Better Business Case

NIMT Performance Improvement

Quality Assurance

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Executive Summary

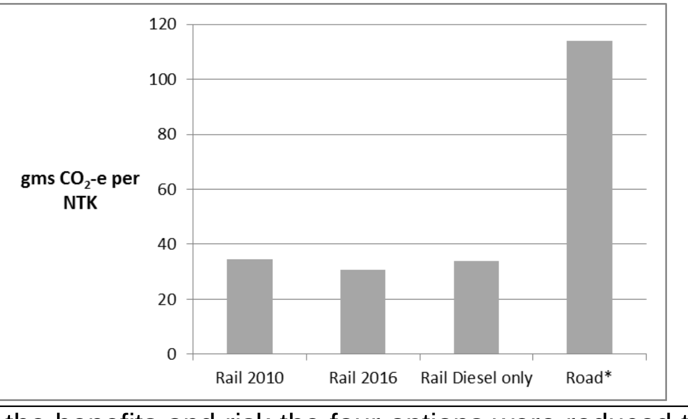
Business Strategy	For KiwiRail to deliver on its long term growth objectives and build a competitive market proposition it has a strategy of standardising our assets, simplifying the business, to reduce complexity and improve operating performance. Creating a simplified operating model is a key business strategy. Lifting operational performance will enable a lift in customer confidence and will unlock revenue growth as key freight forwarders convert more of their freight from road to rail.
Market Demand and Changes	Rail currently carries 16% of New Zealand's total freight volume (tonne-km), and is in direct competition with road transport and coastal shipping to capture the predicted growth in freight volumes over the next 20 years. Success in these markets requires KiwiRail to provide a reliable, cost-effective and consistent service to its customers. Without this certainty, and with strong competition from road transport, rail will continue to be used as an overflow service in the domestic market rather than as a primary freight line haul service provider. The North Island Main Trunk (NIMT) is a critical rail corridor for KiwiRail and one where growth and modal share shift is occurring. [redacted]
Current Situation/Challenges	KiwiRail's current operating performance on the NIMT is directly affecting its strategy of driving modal shift from road to rail, particularly in the domestic market. The premium services between Auckland, Wellington and Christchurch face significant time pressures in meeting customer needs and working around commuter networks and ferry timetables. The NIMT is electrified between Te Rapa and Palmerston North only. Under the current train plan the route is serviced by diesel DL locomotives from Auckland/Tauranga to Hamilton (Te Rapa), electric EF locomotives from Hamilton to Palmerston North, and finally diesel DL locomotives from Palmerston to Wellington (effectively a railway within a railway). The requirement to change locomotives and wagons at Hamilton and Palmerston North creates a degree of complexity and risk to daily operations.

Current daily Freight Task Between Hamilton and Palmerston North Requires	Current freight task delivered by	Current Locomotive Availability Percentages	Current Maintenance spares	Total Fleet Allocated to Hamilton to Palmerston North Section
• 22 mainline locomotives	• 10 EF; and • 12 DL's	• EF = 62.5% • DL = 88%	• EF = 6 • DL = 2	• EF = 16 • DL = 14

	In summary the current freight task requires 22 mainline locomotives in any one day, with the number of spares being determined by the maintenance spares availability percentage. Currently the total number of locomotives committed to this section of the NIMT electric corridor is inflated by the very low availability percentage of the EF fleet. The total number fleet required if the maintenance spare availability percentage was 88% would therefore be 25. In addition to these operational complexities, On Time Performance (OTP) on the NIMT has been impacted by under-performance of the EF locomotive fleet. The EF fleet is a 30 year old asset that has reached a critical point in its life, it is either overhauled and renewed now to last another 20 - 30 years, or it is replaced. The EF fleet over the past six months has had a mean distance between failures (MDBF) rate of around 22,000km (rolling average) up to November 2016which is below the overall fleet target operating level of 50,000km. Note the DL's have a MDBF of around 43,000km (rolling average) for the last 6 months up to November 2016 (generation 2.2 67,000km). The dual network model (diesel and electric) on the electrified section of the NIMT also means locomotive asset are underutilised, with electric locomotives spending 10 out of every 24 hours waiting for an assignment as they cannot be deployed anywhere other than on the electrified sections of the NIMT. The requirement to manage both electric and diesel networks on a single origin to destination sector also means multiple class inventory, technical training, maintenance processes, engineering expertise and depot configurations. Continuing to operate in this way places undue risk on the success of the business, or to put it another way, retaining the status quo is no longer an acceptable option.
Methodology and Objectives	Over the last 24 months KiwiRail staff have worked with a range of external consultants, stakeholders and the RMTU to identify and evaluate options to build a sustainable network to support domestic sector customer growth on the NIMT and materially improve on time performance for premium services. In line with the strategic priorities of the business, the review was guided by the following objectives: • Simplify the operating model and minimise risk • Standardise assets and improve their utilisation • Improve locomotive fleet reliability and availability

	• Minimise adverse environmental impacts

Options	Long list Options considered were to operate either:
	• A Mixed locomotive fleet of diesel and refurbished electrics via a control system upgrade: or
	• A pure diesel model; or
	• A pure electric model:
	  o Second-hand fleet
	  o New fleet

Environment	Whilst a shift to diesel would result in an estimated 10% increase in KiwiRail's emission factor, the net effect on New Zealand's overall emission rates would not be material. Every tonne of freight that is moved onto rail from roads delivers a 66% reduction in greenhouse gas emissions. A shift to diesel on the NIMT will increase the overall rail freight emission factor from 30.80 gms per NTK to approximately 34 gms per NTK, roughly a 10% increase. As the below chart shows KiwiRail achieved a similar reduction in the emission factor since 2010 from the new DL fleet, fuel conservation measures (including the Driver Advice System) and increases in freight volumes. 
Benefits and Risks	Following a detailed assessment of the benefits and risk the four options were reduced to two, with the EF control system and second hand electric options being eliminated as they did not meet the business objectives of simplifying the

	operating model and standardising the asset fleet. The EF control system replacement is considered to be high to moderate risk exercise with any external supplier expected to want to contract on a time and materials basis thereby placing all of the time and cost risk on KiwiRail. The risk that the control system will not work as planned is considered to be unsatisfactory with it taking potentially four years, at best, for any lift in service performance to be seen in the business. The second hand EQ option is considered to be suboptimal as it is introducing another class of locomotive into the fleet and it is a second hand asset. [redacted] Both of the DL and new Electric options are favoured to deliver on the business objectives of simplify and standardise. The DL model: • Is the only model to remove the operational complexity, asset downtime and fleet standardisation • Is the quickest to implement and the first to influence performance improvement objectives • Aligns with international practices, where the majority of rail networks are standardised and are either 100% diesel or electric on a single corridor The EL model: • Has greater implementation risk with the benefits of improved operational performance a minimum of five years away • With any new fleet a bedding-in time is anticipated to get the asset to perform to planned levels. Experience with the EF's and DL's suggests this could take a further three to five years from commissioning. [redacted]
Financial Considerations	A detailed financial model has been developed to determine the long run NPV cost cash flow ranges of the two shortlisted options with assumption based capital and operating expenditure profiles. Costings have been developed assuming the full electrified section between Hamilton and Palmerston North is saturated with either diesels or electrics. The current freight task between Hamilton and Palmerston North requires 22 locomotives on a daily basis plus spares to enable maintenance programmes to be delivered.

	For the diesel model, given that 14 (12 plus 2 maintenance spares) diesel locomotives are already allocated to and operate on this section, only the incremental capital needed to procure the balance of locomotives is included. However the operating costs of the full 25 (22 plus 3 maintenance spares) are used to determine the other expenditures. For the all electric model, the current diesel locomotives operating on this segment will become surplus and are therefore treated as a capital credit in the cash flow summaries. Overall the diesel option delivers a lower NPV cost [redacted] compared to the electric option which produces [redacted]. A lower up-front capital outlay of the DL's over the EL's is partially offset by the lower operating and maintenance costs associated with the electrics.
Conclusion	On balance, the all diesel model is preferred as it has a lower financial cost, lower implementation risk and the speed of which the benefits can be realised on the NIMT are sooner than the new electric model, which based on international experience could be greater than five years away before they are delivering on their potential. There is greater operating complexity in a mixed locomotive fleet model than a single fleet model. An all diesel model is therefore assumed to deliver the required business benefits at lower cost and risk than the other options considered. It should be noted that the electrified section of the NIMT corridor could be retained at an annual estimated operating cost of between [redacted] to protect the option value of the Hamilton the Palmerston North section of the NIMT. If the line was to be decommissioned an estimated decommissioning cost of [redacted] would be incurred, with the lines and jewellery removed, with the poles left standing. The annual electricity and maintenance cost would reduce to approximately [redacted] to ensure the remaining poles remained clear of the track. It is recommended that the electrified section of the NIMT between Hamilton and Palmerston North be retained in place and live with low energy use and reduced maintenance notwithstanding the shift to diesel only operations. Note that the status of the traction infrastructure on the NIMT will be reviewed again and brought back to the Board in three years.
Recommendations	It is recommended that the Board of KiwiRail: • **Approve** the shift to diesel-only operations on the NIMT and the decommissioning of the EF loco fleet; • **Note** the analysis in this paper of the opportunities and costs of leaving the electric traction infrastructure in place on the NIMT;

	• **Approve** leaving the electric traction infrastructure in place and live with low energy use and reduced maintenance notwithstanding the shift to diesel-only operations; [redacted]

1 Introduction

The paper asks decision makers to decide whether it is viable to continue to have two separate locomotive operating systems on a key part of the rail network, and whether the advantages of having an alternative fuel sourced locomotive option in the fleet outweighs the complexity and additional costs it adds to the business.

2 Strategic Case – Making the Case for Change

The Strategic Context

The strategic context provides an overview of the organisation and the outcomes that it is seeking to achieve, or contribute, to through its operations.

2.1.1 Organisational Overview

KiwiRail's vision statement is to be a "Trusted Kiwi-Owned Logistics Partner Growing New Zealand".

The strategic priorities for the business include to:

- Build service reliability
- Improve asset utilisation / productivity and efficiency
- Build ONE KiwiRail team and leadership aligned to our vision and purpose.

The key strategies KiwiRail will use to deliver the above are to:

- Simplify;

- Standardise; and
- Invest

In the context of this paper, improving the performance of the NIMT is a fundamental requirement of customers before they will commit to further freight volumes to the rail corridor. The current performance of the mixed locomotive operating model fleet is a major constraint to delivering on the growth aspirations as customers question the reliability of the network and resist converting from road to rail as a result.

2.1.2 Alignment to Existing Strategies

KiwiRail has been embarking on a strategy to standardise its rolling stock fleet assets since 2010. This has been set out consistently in the Rolling Stock Asset Management Plans[1]. The replacement of old classes of diesel locomotives with the new locomotives, plus the deployment of classes within circuits/corridors namely:

- DX class within the South Island network,
- DL locomotives in the North Island network; and
- DF locomotives in Passenger services

[redacted]

However, the most pressing decision is what to do with the current fleet of electric locomotives that operate on the Hamilton to Palmerston North segment. This decision is overdue and delays in making this decision further will simply add to the length of time it will take to bring this line segment's performance up to the standard both KiwiRail and its customers demand.

A key outcome of the review to KiwiRail's Operating model was the strategy to standardise and simplify the business. This is consistent with the approach that has been taken over the last 6 years to standardise all rolling stock assets and freight operating depots. Simplifying the operating

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[1] Freight Asset Management Plans, FY13,14,15

model by removing unnecessary or additionally complex processes and service offerings in the delivery of the freight task is key to delivering on the business objectives as outlined above.

There is greater operating complexity in a mixed fleet model than a single fleet model. Primarily due to lower EF asset utilisation, additional specialist resources and complexity of train planning to integrate the mixed locomotive fleet.

Investment Objectives, Existing Arrangements and Business Needs

This sub-section assists in providing a compelling case for change by setting out the investment objectives of this proposal, describing the existing business arrangements and outlining the business needs the proposal is intended to address.

2.1.3 Investment Objectives

The investment objectives for this proposal were developed via a series of workshops between key stakeholders in the business and are:

1. Lift freight reliability on the NIMT back to targeted levels by standardising the locomotive fleet, simplifying the train plan and investing in assets.

2. Reduce complexity [redacted]

These factors are used to assess the long list of options refer Table 9.

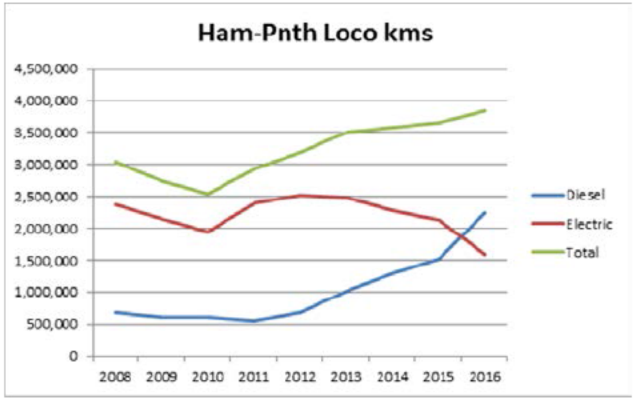
2.1.4 Existing Arrangements and Business Needs

Detailed below is a summary of the existing arrangements and business needs for each of the investment objectives for this business case.

Table 1: Summary of existing arrangements and business needs

Investment Objective One	Lift freight reliability on the NIMT back to targeted levels by standardising the locomotive fleet, simplifying the train plan and investing in assets
Existing Arrangements	The current reliability of the EF fleet has resulted in them being removed from key premier freight services in favour of the DL fleet. There are insufficient electrics to fulfil the current freight task and locomotive power allocation has been prioritised to ensure key freight services are given access to the more reliable diesel fleet. A challenge continues when an EF fails in service and causes a knock-on effect to other trains operating around it. EF mean distance between failures has reduced to an unacceptable level of less than 25,000 MDBF. The EF fleet is the most powerful of the locomotive fleet at 3,000 kilo watts compared to a DL, which is 2,700 kilo watts. The next most powerful is the DX fleet with a kilo watt gross output of 2,460. What this practically means is the speed of the EF's, everything else being equal, will be faster, which translates to approximately 10 - 20 minutes on an average train journey. The train service is required to enter into a terminal and travel to a point where it is safe to carry out the task of exchanging locomotives. Historically train plans were designed with the requirement to enter terminals to exchange wagons which were done at the same time as detaching and attaching the locomotives. The physical task in our train plan assumptions is scheduled on average to take approximately 40 minutes per terminal (noting it can happen faster but 40 minutes is what is allowed in the schedules to enable the actions to be undertaken safely, refer trials undertaken in Appendix B EF/DL)). Above all, the activity adds to the risk that something will delay a train service as there are greater event opportunities for something to go wrong during this process. It should be noted that the above timing benefits have not been a major element in the decision making process. The more critical elements to the decision making process are improving the overall reliability of freight services for customers. On-time performance on the NIMT has suffered as a direct result of the mixed fleet amongst other things. It is not possible to isolate the exact impact of the EF fleet on OTP in terms of a definitive number as there are too many moving variables to analyse. However there is sufficient anecdotal evidence from the operational services teams close to the day to day process to indicate the EF's have the lowest MDBF performance. Mean distance between failure for the EF v DL fleet for the last 6 months is as follows: • EF around 20,000km – refer to Appendix A.2 for EF Asset condition and reliability • DL around 40,000km • DL Gen 2.2 exceeded 80,000 for the first 6 months of 2016 Considerable work has been undertaken on the DL reliability programme jointly between KiwiRail and its locomotive suppliers (CRRC) (refer to Appendix A.1). The relationship between KiwiRail and CRRC has moved from an asset only procurement one to an integrated service

	support agreement. A comprehensive programme is now in place to lift performance and includes amongst other things the following: • Establishment of a permanent after sales support team based permanently in New Zealand. • Establishment of a permanent parts store in New Zealand. Parts will be drawn from the New Zealand based store rather than via China. This will greatly improve lead times for parts availability. • Participate in a DL lifecycle study to establish future overhaul and maintenance programme for the DL fleet. • [redacted] • [redacted] [redacted] Subsequent commissioning processes have been revised to incorporate the learnings of the first batch including the following elements: • Load bank testing in China pre shipment • 6 months shakedown and commissioning process prior to entering into commercial operation • Paired runs with other locomotives The commissioning process has seen much improved results with the Gen 2.2 locomotives showing much better performance (refer to Appendix A.1).
Business Needs	The business requires a consistent and reliable service performance of its network to enable it to grow revenue streams. Customers have stated that there is a direct correlation between reliability of KiwiRail's network and the amount of freight they will direct towards rail. Having a standardised fleet of locomotives and operating under a simplified train plan are key inputs to delivering on the above objectives. A key element to the improvement in the on time performance and reliability of train services is to purify train services to be more direct running to destination which removes the need to stop along the journey to exchange wagons and locomotives. Reduce the requirement to stop and transact in a terminal will reduce congestion and improve overall train performance. When train performance improves customers will gain greater confidence in KiwiRail's ability to deliver a consistent and reliable service. Once this confidence level improves customers have indicated that they will start to move product that is currently on road back to rail. This process will see the Domestic market for rail grow again, with rail picking up a larger portion of the backload freight which has been diverted to the road network to help pay for the higher costs of putting a road unit on instead of a rail unit. The current on time performance of the NIMT with double heading and direct running has lifted to targeted levels of greater than 90%, as demonstrated by the recorded OTP for July and August 2016 of 93%. This improvement is testament to the strategy of eliminating failure

	points on the network and simplifying the train plan.
Investment Objective Two	Reduce Complexity [redacted]
Existing Arrangements	KiwiRail currently operates a mixed locomotive fleet model on a key section of the NIMT. Some 30 years ago an investment was made to electrify the Hamilton to Te Rapa which included the procurement of 22 electric locomotives. This was sufficient to run all services between these two points using the electric fleet. At the time the locomotive fleet was assumed to have a life of 30 years, with the infrastructure assumed to have a life of 50 plus years. Over time the electric fleet has reduced via derailment damage, hitting slips and fire etc. with a portion of the fleet being used for inventory components to support the balance. The balance of the freight task was supplemented by the diesel fleet. As at today the total number of operating EF's in the fleet has reduced to 16, with only 10 (62.5%) of those built into the daily freight plan. The performance and reliability of the fleet has reduced to a level where an increasing level of the fleet are in "servicing" and a decreasing level are built into the plan.  The freight task on the Hamilton to Palmerston North section requires 22 locomotives on any given day plus maintenance spares. This is made up of 12 diesels (of the 48 in the fleet) and 10 electrics (of the 16 operable electrics left in the original fleet of 22) plus maintenance spares. The current load schedules on the electrified segment of the corridor has a weight limit of approximately 900 tonnes per individual locomotive (assuming a DL or an EF). The average load of a train on this corridor is between 1,200 to 1,400, with the maximum load being 1,700 tonnes. Therefore the majority of trains on this corridor have dual locomotives. The electrics are able to do a return journey each day between Hamilton and Palmerston North (approximately 8 hours journey time over the 400km's), while the diesels remain on the train for the entire journey for the Auckland to Wellington leg. Over time the fleet mix has changed, with diesels taking a higher portion of the workload, (refer to the above graph), as the numbers of EF's in the plan have reduced due to EF availability and reliability factors. A mixed locomotive model has limitations if the freight task flexes, with the electric locomotives being confined to the electric section, whereas the diesel fleet can be redeployed.

	The overall freight task on the Hamilton to Palmerston North section has increased recently [redacted]. It can be extrapolated that if nothing is done to arrest the EF fleet overall performance then the fleet will ultimately be substituted by diesels and the electric corridor operating costs will be spread across an ever decreasing fleet. This is both a sub optimal situation and an inefficient use of resources. The EF has requires additional resources to service and maintain the fleet. [redacted] •
Business Needs	Standardising the fleet will remove a unique specialist class of locomotive. [redacted] Train planning and day-to-day operations to require less variables to deal with, making plans easier to design and execute. Minimising the requirement to attach and detach locomotives will reduce risk for our people. [redacted]

3 Economic Case – Exploring the Preferred Way Forward

The purpose of the economic case is to identify the investment option that optimises value for money.

Critical Success Factors

The critical success factors for this investment proposal have been identified by the Project Steering Committee (a sub set of the KiwiRail Executive team) and are described in the table below. This set of factors is used to determine the final preferred option of the shortlisted options.

Table 2: Critical Success Factors

Generic Critical Success Factors	Broad Description	Proposal-Specific Critical Success Factors
Strategic fit and business needs	How well the option meets the agreed investment objectives, related business needs and service requirements, and integrates with other strategies, programmes and projects.	Does it help deliver consistent reliability for customers? Does it reduce complexity and cost? Does it improve commercial performance? Will it help grow the business Will it reduce Carbon Emissions?
Potential value for money	How well the option optimises value for money (i.e. the optimal mix of potential benefits, costs and risks).	*Refer to final financial case*
Supplier capacity and capability	How well the option matches the ability of potential suppliers to deliver the required services, and is likely to result in a sustainable arrangement that optimises value for money.	Is the supplier known to KiwiRail? Have we procured from them previously? How did that go? Are they a strategic supplier?
Potential affordability	How well the option can be met from likely available funding, and matches other funding constraints.	Does the funding scenario fit within the current funding process?
Potential achievability	How well the option is likely to be delivered given the organisations ability to respond to the changes required, and matches the level of available skills required for successful delivery.	Does KiwiRail have the internal expertise within its resources to successfully scope and manage the procurement process?

Long List Options and Initial Options Assessment

A range of options for achieving the investment objectives was generated by KiwiRail Fleet Engineering. These are detailed in *Motive Power Options for the North Island Main Trunk 2013*[2]. Further work has been done in 2016 [redacted].

3.1.1 Options Identification

Under the five dimensions a comprehensive long list of in-scope options have been identified and detailed in the table below.

Table 3: Possible options classified by the five dimensions of choice

Dimension	Description	Options within each Dimension
Scale, scope and location	In relation to the proposal, what levels of coverage are possible?	• Solution applied to 25 kV NIMT • Solution applied to all of NIMT • Solution applied to Auckland to Christchurch
Service solution	How can services be provided?	• Operational solution • Infrastructure solution • Mechanical solution
Service delivery	Who can deliver the services?	• KiwiRail mechanical staff • KiwiRail infrastructure staff • KiwiRail operations staff • External contractors infrastructure • External suppliers mechanical [redacted]
Implementation	When can services be delivered?	• During overhaul • Concurrent with operations

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[2] *Motive Power Options.doc*; available from KiwiRail Fleet Engineering, May 2012

[redacted]

		• During block of line
Funding	How can it be funded?	• Existing capital • Capital in future budgets • Shareholder funding

3.1.2 Long List Options Development

The options developed through consideration of the 'categories of choice' that will be assessed in this business case are described in the table below.

Table 4:

Option Title	Option Description
Status Quo	Remain operating the current EF fleet (16 in fleet and 10 in train plan) and 14 diesels to undertake the freight task. Over time the number of the fleet will decline as locomotives have critical failures increasing cost per unit to operate given the high fixed cost of infrastructure and electricity costs. The overall performance of the line will suffer as the reliability of the EF's is assumed to continue to deteriorate without a major intervention.
EF Control System Replacement	Upgrade the control system with a modern alternative. Requires a prototype exercise to be performed to ensure the new system will work. Previous investigations with [redacted] in 2011 (original suppliers) is that the replacement system overall timing will be approximately 4 to 5 years from start to finish. In accordance with KiwiRail's procurement policy potential suppliers will need to be approached to identify if they can develop a solution to meet KiwiRail's requirements. Replacing the control system still only addresses a portion of the fleet required to operate on the Hamilton to Palmerston North corridor, with a known risk that the fleet will reduce in size over time as locomotives have critical failures. The current corridor freight plan requires 22 mainline locomotives to operate. With only 16 electric units currently available, a mixed diesel and electric model will continue to be required, which does not satisfy the key criteria of simplify and standardise. Replacing the control system will in effect mean the physical locomotives' lives will be extended well beyond the original 30 years originally contemplated when they were first procured. Put another way, if this option is pursued the EF locomotives' chassis will be 60 plus years old at the end of the assumed time horizon (2046). In light of above the other components that will require addressing if the life is extended include:

- Switchgear – VCB, high tensions cable and power brake switch
- Diagnostics system
- Armature Converter Diode
- Firing plugs replacement
- Encoder PCB
- POLI wheelslip system
- Battery Charger system
- Brake system [redacted]
- De rust and painting

Under this option a total of 16 EF's are available for the control system upgrade meaning a reduced number of diesel locomotives would be required to supplement the fleet to move the freight task. It has been assumed that the EF availability percentage can be raised to 88%, meaning 14 of the 16 locomotives would be available for service each day. This would mean, everything else remaining equal, that five diesel locomotives would then be surplus. Noting this will be some four years away and assumes that all 16 locomotives remain operative, and that 10 are kept available whilst the control system is installed.

In summary the key benefits of the EF Control system replacement are:

- Low capital cost compared to the purchase of a new locomotive
- Sustainable for 30 years
- Improved MDBF
- Lower energy costs with a fixed line charge and a variable usage element (compare to diesel)
- Lower maintenance costs (compared to diesel)
- Improved fault finding and diagnostics
- Improved availability

The risks and costs associated with the replacement EF control system are:

- Compatibility issues with current components
- Uncertainty on whether supplier will continue to support such a small fleet – risk is all KiwiRail's
- Updating the control system has implementation risks which suppliers will seek to contract themselves out of leaving KiwiRail exposed to both financial and time risks

	• Economies of scale of the electrification segment are not optimised as it still requires a mixed locomotive fleet • The locomotive is already 30 years old and will be 60 years old at the end of the period. In conclusion this option is the highest risk option.
New Electric Fleet	Replace current fleet plus additional fleet to saturate the corridor with a new electric locomotive of similar specification to the current EF. In terms of numbers to procure three options were considered: • Replace current EF fleet of 16 (14 plus two spares) 1 for 1 • Only replace current EF fleet deployed in the train plan (currently 10 plus 1 spare) • Replace with sufficient electrics to saturate the corridor (22 plus 3 spares) In the context of the overall objective of simplifying and standardising, the last option was chosen as the best outcome. In this scenario the current EF and diesel fleet would be surplus to requirements. The model assumes the EF's are scrapped and the diesels (14) are held and utilised for subsequent diesel acquisitions. In this scenario a suitable candidate locomotive has been identified [redacted], and this has been used for costing and analysis purposes. It should be noted that if this option was selected then a full RPF process would be the most prudent to follow. In summary the key benefits of new Electric locomotives are: • High horsepower • Faster over distance – everything else being equal • Lower service and maintenance costs due to less moving parts • Sustainable hardware and systems • Energy recovery via regeneration • MDBF higher that current EF's and on par or better than the diesel fleet The risks and costs associated with a new electric fleet are: • Large upfront capital investment with a purchase price that could be up to one third higher than assumed in the modelling • Long lead time depending on supplier • Uncertain reliability with potential bedding in issues

	• Safety Case will need to be developed and approved • Four years waiting for the electrics to be built and commissioned
Second Hand Electric Fleet	As above, but replace the current electric fleet with a single cab second hand electric locomotive of similar specification to the current EF. The same assumptions as the new electric locomotives apply to the existing fleet operating on this line segment. A possible solution has been identified 30 [redacted] with the KiwiRail fleet team having visited [redacted] and undertaken a due diligence exercise on the fleet.[4] In summary the key benefits of a second hand electric fleet are: • Procurement cost is substantially cheaper than new electrics • Lower running costs than diesel • Proven performance based on current running and maintenance records • Equivalent horsepower to current electric fleet • Immediate availability and relatively short commissioning time but still expected to be more than 24 months The risks and costs associated with the second hand electrics are: • Whether the performance of the locomotives will the same in New Zealand conditions • Introduction of another fleet will provide a distraction to the limited engineering resource focused on overall fleet improvement programmes • The purchase price certainty [redacted] • Safety case will need to be developed and approved • Another fleet • New class requiring certification • New spares, parts, tooling, testing and training
Diesel Fleet	Remove the electric fleet completely and replace with sufficient DL's to saturate the corridor with a single class of locomotive. With only 10 EF's currently included in the train plan, the balance of the freight task is already undertaken by the DL fleet. The number of diesels to replace the electric locomotives is one for one in the operating plan. Therefore it is assumed that the 10 EF's in the current plan will need to be replaced with 10 DL's and sufficient spares (1) to ensure 10 are available on a daily basis.

[redacted]

	[redacted] In summary the key benefits of the DL locomotive option are: • Lower capital cost than EL's • Standardisation of the NI fleet • Improved operational performance and reliability of the NIMT • Faster commissioning period than a new electric option • Enables maintenance depot rationalisation • Reduced train plan and operational complexity The risks and costs of the DL locomotives are considered to be: • Diesel v electricity cost • Higher energy emissions • Higher maintenance costs per km due to more moving parts • Early life reliability of the DL's
Electrify the NIMT in full	Continue with the Electrification of the NIMT in the non-electrified segments to complete the network. [redacted]

Before this assessment is undertaken a detailed benefits and risks analysis was undertaken with the results shown below.

Main Benefits

An analysis of the potential benefits of the investment proposal were developed via a series of workshops with both key operational and technical engineering staff within the business and are detailed in the tables below against each of the long list options.

Table 5: Analysis of potential benefits that can be expressed in monetary terms

Main Benefits	Description	Who Benefits?	EF Control System	EQ Second Hand	EL New Electrics	DL
Standardise the locomotive fleet	A standard fleet provides economies of scale benefits to the business and simplifies how the business operates across the network	Customers Operational staff	Fail Mixed fleet remains	Partial Introduces another class Single Cab	Partial Introduces another class	Pass Consistent with stated objectives
Customer growth	A lift in reliability and customer confidence which will assist model shift growth	Stakeholders and customers	Fail Uncertain performance. Multi attach/detach process risk retains	Partial Promised uplift, albeit it unproven in New Zealand conditions. Multi attach/detach risk remains	Partial Short term 5 years before benefits realised, high risk of commissioning and settling down period. Multi attach/detach risk remains	Pass Fastest implementation option. Known performance improvement plans. Current direct running model working
Lower long run overall cost of ownership of the rolling stock fleet (up front capital and ongoing maintenance)	A lower cost to serve model makes the overall competitiveness of KiwiRail's service proposition more compelling.	Shareholder and customers	Partial Lower cost per km maintenance,	Partial Lower cost per km maintenance than a diesel,	Pass Lower cost per km maintenance than diesel, but a	Partial Higher cost per km maintenance cost than electrics

	Lower cost of auxiliary components as improved economies of scale with smoother production flows.		albeit a 30 year asset with expected higher tail end performance costs	albeit a 30 year old second hand asset with uncertain tail end perfor-mance cost	higher initial purchase price	due to more moving parts
[redacted]	[redacted]	[redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
[redacted]	[redacted]	[redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]

						[redacted]
[redacted]	[redacted]	[redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]

Table 6: Analysis of potential benefits that cannot be reliably expressed in monetary terms

Main Benefits	Description	Who Benefits?	EF Control System	EQ 2nd hand	EL New Electrics	DL
NZ land transport system emissions	Reduction in overall carbon emissions for New Zealand if modal shift occurs from road to rail	Stakeholders	Pass	Pass	Pass	Pass
Consistent on time performance	Overall reliability performance will improve and in the long run is expected to lift revenue as customers have greater confidence in KiwiRail's network	Customers	Partial In short term no immediate benefits, with final results	Partial 2 years to bed-in with performance in New Zealand	Partial In the short term no, 5 years until benefits realised	Pass Programme in place with supplier to lift performance to

			uncertain and unproven	conditions uncertain		targeted levels
Fleet availability	Consistent locomotive asset availability will simplify train plan and build customer confidence	Customers	Fail No uplift for a minimum of 4 years whilst programme undertaken	Partial Greater than 2 years to bed in with performance in New Zealand conditions uncertain	Partial In the short term no, 5 years until benefits realised	Pass [redacted]
Simplify the train plan	Reduce complexity for train planning and operations	Operations	Fail Current complexity retained	Partial Reduction in complexity but direct running not achieved	Partial Reduction in complexity but direct running not achieved	Pass Simplest model

Main Risks

The main risks that might create, enhance, prevent, degrade, accelerate or delay the achievement of the investment objectives are identified and analysed below.

Table 7: Initial risk analysis

Main Risks	Description	EF			EQ			EL			DL		Comment
		C[5]	L[6]		C	L		C	L		C	L	
Ease of Commissioning and Operational settling in periods	Implementation takes longer and costs more than planned	H	H		H	M		H	H		M	L	Historically the DL commissioning process was not well planned [redacted] however we now have a proven methodology with increased time allowed for commissioning prior to release for commercial service. The safety case for the DL's has already been delivered, whereas the EF, EQ and EL solutions will require a safety case process. EF control system will require further sign off regarding the safety case as changes will be made to the way the locomotive performs EF and EL options have high degrees of uncertainty and risk, both to time and cost
Price Certainty	Final cost is higher than planned	M	H		M	M		M	H		L	L	[redacted]

[5] Consequence

[6] Likelihood

													[redacted]
Operational Safety	Operational safety is adversely impacted	L	L		L	L		L	L		L	L	A pure diesel model eliminates increased points of contact on NIMT operations All other options fail to reduce this risk With one class of locomotives it is easier for our staff to identify with the operational hazards
Main Risks	**Description**	**EF**			**EQ**			**EL**			**DL**		**Comment**
		C[7]	L[8]		C	L		C	L		C	L	
Freight task falls away	Overall freight task reduces thereby reducing the demand on the fleet	M	L		M	L		M	L		L	L	Diesel fleet can be redeployed on other corridors, whereas the electric fleet is locked within the electrification section of the track
Performance fails to lift to required reliability standards	Planned operational performance of the locomotives falls short of assumed levels	M	H		M	H		M	L		M	L	[redacted] EQ's currently 30 years old with a high risk tail end performance Key element on the EF and new EL's is the length of time and potential cost to get to assumed levels. Potentially 5 years plus
Technical Resource	[redacted] Very reliant on	M	H		M	H		M	H		L	L	[redacted]

[7] Consequence

[8] Likelihood

Availability	support from suppliers. [redacted]												[redacted]
Fuel Price	Potential price spikes drive higher energy costs	L	L		L	L		L	L		L	L	Price changes for either diesel or electricity are mitigated via standard price adjustment mechanisms with customers
Procurement partner	Strategic supplier than can support KiwiRail.	H	H		M	M		M	L		L	L	KiwiRail has not procured a new electric mainline locomotive for 30 years Design Supply Test and Commission Ongoing partnering

3.1.3 Options Assessment

This assessment examines each option against a set of business criteria that align to the achievement of KiwiRail's stated business objectives namely:

- Improving fleet availability and reliability
- Asset standardisation and utilisation
- Simplification of operations
- Benefit realisation, or time to market.

Table 8: Summary of Long List Options Assessment against the business objectives

Assessment criteria	EF Control System	EQ Second-hand	EL New Electrics	DL
• Improving fleet availability and reliability	Partially Benefits 4 years minimum from realisation End of life performance uncertain	Partially End of life performance uncertain [redacted]	Pass Modern asset with latest configuration	Pass Modern Asset
• Asset standardisation and utilisation	Fail 30 year old asset Mixed fleet model	Fail 30 year old asset Mixed fleet model	Partially New Asset Mixed fleet model	Pass New Asset Single fleet model
• Simplification of operations	Partial Doesn't meet the stated objective but could if compatibility between electrics and diesels achieved to allow dual running	Partial Single Cab Doesn't meet the stated objective but could if compatibility between electrics and diesels achieved to allow dual running	Partially Doesn't meet the stated objective but could if compatibility between electrics and diesels achieved to allow dual running	Pass Removal of operational complexity
• Benefit realisation and time to market	Fail Uncertain results from control system upgrade, with minimum 4 years before benefits will be realised	Partially Immediate improvement in results if assumed performance achieved in New Zealand conditions Tail performance risk as asset exceeds 50 plus years	Partially Expected results from a new asset are expected to deliver benefits, however potentially 5 years away	Pass Time to market known with high degree of confidence Early benefit realisation
Overall Assessment	Fail	Fail	Partially/Pass	Pass

Based on the above assessment, it is concluded that the EF control system and the second-hand electric fleet will not meet the business objectives and are therefore eliminated. This narrows the options to two, namely a pure new electric or pure diesel model.

4 The Commercial Case

The Procurement Strategy

- New Electrics - EL

If the new electric option was chosen it is recommended that a full Request for Proposal (RFP) process be followed in line with the Government's procurement practices. A detailed technical specification would need to be created first to establish the basis from which tenderers could bid from. Preference would be given to suppliers that could deliver proven fleet options rather than any bespoke design and build option.

The pool of potential suppliers is limited. Known suppliers include, [redacted].

The order size is likely to be a limiting factor in attracting potential suppliers.

Any RFP process will be structured to ensure suppliers deliver a turn-key solution for design, build, testing and commissioning. KiwiRail cannot be exposed to the development of a bespoke solution, with strong preference being given to an existing locomotive solution that is fit for purpose in New Zealand operating conditions. Suppliers will need to demonstrate a strong partnering approach with a commitment to remain closely associated with their product for the life of the asset.

- Diesel

[redacted] The final number to be ordered will be dependent on the final assessment done by the business as to the final makeup of the fleet, including opportunities to remove double heading once performance improves, introduce banking operations to free up fleet, and a final assessment on the availability percentage targets for the fleet [redacted].

[redacted]

Train Planning and Operations

As discussed above in the benefits section, the gains that can be made in train planning and the operating environment are significant in a pure diesel operating model. A mixed locomotive model adds greatly to the complexity associated with ensuring the fleets are optimised within the operational constraints that exist. Train planning must take into account, amongst other things, the following elements when constructing an optimised mixed fleet plan:

- Load schedule constraints of each fleet, on each segment of track
- Locomotive coupling configurations, including minimising the total number of locomotives required, and which fleet connects to what service
- Relative run times each fleet class operates, within load restraints and schedules.

Day of operations has the added complexity in a mixed locomotive model for example ensuring the locomotive allocations and couplings work when the day of operations does not go to plan due to on the day disruptions.

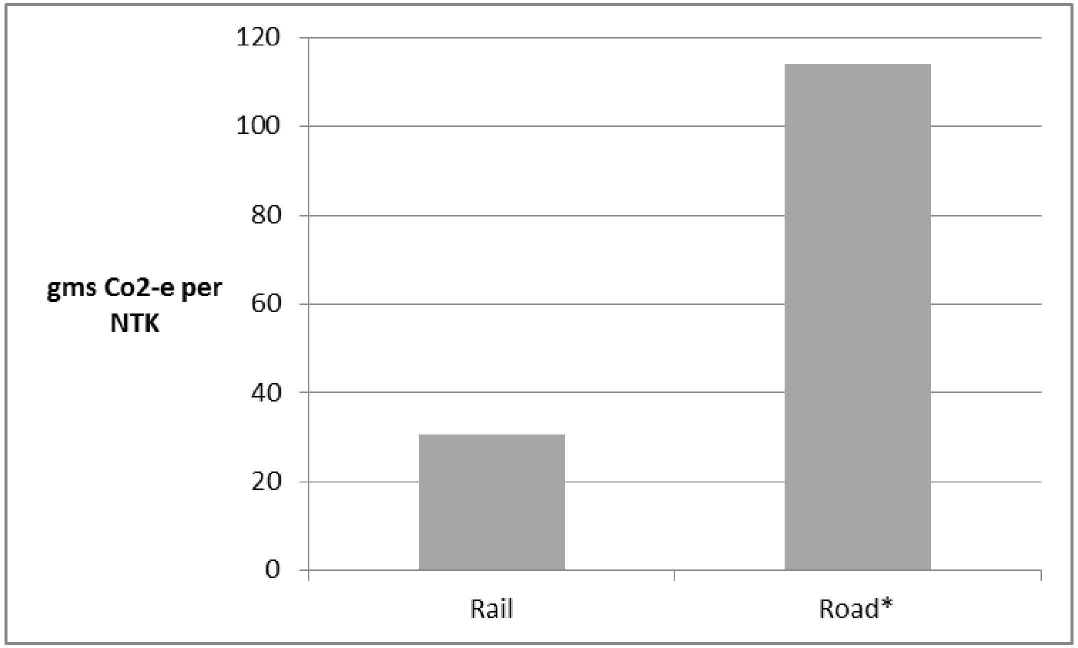
Overall the level of complexity is greatly reduced under a single fleet operating model.

Environmental Considerations

Context

Emissions from rail (142 kilo tonnes), as shown in the latest Greenhouse Gas Emissions Inventory (2014) are less than 1% of all transport emissions. Transport (13,955 KT) accounts for 17% of all New Zealand emissions.

For every tonne of freight that is moved onto rail from roads delivers a 60% to 70% reduction in greenhouse gas emissions. This is based on the associated emission factor for the respective modes – *greenhouse gas emissions produced per net tonne kilometre (NTK)*. Rail freight's emission factor sits at 30.80 gms per net tonne km (NTK). To provide some comparison, the United Kingdom produces a Heavy Goods Vehicle (HGV) emission factor each year and this is currently 114 gms per net tonne km. There is no comparable road freight figure for New Zealand.



Assessment of Emissions for each of the Options

The existing freight task undertaken by the current mix of EFs and DLs produces 18,300 tonnes of GHG emissions. This is used as the base case for assessing the three options:

- Upgrade EFs – decrease in emissions by 4,800 tonnes
- Replacement with DL fleet – increase in emissions by 12,000 tonnes
- Replacement with EL fleet – decrease in emissions by 12,600 tonnes

KiwiRail Greenhouse Gas Emissions for Ham-PNth Track Segments
Based on 12 months to 30 June 2016

			Current Operation	Upgrade EFs	Diesel DLs	Electric ELs
FY16 Freight Task - GTKs		Diesel	940,410,470	582,862,020	1,834,281,594	0
		Electric	893,871,124	1,251,419,574	0	1,834,281,594
			1,834,281,594	**1,834,281,594**	**1,834,281,594**	**1,834,281,594**
Diesel consumption [1]	[litres per GTK]	0.00608				
Diesel emission factor [2]	[kgs per litre diesel]	2.72				
Diesel litres consumed			5,716,658	3,543,158	11,150,409	0
CO2 Emissions [tonnes]			**15,549**	**9,637**	**30,329**	**0**
Electricity emission factor [3]	kg CO2-e per kWh	0.1				
Transmision and distribution loss emission factor [4]	kg CO2-e per kWh	0.0133				
Electricity Energy consumption [5]		[kWH]	24,518,376	34,325,726	0	50,313,300
CO2 Emissions [tonnes]			**2,778**	**3,889**	**0**	**5,700**
Total Emissions		[tonnes]	**18,327**	**13,526**	**30,329**	**5,700**

Sources
[1] Monthly finance fuel analysis report
[2] MfE emission factors 2015
[3] MBIE quarterly electricity data
[4] MfE emission factors 2015
[5] Meridian

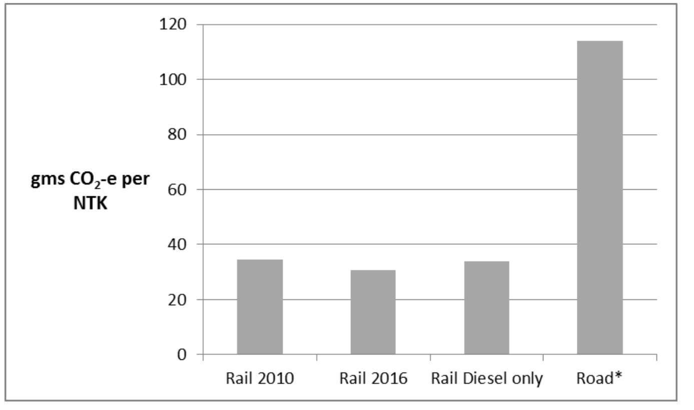
Electricity Emission Factor

The emission factor for electricity used in these calculations is produced by the Ministry for Business, Innovation and Employment (MBIE) each quarter. MBIE uses the actual demand mix from generation sources (hydro, geothermal, wind, gas etc) and the emission factor varies from quarter to quarter. It should be noted that if a North Island only emission factor for electricity was calculated it could be expected to be higher due to the greater percentage of gas, coal and geothermal generation in the mix[9]. Using the national emission factor can therefore be considered to be conservative and will over-estimate the additional emissions by a diesel option on the electrified section of the NIMT.

[9] Indications are that the emission factor may increase from 0.10 (MBIE figure) to 0.42 (combined cycle gas turbine) or even 0.61 (open cycle gas turbine) if the electricity used by the NIMT traction is treated as the last portion of electricity consumed in New Zealand. This would mean that emissions for the EL options increase from 5,700 tonnes a year to 21,800 or even as high as 31,300 tonnes.

Effect on the Rail Emission Factor

A shift to diesel on the NIMT will increase the overall rail freight emission factor from 30.80 gms per NTK to approximately 34 gms per NTK, roughly a 10% increase. As the below chart shows KiwiRail achieved a similar reduction in the emission factor since 2010 from the new DL fleet, fuel conservation measures (including the Driver Advice System) and increases in freight volumes.



Option of Decommissioning the Electrified Section

The relevant choice is between:

- staying linked to the national grid and conveying 25kv across the lines albeit at low loads sufficient to protect the lines from theft; or
- totally disconnect and realise the scrap value of the overhead lines and traction poles.

If we stay connected to the national grid in order to hold our options open, [redacted]. There will also be annual opex costs for a decreased inspection and maintenance regime for the traction system. Estimates of the annual costs to stay connected to the national grid are as follows:

Description	Estimated Cost p.a.
Connection charges (Transpower)	[redacted]
Maintenance and inspection regime (excluding any renewals)	[redacted]
Electricity cost to keep the lines energised (based on current pricing)	[redacted]
TOTAL	[redacted]

In the alternative, KiwiRail can disconnect the NIMT from the national grid. [redacted]

Following disconnection KiwiRail would have no cheap way of reconnecting as exiting renders the substations and connections redundant. [redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]

The next section analyses the financial case for the two shortlisted options.

5 The Financial Case - Financial Analysis of the two Shortlisted Options

Methodology

A detailed 30 year financial model has been developed to determine the long run NPV cost cash flow ranges of the two shortlisted options with assumption based capital and operating expenditure profiles.

Costings have been developed assuming the full electrified section between Hamilton and Palmerston North is saturated with either diesel or electric locomotives. The freight task requires 22 locomotives on a daily basis plus spares to enable maintenance programmes to be delivered.

The financial benefits attributed to improved earnings, or revenue retention have been excluded from the financial analysis as it has been assumed that the benefits will be the same under both alternatives. This is a conservative position given potential loss of revenue if we do nothing, DL vs EL delay.

Input Assumptions

The following assumptions have been made in determining these initial estimates

- Purchase prices
    - DL prices are known as the business procures them on a regular basis. The price used has been developed using external consultants [redacted] estimate of diesel prices Refer to Appendix C.
    - EL replacements are an indicative price based on a specification provided to [redacted] An indicative price of [redacted] per locomotive will need to be tested in the market. It should be noted that the range of pricing can vary significantly, with the [redacted] price considered to be at the low end of pricing for small orders of electric locomotives. The price could be as high as [redacted] per locomotive.
- Time to procure
    - DL's – 18 months from order to the time the locomotives are landed in New Zealand and are ready for the 6 month commissioning process.
    - EL's – 5 years from start to finish, including developing a prototype

- Fuel Costs
    - Diesel – current fuel burn rates of 0.00608 litres per GTK
    - Electrics
        - Fixed line charge [redacted] per annum charged by Transpower
        - Variable line charge based on net electricity used [redacted]
        - [redacted]
    - Fuel costs are mitigated by the business via a FAF (fuel adjustment factor) mechanism [redacted]. Any diesel fuel changes result in a change to the FAF percentage charged [redacted].
    - Any spike in diesel cost will work in rails advantage over road due to rail being a more fuel efficient mode of transport than road.
    - Electrification gives KiwiRail a competitive advantage over road when diesel price is high and the electricity cost is low.
- Reliability
    - MDBF – assumed minimum acceptable level required of 80,000 kms for all fleet configurations
    - OTP NIMT – greater than 85%
- Locomotive Availability – important assumption as this drives the fleet size and number of spares required
    - DL – assumed to be >88% over time
    - Electric – assumed >88% over time
- Maintenance Capital Costs – large capitalised items
    - The diesel fleet has a higher overall cost of capital maintenance on the locomotives due to the diesel engines

- However the electric fleet has a requirement for the maintenance of the overhead traction electricity section from which to generate its locomotive power
- Bogie and wheelset spend for the electric and diesel fleet is very similar – thereby eliminating itself in the analysis
- Rotable overhauls for diesel are based on kilometres travelled. Planned rotable overhauls are scheduled once the locomotive clocks over 700,000+ kilometres at an estimated cost of circa [redacted].

- Cost per km Maintenance – smaller regular items which are pooled together into an overall cost per kilometre rate. The rates assumed are long run average rates and may differ from the rates experienced over the last two to three years
  - DL's [redacted] locomotive kilometre
  - EL's [redacted] estimated per locomotive kilometre
- Number of replacement locomotives required[10]
  - DL's 10 plus one spare minus three due to improved North Island fleet utilisation
  - EL's 22 plus three spares
- Surplus Locomotives
  - All diesel model [redacted].
  - In the all-electric model, [redacted]
- Network infrastructure costs Operating Cost

[10] In all scenarios the freight task on the Hamilton to Palmerston North section requires 22 mainline locomotives plus 3 spares at 88% availability

- The overhead line requires a team of engineers to maintain the line. [redacted]

- Network infrastructure costs Capital Cost (renewals)
  - Overhead line components that will require replacement over the next 30 years, include items such as protection relays, circuit breakers, hiab vehicles etc.
  - Another series of costs that do not receive great visibility within KiwiRail are those associated with working in an around the electrification network safely whilst performing maintenance and capital renewal projects. The additional labour added to gangs to provide the safety elements to work procedures are all capitalised into the project costs associated with say, the upgrading of a bridge, tunnel, culvet etc. The overall cost of performing the capital renewals will be lower if the electrification section of the line was not present, albeit this has not been included in the model.

- [redacted]
  - [redacted]
  - [redacted]
  - [redacted]
  - [redacted]

[redacted]

[redacted]

- [redacted]
  - [redacted]
- [redacted]
  - [redacted]
  - [redacted]

In summary, the all diesel model produces the lowest long run NPV cost cash flow range when compared to the new electric model. The diesel option has lower overall cost, [redacted] which gives confidence that the all diesel financial outcomes will be known with more certainty.

6 Preferred Option

This section brings the above analysis together to determine the preferred option. A rating has been undertaken using the Critical Success factors identified at the beginning of Section 3, with the results shown in the table below.

Table 9: Summary of Short List Options Assessment against the Critical Success Factors

Assessment criteria	EL New Electrics	DL
• Strategic fit and business needs	Partially New Asset Latest technology Retains a mixed operating fleet and a complex operating model	Pass New Asset Single fleet Simplified Operating Model Early benefit realisation
• Potential value for money	Partially Higher NPV cash cost with upfront procurement of replacement fleet Lower operating cost than diesel	Pass Leverages investment already committed Price known with certainty Higher operating cost than electrics
• Supplier capacity and capability	Pass Five year procurement and introduction process	Pass [redacted]
• Potential affordability	Partially High upfront capital requirement	Pass Fits within current capital planning parameters
• Potential achievability	Pass Assumed methodology of design, build, test, commission and commercialise to be followed	Pass Known design, build, test, commission and commercialisation processes
Overall Assessment	Partially	Pass

It is concluded that the all diesel model best meets the success criteria and will deliver on the business objectives or simplify and standardise. The all diesel model is the least risk to implement and has the lowest overall cost and value range.

7 The Management Case – Next Steps Project Management and Framework

[redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

APPENDIX A.1: DL Locomotives - Reliability

<u>Context</u>

- The DL Class locomotive was introduced by KiwiRail in 2010. They were the first addition to the freight fleet since the 1980s.
- The locomotives have been built by the [redacted]. The design strategy for the DL was a double cab locomotive capable of hauling 2,000 tonne. The double-cab DLs have a 2700kW engine with similar pulling power to the electric locomotives. This was a bespoke design for NZ conditions.
- DL locomotives have been deployed around the North Island, including the Auckland-Hamilton-Tauranga 'golden triangle' freight route, Bay of Plenty forestry routes and the southern North Island 'milk route'

[redacted]

[redacted]

[redacted]

APPENDIX A.2: EF FLEET – Reliability and Asset Condition

Context

KiwiRail operates a fleet of 16 EL locomotives, two of which are out of service for long term repairs. The fleet has been operational for approximately 30 years (since mid-1980s) and some aspects of the fleet now require overhaul or replacement to address obsolete technology, deteriorating performance and declining availability. Of the 14 remaining ELs, 10 are required on a daily basis to meet train plan requirements.

[redacted]

Although a recent focus on maintenance of the EF fleet in the past six months has lifted the mean distance between failures (MDBF) rate from approximately 15,000km to 30,947km, it remains significantly below the overall fleet target operating level of 50,000km. However it will be difficult to maintain and/or improve this rate significantly in the future given the age of the fleet and the substantial costs of any improvements.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]