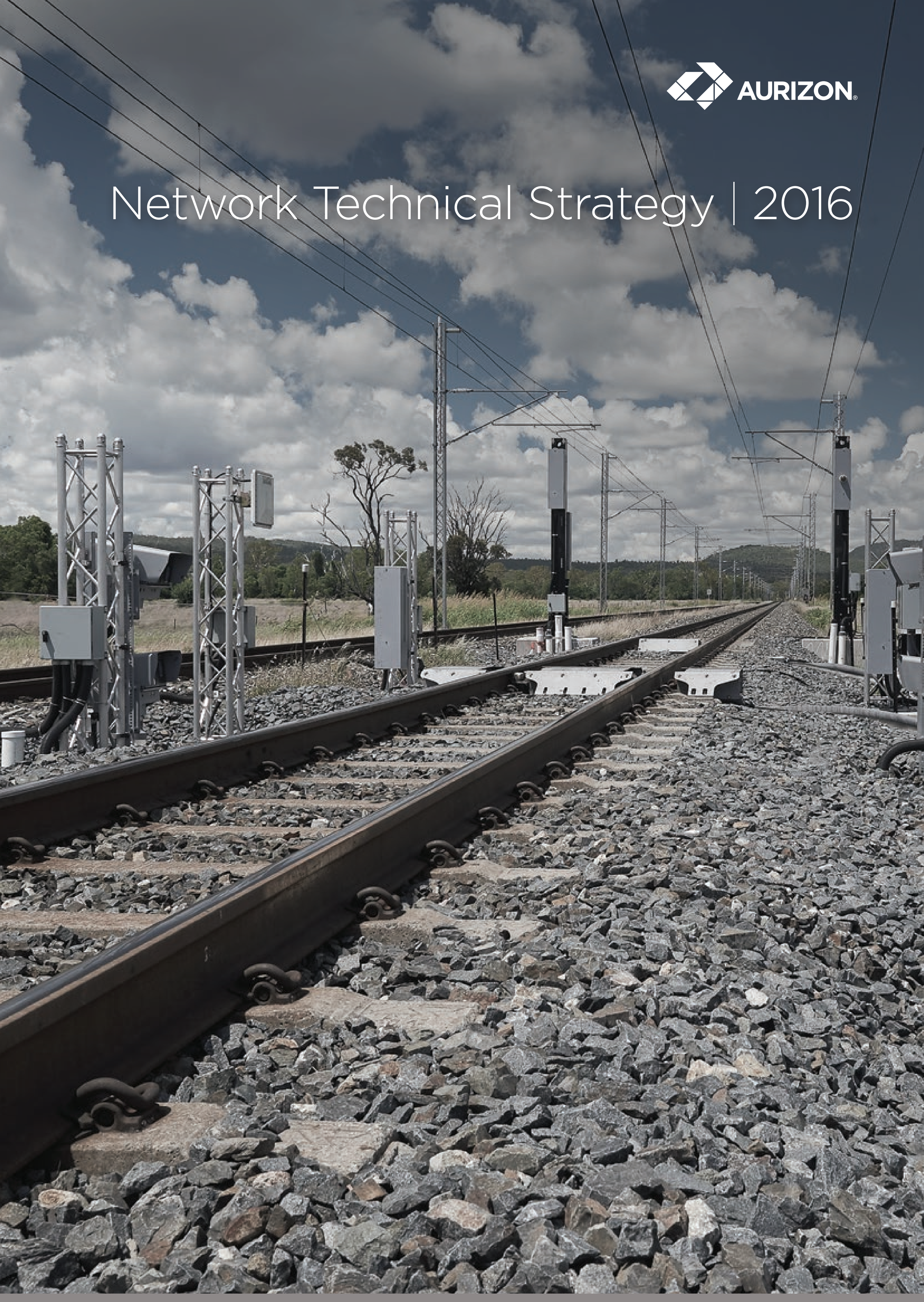
AURIZON

Network Technical Strategy | 2016



Message from Steve Straughan

I'm pleased to release the Aurizon Network Technical Strategy, our roadmap for the long-term future of the Network. It is focussed on achieving the productivity improvement themes of the Aurizon Blueprint.

Delivering improvements to the way we operate, maintain and renew the railway, achieve the expectations of multiple customers, fulfil regulatory requirements and facilitate the strategic intentions of our customers and supply chain partners requires a clear vision and a detailed strategy.

The Technical Strategy discovers and develops complementary opportunities for improvement through innovation and integration. It builds a direction for the future of the Central Queensland Coal Network (CQCN) that supports our customers' goals and improves the efficiency of the supply chains. The Strategy is developed with consideration of market growth possibilities so that decisions made now will not constrain the future.

The Technical Strategy will be published annually with each edition advancing the level of detail forming the strategy. It also complements the Network Development Plan, our growth strategy, by defining those opportunities that can facilitate growth at the lowest cost. I would welcome your ideas and feedback.

Steve Straughan
Manager Planning and Development, Aurizon Network

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PURPOSE

The intent of Aurizon's Network Technical Strategy is to develop innovative ideas that deliver improved productivity and efficiency in the Central Queensland Coal Network (CQCN).

It focuses on complementary opportunities aligned to the asset lifecycle that can deliver improved supply chain performance and benefits for all stakeholders. It's a process to align the future direction of above and below rail businesses.

The Technical Strategy is a process to discover, evaluate, develop and implement opportunities that produce value under all market conditions and phases of the economic cycle. This includes periods of low growth where cost minimisation is important. It is separate from but complementary to the Network Development Plan which focuses on growth.

This process is underpinned by a rigorous application of modelling and analysis that uses the total cost of transportation as the primary measure of benefit.

The opportunities that can deliver the greatest gains for our customers and our business will be identified and prioritised.

The strategy seeks near-term benefits and guides planning for the future within a framework linked to the long-life nature of our assets. We'll make decisions now that won't constrain us in the future.

AURIZON BLUEPRINT

The Technical Strategy provides a detailed means of achieving the Aurizon Blueprint.

It does this by articulating a vision for the future of the CQCN. Opportunities are identified that contribute to the vision and are aligned with these principles:

- An integrated system approach is facilitated.
- There is potential to reduce the total cost of transport.
- Innovation is promoted.
- Sustainability goals are achieved.
- Renewals investment is leveraged.

Opportunities meeting these criteria are evaluated to determine the effect on the total cost of transportation. This will provide a means of comparing opportunities on a common basis to achieve optimum results.

Opportunities with demonstrated value will be assessed regarding timing and risk to form a delivery plan for the Technical Strategy.

This inaugural version of the Technical Strategy includes information regarding those opportunities that are significantly developed as well as those that will be assessed over the coming year.

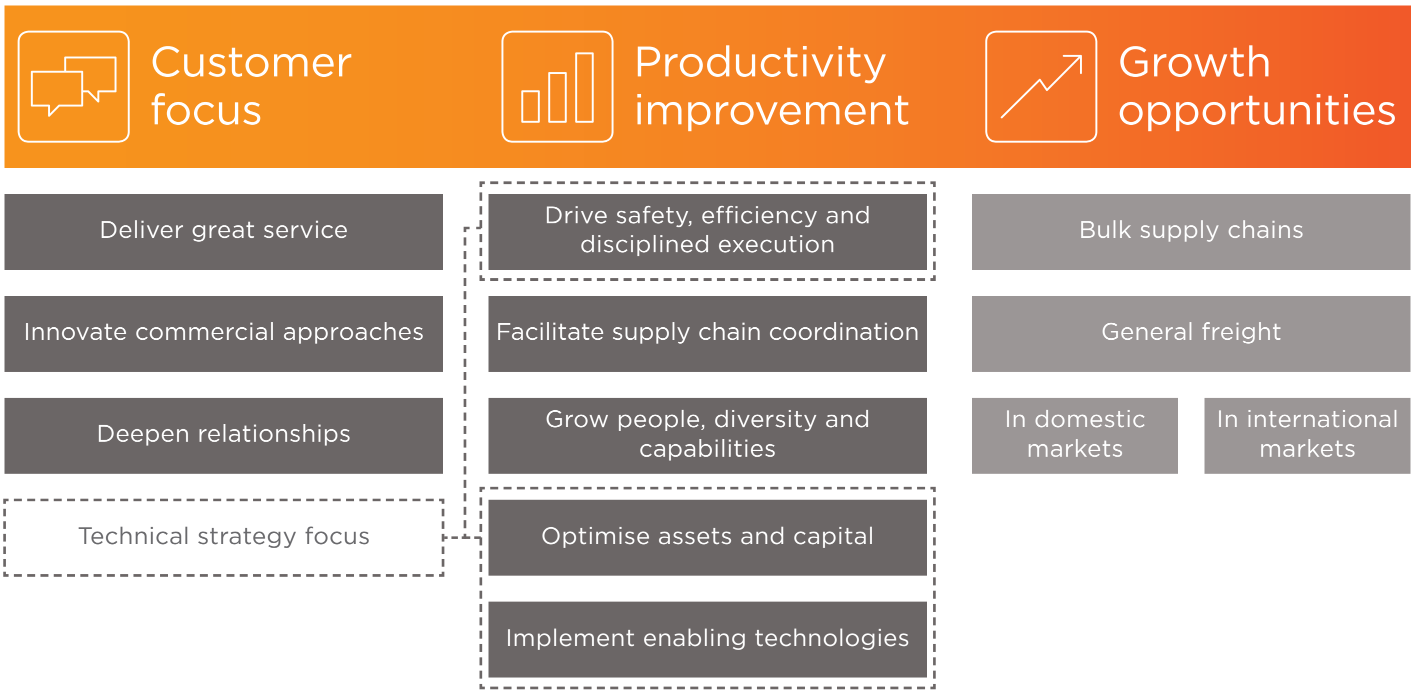
APPROACH

The development of a coherent long-term strategy requires the application of a structured approach. Aurizon Network has determined that the approach requires four elements.

1. An understanding of the components and relationships that define the rail supply chain.
2. A high-level vision for the future.
3. A structured process to select the opportunities making up the Technical Strategy.
4. A set of tools to carry out detailed modelling and evaluations

Figure 1: Aurizon Blueprint.

TO DEVELOP AND OPERATE MULTI-CUSTOMER, RAIL-BASED, INTEGRATED SUPPLY CHAINS



02 The relationships that define the rail system.

A finite set of key factors determine the throughput of the Network. The total cost of transport is determined by the associated capital and operating expenses.

The matrix below identifies these key factors, their interrelationships and the delivery across four functional portfolios.

This understanding facilitates the development of a vision for each functional portfolio and the targeted development of opportunities.

Figure 2: Key factors matrix.

Functional portfolios	Throughput (tonnes / year) =	Key factors: Train consist density (tonnes/m) › Payload › Train length ×	Key factors: Train velocity (m / hr) › Network headway › Average train speed ×	Key factors: Network time (hr / year) › Availability › Utilisation
	Operating the Network		Scheduled separation	Planning and scheduling Conflict resolution
	Infrastructure	Axle load capability Overload limits Clearances	Track alignment Track configuration Asset condition Holding lengths Constraining headways	Reliability Maintenance resources Maintenance techniques
	Operating the trains	Loading process accuracy	Loading process time Unloading process time Provisioning process time Inspect / maintain process time Train length	Dwells Storage capacity Performance to schedule
	Rollingstock	Gross to tare ratio Wagon length Consist configuration	Average train speed Power to weight ratio Braking technology	Reliability Maintenance resources Maintenance techniques Number of consists

OPERATING THE NETWORK

This portfolio encompasses:

- The systems, processes and people that plan and schedule the movement of trains over the Network.
- The systems, processes and people that plan and schedule the maintenance and renewal activities required to keep the Network in a fit for purpose state.
- The operation of the Network infrastructure including electrification and yards through the use of operational systems and safeworking systems to arrange the movement of trains and maintenance vehicles safely.
- Performing the above activities in order to deliver the expectations of quantity and quality of service in accordance with the commercial agreements.

INFRASTRUCTURE

The infrastructure portfolio is concerned with the physical elements making up the fixed infrastructure.

- The track, points and crossings, structures, formation and ballast.
- Signals, interlocking, train detection, telemetry and operational systems.
- Information and communications technology.
- Overhead line equipment and traction power supply.
- Property, corridor security and road rail interfaces.
- Rail maintenance access requirements.

The portfolio also encompasses the management, maintenance, renewal and expansion of the fixed infrastructure and the equipment, information and processes to achieve this.

OPERATING THE TRAINS

The train Operations Portfolio is concerned with those systems, processes, equipment and infrastructure required to perform the tasks of the train cycle.

This portfolio encompasses:

- The assembly of train consists
- Train crewing
- Train provisioning
- Maintenance, inspection and repair activities carried out on assembled train consists
- Operations within yards and the interface between yards and mainlines
- Safe and efficient movement across the railway
- Train loading and unloading processes.

ROLLINGSTOCK

The rollingstock portfolio addresses the physical assets and support systems required for the running of revenue trains:

- The locomotives and wagons.
- The facilities and equipment required for the maintenance and repair activities carried out on rollingstock.

The portfolio also encompasses the management, maintenance, renewal and expansion of the rollingstock and the equipment, information and processes required to support this.

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The process developed to determine the opportunities that will form the Technical Strategy is defined in Table 1: Strategic opportunity development process.

Table 1: Strategic opportunity development process.

PHASE	PROCESS	OUTPUT
DISCOVER		
A process of finding potential opportunities by: ❯ Consultation with above rail operators and the supply chain. ❯ Bringing together ideas from across all Network functions. ❯ Investigating best practice in other railways. ❯ Review other industry developments. ❯ Consider potential of new technologies applied to rail.	Register	Register of possibilities.
IDENTIFY		
Assess possibilities. Test for alignment with the vision. Test for alignment with these principles: ❯ Facilitates an integrated system approach.[1] ❯ Innovation — the application of better solutions to meet business needs.[2] ❯ Has the potential to reduce the Total Cost of Transportation.[3] ❯ Renewals investment may be leveraged to implement the opportunity.[4] ❯ Aurizon's sustainability goals are facilitated.[5]	NO / YES	Record decisions and reasons.
EVALUATE		
Determine the value of the opportunity by measuring the impact on the total cost of transport: ❯ Capability modelling tools are used to assess the affect of the opportunity on supply chain performance. ❯ Operational performance parameters are generated by capability modelling. ❯ Cost to implement opportunity is assessed. ❯ Cost of opportunity and performance parameters used in total cost of transport model to evaluate. ❯ Cost benefit.	NO / YES	Record decisions and reasons.

OPPORTUNITY IDENTIFICATION PRINCIPLES

1. **Integrated system approach.**
   Railway infrastructure and rollingstock need to be specified, operated and maintained as an 'integrated system'. The people operating the railway, and customers, are all part of the system.

2. **Innovation**
   Innovation is the application of better solutions that meet new requirements, unarticulated needs, or existing market needs. It is broader than the exploitation of technical ideas and is the process of generating business improvement ideas and transforming those ideas into commercially successful products and systems.

Strategic Opportunity Development Process

PHASE	PROCESS	OUTPUT
CATALOGUE		
Detail of the opportunity is included in the Technical Strategy. **Value:** › Effect on the total cost of transport. › Key input assumptions. › Conditions that generate the value e.g. timing, tonnage growth, system specific. › Where in the supply chain value is derived. **Risk** › Characterisation of risk. › Timeframe Detail of the likely timeframe to derive the expected benefits. **Interrelationships** The relationship to other opportunities and existing projects: › Technical and systems interfaces. › Data input and output requirements. › Organisational interfaces. › Customer interfaces.		Opportunity tables.
DEVELOP		
Strategic business case development. Concept stage gate assessment.		

3. **Total cost of transportation.**
The key determinant of the value of an innovation opportunity is its impact on the total cost of transportation to the supply chain when compared to current practice. Costs will be assessed over an appropriate time period. Reduced cost while maintaining output is a clear measure of improved productivity. The apportionment of the value derived from productivity improvements to supply chain members should be considered separately.

4. **Leverage renewals investment.**
The need to invest in capital renewals presents opportunities to introduce innovation and new technology. Where renewals investment can be used to implement value adding projects, Aurizon Network will pursue these ensuring the selection of replacement assets is made on a no regrets basis for the future.

5. **Sustainability**
Our search for innovative opportunities will be guided by Aurizon's sustainability commitments, that is:
   - To build a sustainable business that delivers lasting value.
   - Take the safest, most efficient and least resource intensive approach.
   - Apply a balanced view when assessing risk and making decisions, encompassing social, environmental and economic considerations.

Modelling and evaluation tools.

The evaluation phase of the process uses sophisticated modelling to determine the effect of the opportunity under examination on the total cost of transport compared to an established baseline.

ELEMENTS OF EVALUATION

ESTABLISH THE COST OF THE OPPORTUNITY

A study is carried out to establish the lifecycle costs associated with the opportunity and any current costs relevant to the investigation. Cost ranges are identified to facilitate risk assessment.

RENEWALS REQUIREMENTS

Renewals expenditure associated with the opportunity are assessed.

DEVELOP MODELLING INPUT DATA

Required input data is sourced including reliability and performance data associated with the opportunity. Data ranges are established.

DETERMINE MODEL SCENARIOS

Scenarios to be tested include consideration of possible future tonnage demand profiles. Implementation timings for the opportunity under investigation are developed.

PERFORM CAPABILITY MODELLING ANALYSIS

Changes to performance of the supply chains arising from the opportunity are quantified and compared to a baseline. Outputs are generated for cost modelling.

PERFORM COST OF TRANSPORTATION MODELLING

The effect of the opportunity on each cost component and the total cost of transport is quantified and compared to a baseline.

AURIZON SUPPLY CHAINS MODELLING SUITE (ASCM)

The Central Queensland Coal Network is part of several interlinked coal supply chains consisting of multiple mines, ports and above rail operators. The rail Network also supports a small amount of other non-coal rail traffic. This entire system of supply chains has complex interdependencies between the component parts and the input parameters.

Understanding the effect of changes to components of the supply chain on the performance and robustness of the whole supply chain is beyond the capability of simple modelling and assessment techniques. Understanding achievable levels of utilisation of supply chain capital assets and how these can be maximised is key to driving improved productivity.

The ASCM provides a set of software tools that can model access obligations and the performance and interactions of all the components of the supply chains.

It produces outputs of key parameters that can then be used as inputs to the Cost of Transportation Model (CTM) allowing scenarios to be tested for effect on the overall cost of transporting coal and the cost to individual elements of the supply chain.

COMPONENTS

CQSCM

This is a comprehensive discrete event model of the entire Central Queensland Coal Network. It creates the ability to measure and assess the impact of changes to the complete range of supply chain elements on overall capability.

The effect of levels of reliability of individual supply chain components and the range of variability in input parameters can all be tested for impact on supply chain performance.

The model simulates each train movement required to deliver an input tonnage profile. Train cycles are simulated with precision including transit times, train crossing movements, loading and unloading processes, crew changes, provisioning and yard activities.

Maintenance requirements of the infrastructure and the rollingstock are driven by the appropriate metrics to produce a comprehensive strategic view. Maintenance and renewals delivery is replicated with requisite track possessions and the associated impact on rail traffic.

Reliability parameters of the infrastructure sub-systems, rollingstock, load and unload facilities are included in the model. A port capability component will be included to model tonnage draw and product mix.

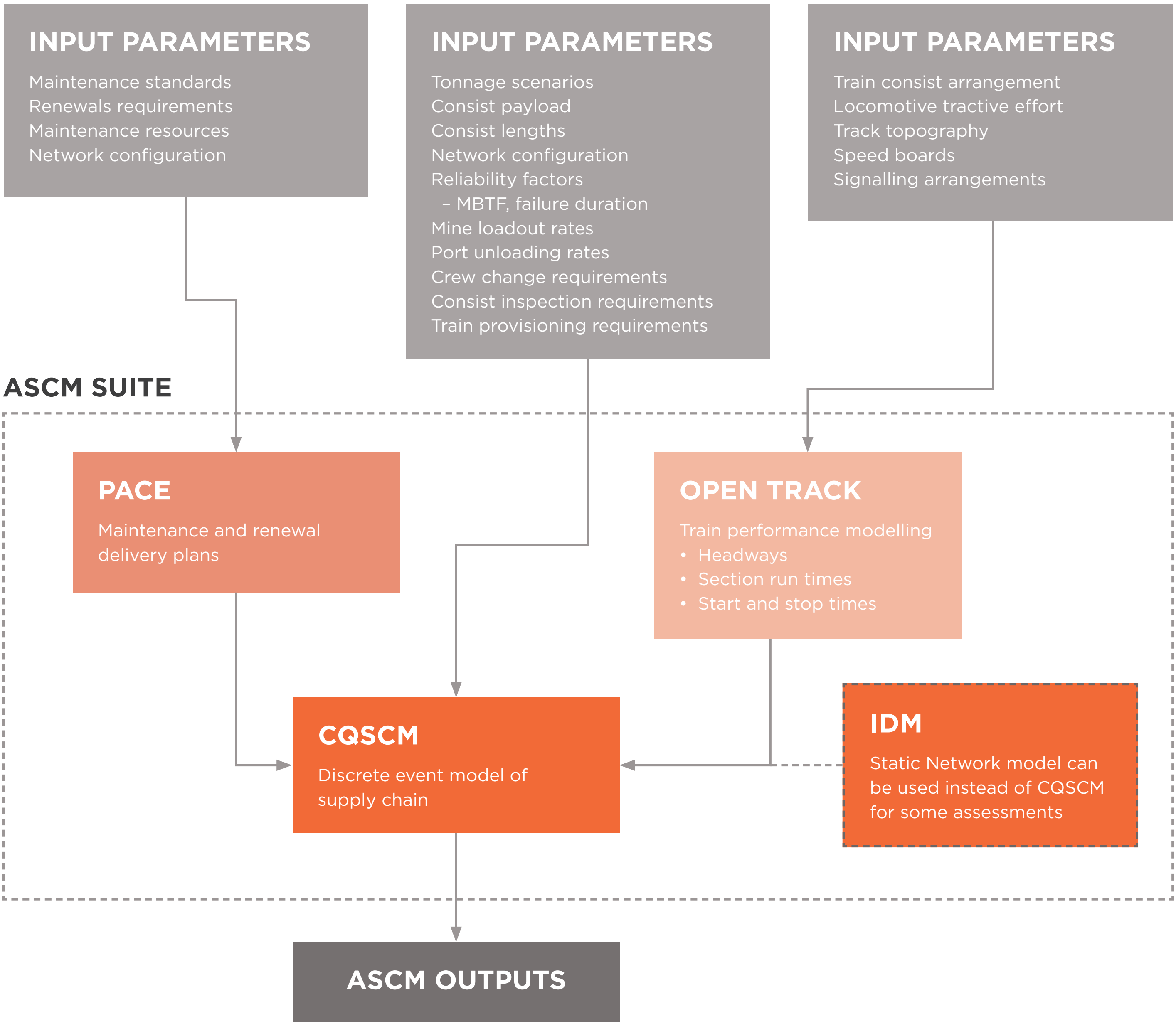
The combination of supply chain configuration, performance, reliability and planning parameters replicated by the model provides a means of testing the effect of changes to individual elements of the supply chain on the overall performance.

The model produces a Monte Carlo simulation providing results as a statistical output.

Possession Alignment and Capacity Evaluation (PACE).
This tool is used to develop strategic maintenance and renewals delivery plans as an input to the CQSCM. PACE uses asset management data of maintenance and renewals requirements and resource availability to generate track possession plans.

OpenTrack
This proprietary software provides the capability to simulate train performance and detailed train movements. This is used to generate accurate and detailed inputs to the CQSCM discrete event model.

Figure 3: Interrelationships of ASCM Tools.



Integrated Development Model (IDM). The IDM is a tool developed by Aurizon Network to support pre-concept and concept studies. The IDM undertakes a static analysis of each section of the rail Network to determine the infrastructure requirements to meet the capacity scenario. This model does not provide the level of detail of the CQSCM. It's useful for carrying out certain analyses that don't require the level of detail produced by the CQSCM.

COST OF TRANSPORTATION MODEL (CTM)

This model is used to assess the potential value of innovation opportunities by calculating the net present cost savings across the rail system. It provides a means of comparing options on a common basis. Reducing cost while meeting output requirements is a clear measure of improved productivity.

The CTM utilises outputs from the Capability modelling suite (or the IDM for high level assessments) to determine above rail and below rail capital and operating costs for each year of the analysis period. Costs will be assessed over an appropriate time period.

This model will produce outputs suitable for the development of a strategic business case in accordance with the Aurizon investment Framework.

ASSET RENEWALS

Asset age and renewal costs are included in the model's analysis.

CHARACTERISATION OF RISK

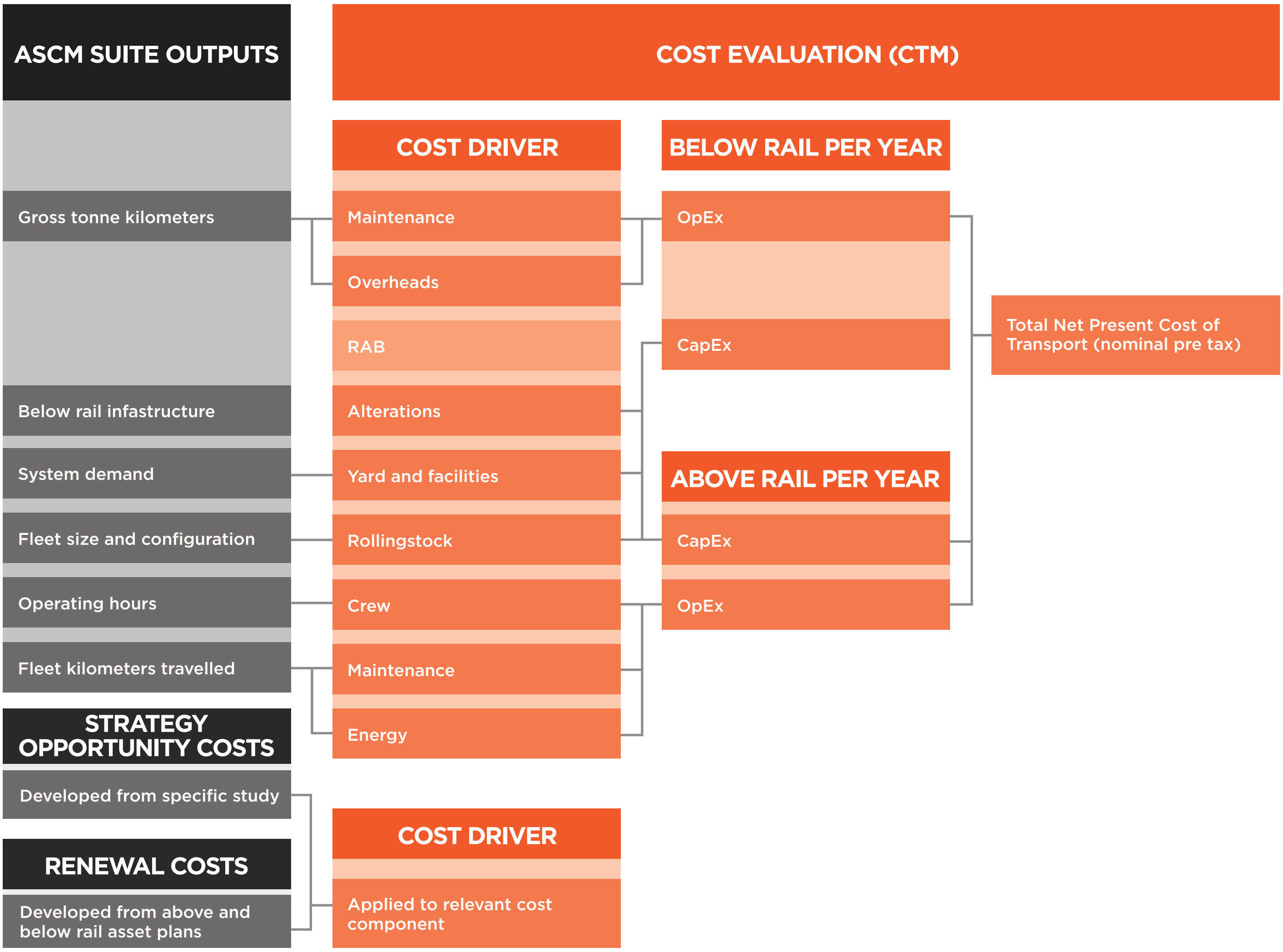
Ranging of cost inputs and other key parameters are included in the analysis process to provide data to facilitate the analysis of risk.

AURIZON INVESTMENT FRAMEWORK

This process is used to develop strategic business cases for value adding opportunities used to obtain investment funding.

The processes for opportunity assessment that make up the Technical Strategy have been developed and aligned to the requirements of the Aurizon Investment Framework. This results in a process that produces outputs aligned with the investment approvals requirements, creating an efficient process.

Figure 4: CTM inputs and functional structure.



OPERATING THE NETWORK

The future vision for operating the Network is centred on delivering levels of availability and utilisation that improve productivity and customer focus to all components of the supply chain. The cost of improvements to availability and utilisation will be optimised against the benefit.

Delivering on this vision will be achieved by building a strategy around the following:

- Network will deliver reliable and accurate plans and schedules by a focus on tools and methods for train service planning and scheduling, maintenance planning, and day-of-operations management and optimisation.
- Delivering reliable train running improving the utilisation of above and below rail resources by reducing unplanned dwells and delays. Mine and port facilities are also more efficiently utilised by reducing idle time.
- The development of sophisticated modelling capability will facilitate better understanding of the behaviour of the total supply chain and the interdependencies between elements. This capability will lead to better decision making and optimisation.
- Accurate and detailed inputs to the planning and scheduling processes will produce more accurate and reliable outputs from these processes. Systems to continually review and revise these inputs will be developed.
- Assumptions on seasonal variations in performance will be accommodated in planning systems.
- Systems to assist in optimisation of plan and schedule development will be developed.
- Improved reporting and analysis of previous performance will drive continuous improvement.
- Decision support tools will be provided to the planning and scheduling and day-of-operations train control processes facilitating our Network operating on an increasingly optimised basis, progressing towards real-time optimisation of the rail schedule. This will reduce the need to build contingency into the schedule, making available more train paths.
- New systems of maintenance planning will balance asset maintenance and reliability requirements with throughput and resources to achieve optimised delivery plans.
- Maintenance resources will be more efficient with detailed forward planning of the delivery of the required scope of work and certainty around the execution of schedules.
- A better understanding of the condition and reliability of all components of the supply chain will provide input to maintenance planning processes.
- The integration of control, routing and planning functionality and automation of routine activities will free staff for more value adding analysis and optimisation activities.
- Real-time information regarding Network and rollingstock performance will be incorporated into decision processes.
- Remote sensing and telemetry will advise status and allow prediction of failures to facilitate contingency planning and loss minimisation.

INFRASTRUCTURE

The future state of the infrastructure will be one where the reliability and availability of the infrastructure systems is optimised with the cost of delivery. Safety of workers, customers and the public will continuously improve, and customer expectations of service levels and cost will be met.

Network will improve resilience and reduce the need for maintenance through new materials, consideration of whole-life cost and improved, efficient design.

The approach to asset management will evolve with condition monitoring, predictive maintenance planning and less corrective maintenance.

New methods and technology for measuring asset condition and performance will be explored including low-cost low-maintenance sources of data.

Data will be stored and processed to produce information for improving reliability, optimising maintenance intervention limits and improving the efficiency of planning and reporting.

The increase in data generated from automated monitoring and assessment of assets will be supported through enhancements to telecommunications capacity including voice and broadband.

Standards relating to maintenance and design requirements will be reassessed.

Systems for identifying fault conditions and actioning rectification will be developed including optimisation tools to achieve the best results under reduced performance conditions.

New techniques and equipment for the delivery of maintenance tasks will reduce track possession and closure times.

The introduction of new technologies that have the potential to provide future, as yet unknown benefits, either on their own or as part of a larger system, will be pursued particularly where asset renewals are required.

Changes that facilitate the introduction of rollingstock with greater capability will be pursued.

We'll work with stakeholders to increasingly improve the train specification and railway system compatibility relationship to minimise damage to all assets and to ensure that the capability of the infrastructure is fully exploited.

We'll pursue innovative ways of reducing the impact of rail operations on the community and the environment. The impacts of noise, light and dust will be a focus.

The ability to increase train density is a function of both the ability of the track infrastructure to support both larger axle load wagons and heavier more powerful locomotives and the need to provide sufficient physical space for larger rollingstock. Opportunities to improve train density will be explored.

OPERATING THE TRAINS

Train cycle time is influenced by the interaction of the train consists and the infrastructure. These factors influence the achievable throughput of trains:

- Headways and signalling arrangements
- Train speeds, track alignment and condition
- Train lengths and lengths of holding locations
- Dwells and delays in train cycle time
- The number of train consists in the system and the effect on congestion.

Opportunities for innovative solutions in this portfolio have the potential to yield significant benefits to capacity increase at low capital cost and higher utilisation of Network and rollingstock assets, increasing capital efficiency and reducing operating costs.

Greater use of automated systems to track rollingstock movement and associated information systems will support and enable information analysis for improved reliability of rollingstock and infrastructure. This technology will also improve the efficiency of data collection for systems requiring the location of rollingstock and the makeup of train consists.

Network will pursue improvements to the provisioning of trains by assessing opportunities around suitable locations, common user facilities and reduced impacts to Network throughput.

Yard activities historically have included rollingstock inspection, testing and minor repairs, train assembly, shunting rollingstock to depot facilities for maintenance and repair and the storage and staging of trains into traffic. Opportunities to improve the productivity and efficiency of these activities will be pursued.

Reduction of critical headways can be achieved by innovative signalling solutions as well as looking at improvements to train speeds and train operating practices.

Improvements to train speed may be achieved through improvements to track alignment and the standards defining the requirements for determining maximum track speed. Track condition maintenance and the processes used to assign speed restrictions may provide opportunities for improvement.

In the future signalling and control functionality may be migrated onto trains, reducing the need for lineside equipment while also providing greater capacity and operational flexibility. Network will investigate the progressive implementation of enabling technologies to facilitate a future transition to this type of technology.

Working collaboratively with mines and ports we'll investigate what value can be unlocked from the train loading and unloading processes by improving the accuracy of loading, the reduction of overload correction and reducing the time taken in the loading and unloading processes. Other enabling technologies that can reduce costs associated with the loading and unloading processes by reducing manpower requirements will also be a focus.

Increasing train lengths can provide for efficiencies by reducing the number of train cycles required thus lowering crew costs. Reducing the number of trains in the system can also benefit cycle times by reducing dwells associated with congestion. Modelling and analysis will determine the optimum parameters for train length and traffic volume combined with strategic investment in below rail infrastructure.

ROLLINGSTOCK

Rollingstock lies at the heart of the railway system. While Network does not own or operate the commercial rollingstock, the way that rollingstock is specified, operated and maintained fundamentally affects the efficiency and productivity of the supply chain.

We'll work with above rail operators to support a vision for rollingstock that is facilitated by the future for other railway system assets. Network will look to develop and implement technology that will facilitate the innovation initiatives sought by above rail operators in the design, operation and maintenance of rollingstock.

Interfaces between the rollingstock and other railway assets will be optimised, adopting a whole-of-life cost approach and maximising the capacity of the supply chain. This will be supported by systems for the acquisition, transmission and handling of information to support optimised interface management.

We'll work towards aligning standards dealing with the interface between rollingstock and infrastructure with other railways, reducing the need for bespoke rollingstock designs. The intent will be to broaden the market for rollingstock procurement reducing capital costs and obsolescence risk.

Condition monitoring of rollingstock can be facilitated by provision of suitable trackside locations and access to necessary services. Information and communications technology infrastructure will enable greater use of condition monitoring by above rail operators.

Systems that provide advice to train crews regarding optimum driving inputs can improve train punctuality, energy consumption and reduce wear and tear on rollingstock and infrastructure. These systems require accurate topographical information and real-time Network status. Network will work to facilitate access to this data.

Peaks in demand for coal transport, combined with multiple train fleets held by above rail operators, leads to excessive fleet size and storage requirements. Innovative approaches will be investigated to optimise the total number of train consists deployed.

The following tables provide a summary of innovation opportunities that are at various stages of assessment. Those that have progressed to the evaluation stage have further detail included in Appendix 8 – Opportunity Evaluation Reports.

Innovation opportunities have been divided into four portfolios each representing a key aspect of the railway. Opportunities in many cases sit across more than one portfolio and assessment of value through to implementation will require management across a number of disciplines and organisational interfaces. The Technical Strategy will aid the identification and management of these interfaces.

OPERATING THE NETWORK

Table 2: Operating the Network opportunities.

Opportunity – Operating the Network.	**Priority** Low / Medium / High	Refer to Appendix 8 for detail	**Development Phase**						
			Discovery	Identification	Evaluation	Concept	Pre-feasibility	Feasibility	Execution
Develop more accurate input parameters for planning and scheduling processes including seasonal variation.	Medium		●	◔					
Common user minor maintenance facility provided by Network.	Medium		●	◔					
Improve section headway by increasing the speed trains can enter yards.	High		●	◔					
Determine optimum system availability.	High		●	◔					
Advanced Planning and Execution Operational Technology (APEX) – system for improved train planning and scheduling, day-of-operations movement and maintenance planning.	High	1.2	●	●	●	●	●	●	◕
Possession Alignment and Capacity Evaluation tool (PACE) – planning tool for maintenance and renewals track possessions including and optimisation of resources and revenue traffic.	High	1.3	●	●	●	●	●	●	◕

INFRASTRUCTURE

Table 3: Infrastructure opportunities.

Opportunity – The infrastructure.	Priority (● Low ● Medium ● High)	Refer to Appendix 8 for detail	Development phase: Discovery	Identification	Evaluation	Concept	Pre-feasibility	Feasibility	Execution
Increase overload limits. Improves train density.	High		●	●	◔				
Speed and cant review. Improve wheel and rail wear. Lift isolated permanent speed restrictions to increase average train speed.	Medium		●	●	◔				
Infrastructure upgrade required to support 160t locomotives.	Medium		●	●	◔				
Increased Train Density. Higher gross to tare ratio. Includes axle load increase.[1]	High	1.1	●	●	●	X			
Journey to Automation. Improve data and analytics to improve asset condition and infrastructure reliability and/or reduce cost of delivery.	High		●	●	◑				
Digital Train Control Radio. Improved reliability, reduced dwells under safeworking fault conditions, enable future signalling technology.	High	1.8	●	●	●	●	●	◔	
New resurfacing assets targeting 50% productivity uplift. Improved availability, reduced cost of maintenance delivery.	Medium	1.7	●	●	●	●	●	●	◕
New ballast cleaning machines targeting 45% productivity uplift. Improved availability, reduced cost of maintenance delivery.	Medium	1.7	●	●	●	●	●	●	◕
New spoil wagons. Improved availability, reduced cost of maintenance delivery.	Medium	1.7	●	●	●	●	●	●	◕
New mobile flashbutt welding machines. Improved track reliability.	Medium	1.7	●	●	●	●	●	●	◕
New turnout undercutter. Improved availability, reduced cost of maintenance delivery.	Medium	1.7	●	●	●	●	●	●	◕
Network Asset Management System (NAMS). Improve asset condition and reliability. Reduce cost of delivery.	High	1.4	●	●	●	●	●	●	◕
Supersites are the co-location of above and below rail wayside condition monitoring equipment at Network provided locations.	High	1.5	●	●	●	●	●	●	◑
Reduced Wagon Length through Use of Rotary Dump. Improve train density.[2]	Medium		●	X					

[1] Suspended as rigorous evaluation indicates that this opportunity does not yield a reduction in total cost of transportation. See Appendix.

[2] Suspended as this idea did not pass the principles test particularly Integrated System Approach.

OPERATING THE TRAINS

Table 4: Operating the trains opportunities.

Opportunity – Operating the trains.	Priority (Low / Medium / High)	Refer to Appendix 8 for detail	Development phase: Discovery	Identification	Evaluation	Concept	Pre-feasibility	Feasibility	Execution
Improved train loading accuracy. Increase train payload.	Medium		●	◔					
Opportunity for consist sharing across operators. Reduce total consists reducing congestion, improve average train speed.	Medium		●	◔					
Train Length Optimisation – understand the optimum train configuration for each CQCN system.	Medium		●	●	◔				
Train Overlength Study – assess limited number of overlength trains in each system.	Medium		●	●	◔				
Identify improved processes for train unloading. Improve train average speed.	Medium		●	●	◔				
Reduced Headway between Hatfield and Yukan in Goonyella. Improve constraining headway increasing train velocity.	High		●	●	◔				
Reduce Newlands Headway to 30mins (DTC to RCS and additional passing loop). Improve constraining headways increasing train velocity.	High		●	●	◔				
Reduce Blackwater Headway (Windah – Westwood and Tunnel – Edungalba) Improve constraining headway increasing train velocity.	High		●	●	◔				
On-Train Repair. Reduce time for rollingstock repairs, increase asset availability and train velocity.	Medium	1.6	●	●	●	●	●	●	◕
Reduce Moura Headway (Mount Rainbow – Fry). Improve constraining headway increasing train velocity.[1]	Low		●	●	X				
Bauhinia Branch Upgrade to RCS. Improve constraining headway increasing train velocity.[2]	Low		●	●	X				

[1] Suspended due to current status of Moura system demand. To be reassessed if Moura status changes.

[2] Suspended as no requirement for additional capacity. To be reassessed if status changes.

ROLLINGSTOCK

Table 5: Rollingstock opportunities.

Opportunity – Rollingstock.	Priority Low Medium High	Refer to Appendix 8 for detail	Development phase Discovery	Identification	Evaluation	Concept	Pre-feasibility	Feasibility	Execution
Improve clearances. Allow for new stock outline that is compatible with other railway systems. Reduce rollingstock capital cost, allow higher capacity rollingstock.	●		●	●	◑				
Improve clearances. Allow for new stock outline that is compatible with other railway systems. Reduce rollingstock capital cost, allow higher capacity rollingstock.	●		●	●	◔				

APPENDIX 8.1 HIGHER TRAIN DENSITY (HTD)

DISCOVERY

Above rail operators expressed a need to understand what rollingstock could be specified in the future for either expansion of fleet and for end-of-life replacement of current fleet.

An increase to train density by upgrading below rail infrastructure to support higher axle load wagons and heavier locomotives than current has the potential to provide for improved productivity from above and below rail assets.

The current capability within the below rail infrastructure and the opportunity to leverage necessary asset renewals may provide a viable path to an increased Network load capability.

IDENTIFICATION

Alignment with vision.

This opportunity had clear alignment with the future vision in a number of aspects:

Infrastructure

- Changes that facilitate the introduction of rollingstock with greater capability will be actively pursued.
- Opportunities to improve train density will be explored.

Operating the trains.

- Reducing the number of trains in the system can also benefit cycle times by reducing dwells associated with congestion.

Rollingstock.

- We'll work with above rail operators to support a vision for rollingstock that is facilitated by the future for other railway system assets.
- We'll work towards aligning standards dealing with the interface between rollingstock and infrastructure with other railways, reducing the need for bespoke rollingstock designs. The intent will be to broaden the market for rollingstock procurement reducing capital costs and obsolescence risk.

ALIGNMENT WITH PRINCIPLES

Integrated system approach.

Future rollingstock procurement may be able to exploit synergies with standard gauge specifications to reduce procurement costs and achieve greater fleet standardisation

Innovation

Higher locomotive masses provide increased tractive effort and power providing a reduction in the number of locomotives per train.

Sustainability

Greater rollingstock productivity improves above rail capital efficiency.

Ability for above rail operators to standardise wagon designs across multiple operations benefits business resilience.

Leverage renewals investment.

If proven to be cost effective, a change to infrastructure capability could be aligned to future rollingstock fleet replacement requirements.

Future Network asset replacement requirements provide opportunities to provide asset upgrades to a higher standard.

Total cost of transportation.

Higher train density provides a reduction in the rollingstock fleet size and operating costs. Over time this may offset the required capital to upgrade the infrastructure.

EVALUATION

The evaluation compares the Business As Usual (BAU) case against the upgrade of infrastructure for heavier trains – the Higher Train Density (HTD) case.

Key input assumptions.

Figure 5 provides a proposed axle load specification to define the future axle loads and minimum axle spacing of future 30 tal wagons and 160t gross locomotives. This specification was developed based on input from rollingstock suppliers regarding likely achievable future rollingstock specifications.

1. A design and condition standard suitable for the proposed axle load specification for track, turnouts and structures was developed.

2. An assessment of the design standard and condition of infrastructure assets in the CQCN against the new standard was carried out and cost estimates developed. The infrastructure assets assessed included:
    a. Bridges
    b. Rail
    c. Sleepers
    d. Turnouts
    e. Ballast
    f. Formation.

Note – Culverts and pipes were not included in the assessment due to the lack of sufficiently detailed information at the time of assessment. This represents a significant cost element that has not been included in the evaluation.

3. The change to maintenance and asset renewals requirements of infrastructure under the proposed axle load specification was determined and cost estimates developed.

An increase in clearance envelope will also be required to allow for larger physical dimensions of rollingstock. A clearance assessment against a kinematic envelope generated from the future rollingstock outline is being undertaken, however, the costs to increase clearances in the Network have not been included in the evaluation process.

Results of engineering analysis.
The engineering analysis carried out identified the required replacement and upgrade work required in each system to support the increased load capability and a high-level cost estimate for these upgrades. Table 5 provides a summary of the engineering analysis.

Figure 5: Proposed axle load specification.

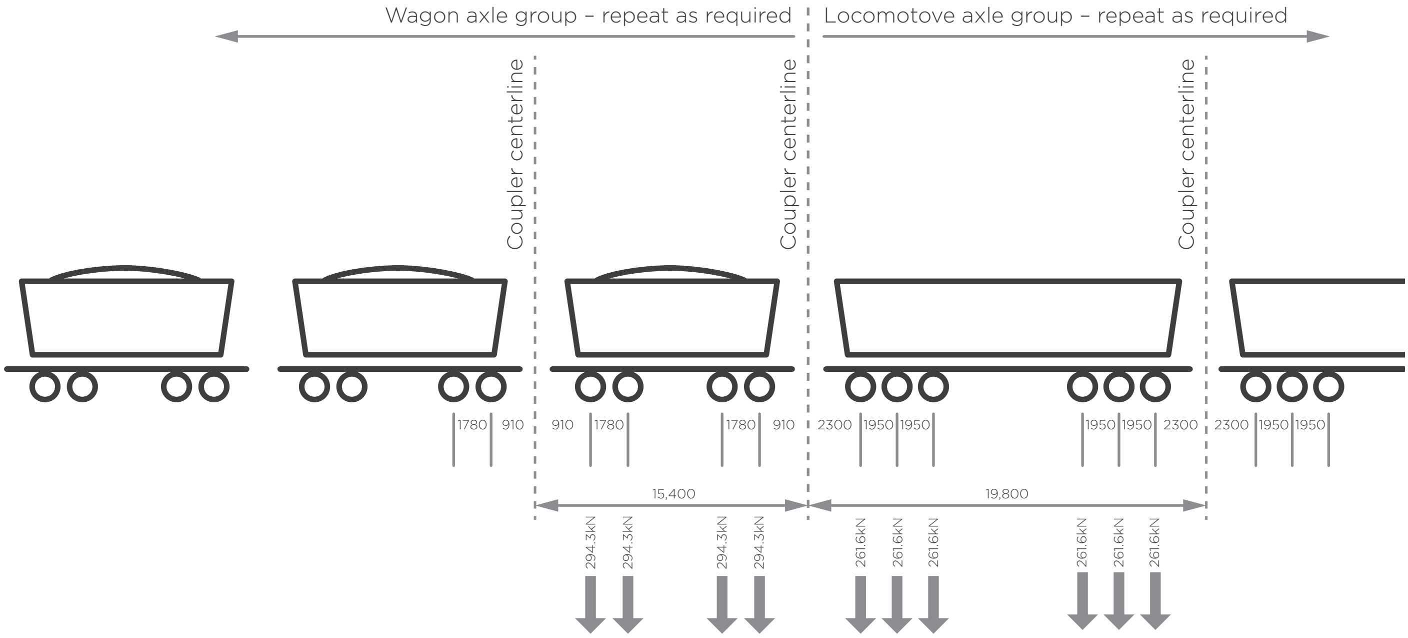


Table 6: Infrastructure upgrade scope and cost estimates.

Component	Goonyella	Newlands	Blackwater	Moura
Bridges: No. to replace/Total No.	36/69	9/32	58/126	29/29
Bridges: Cost Estimate: A$ (2016)	$383.6m	$88.1m	$572.0m	$223.9m
Sleepers: No. to replace	713,122	204,151	461,910	26,272
Sleepers: A$ (2016)	$462.1m	$128.3m	$258.2m	$10.3m
Turnouts: No to replace	179	14	160	26
Turnouts: A$ (2016)	$151.2m	$11.8m	$135.2m	$22.0m
Track upgrade: Km rail and sleeper	5.2	5.7	46.4	7.6
Track upgrade: A$ (2016)	$6.8m	$7.4m	$60.2m	$9.4m
Total per system: A$ (2016)	$1,003.7m	$235.6m	$1,025.6m	$265.5m

Total cost of transportation results.
Cost analysis has been carried out with the parameters listed in Table 7 below.

Blackwater system.
The pre-tax net present cost difference between continuing with the current infrastructure standard and increasing the standard to support higher train densities in the Blackwater system for 3% CAGR is presented in Figure 6.

The change in the contributions of each of the cost components is shown indicating that despite relative reductions in above rail operating costs and expansion costs for tonnage growth, the overall cost to the supply chain of upgraded capability would be $450 million over 25 years.

Table 7: CTM input parameters.

Parameter	Value
Tonnage growth low	1% CAGR
Tonnage growth medium	3% CAGR
Period	25 years
Systems	Blackwater excluding Moura
	Goonyella and Newlands combined
Discount rate below rail	WACC – 7.17%
Discount rate above rail	13%
Transition to HTD	2028
Capital Sensitivity	-50% applied to below rail upgrade estimates

Figure 6: Net present cost component Delta Blackwater system 3% p.a. tonnage growth.

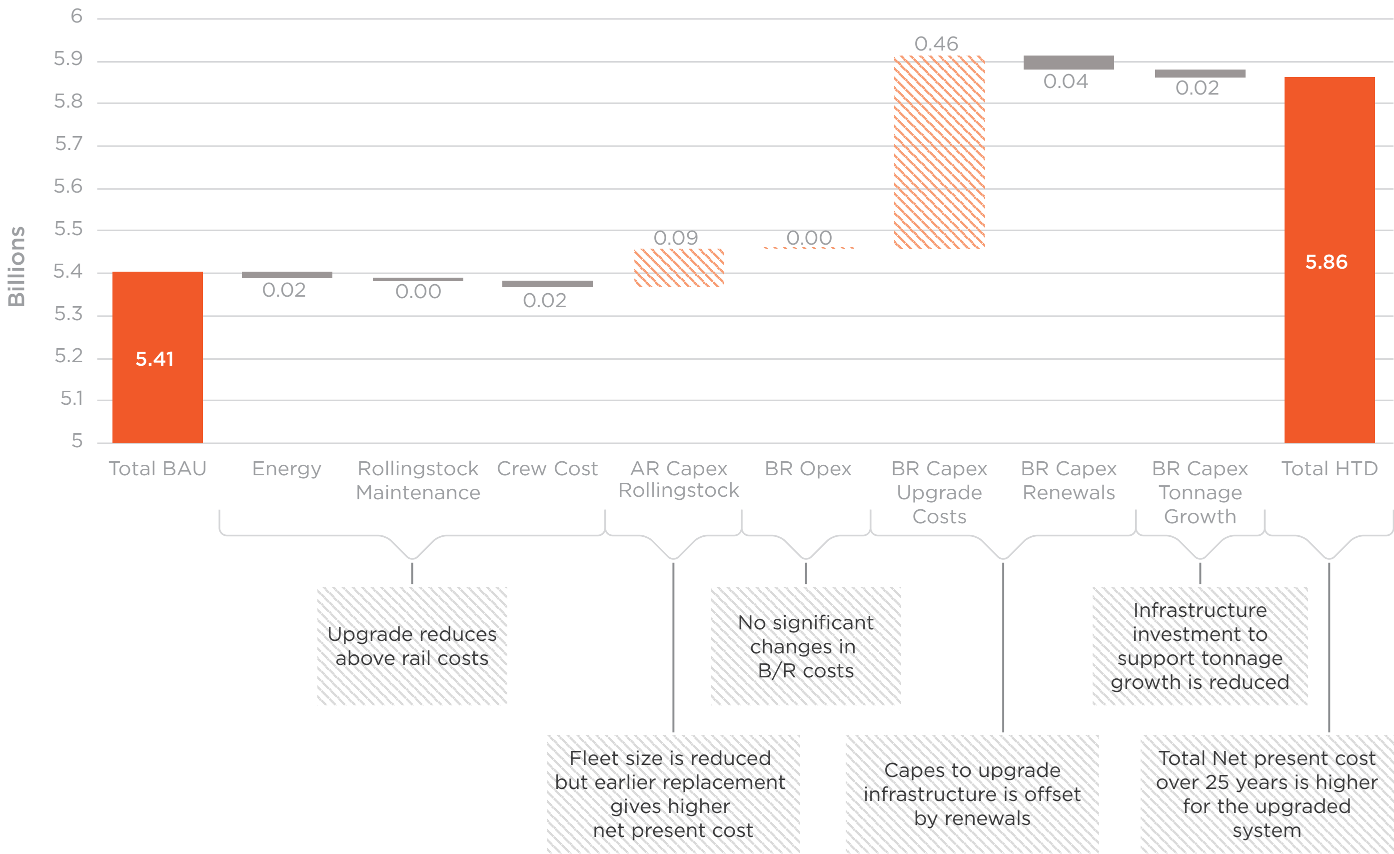


Figure 7 shows costs in nominal terms over the analysis period. An ongoing reduction in above rail operating costs is realised from the year of implementation for the HTD case against the BAU case.

The HTD case brings forward capital expenditure for the replacement of rollingstock. While the fleet size is reduced in the HTD case, the earlier investment results in a higher net present cost.

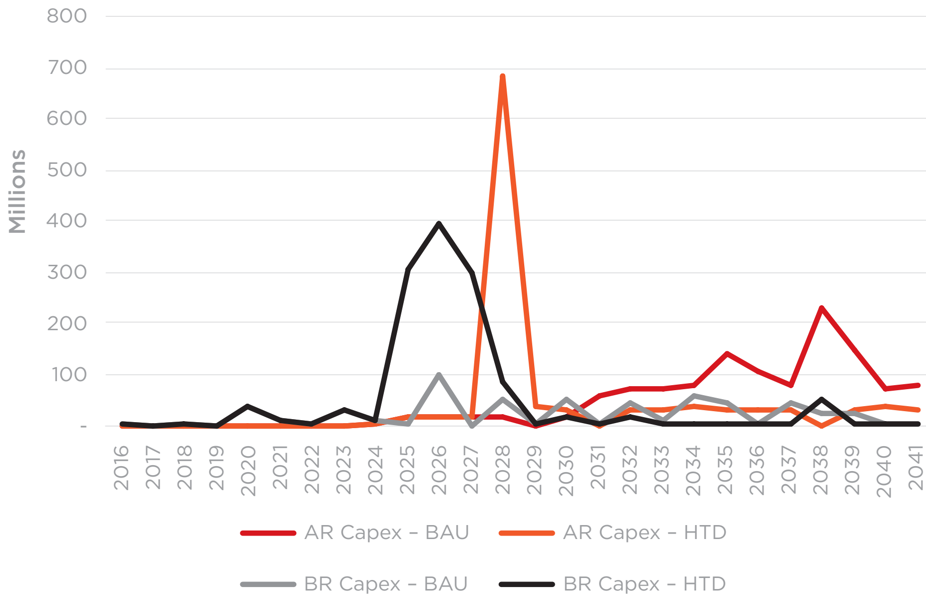
Below rail Capex for upgrades is approximately $900 million spread over three years. This does reduce the renewal and expansion capital requirements in later years.

Analysis at lower tonnage growth of 1% CAGR indicates a greater difference between the net present cost results of the BAU to HTD cases. The HTD case is $500 million more expensive.

The capital costs of infrastructure upgrades are based on high-level estimates. A sensitivity analysis was carried out against these costs. Figure 8 shows that despite a 50% reduction in the costs of upgrades to structures and turnouts, the net present cost position is still negative by $280 million.

Figure 7: Blackwater 3% tonnage growth cash flow in $2016 over the analysis period.

Capex summary annual cost.
Blackwater system 3% p.a. tonnage growth.



Opex summary annual cost.
Blackwater system 3% p.a. tonnage growth.

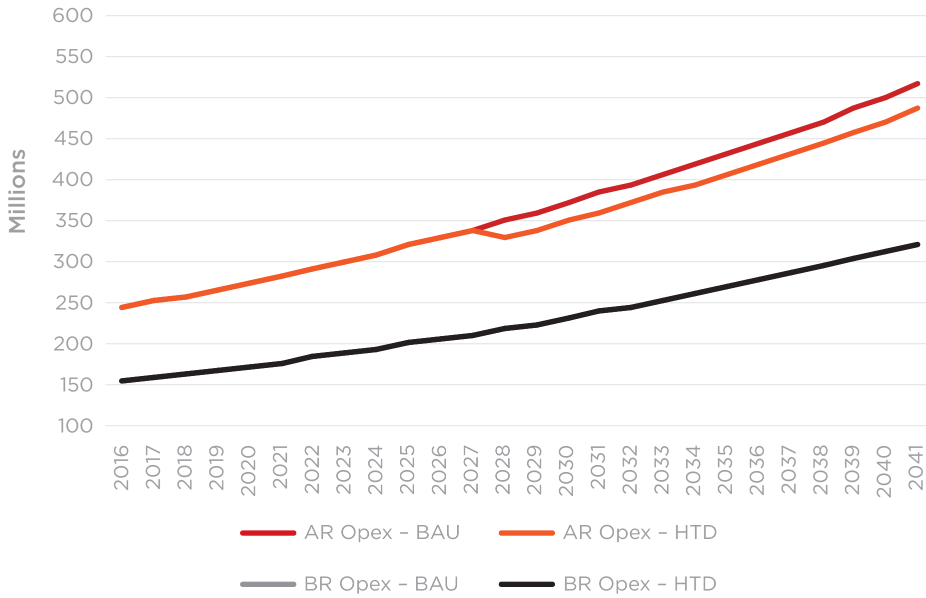


Figure 8: Net present cost component delta Blackwater system 3% p.a. tonnage growth BR Capex reduced 50%.

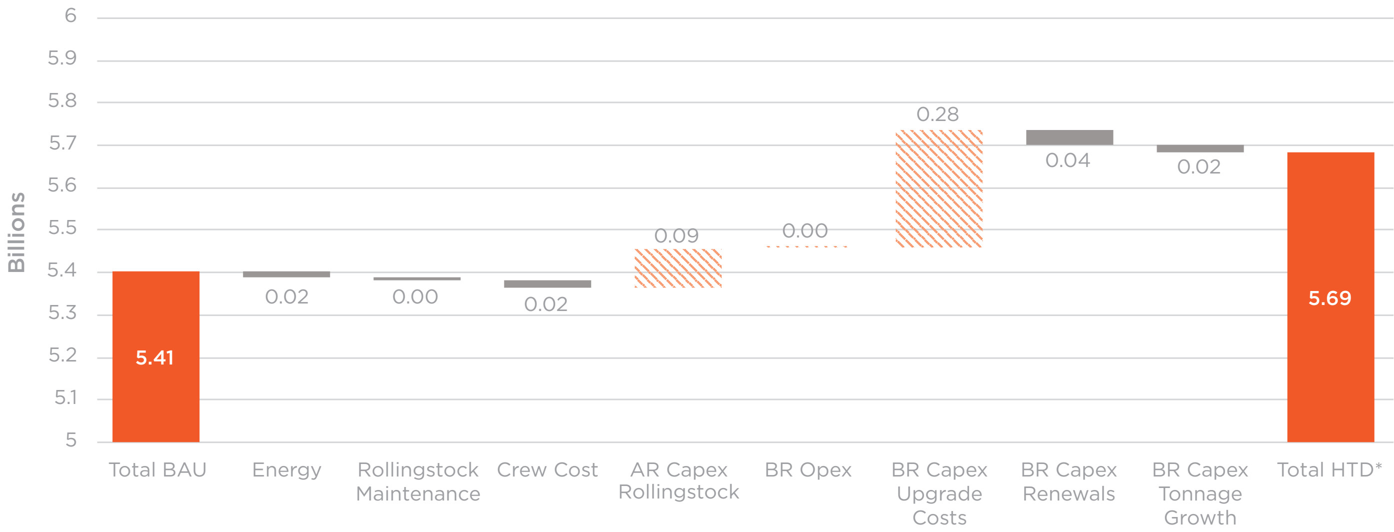


Figure 9: Goonyella/Newlands system 3% p.a. tonnage growth.

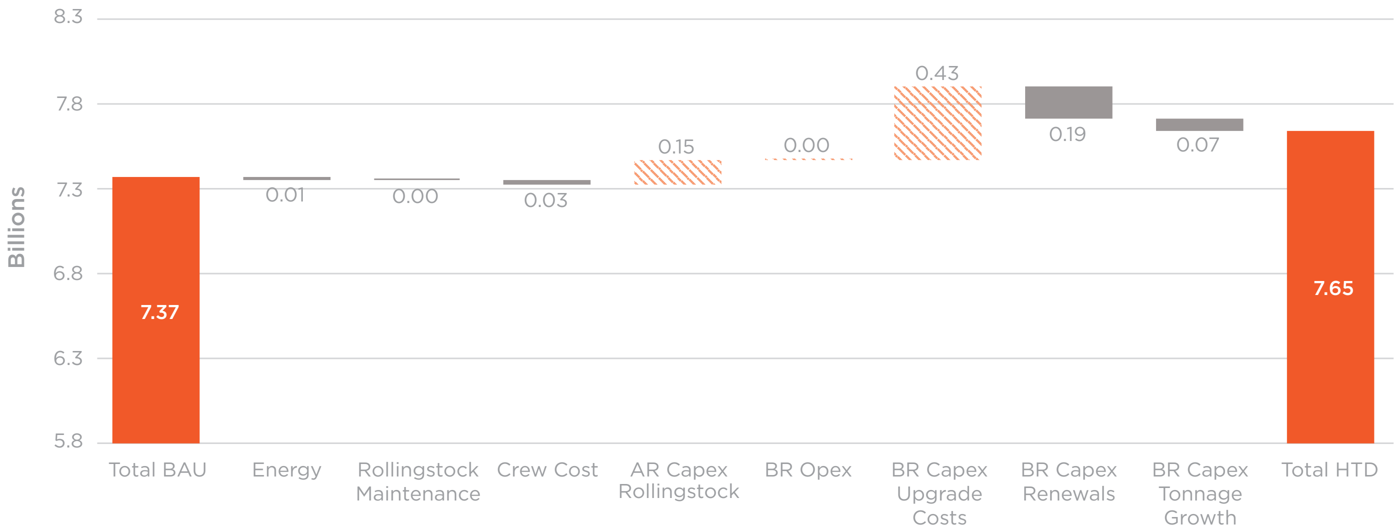
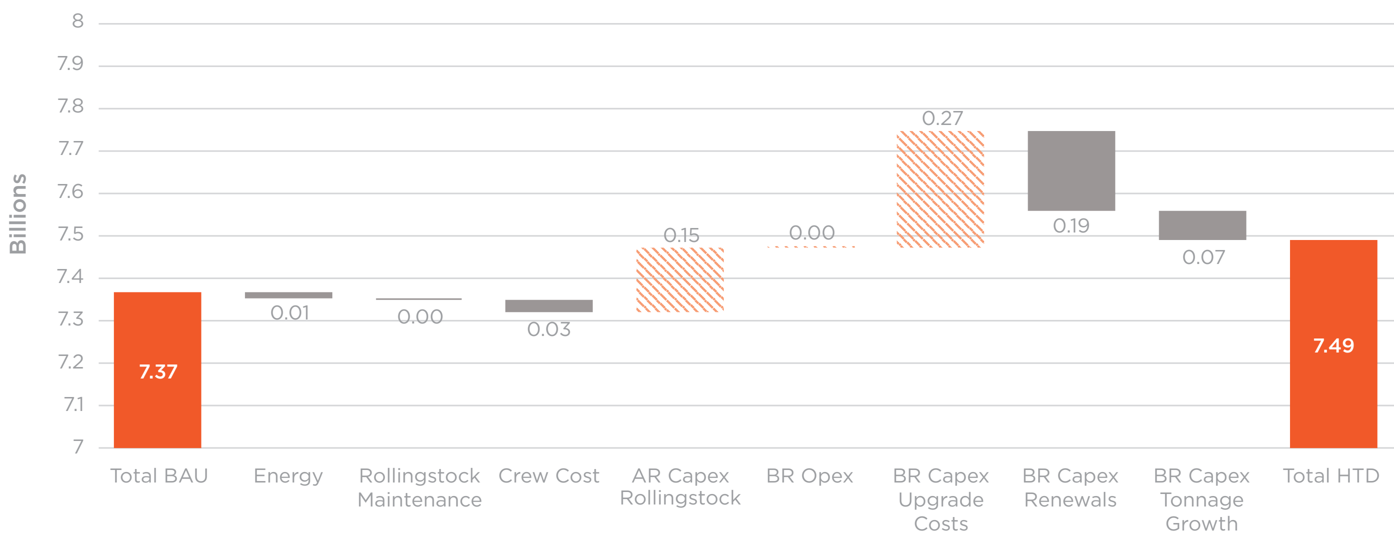


Figure 10: Net present cost component delta Goonyella/Newlands system 3% p.a. tonnage growth BR Capex reduced 50%.



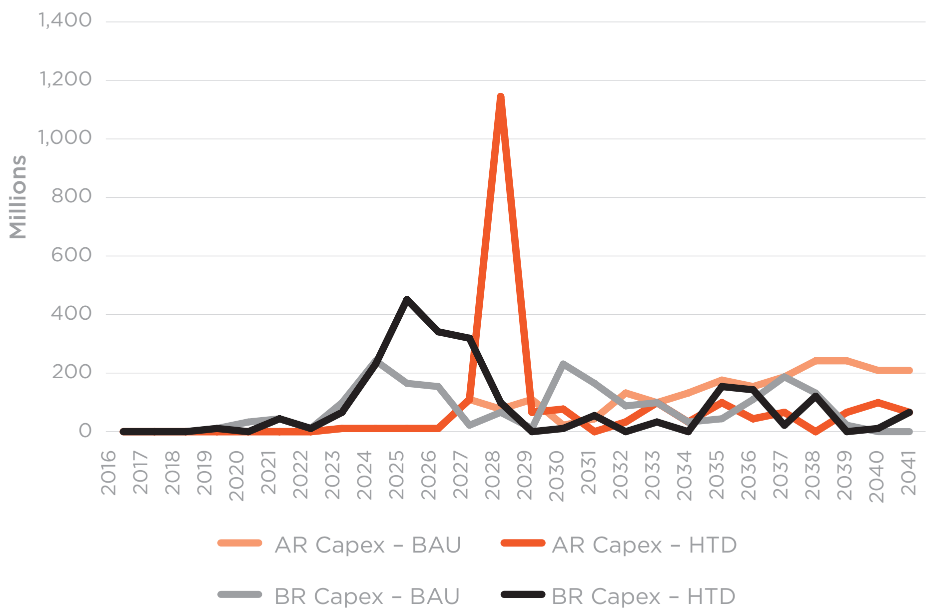
Goonyella Newlands system.
These systems were analysed as one due to the significant interaction between systems and the likely expansion of Abbot Point for future tonnes from the Goonyella system.

The results for the Goonyella Newlands system are similar in characteristic to the Blackwater system, however, the net present cost differential is lower at $280 million for 3% annual tonnage growth as shown in Figure 9.

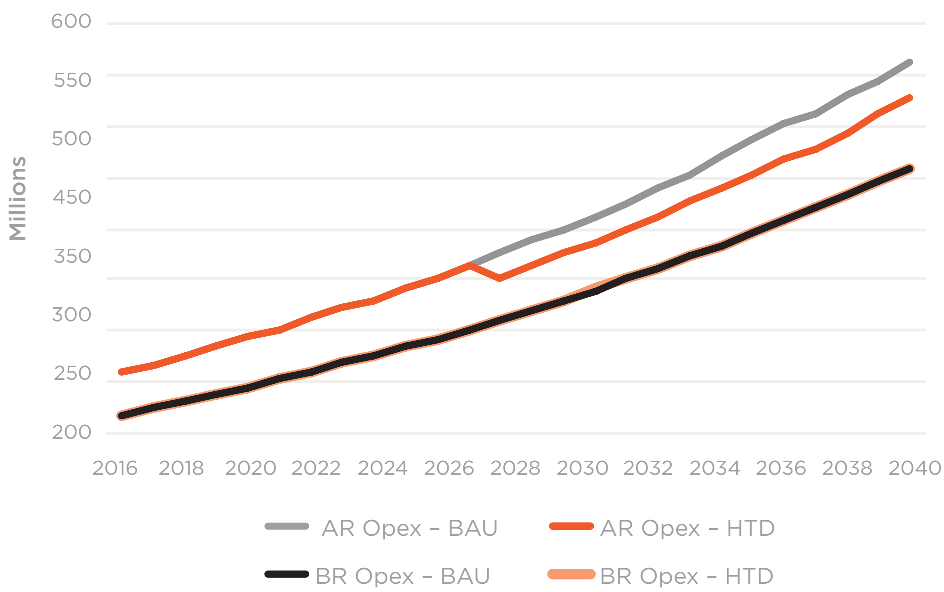
When below rail capital cost sensitivity is applied the net present cost differential reduces to $120 million.

Figure 11: Goonyella and Newlands 3% tonnage growth cash flow in $2016 over the analysis period.

Capex summary annual cost.
Goonyella/Newlands system 3% p.a. tonnage growth.



Opex summary annual cost.
Goonyella / Newlands system 3% p.a. tonnage growth.



CONCLUSIONS TO ANALYSIS

No positive cost benefit to the supply chain has been identified from the evaluation of the opportunity undertaken. A summary of the results of the total cost of transportation analysis is given in Table 8.

Further it's important to note that a potentially significant cost component to upgrade the infrastructure, i.e. culverts and clearances hasn't been included due to insufficient data being available at the time of evaluation. The inclusion of these costs would make the already negative cost position of the HTD opportunity even less desirable.

Recommendations

The results indicate that for the growth scenarios considered, increasing the capability of the Network infrastructure for higher loads is not viable.

The results of the two scenarios studied indicate that a higher rate of tonnage growth may yield a positive outcome which will be investigated in the Network Development Plan.

The evaluation has revealed that the following related opportunities should be investigated:

- Infrastructure upgrade to facilitate 160t locomotives with current 26.5 tal wagons.
- Infrastructure upgrade to facilitate higher wagon overload limits.

Table 8: Summary net present cost results.

System	1% Tonnage CAGR	1% Tonnage CAGR Below Rail Capex Sensitivity (-50%)	3% Tonnage CAGR	3% Tonnage CAGR Below Rail Capex Sensitivity (-50%)
Goonyella and Newlands	$390m	$230m	$280m	$120m
Blackwater	$500m	$330m	$450m	$280m

Note: Positive (+) value indicates higher cost for Higher Train Density Upgrade.

INTERRELATIONSHIPS

Opportunity	Association
Above rail fleet renewal	Specification of replacement locomotives and wagons
Clearances	Rollingstock of higher mass will be physically larger requiring additional clearance to infrastructure.

APPENDIX 8.2 ADVANCED PLANNING AND EXECUTION OPERATIONAL TECHNOLOGY (APEX)

DISCOVERY

Increased Network demand combined with manual processes and 10-year-old systems for the scheduling and management of train movements created the need to assess replacement systems that could also provide additional benefits.

IDENTIFICATION

Alignment with vision.

Potential solutions investigated provide capabilities aligned to the future vision. In particular by fulfilling the following aspects of the Vision:

Operating the Network.

Network will deliver reliable and accurate plans and schedules by a focus on tools and methods for train service planning and scheduling, maintenance planning, and day-of-operations management and optimisation.

Delivering reliable train running, improving the utilisation of above and below rail resources by reducing unplanned dwells and delays. Mine and port facilities are also more efficiently utilised by reducing idle time.

Systems to assist in optimisation of plan and schedule development will be developed.

The integration of control, routing and planning functionality and automation of routine activities will free staff for more value adding analysis and optimisation activities.

Operating the trains.

The opportunity has the potential to reduce dwells and delays in train cycles.

Alignment with principles.

The Apex opportunity facilitates the strategic principles as described below.

Integrated system approach.

Development of a customer web portal providing reports, maintenance programs and requests, customer forecasts, train orders and a live Network overview facilitates an integrated system.

Innovation

Multiple innovations are facilitated:

- Capabilities to automate the conflict detection, resolution and replanning process.
- Network plan and schedule optimization capabilities.
- Providing a platform for 'auto routing' in the future.

Sustainability

The delivery of greater Network utilisation and productivity facilitates the delivery of lasting value.

Leverage renewals investment.

The need to replace existing aging systems provides an ability to leverage this investment requirement to implement higher capability systems.

Total cost of transportation.

There is potential for innovative planning, scheduling and train control systems to improve Network utilisation and reduce cycle times. This may result in lower total cost of transportation by reducing cycle times and rollingstock assets required.

INTERRELATIONSHIPS

Opportunity	Association
FMT	Communication of above rail schedule requirements Topological information
PACE	Long and short-term infrastructure maintenance planning and scheduling processes

APPENDIX 8.3 POSSESSION ALIGNMENT AND CAPACITY EVALUATION TOOL (PACE)

DISCOVERY

The need was identified for a more sophisticated means of maintenance and renewals planning that enables the development of access plans optimised against three key criteria:

- Supply chain throughput
- Asset reliability
- The cost of delivering maintenance.

IDENTIFICATION

Alignment with vision.

Potential solutions investigated provide capabilities aligned to the future vision. In particular by fulfilling the following aspects of the vision :

Operating the Network.

The future vision for operating the Network is centred on delivering levels of availability and utilisation that improve productivity and customer focus.

Network will deliver reliable and accurate plans and schedules by a focus on tools and methods for train service planning and scheduling and maintenance planning.

The development of sophisticated modelling capability will facilitate better understanding of the behaviour of the total supply chain and the interdependencies between elements. This capability will lead to better decision making and optimisation.

New systems of maintenance planning will balance asset maintenance and reliability requirements with throughput and resources to achieve optimised delivery plans.

Maintenance resources will be more efficient with detailed forward planning of the delivery of the required scope of work and certainty around the execution of schedules.

Alignment with principles.
The Apex opportunity facilitates the strategic principles as described below.

Integrated system approach.
This opportunity has the potential to improve the integration of infrastructure maintenance planning with traffic planning.

Innovation
Significant innovation is introduced by the development of new software systems and in the supporting business processes required.

Sustainability
The delivery of greater Network availability and more efficient use of maintenance resources facilitates the delivery of lasting value.

Leverage renewals investment.
There is not significant renewals investment benefit, however, the project has research and development tax benefits as well as relatively low development costs.

Total cost of transportation.
There is potential for improvement to Network availability providing additional capacity. Better maintenance possession plans may reduce cycle times. Better utilisation of maintenance resources has the potential to lower infrastructure maintenance costs.

These factors may all contribute to a lower total cost of transportation.

INTERRELATIONSHIPS

Opportunity	Association
APEX	Long and short-term infrastructure maintenance planning and scheduling processes
NAMS	Asset condition and maintenance scope development

APPENDIX 8.4 NETWORK ASSET MANAGEMENT SYSTEM (NAMS)

DISCOVERY

The need for a system that would improve the operational effectiveness of Network's asset management effort was identified. The required components are:

- Collection and validation of asset management information including quantity, type, condition, criticality and maintenance history.
- Designing, building and implementing supporting technology, including a single system for asset management with mobile communications and GIS capabilities.
- Improving asset management processes to ensure business rules and processes are effectively refined to take full advantage of new technical capabilities.
- Consulting with, training and supporting impacted people through the changes to ensure a smooth integration of the changes into business operations.

IDENTIFICATION

Alignment with vision.
Potential solutions investigated provide capabilities aligned to the future vision. In particular by fulfilling the following aspects of the vision:

Operating the Network.
The future vision for operating the Network is centred on delivering levels of availability and utilisation that improve productivity and customer focus.

Maintenance resources will be more efficient with detailed forward planning of the delivery of the required scope of work and certainty around the execution of schedules.

A better understanding of the condition and reliability of all components of the supply chain will provide input to maintenance planning processes.

Infrastructure
The approach to asset management will evolve with condition monitoring, predictive maintenance planning and less corrective maintenance.

Data will be stored and processed to produce information for improving reliability, optimising maintenance intervention limits and improving the efficiency of planning and reporting.

Systems for identifying fault conditions and actioning rectification will be developed including optimisation tools to achieve the best results under reduced performance conditions.

Rollingstock
Interfaces between the rollingstock and other railway assets will be optimised, adopting a whole-of-life cost approach and maximising the capacity of the supply chain. This will be supported by systems for the acquisition, transmission and handling of information to support optimised interface management.

Alignment with principles.
The NAMS opportunity facilitates the strategic principles as described below.

Integrated system approach.
This opportunity has the potential to improve the integration of infrastructure maintenance planning with traffic planning.

Innovation
Significant innovation is introduced by the development of new software systems and in the supporting business processes required.

Sustainability
Better planning of maintenance and renewal activities based on more accurate knowledge of asset condition and previous maintenance history will deliver greater value, reduce resource use and improve productivity.

Leverage renewals investment.
There is not significant direct renewals investment benefit, however, the project has the potential to reduce infrastructure maintenance costs by better planning, resource utilisation and whole-of-life management of assets.

Total cost of transportation.
There is potential for improvement to Network availability providing additional capacity. Better utilisation of maintenance resources and less reactive maintenance has the potential to lower infrastructure maintenance costs.

These factors may all contribute to a lower total cost of transportation.

Evaluation
NAMS has been evaluated to deliver savings in below rail operational expenses over 10 years commencing from FY2017 based on:

- Decreasing Network-caused derailments.
- Decreasing number of cancelled trains due to unscheduled (civil) maintenance.
- Decreasing train delays due to Network (civil) issues.
- Decreasing corrective maintenance.
- Decreased costs of obtaining asset information.
- Improvements in maintenance workforce efficiency.

INTERRELATIONSHIPS

Opportunity	Association
PACE	Infrastructure maintenance and renewals scope development.

APPENDIX 8.5 SUPERSITES

DISCOVERY
The use of wayside equipment to measure rollingstock parameters is beneficial to the asset management of both the rollingstock and the infrastructure. This opportunity provides the facilities for all above rail operators and Network to install a range of wayside equipment at strategic locations on each system.

IDENTIFICATION
Alignment with vision.
This opportunity contributes to the following elements of Network's strategic vision.

Infrastructure
Yard activities historically have included rollingstock inspection, testing and minor repairs, train assembly and shunting rollingstock to depot facilities for maintenance and repair and storage and staging of trains into traffic. Opportunities to improve the productivity and efficiency of these activities will be pursued

Rollingstock
Interfaces between the rollingstock and other railway assets will be optimised, adopting a whole-of-life cost approach and maximising the capacity of the supply chain. This will be supported by systems for the acquisition, transmission and handling of information to support optimised interface management.

Condition monitoring of rollingstock can be facilitated by provision of suitable trackside locations and access to necessary services. Information and communications technology infrastructure will enable greater use of condition monitoring by above rail operators

Alignment with principles.
The Supersites opportunity facilitates the strategic principles as described below.

Integrated system approach.
The Supersites facilitate the measurement of parameters related to the interface of the rollingstock with the infrastructure. This builds the capability of operating and maintaining infrastructure and rollingstock as an integrated system.

Innovation
This opportunity facilitates the introduction of innovative technology and the collection and distribution of the data collected allows business improvement processes to develop.

Sustainability
Remote inspection and data collection improves safety. More efficient maintenance practices are facilitated reducing costs.

Total cost of transportation.
Potential reductions in rollingstock and infrastructure maintenance costs contribute to a lower total cost of transport.

INTERRELATIONSHIPS

Opportunity	Association
NAMS	Asset use and condition data

APPENDIX 8.6 ON-TRAIN REPAIR FACILITIES

DISCOVERY

An above rail operator identified benefits from reducing the need to break up train consists for some repair needs by implementing innovative practices. This could be enabled by the provision of suitable access by Network to specific locations on the CQCN.

IDENTIFICATION

Alignment with vision.

This opportunity contributes to the following elements of Network's strategic vision.

Operating the trains.

Yard activities historically have included rollingstock inspection, testing and minor repairs, train assembly and shunting rollingstock to depot facilities for maintenance and repair, storage and staging of trains into traffic. Opportunities to improve the productivity and efficiency of these activities will be pursued.

Rollingstock

Rollingstock lies at the heart of the railway system. While Network doesn't own or operate the commercial rollingstock, the way that rollingstock is specified, operated and maintained fundamentally affects the efficiency and productivity of the supply chain.

We'll work with above rail operators to support a vision for rollingstock that is facilitated by the future for other railway system assets. Network will look to develop and implement technology that will facilitate the innovation initiatives sought by above rail operators in the design, operation and maintenance of rollingstock.

Alignment with principles.

The On-Train Repair (OTR) opportunity facilitates the strategic principles as described below.

Integrated system approach.

Provision of the Network infrastructure and systems to facilitate OTR enables better integration of above rail and below rail operations.

Innovation

Providing OTR facilities enables the introduction of significant innovation in rollingstock maintenance practices.

Sustainability

Reducing the need for shunting vehicles for maintenance has a positive impact on resource usage. Cost reduction benefits the sustainability of the business.

Leverage renewals investment.

The need for yard infrastructure renewals can be aligned with changes to facilitate OTR.

Total cost of transportation.

Reduction in shunting activities has the potential to achieve better utilisation of rollingstock assets reducing the total cost of transportation.

INTERRELATIONSHIPS

Opportunity	Association
APEX	Scheduling requirements for OTR activities.

APPENDIX 8.7 MECHANISED MAINTENANCE EQUIPMENT

DISCOVERY

New developments in mechanised track maintenance equipment can provide higher production rates and improved availability. This includes mainline and turnout resurfacing, ballast cleaning, and mobile flash butt rail welding capabilities.

IDENTIFICATION

Alignment with vision.

This opportunity contributes to the following elements of Network's strategic vision.

Operating the Network.

The future vision for operating the Network is centred on delivering levels of availability and utilisation that improve productivity and customer focus to all components of the supply chain. The cost of improvements to availability and utilisation will be optimised against the benefit.

Infrastructure

The future state of the infrastructure will be one where the reliability and availability of the infrastructure systems is optimised with the cost of delivery.

New techniques and equipment for the delivery of maintenance tasks will reduce track possession and closure times.

Alignment with principles.

The Mechanised Maintenance Equipment opportunity facilitates the strategic principles as described below.

Integrated system approach.

Improved track quality and return to service.

Innovation

New technology developments are introduced.

Sustainability
New equipment will introduce standardisation to the maintenance fleet improving fleet maintenance management and operator knowledge requirements building business sustainability.

Leverage renewals investment.
The enhanced capability can be introduced as part of the requirement to replace aging mechanised maintenance equipment.

Total cost of transportation.
Reduced track maintenance costs and improved availability contribute to a lower total cost of transport.

INTERRELATIONSHIPS

Opportunity	Association
PACE	Production rates and resource requirements for maintenance planning.
NAMS	Asset information

APPENDIX 8.8 RADIO REPLACEMENT

DISCOVERY

The need was identified for a replacement of the existing Train Control Radio (TCR) system in response to changes in radio spectrum allocation and to achieve system reliability requirements.

The introduction of more sophisticated digital technology could provide the possibility of introducing additional capabilities into the Network for data as well as voice communications.

IDENTIFICATION

Alignment with vision.
Potential solutions investigated provide capabilities aligned to the future vision. In particular by fulfilling the following aspects of the Vision:

Infrastructure
The future state of the infrastructure will be one where the reliability and availability of the infrastructure systems is optimised with the cost of delivery. Safety of workers, customers and the public will continually improve, and customer expectations of service levels and cost will be exceeded.

The introduction of new technologies that have the potential to provide future, as yet unknown benefits, either on their own or as part of a larger system, will be pursued particularly where asset renewals are required.

Changes that facilitate the introduction of rollingstock with greater capability will be actively pursued.

Operating the trains.
In the future, signalling and control functionality may be migrated onto trains, reducing the need for lineside equipment while also providing greater capacity and operational flexibility. Network will investigate the progressive implementation of enabling technologies to facilitate a future transition to this type of technology.

Alignment with principles.
The Radio System Replacement Project (RSRP) opportunity facilitates the strategic principles as described below.

Integrated system approach.
This opportunity integrates the TCR, Maintenance Supervisory Radio, Remote Monitoring, Wayside radio, and Shunting radio systems into a single system.

Furthermore, the adoption of the TETRA digital radio system can support the implementation of new operational systems

Innovation
Significant innovation is introduced by the development of a digital radio system including dynamic control boundary changes and the transfer of data for control and safety functions.

Sustainability
The design life of the radio system is 30 years and is designed so it doesn't require a widespread refresh to facilitate technology changes in related fields.

Total cost of transportation.
There's potential to support advanced rail technology platforms (such as ATP) to improve the safety of train operations, to enhance train operator profitability provide alternatives to the construction of new infrastructure through better utilisation of Network capacity.

INTERRELATIONSHIPS

Opportunity	Association
APEX	Train control communications and safeworking procedures.

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