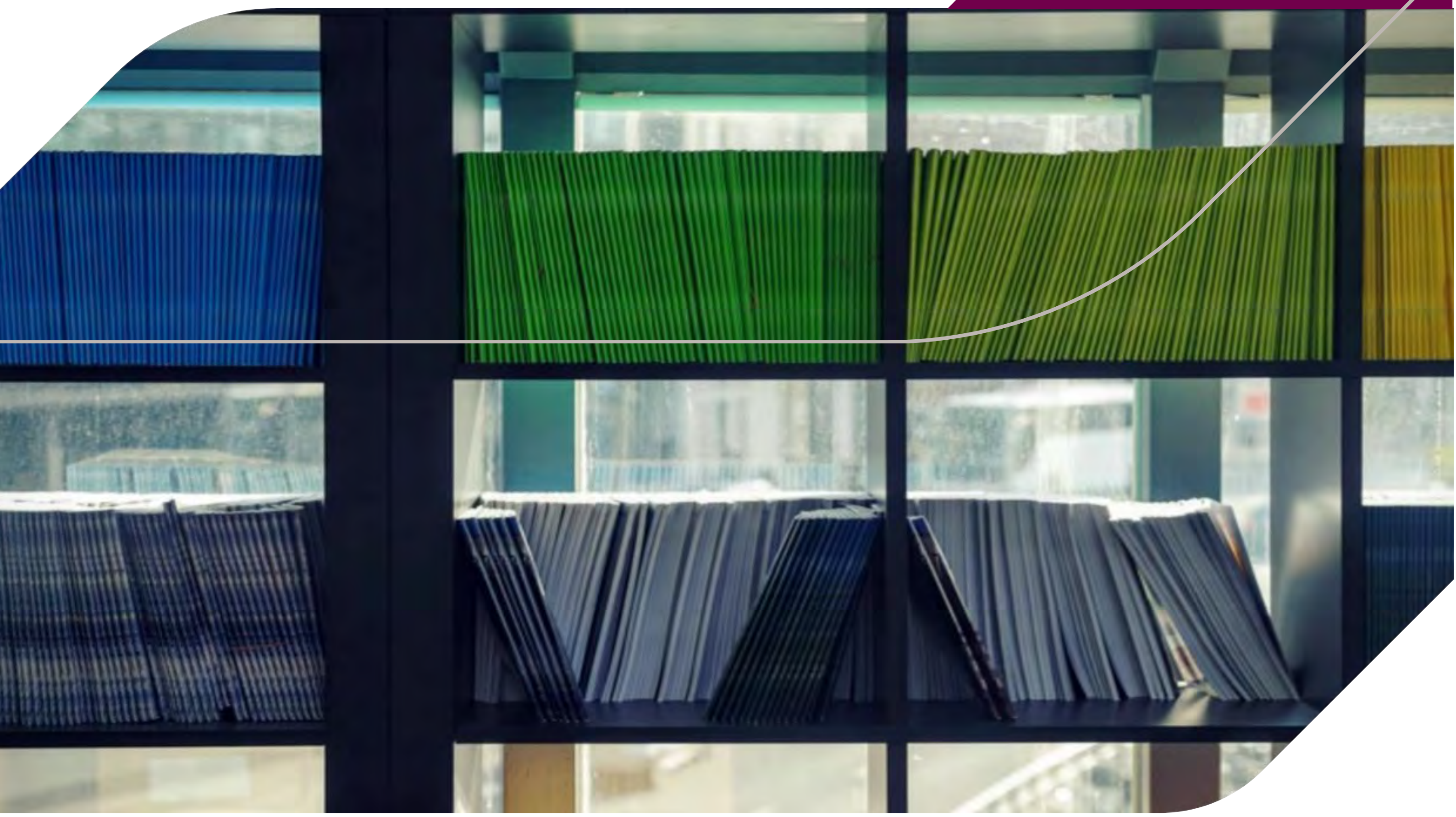


MU dual voltage 1600V / 25kV architecture

In a modern dual voltage multiple units, generally the traction line down the length of the unit is 25kV. However, dependent on the Options considered, it may be that the traction line is better suited to 1600V.



Appendix F
Vehicle specification



Technical note

To	Arnaud Deutsch	Copied	Chris Hoskin, Luke Foy and Marina Davydova
Company	RPS		
From	Munira Somani		
Project	0369 LNIRIM Phase 1	Issue	1.0
Subject	A4 Vehicle Specification	Date	9 September 2021

A4 – Vehicle specification

Introduction

This technical note provides an outline specification for the new units.

Train technical specification

Included in Appendix 1 is a headline of the Train Technical Specification (TTS). It provides the introduction and structure of the TTS which is to be built during the live procurement project with inputs from a range of stakeholders including GWRC, KiwiRail, Horizons, passenger groups, and operating staff. The TTS structure utilises IPEX's years of experience and lessons learnt from previous procurements. It provides a readily understood structure that is appropriate for manufacturers, procurers, and evaluators alike.

The TTS should be constructed as a performance specification whereby it specifies what the units need to achieve, not how they will achieve it. Experience has demonstrated that empowering the manufacturers to utilise their specialist skills in train design and manufacture provides a much better, and much more efficient (and therefore cost attractive), solution than over-specification of components of the physical architecture of the train by the procurer.

Outline specification

The new trains are to be tri-mode multiple units (1600 V DC + onboard energy storage (OBES) + compression ignition (CI) generator)

The units shall be of a regional design capable of operating across all of New Zealand's railway topography, with a gauge of 1067 mm. The units shall initially operate between Wellington and Masterton (Wairarapa line) and Wellington and Palmerston North (Manawatu line).

The nominal fleet order size shall be 22 units. Options may be granted for further orders.

> This, along with the operation across "all of New Zealand's railway topography" and "initially operate between…" leaves the path open for this to be a national product.

The units shall comply with the New Zealand railway standards NRSS, and further comply with the relevant New Zealand Standards, Australia and New Zealand Standards, Railway Group Standards, and Railway Industry Standards as specified in the TTS.

The units shall either comply with *Rolling stock static gauge Drg No. 13090429 in NRSS/6 Engineering Operability Standards* or being proven gauge clear by comparative gauging.

Rolling stock static gauge drawings make assumptions on suspension movements of trains. More modern rolling stock, taking advantage of bogie and suspension ride improvements, tend to invalidate the assumptions made for such static gauges. It is therefore legitimate to enable a manufacturer to model a control vehicle using the static gauge and then compare that with their product to prove gauge compliance where their unit would otherwise fail the static gauge.

Each unit shall be no more than 92m in length over couplers, with a driving cab at each end.

Nominally the unit will comprise four vehicles of 21-23m, and 2.75m wide although this can be left to the manufacturer as a good way to maximise width is to provide an articulated unit with short vehicles which may result in a five vehicle unit, or for example in the case of Stadler's FLIRT where a "power pack" module is inserted in the middle of the vehicle which contains the batteries and compression ignition generators with a central passenger corridor.

The unit shall be capable of providing level boarding for at least two doors per side at a platform height of 680 mm ARL. The manufacturer shall minimise changes in floor height within the unit. It shall be possible for a wheelchair occupant to move within the unit between two level boarding doors on each side.

Each unit shall have at least eight doors per side (nominally two per vehicle) and the Manufacturer shall demonstrate the unit's design does enables passenger boarding and alighting to meet dwell time requirements. The Manufacturer shall provide suitable weather protection between the doors and the saloons. The preference is for end doors.

The unit must have the ability for a door failure not to impact on any passenger, particularly those in a wheelchair. The requirement for two level boarding doors joined by a wheelchair accessible path will almost certainly lead to a solution with a wide gangway between two vehicles with the doors at the ends.

The unit shall be fitted with automatic selective door opening (ASDO) for the short platforms on the route, and for when a train comprises of more than one unit. The units shall additionally be fitted with correct side door enable (CSDE). The Manufacturer shall propose a robust, proven, solution.

The maximum operating speed of the units shall be 120 km/h both in 1600V DC and self-power modes.

The units shall be capable of operating the GWRC V4 timetable.

The units are expected to perform splitting and joining operations in traffic. The coupling procedure must therefore be achievable within two minutes by a single Driver while remaining in the cab of one of the units.

The units shall be capable of operating in multiple up to two units for regular operation and four units for rescue and recovery. A single unit must be capable of dragging or propelling two failed units. The units shall be capable of coupling to the existing Matangi fleet.

The multiple operation recovery length is to enable a failed two unit to rescue another failed two car unit. However, in terms of traction power, it is more useful if a single unit can rescue a twin failed unit. Enabling like for like coupling means a Matangi can rescue a failed regional unit and vice versa.

The traction architecture of the unit shall be an electric multiple unit with the traction power provided by 1600V DC overhead, on-board energy storage provided by batteries, and a compression ignition generator to recharge the batteries and provide traction power where the batteries are depleted. There shall be one pantograph per unit for 1600 V DC overhead line collection for traction and battery recharge.

The unit shall be designed so that full performance can still be obtained when the unit has one traction subsystem unavailable (traction inverter and traction motors).

It is likely the solution may well be for a unit with four motored bogies and four trailer bogies, but this should be left to the manufacturer particularly as defining the numbers of bogies defines the number of vehicles which as described above, it is better not to do.

The battery shall be capable of providing sufficient energy for the Reference Diagrams specified with a baseline assumption of 80 km range. The CI generator(s) shall provide battery recharging and traction energy as required where the batteries are unavailable for use.

> Although it has been calculated that a workable solution would be two 390kW CI generators and 700kWh of batteries, this should be left open for the manufacturers to bring their expertise, and these figures should be used as a benchmark for comparison with the bid responses.

The braking system shall be designed to regenerate energy to the batteries in the first instance, and only resort to rheostatic braking when the batteries are fully charged. Manufacturers shall justify their solution.

> It may be possible not to require rheostatic resistors if the modelling demonstrates the batteries are never likely to be fully charged, or, for example, if the system is designed to use the batteries as a boost when they are nearly full so that they always have capacity for braking. The specification should enable the manufacturers to make a choice here. This assumes that Wellington does not have any capability to regenerate into the overhead. If it is does, this should also be included in the specification.

The on-board energy storage system shall be designed with geo-location to enable emission-free station stops where the unit does not utilise the CI generator at any point while the unit is within the station limits. Dwell times can vary from 7 - 33 minutes at intermediary stations.

Automatic power changeover (APCO) shall be achievable while the unit is operating at full speed without any noticeable jerk or discomfort for passengers. The manufacturer shall propose the architecture of the APCO system, although the preferred solution would be Packet 44 Eurobalises.

> The architecture proposal is to enable manufacturers to offer different solutions although a preference is stated. Packet 44 Eurobalises are those used for ETCS so is a common architecture.

The numbers of different types of bogies should be minimised. The design of the motor and trailer bogies shall be as similar as possible.

> This is intended to prevent a very particular oddity that Hitachi, for one, has achieved with some recent fleet introductions where units have three or four different bogie types. By enforcing similarity between motor and trailer bogies, a reduction in spares should be achievable.

The driving cab shall have an offset driving position to allow the fitment of an end door detrainment ramp. The cab shall also be fitted with space for Instructor's seat. The Instructor's seat must enable the Instructor to be able to read the speed and TMS screens on the driver's desk. If that is not possible, repeater screens shall be provided. The Instructor's seat shall be fitted with an emergency brake plunger in reach of a seated Instructor.

The end door detrainment ramp shall be fitted to enable detrainment in single bore tunnels. It shall be deployable by one member of staff. Stowage of the ramp must not impede the driver's view. The driver's sight lines shall be as good as, or better, than those of a Matangi unit.

The unit shall be fitted with a Train Manager's office. It is preferable that this near the toilet.

> Locating this near the toilet is merely to minimise the number of fixed, full height, obstructions in the train. Further consideration should be given to whether this is necessary at all. Many operators are removing TMs offices as they take up valuable space, particularly on units as short as four vehicles. In addition, although a TM office is necessary on the current loco-hauled carriage fleets, in the case of a multiple unit there is always a rear driving cab available.

The units shall be fitted with a minimum 250 fixed seats per unit. There shall be four wheelchair spaces per unit, accessible from level boarding doors.

Overhead racks shall be provided above all fixed seats. Luggage stacks shall be provided throughout the unit near the doors. There shall be storage for six bicycles per unit.

There shall be two controlled emission toilets (CET) per unit. At least one of the toilets shall be accessible and located near the wheelchair spaces.

Passenger heating, ventilation, and air conditioning (HVAC) shall be provided throughout the unit. This shall be controllable by the train crew. A separate HVAC system shall be provided for the Driver, with controls on the Driver's desk.

Other considerations include whether the seats should be cantilevered off the wall to ease cleaning; whether to mandate not fitting folding seats or are folding seats an option for the bicycle spaces; the fitment of seat back tables; what proportion of bay and airline seating; how many luggage stacks; what needs to fit on the luggage racks; and whether bio-reactor toilets should be fitted instead as they are becoming a more common proposition for new trains.

Appendix 1.

Train Technical Specification (TTS) headline

0369 - A4 - GWRC TTS v0.1.pdf

Greater Wellington
Te Pane Matua Taiao

In association with

horizons
REGIONAL COUNCIL

Train Technical Specification

On-board energy and electric multiple unit

Approval Record

	Name	Role	Signature
Prepared			
Approved			
Authorised			

Revision Record

Issue	Amendments	Date
V0.1		7/9/21

Table of Contents

Annexes

1. Introduction

Information

0001. Through its Metlink operation, Greater Wellington Regional Council (GWRC) provides long distance passenger rail services on the Wairarapa Line (WRL) that connect the Wairarapa communities with Wellington. KiwiRail provides long distance passenger rail services from Palmerston North to Wellington on the Manawatu Line connecting the Manawatu and Horowhenua communities with Wellington. The Wairarapa and Manawatu Line services are an established, integral, and well-utilised component of the lower North Island transport system. Information

0002. Patronage on the WRL has grown by 15% over the last 10 years, with a peak period patronage increase of 24%. The Manawatu Lines patronage has seen annual growth of 3.1% over the last four years and is now operates at capacity. The patronage growth shows that both the Wairarapa and Manawatu services are enabling modal shift from private motor vehicles. Information

0003. The current longer distance passenger trains are coming to end of life which is resulting in increasing maintenance costs, customer expectations not being met and risk of service withdrawal. The level of customer amenity provided by these carriages is poor by 21st century standards and is the subject of regular passenger complaints. Information

0004. To meet customer demands GWRC requires a Multiple Unit fleet that delivers the following: Information

a. Units that can accommodate greater numbers of seated passengers than the legacy rolling stock to support expected growth, but in intercity levels of style and comfort; Information

b. an interior design and layout that will support the multiple functions of the intended operation ranging from shorter Information distance commuting to long distance business and leisure travel, is inclusive for all customer demographics and reduces access barriers to travel;

	c. use of the latest technology to improve passenger information and connectivity and provide real time data updates for rapid service recovery;	Information
	d. high levels of reliability and availability to ensure a consistent delivery of service while featuring the capability to minimise the effect on customer experience in the event of a loss of external power supply;	Information
	e. achieves performance levels that are complementary to the existing Matangi fleet to aid in timetable planning;	Information
	f. Innovative and robust solutions for operation on sections of the Operational Network that are not electrified; and	Information
	g. reduction in emissions to an absolute minimum, ensuring any fossil fuel emissions are only emitted away from stations.	Information
0005.	It is important that the Units are designed to achieve the passenger, operational, and technical environment requirements within which they will operate.	Information
0006.	The Manufacturer will be expected to cooperate closely with GWRC, the Operator, and KiwiRail throughout the process from negotiation, contract, design, testing, commissioning, and in-service reliability proving, to achieve an optimum overall system design.	Information
1.1.	**Purpose**	Information
0007.	The purpose of this Train Technical Specification (TTS) is to define the technical output requirements for the Units.	Information

[redacted]

[redacted]

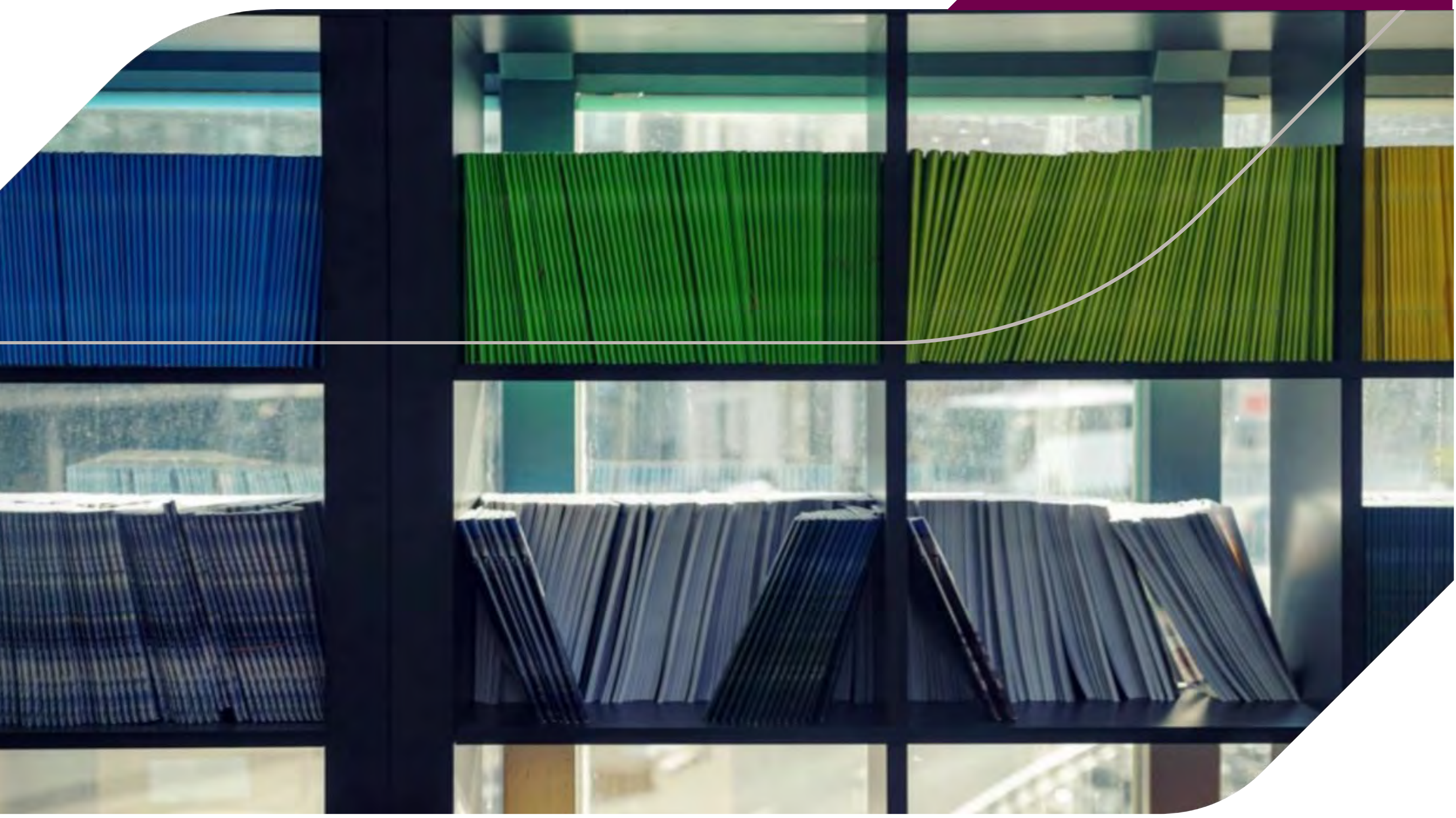
[redacted]

[redacted]

[redacted]

[redacted]

Appendix K
COVID impact demand modelling



MEMO

data inspired by people

Version 1.0
Date 01/07/2021
To RPS (Arnaud Deutsch, Rhys Hayward)
Author Lynxx (Tash Roujeinikova, Beau Bellamy)

Executive Summary

- Work from home trends are likely to supress patronage growth, due to proportions of the rail users now working from home an additional 1-2 days a week or permanently. These trends are likely to be long-term due to growing acceptance of working from home.
- Mode Shift trends are likely to supress patronage growth in the short-term but are not expected to persist in the long-term due to the likelihood of vaccination roll-out and a return to pre-covid behaviour.
- Population trends could have opposing effects on patronage growth, depending on which effect becomes more dominant in the long-term. In the long-term, regional relocation (due to improved work from home opportunities) is likely to offset reduced immigration from border closures (which are expected to open after New Zealand & worldwide vaccination roll-out). This regional relocation will drive greater population growth to the rail catchment areas and increase patronage growth in the long-term.
- Fare trends may have minor suppression of patronage growth due to rail users not finding value in monthly/multi-trip tickets (when working from home more) and choosing to travel even less. This is not likely to be a long-term significant impact, particularly if fares are modified to compensate for reduced travel.
- Lynxx presents a combined set of likely hypotheses for a final post-covid patronage projection but cautions that the hypotheses are likely to have interaction effects and result in lower magnitude changes. The worst- and best- case scenarios form maximum likely outcomes. Under these combined hypotheses, we expect a minor reduction in growth for the base-case projections, but increased growth in the best-case projections.

Objective

This memo accompanies the GWRC Covid Model.xlsm Excel model for exploring potential impacts of Covid on long-term rail demand in Manawatu and Wairarapa. The memo discusses individual hypotheses and their potential impacts on demand, the parameters chosen for best-to-worst case scenarios, and a final set of projections that incorporates multiple likely hypotheses.

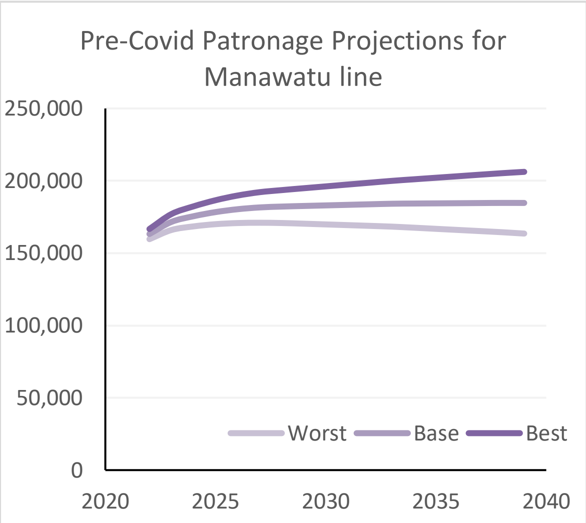
Patronage Forecast Methodology

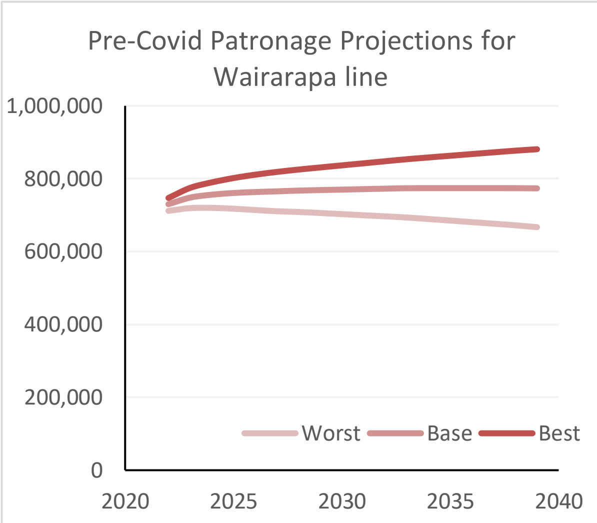
Lynxx has developed patronage forecast models for the Manawatu and Wairarapa rail lines as functions of population projections with/without additional growth, proportions of public transport users in the population, and distributions of travel/remote work patterns.

These projections are designed to explore various long-term and overlapping impacts of Covid. They differ in methodology from Lynxx's Lower North Island Business Case projections, which are based on time series projections of pre-Covid rail patronage figures.

The projections are separated into worst-, base-, and best-case projections based on the underlying Stats NZ population projection ranges. The best case scenario is expected to result in slow, long-term growth. The base case scenario (essentially the middle range) is expected to result in a long-term plateau of patronage demand (due to the plateau of population growth), and the worst case scenario is expected to result in a long-term reduction in demand due the negative population growth.

Varying individual hypotheses are subsequently explored for Manawatu and Wairarapa forecasts, with the likeliest hypotheses combined and presented.

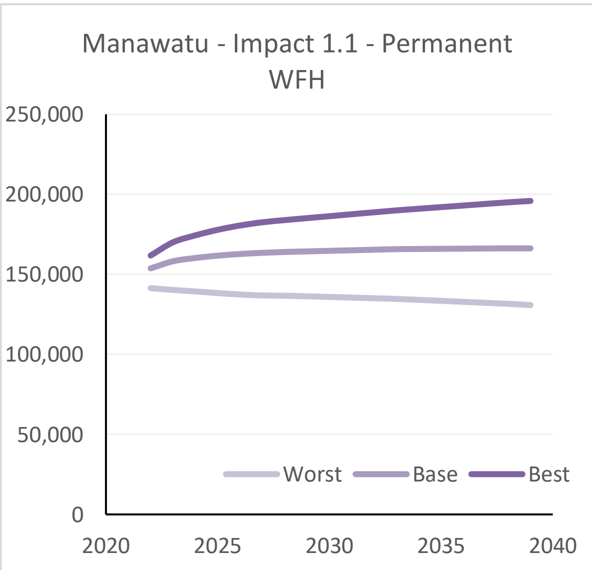


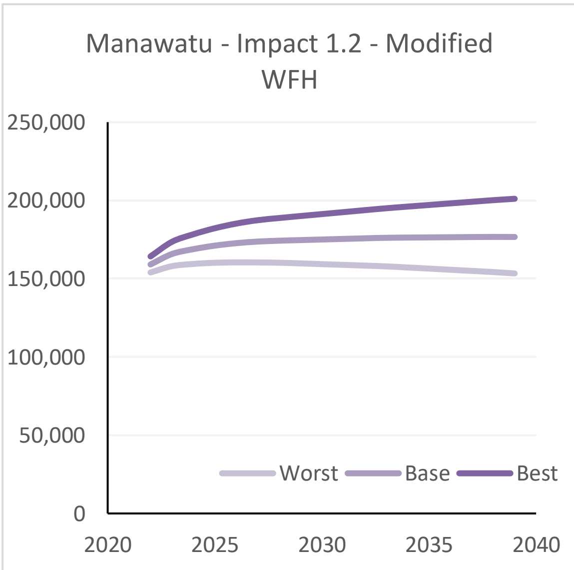


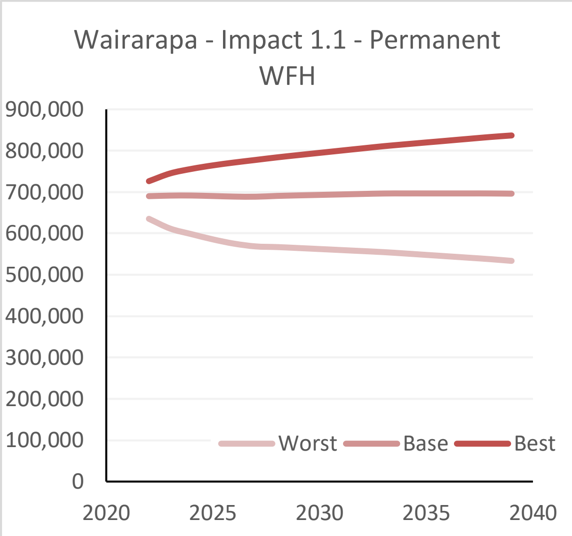
Hypothesis 1 – Working From Home

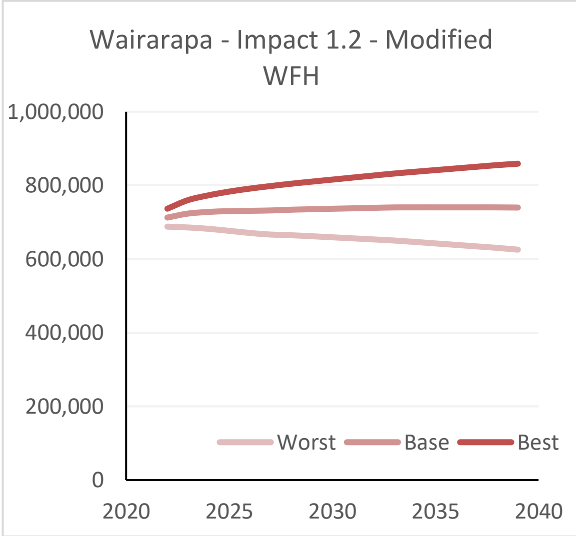
Due to Covid fast tracking the ability and organisational acceptance of working from home (WFH), people may choose to WFH more often. There are two potential impacts here – people now working remotely full-time (resulting in a reduction in total peak demand), and people who now WFH several days a week (resulting in changed distributions of travel patterns). Analysis comparing February 2020 and February 2021 patronage across the lines showed drops in Monday and Friday patronage (in addition to overall patronage drops), suggesting a potential long-term shift to 1-2 days WFH.

Impacts are treated as independent, but can be combined in the Excel model.









For impact 1.1, Lynxx applied peak demand drops of 20%, 10%, and 5% for each worst to best case scenarios. Here, a proportion of the population now permanently works from home.

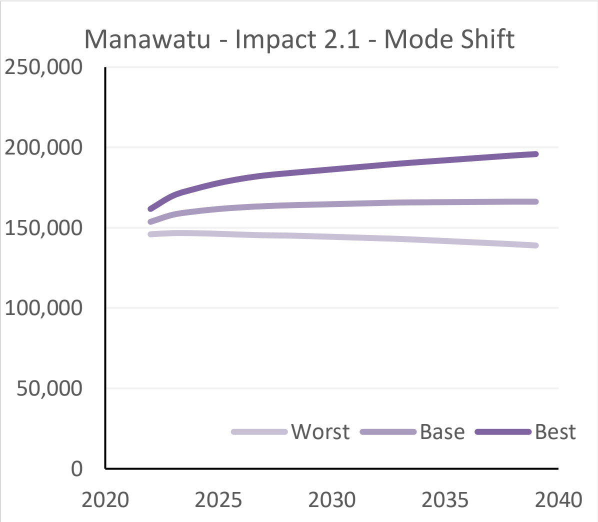
For impact 1.2, Lynxx assumed 2-5% reductions in those travelling 4 and 5 days a week, with those travellers assumed to now travel 2-3 days a week. Here, the population still commutes to work via the Manawatu line, but workers who previously worked 4-5 days a week are expected to WFH an additional 1-2 days.

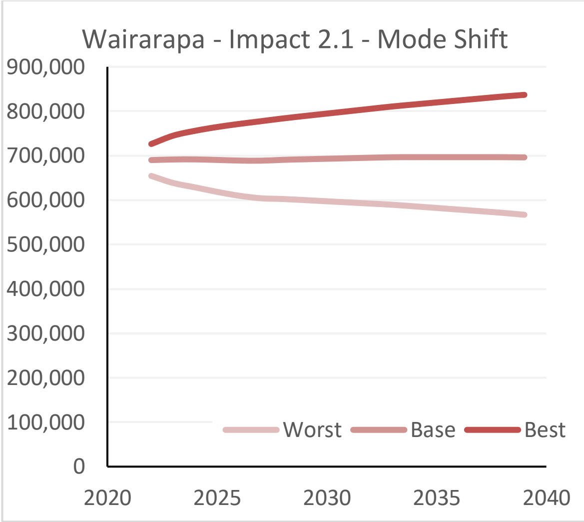
Both impacts result in suppression of patronage growth, although the trends of "best case -> growth", "base case -> plateau" and "worst case -> decline" remain the same.

Hypothesis 2 – Mode Shift

Due to experience with social distancing protocols and general growing discomfort with catching public transport, people may permanently mode-shift from rail to cars. Although studies in other countries have indicated significant mode shift effects (~50% reduction in rail in Canada, ~66% reduction in rail in India), New Zealand was not affected by covid infections as much. February 2021 rail analysis indicated the current patronage was down ~15% on pre-covid levels. Lynxx assumed this 15% drop could potentially be attributed to mode shift for worst-case projection, and assumed 10% and 5% drops for base- and best-case projections.

Assuming that vaccine rollouts progress without issue, this hypothesis may not apply in the long-run as people may shift back from cars to rail once comfortable.





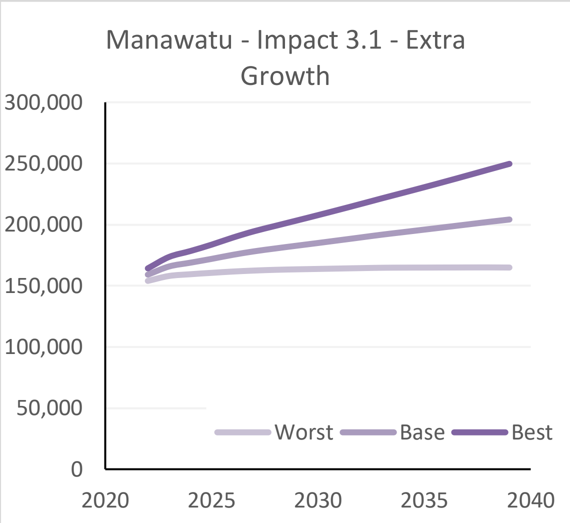
The resulting impact is very similar to that of impact 1.1, as the effects of mode shift are the same/similar as reduced peak travel. The trends of "best case -> growth", "base case -> plateau" and "worst case -> decline" remain the same.

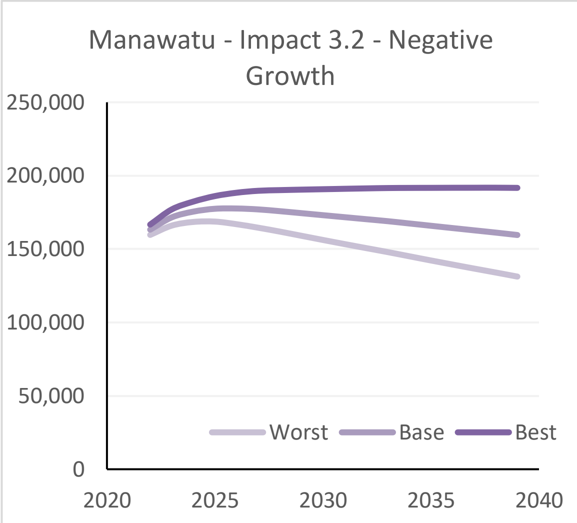
Hypothesis 3 – Population

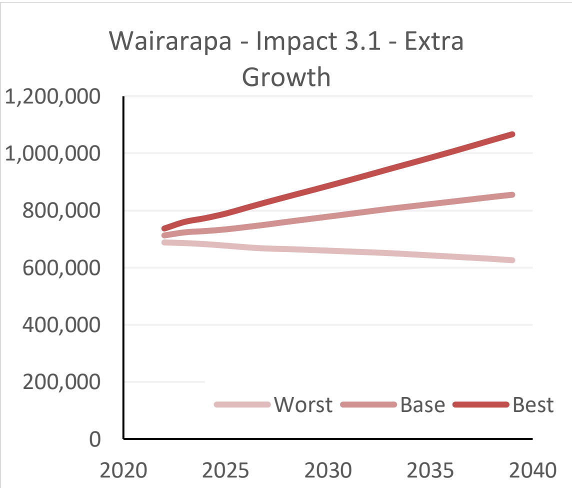
The population figures underlying the patronage projections are sourced from Stats NZ population projections published in 2017. Covid has resulted in factors that could significantly affect these projections in both directions, depending on which effect is dominant in the long-term.

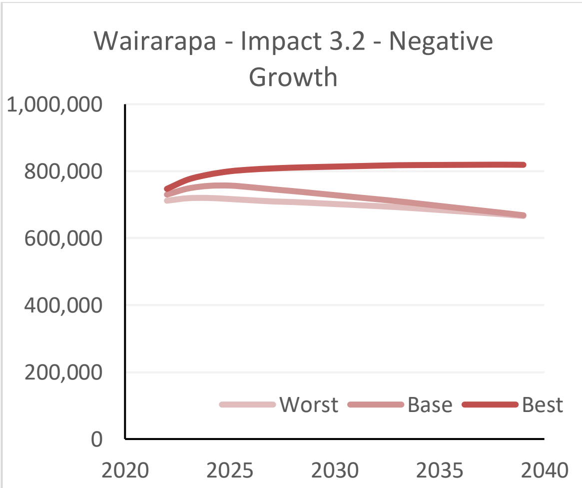
Impact 3.1 is that WFH acceptance allows people to move further from the cities and into regional areas for cheaper land and property, while maintaining their existing employment opportunities through a mixture of long commute and WFH. Lynxx models this through additional population growth (0.5-1.5% p.a) assumptions and the same 4-5 day WFH shifts as in Impact 1.2. This is expected to be a more long-term impact due to the lag associated with people moving regionally.

Impact 3.2 is that the effects of closed borders on immigration (such as reduced international students or skilled migration) take longer to return to pre-covid levels, putting a damper on population growth. Additionally, when international borders open up and vaccination levels are high worldwide, locals may take the opportunity to travel more to make up for missed tourism and holidays. Lynxx models this through negative population growth (-1.5%-0.5%) assumptions.





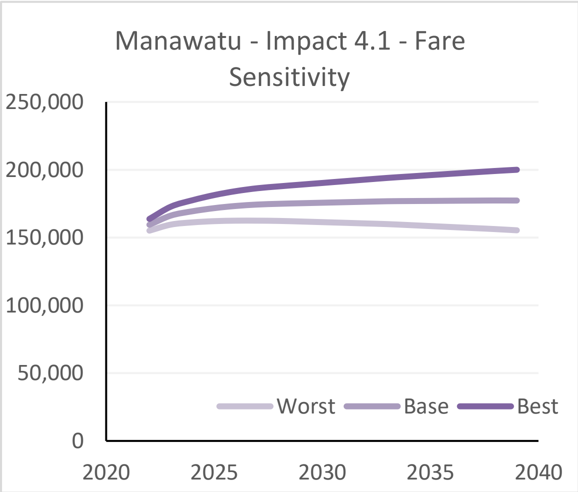


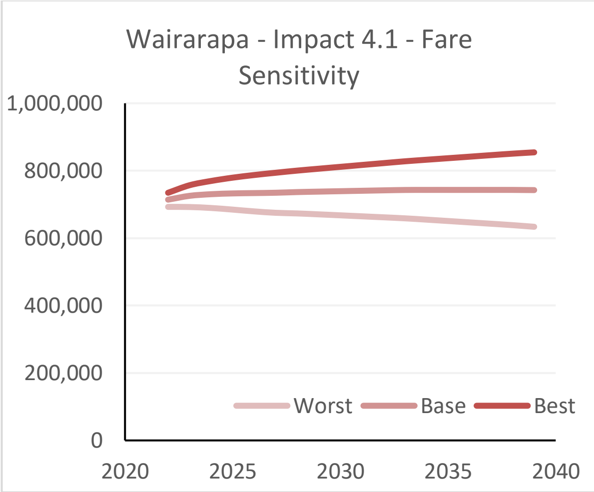


The impacts of alternative population growth have significant impacts on the patronage projections, due to the extra (or reduced) pool of potential rail users. Under Impact 3.1, the best- and base-case projections turn to growth, and the worst-case projection is a plateau. This reverses under Impact 3.2, with the best-case projection plateauing and the base- and worst-cases experiencing significant drops.

Hypothesis 4 – Fares

If fare price structures don't change to accommodate reduced travel patterns, people working from home more may feel that they do not get the same price value from seasonal/monthly/multi-trip tickets and may rely on public transport even less. This hypothesis is an extension to accompany Hypothesis 1. Price-demand elasticity research in the UK suggests that percentage changes in fares can result in lower-magnitude changes in demand - Lynxx has assumed 3-5% drops in peak demand for each case.





The resulting change in patronage projections is minor, and the trends of "best case -> growth", "base case -> plateau" and "worst case -> decline" remain the same.

Combining Likely Hypothesis

All hypothesis and related impacts have been discussed individually but are likely to interact with one another and have different long-term likelihoods.

It should be noted that we have taken the simplistic approach of combing the hypotheses in an additive approach and do not consider any potential interactive affects. Any interactive affects are likely to reduce the overall impact with the following results indicating the maximum potential outcome. We would caution making any conclusions made from combining hypotheses. We provide this view for an order of magnitude comparison. Of the impacts, the following have been combined to produce an overall projection of long-term covid effects:

- Impact 1.1 – A proportion of the population WFH permanently
- Impact 1.2 – The population changes their WFH behaviour to commute less
- Impact 3.1 – Greater additional population growth and modified WFH behaviour expected

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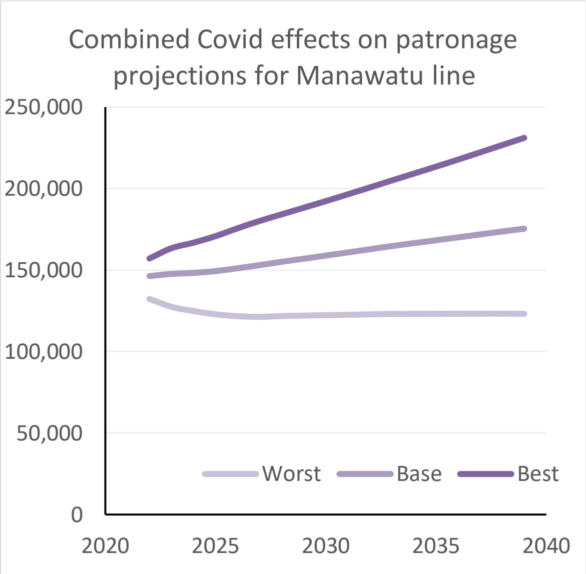

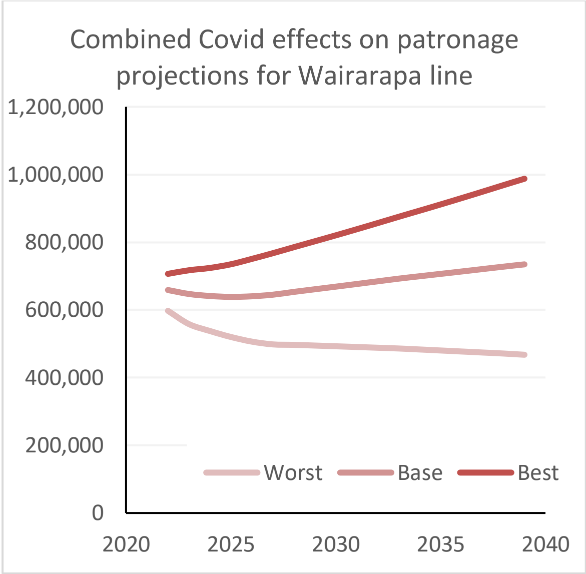

The overall effect is a minor reduction in patronage projections for the base cases, as the additional population growth is offset by the reduction in travel due to WFH trends. Here, the worst-case scenario expects a plateau and decrease of demand for Manawatu and Wairarapa respectively, while the base-case and best-case expect long-term growth of varying magnitude for both.

The uncertainty between the best- and worst-case projections is wider compared to the pre-covid projection, due to the additive parameters applied to each case.

Figures

Annual figures and adjustable parameters are available by selecting various hypothesis in the 'Cockpit' tabs in GWRC Covid Model.xlsm. The final combined hypothesis result is presented below in table form, compared with the unmodified projections and the upper/lower bounds of the baseline Lower North Island Business Case projections.

Manawatu Annual Peak Rail Patronage

	Unmodified Projections			Combined Hypothesis Projections			LNIBC Projections (provided for context)	
Year	Worst	Base	Best	Worst	Base	Current	Lower	Upper
2022	160,000	163,000	167,000	132,000	146,000	157,000	146,000	146,000
2026	171,000	180,000	190,000	122,000	151,000	176,000	156,000	161,000
2030	170,000	183,000	196,000	122,000	159,000	192,000	163,000	176,000
2034	168,000	184,000	201,000	123,000	167,000	209,000	167,000	191,000
2038	164,000	185,000	205,000	123,000	174,000	227,000	168,000	206,000

Wairarapa Annual Peak Rail Patronage

	Unmodified Projections			Combined Hypothesis Projections			LNIBC Projections (provided for context)	
Year	Worst	Base	Best	Worst	Base	Current	Lower	Upper
2022	712,000	730,000	747,000	597,000	659,000	707,000	704,000	704,000
2026	714,000	763,000	811,000	506,000	640,000	751,000	776,000	790,000
2030	703,000	770,000	837,000	493,000	669,000	820,000	838,000	875,000
2034	689,000	774,000	858,000	483,000	699,000	893,000	892,000	961,000
2038	672,000	774,000	877,000	471,000	728,000	969,000	936,000	1,046,000