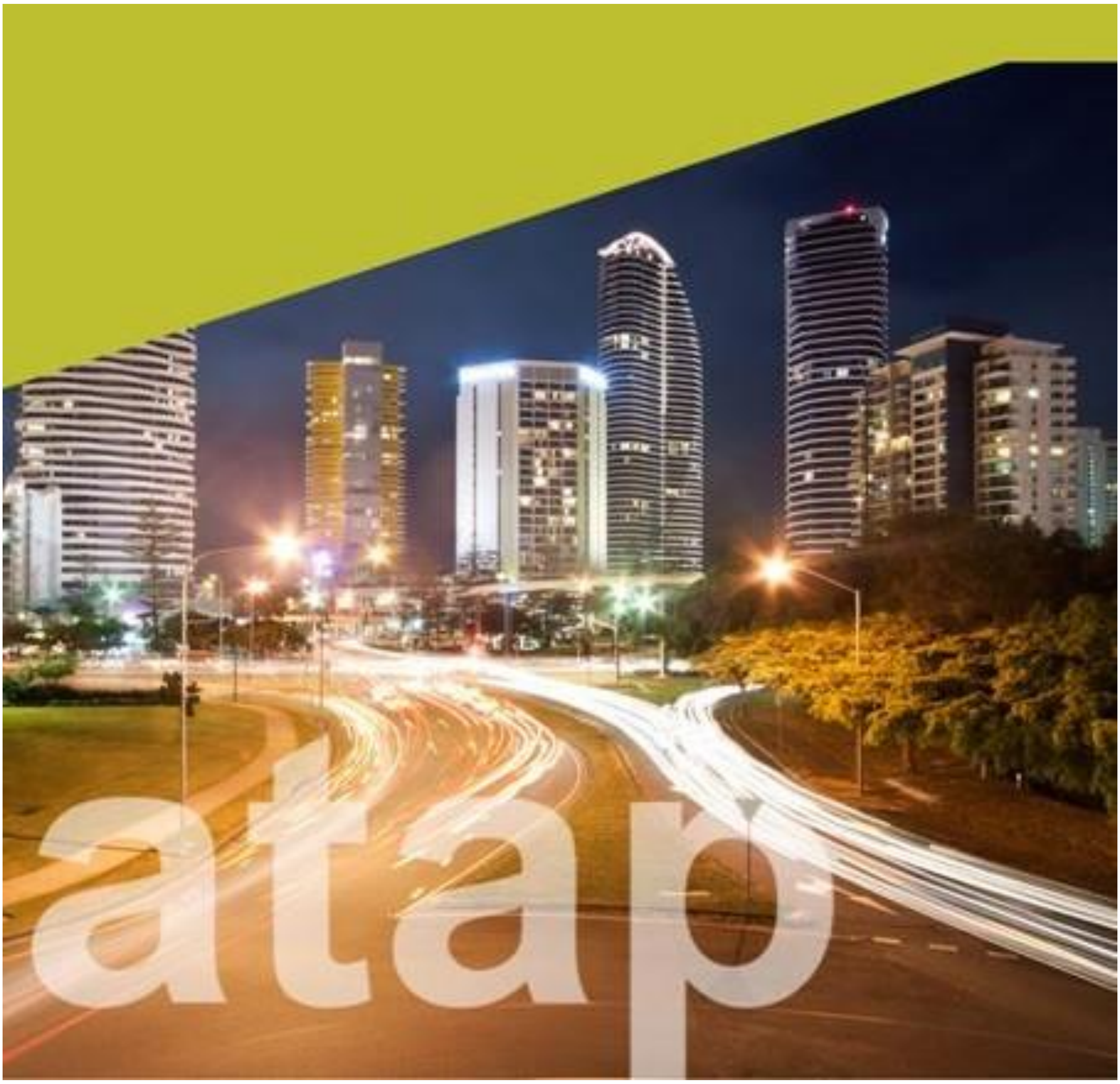
INFRASTRUCTURE AND TRANSPORT MINISTERS

Australian Transport Assessment and Planning Guidelines

M3 Freight rail

August 2021



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At a glance

- This mode–specific guidance provides methodologies and parameter values for the assessment of freight rail initiatives in urban and inter-urban areas. It supplements the general methodology guidance provided elsewhere in the ATAP Guidelines.
- Rail freight assets are characterised as being above-rail or below-rail. Above-rail generally refers to those assets that can be easily and quickly redeployed, essentially rollingstock. Below-rail refers to fixed infrastructure (steel rails, sleepers, formation, ballast, bridges, signalling, etc).
- In the past, rail freight systems in Australia were largely owned and operated by state and federal governments in a vertically integrated manner. Over time, much of the system has been privatised, with above rail operations separated from below rail operations.
- Freight rail operates within a logistics chain, of which rail line haul is just one component of an increasingly multi-modal logistics chain particularly for containerised freight.
- Freight rail carries both bulk and containerised traffics.
- The demand for freight transport is a derived demand. In deciding which transport mode to use, freight consignors consider service quality as well as price. Service quality attributes are: point to point transit time; on-time reliability; convenient departure and arrival times (service availability); and freedom from damage/loss.
- The demand for freight rail is influenced by a range of factors: socio-economic, economic, technological and governance. Assessment of freight rail demand considers: market segmentation, origin-destination information, logistics aspects, growth trends and the degree of contestability across modes. Demand estimation approaches include: diversion rates, elasticities and logit models.
- Capital costs in freight rail involve both fixed infrastructure and rolling stock, with asset lives varying significantly across asset components. Fixed infrastructure assets can involve very long economic lives, and investment lumpiness. Recurrent costs involve maintenance and operating costs of both fixed infrastructure and rollingstock.
- Unit cost parameter values are presented for freight rail locomotives and wagons (rollingstock) and operating costs. The differences between joint, common, avoidable and fully distributed costs are outlined.
- Benefit estimation for freight rail follows the same principles as outlined in ATAP Part T2 and mode-specific guidance (M-Parts). Aspects addressed include changes in consumers' and producers' surpluses, benefits associated with freight diverted from road to rail including changes in decongestion costs, road crash costs and environmental externalities. A summary is provided of initiative types and their associated benefits.
- Guidance is also provided on the measurement and monitoring of the impacts of freight rail initiatives on system efficiency and service performance.

1. Introduction

This document provides specialist Mode Specific Guidance on Freight Rail. It complements other parts of the ATAP Guidelines, applying the generic ATAP principles, framework and methodologies to freight rail. The material will assist practitioners in the assessment and planning of freight rail, most specifically in appraising rail freight initiatives.

M3 addresses aspects that are specific to freight rail initiatives, where appropriate cross-referencing concepts and data from other parts of the Guidelines to minimise duplication.

1.1 Links to other parts of the Guidelines

M3 is one of several areas of Mode Specific Guidance provided in the ATAP Guidelines. As with all ATAP mode specific guidance, M3 is built on, and applies, the generic principles and methodologies underpinning the Guidelines.

The most closely related parts of the Guidelines are:

- F3 Options Generation and Assessment
- T2 Cost–Benefit Analysis (CBA)
- M2 Road Transport — reflecting the fact that road and rail compete for some freight traffic.

While this guidance, can be used on a standalone basis, users are advised to also be familiar with these complementary parts.

1.2 Content and coverage of M3 guidelines

This module provides guidance on how the generic transport appraisal approach should be applied to freight rail projects. ATAP T2 Cost–Benefit Analysis sets out the basic principles for application to transport appraisals..

Freight rail initiatives have some unique features requiring them to be treated differently from other transport initiatives through the appraisal process. These features include:

- The majority of above rail operators in Australia are represented by private companies as opposed to public ownership. As a result, many freight rail initiatives will be considered on a financial basis by private operators.
- In some cases, freight rail initiatives will be proposed and funded by government, particularly investment in new freight rail lines. In these cases, cost–benefit analysis (CBA) is required to complement the operator’s financial analysis. In particular, CBA allows external impacts on society, such a safety and environmental costs to be accounted for in the assessment of initiatives. It also allows for the full network impacts of freight rail initiatives to be accounted for, e.g. on closely related road freight.
- The distribution of freight rail transport costs and benefits contrasts with road-based operations where, apart from toll roads, the infrastructure is supplied as a public good. Some rail infrastructure is however publicly owned, for example, the Australian Rail Track Corporation (ARTC) network, which is theoretically is available to all comers.

- There is a range of indirect costs and benefits potentially impacting on society generally. These include mode transfer from road to rail, changes that affect the volume of road traffic and congestion, potentially reduced prices of consumer goods if reductions in freight charges are passed on through the logistics chain, and consumer goods arriving at market in better condition.
- Rail freight services are often provided as part of larger logistics chains, with associated inter-relationships within that broader system.
- Ongoing costs associated with freight rail are typically proportionately small compared with initial capital outlays on major infrastructure and rollingstock. Ongoing costs include operating and maintenance costs. Re-investment in assets such as half-life component change out (CCO) refits, although an ongoing cost in a timing sense, are generally treated as a capital cost rather than as an operating expense. This guidance, ATAP Part M3, provides generic unit cost data, but it is noted that costs vary between operators, jurisdictions, terrains and equipment types, and analysts are encouraged to seek and apply data that is most appropriate to the initiative under consideration. Notwithstanding that, the numbers in this guidance provide a base set of parameters against which other estimates can be compared for reasonableness.
- Optimism bias, wherein costs tend to be under-estimated and demand over-estimated, is prevalent in major infrastructure projects, including freight rail initiatives. Economists need to use best practice techniques to estimate costs and demand and should benchmark estimates against evidence from other comparable locations and situations. A major problem is that very few rail operations are directly comparable except at a relatively superficial macro level, yet most projects the analyst will encounter are very specific in a micro sense. One of the most critical risks relates to the failure by rail to meet expectations to capture market share from road competitors. For further discussion, see ATAP Part O1 on Optimism Bias.

Freight rail initiatives will typically have a number of impacts that need to be taken into account in an economic appraisal. These impacts can be broadly categorised as:

- *Investment costs* — Investment costs incurred with the initiative (the Project Case), along with investment costs in the absence of the initiative (the Base Case), need to be taken into account.[1] Like other large transport infrastructure, freight rail initiatives commonly incur substantial investment costs, involving assets with very long economic lives. Further, freight rail initiatives are typically large scale “lumpy” investments with often minimal residual/salvage value or alternative deployment once installed.
- *Operating and maintenance costs* — Over the life of most freight rail initiatives, operating and maintenance costs will be significant for both the Base Case and Project Case, but usually much less than the initiative’s investment costs in present value terms. Some of these costs can be considered variable in the short term, others are institutionally variable in the medium term — staffing, others are variable only in the long term — for example the scale and scope of maintenance and servicing depots and workshops.
- *Benefits* — The term ‘benefits’ includes all impacts on above and below rail operators, owners, and customers (freight generators) and on the wider community that result from the initiative relative to the Base Case. The impacts can be both positive (a benefit) and negative (a disbenefit or cost).

[1] Regarding additional investments over the appraisal period that may be needed to meet population growth or other drivers of service growth, there are two approaches in Australia. Infrastructure Australia (2017) requires that such additional investments not be accounted for in the Base Case or Project Case unless funded or committed by Government. The other approach, to include them in both cases, is used by some jurisdictions. See further discussion of Base Case definition in ATAP Part T2 Section 1.6.

The results of the economic appraisal are driven by the incremental changes that occur between the Base Case and the Project Case. This is the case for generating benefits, investment costs and operating and maintenance costs. In all cases, the Guidelines recommend that the Base Case and Project Case be clearly described to show how the incremental changes arise.

1.3 Relevance by scale of initiatives

The assessment of freight rail initiatives will vary with the scale of the initiative. The smaller the initiative, the smaller is the need for the more detailed assessment techniques. Users should proceed as follows:

Major initiatives

For major initiatives, the guidelines presented here in ATAP M3 apply in full. With respect to demand modelling, major initiatives lead to impacts across various modes. In freight rail, multi-modal demand models are sometimes required — see ATAP T1 Travel Demand Modelling for guidance on their use. In cases where a multi-modal model is not available, or where the multi-modal effects are considered to be of a smaller localised scale, the simpler techniques can be used.

Smaller initiatives

Smaller initiatives will have lower costs, and lower risks. Simpler assessment techniques will usually suffice, although rigour in their application is still important.

1.4 Structure of this guidance

After this introductory chapter, the remaining chapters of the M3 guidelines are laid out as follows:

- **Chapter 2** provides an overview of the ATAP assessment process, including the assessment model and approach to Cost-Benefit Analysis.
- **Chapter 3** discusses aspects of freight and rail that distinguish it from transport projects generally. It explains some rail nomenclature, the logistics chain, and some contemporary issues in the rail industry.
- **Chapter 4** offers advice on estimating freight demand. It discusses the logistics chain of which rail line haul is just one component of an increasingly multi-modal logistics chain particularly for containerised freight. Other topics addressed are market research methods and demand estimation for initiatives using cross-elasticity, diversion rate and logit model methods.
- **Chapters 5 and 6** cover capital and operating cost categories associated with freight rail projects respectively. The chapters feature guideline cost rates for freight rail infrastructure, locomotives and wagons (rollingstock) and operating costs. Chapter 6 also addresses the complex issues of joint, common, avoidable and fully distributed costs.
- **Chapter 7** discusses the potential benefits associated with freight rail projects and provides a framework for identifying which benefits are likely to be generated by particular types of project and to whom they apply. It covers methods for estimating the economic costs and benefits of freight rail initiatives. Aspects addressed include changes in consumers' and producers' surplus and benefits associated with freight diverted from road to rail.
- **Chapter 8** covers other aspects of cost–benefit analysis when applied to freight rail initiatives.
- **Chapter 9** provides guidance on the measurement and monitoring of the impacts of freight rail initiatives on system efficiency and service performance.

2. The ATAP assessment approach

This chapter provides a brief overview of the ATAP assessment approach as the relevant context for the guidance in the rest of M3. The approach provides the basis for assessing all problems, options and initiatives, including for roads.

2.1 The ATAP assessment model

The ATAP assessment model is presented in Section 3.3 of ATAP Part F3. It consists of:

- Clarification of relevant jurisdictional goals, transport system objectives and targets — It is important to be clear from early in an assessment about which of these are relevant in the given assessment
- Consideration of strategic merit / alignment — The degree of strategic alignment of the initiative being assessed (or the problem being solved) with goals, transport system objectives, targets, policies and strategies
- Generation of a wide range of options for solving the problem being assessed. Note that IA (2018) require that at least two Project Cases be presented in business cases submitted to them
- Assessing options and initiatives through the use of CBA and the Appraisal Summary Table (AST) (see ATAP Part T2). The AST provides the mechanism for presenting all appraisal results — monetised and non-monetised — side-by-side in a single location. This approach recognises that all benefits and costs — monetised and non-monetised — are relevant to the appraisal of initiatives
- The AST also includes quantitative and qualitative impact descriptions — these are necessary inputs to calculating monetised and non-monetised benefits, costs and impacts. Presentation of these inputs can also be of assistance to the decision-maker. Non-monetised impacts that are non-quantifiable can only be described in qualitative terms
- Bringing together all aspects of the assessment into a Business Case (see ATAP Part F4).

2.2 Cost–benefit analysis

CBA plays a central role in ATAP assessment (and is a strong focus of M3). ATAP Part T2 discusses how CBA should be applied in the appraisal of transport in Australia. The rest of this chapter summarises the most important features in CBA as a backdrop for the discussion in the rest of M3.

A CBA is a comparison of the Base Case and the Project Case over the appraisal period where the:

- Base Case is the situation over the appraisal period without the option/initiative being assessed
- Project Case is the situation over the appraisal period with the option/initiative being assessed

The Guidelines recommend that the Base Case be defined as the “Do-Minimum” option (see ATAP Part T2, Section 1.6)

T2 also notes two approaches in Australian practice with respect to assumptions about the future transport network in the Base Case (see T2, Section 1.6):

- The *committed expenditure approach*: Include in the Base Case and Project Case only future initiatives that are committed and funded. IA (2018) requires this in submissions to it.

- The *planning reference case approach*: Specify a ‘planning reference case’ of initiatives across the transport network for the entire appraisal period, reflecting strategic planning. Reflect realistic future funding in the reference case, requiring liaison with Treasury Departments on future funding envelopes.

The ATAP Guidelines acknowledges that both approaches are used across the country.

IA recommends that proponents adopt a ‘do-minimum’ base case in developing business case and cost-benefit analysis (CBA) for all transport projects (IAAF 2018, B1. D.1). ATAP Part T2, CBA guidance (section 1.6), also recommends adoption of a ‘do-minimum’ base case rather than a ‘do-nothing’ or ‘reference case’ approach.

The benefits, costs and results in a CBA are calculated from incremental changes between the Base Case and Project Case

Where an asset reaches the end of its economic life before the end of the appraisal period, the asset is replaced at the end of its life

When assets have part of their economic life left at the end of the appraisal period, a residual value should be included at the end of the appraisal period (see T2, Section 3.3).

The primary results from a CBA are the net present value (NPV) and the benefit cost ratio (BCR). An option or initiative is considered economically viable when NPV > 0 and BCR > 1. For identifying the economically best option by comparing options of varying scale for an initiative, incremental BCR (IBCR) is recommended. Formulas are presented here in Appendix C.

The following distinctions are drawn between categories of travel:

- Existing: Travel in the Base Case that continues in the Project Case
- Induced: The sum of diverted and generated:
  - Diverted: Travel that switches from one mode, route, time of day, origin or destination as the result of an initiative
  - Generated: Altogether new travel resulting from an initiative.

3. Freight rail considerations

This chapter contains freight rail specific background information.

3.1 Above rail

The term ‘above rail’ generally refers to the rollingstock — locomotives and wagons that travel above the rail. There is often some ambiguity in the sense of which assets are actually above rail in a physical sense. For example, signal and telecommunications systems are normally placed on poles or gantries and therefore above the rail. However, increasingly these systems are physically located underground in secure channels. As a rule, ‘above rail’ means those assets that can be easily and quickly redeployed.

3.2 Below rail

The term ‘below rail’ refers to rail, sleepers, formation and ballast, bridges culverts and drains. They are generally considered fixed infrastructure. The costs of reclaiming and redeployment usually exceed the costs of redundancy, the exception being steel rail, which is often reused on lower priority lines. For telecommunications, signalling systems and software arises and it is perhaps best to follow the Queensland Competition Authority (QCA) guidance which treats these as a below rail asset.

3.3 Capacity — seasonality and other factors

Freight is not a homogenous entity and each type of product has its own demands on the transport system. There are many ways of segmenting commodities:

- Chemical composition — hazardous, non-hazardous, food-grade, explosive, load compatibility
- Format — solids, liquids, gases, powders
- Shapes — long, short, bulky, over-dimension
- Consignment/package size — container load, bulk, break-bulk, packaged, bundled, unitised.

Australia is a major agricultural producing country and the seasonality of many products acutely impacts rail performance. Many wagons such as grain hoppers are built for a specific purpose and have no other application. In drought or other adverse weather conditions, there may be considerable idle fleet capacity, which cannot be used.

Other products such as foods and retail goods have a more stable demand. There are, however, peaks coinciding with the pre-Christmas period and end of financial year sales; and pronounced down turns post-Christmas. Generally, this freight is containerised in a mix of solid-wall containers and curtain-sided containers.

Container transport can be used to service the international shipping market and domestic customers. Import export containers (IMEX) are traditionally destined for the major shipping ports for export or distribution centres for imports. Domestic containers can service interstate markets, such as supermarket volumes moving between capital cities.

Industrial products are tied to sectoral needs thus products such as cement, steel and building materials are tied to the general strength of the economy. Fertiliser and agricultural chemicals are tied to the agricultural sector. Many of these products are railed siding to siding in whole or part trainload quantities.

Bulk minerals are primarily aimed at the export market the demand for which seems inexhaustible in the sense that there is pressure to fill all orders. These products are railed 24/7 365 days per year, direct point to point in whole trainload quantities.

General freight logistics chains are moving to a 24/7 operation. This means increased opportunity for shuttle-type services that maximise the productivity of rollingstock and terminals, which a decade ago rarely existed except for very long haul and interstate routes. The major exception to this is intermodal port operations in capital cities where there is normally very little 'out of hours' landside activity.

3.4 Supply side: capacity and productivity gains

Generally, rail network capacity is fixed and incremental increases are not normally possible.[2] For example, upgrading a single bridge or piece of track without upgrading supporting infrastructure may mean the network is still constrained in other areas and these may negate many of the benefits associated with a one-off upgrade.

Investment in incremental rail infrastructure capacity is extremely 'lumpy'. Take for example a track upgrade, which increases axle loads and therefore carrying capacity. This cannot be undertaken in a piecemeal way and if the freight travels on adjoining parts of the network built to a lower specification, then this governs the overall operation.

3.5 Ownership, operation and configuration of rail operations

Apart from the privately owned iron ore railways in Western Australia, until privatisation of the railways in Australia around 2000, railways were vertically integrated state or commonwealth owned and operated entities. Thus each 'system' had its own track, locomotives, wagons, operating procedures, procurement branches, telecommunications, civil, mechanical and electrical engineering branches, track and facilities maintenance, staff training and safety regimes, industrial awards, OH&S, rules books etc. Each of the railways operated in isolation as geographic monopolies where the gauge of track and running rights provided a formidable barrier to entry.

Privatisation has in most cases separated the above rail operation from the below rail operation.

Although below rail assets are still geographic monopolies, there are reduced barriers to the above rail operators via "access agreements" and pricing discretion has been largely removed from operators and replaced by government-regulated regimes.

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[2] How train paths are arranged (even on a single track network) can change the network's capacity. Improved signalling, for example, might materially increase network capacity by reducing headways. However, improving signalling in one section will rarely have impacts beyond the immediate area and does not solve other problems. Improved signalling as a network project typically takes several years.

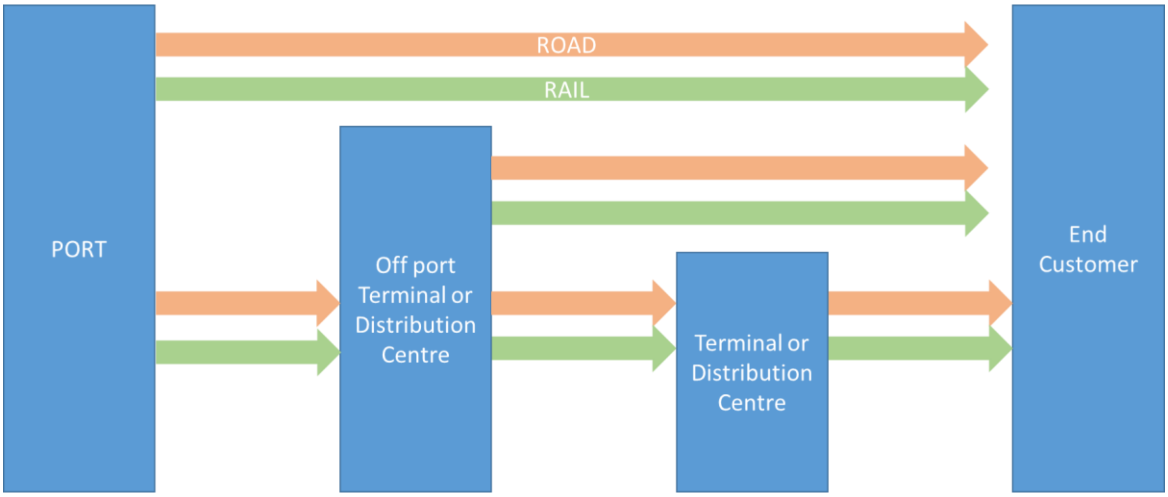
In the era of the commercial railway as opposed to the government railway, there has been a significant change in rail operations, finance and investment. Almost without exception, financial analysis has overtaken economic appraisal as the tool for investment decision making for above rail operations. Below rail investments, which are still largely financed by governments are typically conducted using an economic cost-benefit analysis framework.

3.6 Logistics chains in the economy

Logistics chains can be relatively simple for products such as coal, which is transported in trainload quantities from mine to port terminal — also known as ‘pit-to-port’. Other products are much more complex with multiple stages and modes involved. Consider a simple consumer product such as imported garments. Typically, this is containerised and offloaded from a ship at the port by the stevedore. From the port, the container is trucked to an inland terminal or distribution centre where it is unpacked and then stored awaiting dispatch, often to a receiving distribution centre. Transport from the distribution centre may be performed by truck to the end-customer, or to a rail terminal and then railed to the receiving centre. There, the load may be further deconsolidated and delivered to the end-customer by truck.

Figure 1 below shows schematically the intermodal chain options that are available.

Figure 1 Simplified presentation of the range of intermodal logistics chains



Note: While terminal or distribution centre to end customer by rail is an option, it is unlikely.

4. Freight rail demand estimation

4.1 Introduction

This chapter discusses rail freight demand, including:

- Derived demand
- Demand drivers which influences demand volume, timing
- A process for assessing freight rail demand
- Demand ramp up once the initiative is operational
- Demand capping
- Annualisation and long term growth effects.

4.2 Derived demand

The demand for freight transport is known as a 'derived demand' because freight transport is an input to the production of final goods and so is not demanded for its own sake. The elasticity of demand for freight transport tends to be low overall, but not zero, because the cost of transport amounts, in many cases, to only a small proportion of the prices of goods. So an increase of a given percentage in freight rates will produce a much smaller percentage increase in the price of the good carried.

The elasticity of demand for freight transport for a single good is given by

$$f\left[\frac{E_s E_d}{E_s - (1-f)E_d}\right]$$

where E_d and E_s are respectively the elasticities of demand and supply for the good transported, and *f*, the fraction of the demand price spent on transport. As E_s approaches infinity, the elasticity of demand for freight transport becomes $f\,E_d$, which is known as 'Marshall's law' (Bennathan and Walters 1969).

Say $f = 0.1$, $E_s = 2$ and $E_d = –1$. Then the formula gives 0.1 × 2 × (–1) / [2 – 0.9 × (–1)] = –0.069 as the elasticity of demand for freight transport. If the elasticity of supply is infinite, Marshall's law gives the elasticity of demand for freight as 0.1 × –1 = –0.1. So if the price of the product transported was $100 per tonne of which $10 is the freight rate cost, a 10% increase in the freight rate to $11 would increase the price of the product to $101. The product having a price elasticity of demand of –1, a one dollar or 1% increase in the product's price reduces the quantity purchased by 1%. Thus a 10% increase in the freight rate reduces the quantity of freight to be carried by 1%, implying a price elasticity of demand for freight transport of –0.1.[3]

While the price elasticity of demand for freight transport overall (freight rates by road and rail changing in the same proportions) is likely to be low (but not zero), price elasticities for individual transport modes (rail with the price of road held constant and vice versa) tend to be much higher. A fall in the price for one mode will attract market share from other modes.

[3] Generalised cost could be used in the formula instead of freight rate, but the value of *f* would have to be recalculated and the estimated elasticity for transport would apply to generalised cost, not the freight rate.

Improvements to the rail freight network may contribute to making some economic activities more viable and lead to the creation of new rail freight markets, but this tends to be at the margins or where there is a significant change to rail accessibility. For example, the construction of a new rail line in the vicinity of a minerals deposit might encourage the development of a mine site.

4.3 Service quality

In deciding how which mode to use, consignors consider service quality as well as price. Service quality attributes are:

- Point to point transit time
- On-time reliability
- Convenient departure and arrival times (service availability)
- Freedom from damage/loss.

The relative importance of each of these in an individual consignor's decision will vary with the nature of product, for example, perishable/non-perishable, fragility/packaging, consignment size, value per unit of weight, and requirements of the end-customer. In some cases, service quality will be more important than price in affecting consignors' decisions. Demand elasticities can be specified for individual service quality attributes, for example, the percentage change in rail or road freight from a one percent reduction in rail transit time.

4.4 Demand drivers

A range of factors influence the demand for infrastructure, including rail transport. According to IA (2009) the following factors are likely to have the greatest significance for Australia's infrastructure systems:

- **Socio-demographic change** — total population, population mix (especially age profile), population distribution, values
- **Economic change** — size and mix of the economy, growth, globalisation, labour markets
- **Energy prices** — particularly the potential mix and cost of energy sources for various sectors of the economy
- **Climate change** — the impact of change in climate patterns such as temperature, run-off projections, sea level rise and storm surge probabilities on the demand for infrastructure and the maintenance of our existing infrastructure networks
- **Technological change** — whether change in technology will reduce or increase the demand for certain infrastructure systems, create entirely new demands; and/or change the way infrastructure systems are built, managed and operated
- **Governance change** — changes in the wider system of government (not individual project governance) that may shape the demand for services and/or the way in which government respond to those demands.

A low cost approach is to conduct a desk study into each of the components identified above to develop a framework for assessing the influences on future production and consumption trends. When used in conjunction with industry consultation, this will provide crucial background to the forecasting process.

4.5 Steps for assessing freight rail demand

The process for estimating the impacts of a freight rail initiative on the quantity, location and mode of travel is generally undertaken through the steps discussed in the sub-sections below.

4.5.1 Step 1 — Market segmentation

In order to understand how rail freight demand is impacted by investment, an understanding of the product and market for rail freight users must be undertaken. A normal market segmentation process is to cluster commodities based on:

- Type of product — solid/bulk, powder, liquid, gas.
- Typical consignment/pack size — whole trainload, partial trainload, container load, less than container load.
- Load configuration — refrigerated, bulk, break-bulk, palletised, containerised, unitised.
- Industry sector — to align with Australian Bureau of Statistics and other statistical data.

A lot will depend on the level of detail the analyst is able to obtain. A suggested clustering is shown in Table 1.

Table 1 Market segmentation by commodity clustering

Group	Items
Building Materials	Steel, Cement, Concrete, Timber etc.
Chemicals	Chemicals, Fertilisers, Explosives, Acids etc.
Fuel	Fuel, Bitumen, Gas etc.
General Freight	Store Goods, Freight Forwarders etc.
Miscellaneous	Empty containers and Unknown Contents
Broadacre Crops	Grains, Sugar, Legumes and Pulses
Quarry Materials	Sand, Gravel, Coal, Iron Ore, Minerals etc.
Horticulture	Fruit and Vegetables
Livestock	Cattle, sheep, pigs

4.5.2 Step 2 — Develop an origin–destination matrix based on the estimated impacted freight market

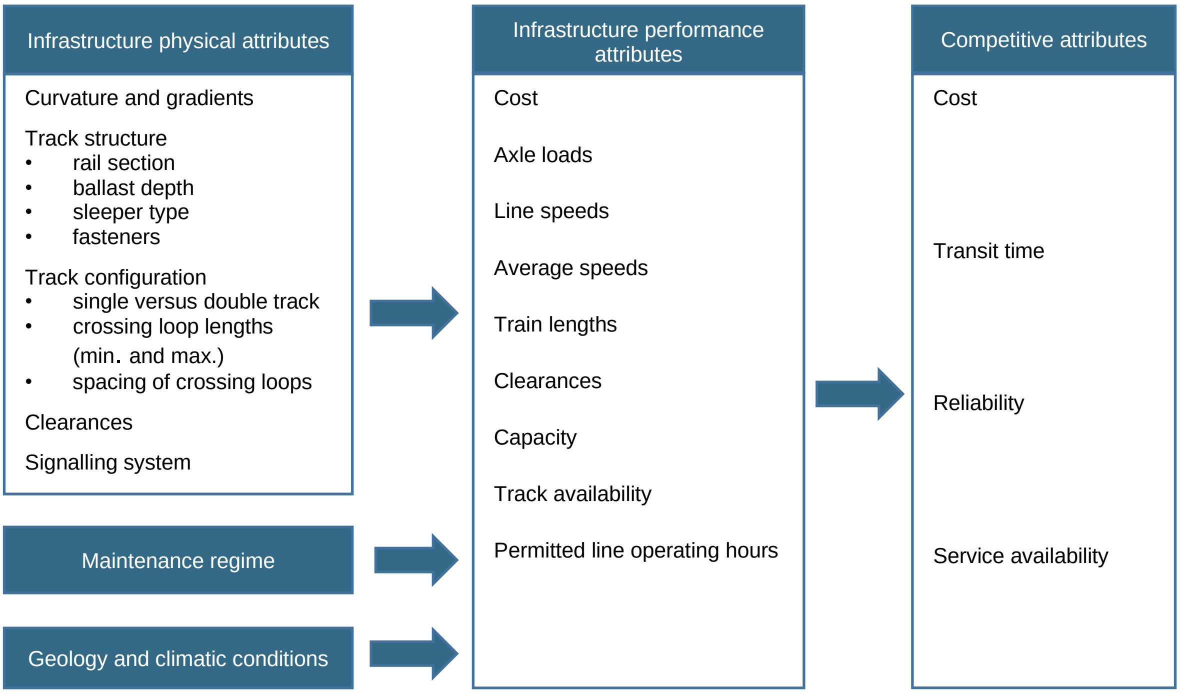
This can be as simple or complex as the task demands. Since rail corridors are relatively linear, the O-D matrix essentially plots locations and tonnage along the map. A road network is generally more complex in terms of lateral geographic coverage). The matrix is then estimated for each product/market segment within a rail corridor.

4.5.3 Step 3 — Develop a logistics model for each mode

In order to compare the cost of transport for identified commodities or products across a corridor a comparative rail and road operating model must be constructed.

The conventional approach to designing rail market offerings is illustrated in Figure 2. The infrastructure determines what sort of service can operate in terms of capacity and transit time.

Figure 2 The conventional link between infrastructure and service



Source: Adapted from AECOM 2014, Resources Rail Lines Working Paper 2 Market Report (confidential report to Queensland Department of Transport and Main Roads, Brisbane)

In developing a conceptual railway operation, the mode's competitiveness is influenced by the overall 'package' of price and service characteristics which are critical to determining market share as illustrated in Figure 3. Against this must be compared the relative price service package offered by road competitors or alternative operations.

Figure 3 Market Drivers and Impact on Land Transport Demand

Increasing Importance	Key Market Drivers		Quantitative Evidence
	Price		➢ Price is the primary driver for virtually all traffics, particularly in the general / containerised freight market. There may be situations where specialist handling requirements (e.g. HAZCHEM etc) and / or major bulk movements dictate requirements that impact on the influence of price in the choice of mode.
	Service Characteristics	Transit Time	➢ Transit time is factored into overall delivery times to customers

Key Market Drivers		Quantitative Evidence
	Reliability	➢ Freight forwarders factor reliability 'risk' into their decisions. ➢ Reliability impacts on pick-up and delivery costs (i.e.: trucks waiting longer than expected bear additional costs) ➢ Reliability is a critical factor as operators want to work to tight time windows ➢ Rail is perceived as less reliable than road — when a train gets delayed the impact is much greater
	Service Availability	➢ Pushing back loading cut off times can help to shift tonnes to rail as this facilitates daytime loading and avoids cost penalties for 'out-of-hours' loading ➢ Rail services need to be scheduled to best utilise pickup and delivery resources ➢ Preference for goods to arrive before opening-of-business and shipped out after close-of business and JIT inventory practices will dictate operational parameters.

Source: Adapted from AECOM 2014, Resources Rail Lines Working Paper 2 Market Report (confidential report to Queensland Department of Transport and Main Roads, Brisbane)

4.5.4 Step 4 — Identify additional rail costs

In addition to the freight rail linehaul costs, rail may involve additional costs across the supply chain:

- Pick up and delivery (PUD) costs to transfer freight from the rail hub to/from customer/producer
- Lifts at intermodal terminals or at shipping ports
- Costs for accessing terminals or shipping ports

These additional costs can limit rail's ability to gain market share. For example, depending on the circumstances involved, Pick-up and Delivery (PUD) / modal interface handling costs on a railway can account for in the range of' 15% to 40% of the total delivery cost for a container by rail.

4.5.5 Step 5 — Develop models over time

In order to develop annual growth rates, the analyst should examine broad macro-economic trends at the local and regional level at a minimum and depending on the product consider the wider implications of state, national and international influences. Given the difficulty in forecasting, factors such as global warming and mitigation measures, impacts on agriculture, emergence of new international competition should be considered.

In addition, the analyst will need to consider product or commodity specific growth impacts. Changes in technology and in the use of a product or commodity may be considerations.

Long-term demand forecasting is an inexact science and when the size of benefits from an initiative are strongly related to demand, there are major risks. Taking agricultural production and its transport demands as an example, there are several factors to consider. First, there is seasonality. This can be short term, e.g. summer or winter grains, or longer term, e.g. the sugar cane season lasts for 5-6 months in Queensland. Second, there are peaks particularly for perishables or where there are limited storage facilities and a large amount of the product must be moved in a very limited time. At the same time, investment in appropriate storage may solve this but some of the major storage facilities, e.g. grain silos, may be nearing the end of their economic, technological, or logistical life. Third, there is the long-term growth pattern. This is difficult to predict given factors such as El Niño and La Niña, global warming, water supply and irrigation.

A range of future demand scenarios can be run based on different forecasts for macro-economic growth, exchange rates and oil prices. A spreadsheet model is an ideal way for testing a range of options and scenarios.

4.5.6 Step 6 — Define the contestable market

The contestable market is a subset of the whole market that rail could win. It is impossible for rail to contest some markets, due to:

- Extremely short-haul, fast transits making rail uncompetitive.
- Lack of network geographic coverage, e.g. there is no railway.
- Rail costs making it uncompetitive.
- Overcomplicated logistics chain.
- Greater flexibility of road transport.

This will be an iterative process because new problems and solutions can emerge as more research and analysis is performed.

4.5.7 Step 7 — Estimate rail market share

The approaches outlined below, including cross elasticity, diversion rate and logit models, can be used to develop forecast changes in rail market share.

Cross-elasticity approach

The relevant cross-elasticity is the percentage change in road freight from a one percent change in the generalised cost, freight rate, a service attribute such as reliability or frequency, or the generalised cost for rail. The value of the cross-elasticity would be taken from experience elsewhere in broadly comparable situations.

Diversion rate approach

The ‘diversion rate’ resulting from a freight rail initiative is the proportion of the ‘new’ freight that would otherwise travel by road transport. Say a new rail service carries 10,000 tonnes of freight per year from a given origin to a given destination in the project case and zero in the base case. The entire 10,000 tonnes is ‘new’ freight to the rail service. If 7,000 tonnes of the new freight would travel by road in the base case, then the diversion rate is 70%. In the absence of any other modes of transport, the other 3,000 tonnes of new freight would come from expansion of output by producers at the origin or diversion of existing freight in favour of either the origin or destination of the new service (a buyer changing their source of supply or a seller changing to another market).

The diversion rate approach to forecasting mode shift is discussed in ATAP Part M1 where it is suggested that there is good degree of consistency in diversion rates across project types and countries.

The diversion rate for a change in rail price is $\frac{dQ_{road}}{dP_{rail}} / \frac{dQ_{rail}}{dP_{rail}}$. It is related to the cross-elasticity $E_{road-rail} = \frac{dQ_{road}}{dP_{rail}} \frac{P_{rail}}{Q_{road}}$, as follows:[4]

$$Diversion\ rate_{road,rail} = \frac{\frac{dQ_{road}}{dP_{rail}}}{\frac{dQ_{rail}}{dP_{rail}}} = \frac{\left(\frac{dQ_{road}}{dP_{rail}} \frac{P_{rail}}{Q_{road}}\right) Q_{road}}{\left(\frac{dQ_{rail}}{dP_{rail}} \frac{P_{rail}}{Q_{rail}}\right) Q_{rail}} = \left(\frac{E_{road,rail}}{E_{rail}}\right)\left(\frac{Q_{road}}{Q_{rail}}\right)$$

Logit Models

Logit models are complex techniques for estimating mode share based on the relative price – service characteristics of each mode. A simple model might include price as the single service attribute. Other service attributes that could be included are transit time, reliability, flexibility and short term/surge capacity. The model estimates rail’s market share using utility functions that incorporate the ‘package’ of price and service characteristics for each mode. For a given change in price and service characteristic inputs, the model determines the change in mode share.

Utility for each mode is specified as a linear function of price and service quality attributes.

Rail: $U_{rail} = \beta_{FR} FR_{rail} + \beta_T T_{rail} + \beta_{RY} RY_{rail} + \beta_{SL} SL_{rail}$

Road: $U_{road} = \beta_{FR} FR_{road} + \beta_T T_{road} + \beta_{RY} RY_{road} + \beta_{SL} SL_{road} + K_{road}$

where:

Component	Rail input	Road input	Coefficient
Freight rate (FR)	FR_{rail}	FR_{road}	β_{FR}
Transit time (T)	T_{rail}	T_{road}	β_T
Reliability (RY)	RY_{rail}	RY_{road}	β_{RY}
Service availability (SL)	SL_{rail}	SL_{road}	β_{SL}

[4] It was noted above that the cross elasticity could be defined with respect to generalised cost, freight rate, or a service attribute. The same definition needs to be applied consistently to the diversion rate and price elasticity for the relationship to hold.

and K_{road} is the 'mode specific constant' for road.

Reliability and service availability can be defined and measured in a variety of ways. For example, reliability could be assessed as the standard deviation of transit times, or the percentage of on-time or late arrivals with 'on-time' being defined as arriving within a given number of minutes after the scheduled time. Service availability could be interpreted as service frequency or as lateness of departure time or earliness of arrival time. Whichever definition and measure is used, it is essential that the same definition and measure be used for forecasting purposes as for model calibration.

Using the above definitions for the utility of using rail and road, the probability of rail being chosen as the preferred mode, and hence rail's market share is:

$$Prob_{rail} = \frac{e^{U_{rail}}}{e^{U_{rail}} + e^{U_{road}}}$$

where:

$Prob_{rail}$ = Rail's market share, measured as the probability of rail being chosen as the preferred mode

U_{rail} = Rail attractiveness as measured by its utility equation

U_{road} = Road haulage attractiveness as measured by its utility equation.

Rail tonnes is then calculated as:

Rail tonnes = total tonnes × market share ($Prob_{rail}$)

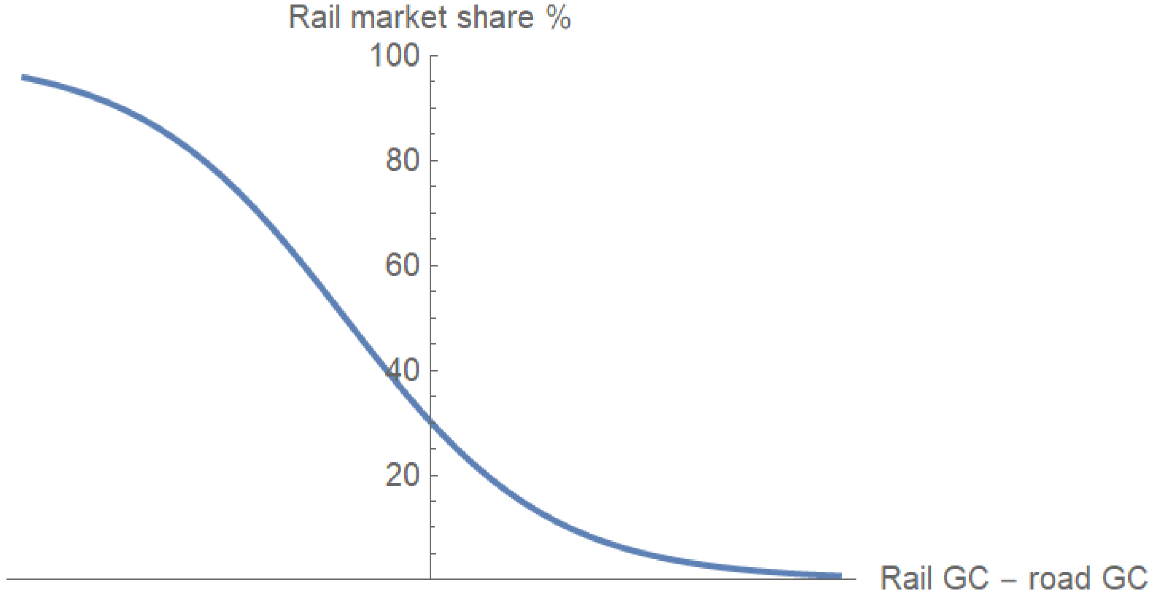
The logit model is represented visually as the S-shaped curve, as shown in Figure 4. In Figure 4, rail's percentage market share relative to road depends on the difference between its generalised cost (GC) and the generalised cost by road. The utility function can be converted to a generalised cost function by dividing through by the coefficient for the freight rate, β_{FR}.

$$Generalised\ cost = FR_{rail} + \frac{\beta_T}{\beta_{FR}} T_{rail} + \frac{\beta_{RY}}{\beta_{FR}} RY_{rail} + \frac{\beta_{SL}}{\beta_{FR}} SL_{rail}$$

The values of time, reliability, and service availability appear as the coefficients.

In figure 4, rail secures a 30% market share if both modes have identical generalised costs. The mode specific constant serves to shift the share in favour of one mode away from other. If both modes have identical price and service attributes and the mode specific constant is zero, market shares will be split 50:50. If the demand modelling is based a logit model, the welfare gain can be estimated directly from the model, using the 'logsum' approach. For a detailed discussion, see ATAP Part T2, Appendix C.

Figure 4 Illustrative logit curve



The logit model can be calibrated from research undertaken elsewhere or a stated preference survey of consignors in which they are asked to make hypothetical choices between road and rail given different price and service quality combinations.

The logit model can be applied at multiple levels, in which case, it is called a 'hierarchical logit model'. For example, at the highest level, there could be a choice of how much freight to transport compared with other uses of resources (for example, producing less of the product being transported). Then, at the next level down, there could be a choice between alternative origins for purchasers or destinations for suppliers of goods transported, then a choice between road and rail, and finally between alternative price–service quality combinations offered by rail (for example, a faster, more expensive service or a slower, cheaper service).

4.6 Demand ramp-up

Freight rail forecasts are normally based on continuous growth rates year after year. Investment in freight rail infrastructure will improve the efficiency and cost of rail operations and may create an incentive for producers to increase volume production in certain circumstances. However, the full impact of investment rarely occurs instantaneously. Typically, there is an initial ('short run') impact, which subsequently continues to increase over time ('long run') although at a gradually decreasing rate.

It may take time for rail to gain market share from road as consignors change longstanding practices and may wait to see how a new or improved rail service performs before deciding to take advantage of it.

'Ramp-up' information relating to freight rail is an under-researched topic internationally, including in Australia. For many commodities, there is often only a very tenuous cause and effect linkage and the multicollinearity between the variables and factors influencing mode share and market size further blurs the issue.

The analyst should consider a ramp up period for inclusion in the CBA based on experience elsewhere, consultation with industry and judgement.

4.7 Demand capping

As discussed below in Chapter 8, the recommended appraisal period for rail appraisals is 50 years. It is very difficult to forecast demand this far into the future. Typically demand forecasts may extend out for 20 years into the future, sometimes 30 years. Given that, a separate approach is required for estimating demand beyond the last forecast year to the end of the appraisal period.

This is typically handled by applying a demand cap (i.e. zero growth) beyond a future year. In the majority of cases, demand growth should be capped after the last modelled year. Alternatives are to assume a much lower compound or linear growth rate after the last modelled year.

The impact of discounting in a CBA means that the benefits and costs in the latter years of the appraisal period may not be large. Nevertheless, sensitivity testing should be undertaken in the CBA to test the effect of different demand caps.

In some cases it may be appropriate to assume that demand for a particular freight task ceases altogether. For example, a coal mine might find no markets after 20 years because climate change policies have reduced the demand, or alternatively the mine's economics lead to a cessation of demand because production costs exceed revenue.

4.8 Freight rail demand annualisation factors

Annualisation factors are required in CBA to convert daily, weekly or seasonal demand and benefit estimates into annual estimates.

The preferred approach is to base annualisation factors on the characteristics of the commodity transported by freight rail. Many consumer products are hauled 24/7 so an annualisation factor applied would be consistent with a constant yearly operation. With maintenance of above and below rail assets an annualisation factor of 300 operating days per year is standard. Highly seasonal products are more difficult and should be based on actual data where available. Grain, for example, may experience a high volume of rail movements over three months around harvest time but have lower rail movements for other times of the year. An increasing level of on farm storage and bunker storage at grain handling sites has smoothed this demand in recent years.

5. Capital costs for fixed infrastructure

5.1 Capital cost classification

Capital costs are typically classified as being long term and one-off expenditures. Table 2 provides a typical rail freight capex categorisation.

Table 2 Capex classification

Factor	Capex
Purpose	For long term investments in assets
Timing	Usually one off
Reporting	Reported on balance sheet Reported in a business case
Economic Cost typology	Fixed Extremely lumpy Discrete
Sunk Cost	In some cases
Scale	Usually large
Residual/Salvage	Residual value or asset redeployment

In defining and categorising these costs, the following factors are relevant:

- Accounting designation: Capital costs may be considered long term costs and represent an asset for balance sheet purposes. Operating costs may be considered short term costs and are expensed through the profit and loss statement.
- Duration of economic life: capital cost is synonymous with long asset life such as track, locomotives etc. Generally, it will be impossible to stop or scale back the investment once it commences. In contrast, operating costs may normally be considered a variable cost or activity, which can be rapidly modified or tailored to the scale of the operation.
- Fixed or variable costs: In the rail sphere, a capital cost is normally associated with a fixed asset such as a bridge, branchline or locomotive. An opex may be considered a variable cost or activity that can be rapidly modified or curtailed. This could include items such as fuel consumption. Many areas are blurred, such as labour where permanent staff might be considered fixed in the medium to long term but casual hire would be considered an operating expense that could be rapidly expanded or reduced to suit the operation.

5.2 Capital projects

Table 3 is a list of typical capital projects the appraiser is likely to encounter in a freight rail investment evaluation.

Table 3 Categories of capital investment

New infrastructure	Improvement to existing assets
Track, junction, loop	Improved curve and vertical geometry
Bridges and culverts	Bridges and culverts
Siding or terminal	Lengthened loops, sidings
Flood and bushfire protection	Flood and bushfire protection
Locomotives	Locomotives
Wagons	Wagons, braking systems, etc
Signalling systems	Signalling systems
Buildings and warehouses	Substation upgrades
Electrification	Wiring, structures, transformers etc

Note: Rollingstock (locomotives and wagons) capital expenditure is discussed in Chapter 6.

5.3 Capital cost characteristics

This section covers some of the characteristics of freight rail capital costs, some of which are different to conventional road-based transport capital costs.

5.3.1 Extreme lumpiness of capex and assets

Freight rail capital projects are known for the lumpiness of their investment. Lumpiness refers to the indivisibility of assets — for example, it is impossible to have half a bridge. Most rail projects are relatively expensive, often in the hundreds of millions of dollars, complicated and protracted in their delivery phase. The result of this lumpiness is that rail freight assets can be underutilised at the initial investment point, with demand building up over time. This represents the all-or-nothing nature of freight rail investments and operations.

5.3.2 Long economic lives, redundancy and technological change

Many rail assets have extremely long economic lives. Suggested parameter values are presented in Appendix A. Concrete bridges and structures are typically rated to 100 years. Locomotives are typically designed for a 25 to 30-year economic life but there are still a considerable number of 40-year-old locomotives in fleets. One of the major problems with such long-lived assets is technological redundancy. Newer assets can be much more efficient with higher capacity and have comparatively lower cost maintenance and operating costs. There is therefore a distinction between economic life and technological life.

5.3.3 Asset reallocation

Many rail assets can be reassigned to lower priority uses and locations. This is particularly the case for steel rail which is usually reclaimed and reused. For example, if the rail on a mainline is due for replacement, it is normal practice to use a heavier and better quality rail. The old rail is recovered and often deployed to a branchline where it replaces an inferior steel which is then used on a lesser quality line or is scrapped. The overall effect of this cascaded program is to upgrade parts of the network and considerably lengthen the economic life, increase productivity and reduce maintenance costs.[5] Other assets such as older locomotives and wagons are often redeployed to lower priority uses when they are replaced by newer higher capacity units.

5.3.4 Residual and salvage value

As noted above, many rail assets have extremely long economic lives and some assets that have become technologically obsolete in their current use can be repurposed for lower priority deployments. The parameter values in Appendix A give some estimates of the expected economic life of various pieces of rail equipment. Where assets are considered to have remaining value at the end of the appraisal period, the advice in section 3.3 of ATAP Part T2 should be followed to estimate a suitable residual value.

5.3.5 Sunk costs

Sunk costs should not enter into CBAs. If an asset created in the past has no opportunity cost or alternative use, its status will be the same in the base case and the project cast. If part of the cost incurred in the past can be recovered by selling the asset, this value can be included as a cost if the project uses the asset or as a negative cost if the project enables the asset to be disposed of. For example, say the project being appraised uses a length of track built in the past. The initial construction cost of the track is sunk and therefore irrelevant to the CBA. In the base case, the steel rails could be sold for scrap. This would be an offset to the investment cost.

5.3.6 Disruption costs during construction/ rehabilitation/ maintenance

Disruption costs should be accounted for both in the Project Case and the Base Case. A major reason for many upgrades is to reduce service disruptions, downtime and costs by replacing older high maintenance assets with newer ones. Direct impacts on the rail operators include delays, potentially slower transits that add to labour costs. Other impacts relate to adjacent land use in the form of loss of amenity due to noise, night lighting and air quality.

5.3.7 Escalation factors/ adjustments for long term CPI

The escalation of capital costs for freight rail investments should be consistent with ATAP O1 Cost Estimation guidance.

ATAP Part T2 notes that it is usual to undertake CBAs in real terms and financial analyses in nominal terms. There should be inflation adjustments that convert between the CBA in real terms and the financial analysis in nominal terms.

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[5] Caution is required, however, to ensure that this does not support the underestimation of project capital costs.

6. Recurrent costs

A key component in the economic appraisal of any freight rail initiative is the difference in recurrent costs (operating and maintenance) between the Base Case and the Project Case. As required in ATAP Part T2 Section 5.2, recurrent costs need to be projected over the entire appraisal period for the Base Case and the Project Case. This allows the differences between them to be calculated for the entire appraisal period.

This chapter sets out a practical and robust approach to estimating rail freight recurrent costs so that they can be estimated for the Base Case and Project Case. For each of these cases this is done in three steps:

- Estimate the rail freight operating resources needed in each of the Base Case and the Project Case (Section 6.1).
- Establish the unit costs for each resource category (Section 6.2)
- Multiply the resource and unit cost estimates to calculate the annual cost across all resource categories for Base Case and Project Case.

Some jurisdictions may have their own specific approaches to calculating operating costs. These can be used subject to a demonstration that they fully capture the changes in operating costs and are applied consistently.

6.1 Operating cost classification

Operating costs incorporate all recurrent costs, including annual and periodic maintenance costs. The capital costs of freight rail rolling stock, including the costs of mid-life refurbishment and the disposal value at the end of the vehicle's economic life, are also addressed in this chapter. These are often also expressed as an annualised average cost, which may be added to the operating costs to give the total annualised costs of an initiative for use where required.

Operating cost classifications are shown in the table below.

Table 4 Opex classification

Factor	Opex
Purpose	For short term purposes
Timing	Usually recurrent
Reporting	Reported in Profit and Loss Statement Reported in a business case
Economic Cost typology	Variable Divisible and scalable Continuous
Sunk Cost	Not applicable
Scale	Can often be minor relative to capex
Residual/Salvage	Not applicable

As an overall summary of operational costs items is provided in Table 5.

Table 5 Operational costs and classification

Line haul costs	Terminal Costs	Track, junctions and sidings	Overhead and administration
Energy, lubricants and replenishment supplies and labour	Terminal operating cost including energy, maintenance and crewing	Maintenance and rehabilitation cost	Management and supervision
Locomotive and wagons maintenance cost	Cleaning, repair, quarantine and waste disposal facilities	Inspections and compliance costs	Energy and utilities
Train crew cost including allowances for uniforms, accommodation and meals	Materials handling equipment, storage and warehousing facilities	Security and safety including level crossing protection	Telecommunications , utilities and office support
Signaling, telecommunication, safety and train control systems	Intermodal interface expense including truck accommodation	Flood and bushfire protection or mitigation	Profit margin
Supervision and overheads	Security and safety including acoustic barriers		
Access charges if applicable	Office and shed accommodation Facilities (e.g. hardstand structures) required to make effective rail freight transfers possible		
OH&S and other statutory compliance	Telecommunications, utilities and office support		

The line haul costs are associated with actual train operations and the work done to prepare a train for haulage. In most cases the energy, crewing costs and access charges are the biggest cost items. Access charges are a proxy for track costs plus a margin — thus they are a financial cost as distinct from an economic cost if the analysis already includes an estimate of the capital costs of a project. Some access charges include a pass through of energy charges in the case of electrified lines controlled by the below rail operator.

Terminal costs relate to all activities performed at terminals and sidings. Typically, this involves intermodal transfers to and from trucks, making up and breaking up of trains, shunting activity, wagon loading and unloading, storage and warehousing.

Track charges relate to keeping the track in operational condition. Almost always, track work is performed while the track is operational with speed restrictions or safety precautions in force during the process. The additional cost to train operations of delays should be included in economic analysis.

A key component in the economic appraisal of any freight rail initiative is the difference in recurrent costs (operating and maintenance) between the Base Case and the Project Case. The difference may be taken to be the difference in operating resources between the two cases multiplied by the relevant unit operating costs.

6.2 Train operating resources estimation

6.2.1 Methodology

Table 6 sets out methods to calculate the annual operating resource cost associated with the provision of rail services. If there are a number of different train types/sizes/commodities/origin-destination combinations, this same exercise must be repeated for each service for the Base Case and Project Case. When the initiative involves changes to a group of services, this method can be applied to all the routes affected between the Base Case and the Project Case. The total operating resource cost for all these routes are summed for each of the two cases, and the difference (Project Case – Base Case) is then calculated.

At a minimum, costs need to be a function of train/vehicle/crew-hours and train/vehicle-km operated and of the number of vehicles required for the operation.

These operating resource cost estimates are then multiplied by relevant unit costs (see below in this chapter) to calculate train costs and annual operational costs for the Base Case, the Project Case and the incremental difference between them.

Four groups of operating resource cost inputs, which are derived from service characteristics including number of services, train configuration, service distance and transit hours, are usually required:

- Train kilometres and train hours separated into active (mobile), idling (active), or inactive. This is a key driver of crewing hours and allowance. Allowance must be made for terminal time plus servicing and replenishment activities per cycle plus headways between trains.
- Locomotive kilometres and locomotive hours separated into active (mobile), idling (active), or inactive. Many trains in Australia are hauled by multiple locomotives in combination. It is normal practice to shut down one locomotive for return empty legs, which have a much lower trailing mass to haul.
- Wagon kilometres and wagon hours separated into active (mobile), idling (active), or inactive.
- Spares allowances applies to locomotives, wagons and train crews. Current best practice is for a 5% allowance, but this typically applies to larger pooled operations e.g. Goonyella Coal Cluster where resources can be shared among many operations. It is difficult to have a 5% allowance for a single train or small operation.

For economic appraisal purposes, train operating resource estimates must then be established for each year of the appraisal period, for each of the Base Case and the Project Case.

Table 6 Method for estimation of train operating resources

Task	Comments
Estimate line haul distance and running time	Line haul lengths are available from the operator database or a map in the case of yet to be constructed new track Running times may be estimated from existing timetables or estimated based on benchmarks. Allowance should be made for factors such as other trains, single or duplicated track, position of crossing loops and expected delays. Train simulation models provide some guidance although a simplistic model can be created in a spreadsheet. Different trains operate at different speeds for example coal trains are usually geared to a maximum 80 km/h to maximise carrying capacity. Lighter container trains are geared to higher speed operations, sometimes up to 115 km/h although average point to point, speeds are considerably lower. As a simple average bulk mineral trains average about 50 km/h and container trains about 70 km/h for end-to-end based on timetables.

Task	Comments
Estimate required headways (frequency)	Unless there are published headways, half an hour is typical in Australia based on benchmarks. Terminal capacity at point of origin is often a key factor in the ability to assemble several trains concurrently in the same marshalling yard because of equipment availability and terminal footprint.
Derive theoretical peak period short term burst requirement	This represents the theoretical maximum number of round trips a train set can perform in a specific period of time usually a 24- or 48-hour cycle but sometimes a 7-day cycle for longer or more mixed/complex train operations. Peak capacity = Nominated period ÷ cycle time. Cycle time = headway (rounded up to half hour) + origin terminal time (rounded up to quarter hour) + forward running time (rounded to nearest half hour) + destination terminal time (rounded up to nearest half hour) + headway (rounded up to half hour) + return running time (rounded to nearest half hour) + allowance for replenishment, refuel, servicing + allowance for minimum statutory layover time per round trip. Minimum layover time after deducting reasonable terminal time is one hour per round trip. In some isolated cases, where a crew must perform forward and return legs, there are statutory maximum driving hours before compulsory breaks are invoked, and these must be included as non-productive time. The longer the peak period, the more opportunity there is to perform multiple cycles and therefore less wasted time and resources.
Derive route operating statistics for typical periods, but ultimately in an annualised format	Train/locomotive/wagon kilometres per year = round trips × haul kilometres. Train/locomotive/wagon active hours per year = round trips × cycle time Train/locomotive/wagon inactive hours per year = total hours – (round trips × cycle time) Train crew = same as train active hours per year Peak vehicles — additional rollingstock required for peak volumes and operations. This is particularly relevant for seasonal commodities, such as grain.
Allowances for spares	In addition to the number of locomotives, wagons and crew to support the forecast peak period demand an allowance for additional rollingstock and personnel for contingencies such as unexpected or inevitable breakdowns and equipment or staffing issues such as sick or holiday leave, rostered days off, etc.

6.2.2 Operations modelling

Rail operations need to be modelled to generate the key operational statistics required for any appraisal. A two-step process is recommended.

Step1 Create a static train model

A generic train based on a particular configuration of locomotives, wagons, payloads all subject to conventional rules such as up to maximum authorised train length and trailing mass as outlined in load tables covering operating procedures for above-rail operators.

It is also necessary to consider the return leg. In most cases in Australia, the return leg is empty in the case of mineral, grain and tanker trains. This enables the operator to depower the locomotive effort to save energy costs. Container trains are more problematic even though loading is typically unbalanced — forward and return. A container train still has to transport the empty boxes to the point of origin, thus although there is no payload in the conventional sense there is still the cost of repositioning the containers and the wagons.

Many railways operate numerous trains even over the same piece of track and using the same terminals and staff so it may be necessary to simulate a number of trains.

Step 2 Create a dynamic train operation model

In order to optimise the operation, it is necessary to develop a cycle time based on achievable sectional times and acceptable terminal times. This has important implications for the amount of rollingstock required and hence the capital cost associated with particular movements and whether or not rollingstock, staff or other variables can be shared with other uses when not engaged in the modelled activity. If there are no alternative uses, then the modelled train will have to bear the cost of unavoidable expense associated with down time. It is also important to determine if the activity will exceed the capacity of the line or the terminals.

6.2.3 Operational model outputs

The type of train model depends on the actual operation being simulated and the type of intervention. For example, curve easing may allow slightly higher operating speeds over particular sections leading to a theoretical decrease in cycle time. Upgrading a bridge for higher axleloads may permit larger and more powerful locomotives to haul larger trains and payloads or alternatively, at the same payload can be carried by lesser number of higher mass wagons or at higher speeds.

In designing bespoke trains there is an emphasis to model best practice. Very often this is unachievable and relevant benchmarks should be applied as a reality check.

For the economic appraisal, train operating resource estimates must be established for each year of the appraisal period, for each of the Base Case and the Project Case. As noted elsewhere, if there are a number of different train configurations these must be included. The main train operating statistics are summarised in Table 5.

Table 7 Train operating statistics

Item	Definition
Train kilometres	Annualised train kilometres attributable to this initiative.
Locomotive kilometres	Annualised locomotive kilometres as above but allowance must be made for the use of multiple locomotives on many trains.
Wagon kilometres	Annualised wagon kilometres as above but allowance must be made for multiple wagons on each train.
Train-hours	Annualised but separated into: • Active hours in transit • Active hours at rest — sidings, terminals, loops etc. • Inactive (idle) hours where the train cannot be redeployed hence the resource cost must be attributed to this initiative.
Locomotive hours	As for train hours and sub-categories
Wagons hours	As for train hours and sub-categories
Crew hours	As for train hours and sub-categories

6.3 Rolling stock capacities, economic lives and costs

6.3.1 Freight locomotives

Locomotive capacities and lengths

Table 8 lists locomotive types used in Australian heavy rail systems. This will assist the analyst to develop a practical train size which can then be costed and used to compare Base and Project Cases in the CBA. Note that in some cases there is a major discrepancy in typical load and train capacity, particularly in the case of container wagons. The intention is for the analyst to develop a bespoke optimised train size when used with the wagon information below and a set of load tables available through the network own networks with a variety of gauges.

The table contains a mix of generic locomotive types suitable for use in economic appraisals conducted in several states and territories for various train configurations.

Table 8 Locomotive capacities

Locomotive type	Mass	Length	Nominal payload (tonnes)			
			Flat	Hilly	High speed	Minerals
Non-standard DEL 1500hp	90	20	800	700	500	800
Non-standard DEL 2000hp	90	22	1000	800	700	1000
Non-standard DEL 3000hp	110	22	1200	1000	900	1600
Non-standard DEL 4000hp	120	22	1500	1300	1100	2000
Non-standard EL 4000hp	110	22	1500	1300	1100	2000
Standard DEL 2000hp	100	20	1000	800	1000	1200
Standard DEL 3000hp	110	22	1200	1000	1200	1400
Standard DEL 4000hp	130	22	1600	1400	1600	2000
Standard DEL 5000hp	170	24	2000	1800	2000	2200
Standard EL 4000hp	170	24	1600	1400	1600	1600

Note: DEL = Diesel-electric, EL= Electric

Source: Cardno estimate based on industry knowledge and a variety of industry sources.

Included are some older previous generation locomotives with lower capacity than the present best practice (non-standard). They are included for comparison purposes of Base Case where older equipment might be replaced by newer units. Many newer locomotives use AC traction motors that offer up to thirty percent more hauling power than the previous generation DC units.

Locomotive capital costs

Appendix A provides detailed unit locomotive capital costs.

All locomotives used in Australia contain a significant amount of overseas components. Some are in fact fully imported while others are in kit form and assembled locally sometimes with local parts added. Fluctuations in the Australian Dollar (AUD) can have major impacts on the prices paid for locomotives. This is especially important when factoring in half-life refits called Component Change Out (CCO), which are normally costed as percentage of the new locomotive price.

The recommended method to estimate annual locomotive capital costs is to create a whole-of-life cost model. Cash flows comprise the initial purchase cost and typically a half-life refit (component change out, CCO) costing 30% of the purchase price, and a 5% residual value the end of the assets' life of 25 or 30 years. The present value of these cash flows can be annuitised over the asset's life at the discount rate. Numerical examples and an Excel formula for this are given in Appendix A2.1.

The analyst must determine if these parameters are suitable and modify as appropriate. For example, if a trainset is bought to service a mine with a 20-year life, even though the locomotive asset has a possible extra 10 years economic life, it may have alternative uses and can be sold off for a much higher price than the end of life value.

For estimating vehicle economic values at any other time in their lives (e.g. at the end of the appraisal period where this does not coincide with the end of the vehicle's economic life), to remain consistent with ATAP Part M1 (Public Transport), we assume that economic depreciation of vehicle values follows a diminishing value (DV) curve, i.e. the value falls by a constant percentage per year of the vehicle's start year value. The alternative is to use straight-line depreciation, which may be methodologically superior in the case of rail assets, which have exceptionally long economic lives.

Locomotive maintenance and servicing cost

Appendix A provides unit costs for locomotive maintenance and servicing costs.

Where a Base Case uses older equipment, which are more prone to breakdown and fatigue, the analyst should modify the estimated unit rate for maintenance. Note that when a locomotive is performing a line haul, it incurs both a cost per kilometre and a cost per hour. The hourly cost of near static conditions such as at a terminal can be significant in particular operations such as short haul coal trains where a considerable amount of cycle time is consumed at load outs or receival facilities.

6.3.2 Freight wagons

Wagon capacities and lengths

Table 9 some generic wagon types used in Australian heavy rail systems. This will assist the analyst to develop a practical train size which can then be costed and used to compare Base and Project Cases in the CBA. Note that in some cases there is a major discrepancy in typical load and maximum load, particularly in the case of container wagons. A double slot container wagon can theoretically handle 2 x TEUs of up to about 24 tonnes gross mass or a single TEU up to about 26 tonnes gross mass including the tare mass of the container. In Australia, the typical payload mass per TEU is about 11-12 tonnes for general freight. Specialised loads may be considerably heavier — grain or packaged frozen meat is about 20 tonnes.

Included below are some older previous generation wagons with lower capacity than the present best practice. They are included for comparison purposes of constructing a valid Base Case where older equipment might be replaced by newer units in the Project Case.

Table 9 Generic wagon capacities and dimensions

Wagon Type	Length (metres)	Tare (tonnes)	Typical load (tonnes)	Max load (tonnes)	Max total (tonnes)
Double slot container Wagon	14.5	16	30	84	100
Triple slot container Wagon	20	22	45	78	100
Double slot well wagon	15	18	60	82	100
Rail tank car - LPG/LNG 80 tonne	16	25	50	55	80
Rail tank car - LPG/LNG 60 tonne	15	22	35	38	60
Mineral Hopper 160 tonne	20	25	132	135	160
Mineral Hopper 120 tonne	18	25	95	95	120
Mineral Hopper 100 tonne	16	25	75	75	100
Mineral Hopper 80 tonne	14	20	60	60	80
Grain/Bulk Commodity Hopper 100 tonne	17	22	78	78	100
Grain/Bulk Commodity Hopper 80 tonne	15	20	60	60	80
Grain/Bulk Commodity Hopper 60 tonne	14	18	42	42	60
Open flat wagon 100 tonne	20	20	80	80	100
Open flat wagon 80 tonne	18	17	60	60	80
Open flat wagon 60 tonne	16	15	42	45	60
Box wagon 80 tonne	17	22	55	58	80
Box wagon 60 tonne	15	18	40	42	60

Source: Cardno estimate based on industry knowledge and a variety of industry sources.

The above generic values should be applied where specific local information is not available. Alternatively, the analyst can customise their own fleet and train size based on expected train length and expected trailing mass limits determined by locomotive tractive effort, terrain and train length governed by loop size.

Wagon capital costs

Default capital costs (exclusive of GST) for new vehicles are shown in provided in Appendix A.

As in the case of locomotives previously discussed, the recommended method in accounting for wagon capital costs is to create a whole of life cost model. Thus the upfront capital cost, a percentage mark-up for a refit in year 13 or 15, less a residual value at the end of the working life are summed and amortised over the economic life of the asset, typically 25 or 30 years.

Wagon maintenance and servicing cost

Appendix A provides unit costs for wagon maintenance and servicing cost.

Wagon servicing and maintenance cost is normally estimated on a yearly basis and apportioned on a per kilometre basis. It could be assumed that new equipment is more reliable and has lower costs than older equipment, which is more prone to breakdown and fatigue.

6.3.3 Economic lives, rehabilitation costs and residual values

Based on Australian experience, freight rail rollingstock typically has a life expectancy of 30 years. In practice, some rail assets are still in operation after 50 years. Generally, however, with the upward trend in axleloads and vehicle capacities, technological and logistical obsolescence is the main determinant of the optimal life of assets. Factors influencing optimum economic lives include the following:

- Initial vehicle specification and standard of construction (both chassis and bodywork).
- Rollingstock utilisation (service hours or service km operated per year).
- Any major rehabilitation or overhaul undertaken during the asset life.
- Standard of maintenance.
- Continuing availability of spare parts.
- Obsolescence, resulting from technology developments and cost efficiency improvements such as lower tare mass for new vehicles,

Given the vehicle economic lives assumed, allowance should be made for a major (‘mid-life’) rehabilitation during the life of wagons. For rail vehicles, rehabilitation costs are typically in the range 25% to 35% of new vehicle costs as some elements of the vehicles such as braking and control systems may be technologically obsolescent by the time of rehabilitation.

Economic appraisals also require estimates of the residual values of vehicles at the end of their economic lives (time of disposal) or the end of the appraisal period where this does not coincide with the end of their economic life.

6.4 Operating costs

6.4.1 Default unit costs

A set of default ‘typical’ unit operating costs (exclusive of GST) for various components applicable to freight rail operations in Australia is provided in the Table below and supported by Appendix A. Where local or customised values are available (and are reliable) they should be used in preference to these generic parameters.

Table 10 Simplified operating cost summary (December 2018)

Cost category	Units	Cost per train
Train crew	$/train-hour	$200
Locomotive energy	See notes below	
Locomotive Servicing Mobile	$/unit-km + $/unit-hour	$1.30+ $20.00
Locomotive Servicing Stationary	$/unit-hour	$20
Infrastructure operations & maintenance	$’000 pa/track-km or track access charge	$20,000
Overhead costs	% on other operating costs	5%

Cost category	Units	Cost per train
Profit margin	% on total operating costs	15%

Table notes: Locomotive energy may be supplied:

- *Though the grid in the case of electric locomotives (EL) with charges levied as a pass-through or, in the case of Queensland, as access charges*
- *Diesel fuel for diesel electric locomotives (DEL). This is relatively complex since different locomotives have different levels of fuel efficiency, haulage capacity and other factors such as terrain, load, tractive effort all play a part. Recent locomotives are being fitted with AC traction motors which offer up to 30% more efficiency than the older DC motors. This has a critical impact on fuel consumption. Newer locomotives have more efficient electronic management systems and can shut down banks of cylinders when not required to save fuel, particularly at idle.*
- *The profit margin is not counted as part of resource costs for CBA purposes. It is only relevant for estimating prices where required for demand forecasting purposes, including mode shares.*

Source: Appendix A

The discussion below provides interpretation and further commentary on the unit cost figures provided.

The operating costs in the tables are divided into five categories:

- **Train operating costs.** The major components are:
  - Train crew costs — all direct costs for on-train crew (drivers, guards, etc.), including both wage costs and direct on-costs (payroll tax, superannuation, uniforms, and indirect costs such as meals, accommodation, allowances, etc.). They are normally expressed per staff hour and converted into train hours and include a nominal allowance for downtime whether planned or unavoidable.
  - Energy — consumed while mobile and when at rest in terminals/loops /sidings. This is normally expressed as a cost per km or a cost per hour.
  - Locomotive and wagon maintenance and servicing — based on service activity there is a cost per kilometre and a cost per hour. For example, a locomotive's wheels will not wear out while stationary but a locomotive under power will wear out engine parts even when it is immobile. For this reason, there is a two- part cost driver for locomotive and wagon maintenance costs.
  - Locomotive replenishment — lubricants and consumables — consumed on a per hour basis.
  - Locomotive and wagon capital cost — attributable to this movement unless there are alternative deployments to share usage and costs. The preferred method is to estimate an annualised whole of lifetime cost (including half-life, CCO) and then allocate it on a per hour basis consistent with expected use. This vastly simplifies the apportionment task for season equipment, which has no alternative uses.
- **Terminal Costs.** The major components are:
  - Ground crew for shunting, marshalling — costs on a per train or per wagon basis
  - Materials handling — gantries, heavy and light forklifts, container stackers — costed on a per lift basis. Pallets are not normally handled as part of the general rail terminal operation.
  - Energy — lighting, power take-offs for refrigeration.
- **Infrastructure operating and maintenance costs.** This cost can be approached in two ways:
  - Using access charges, which exist in the public domain as a proxy for cost (including a margin and return on capital). This is relatively easy to apply and uses a flagfall plus variable component. Note that some access charges include a premium for particular types of train and track sections the train will occupy. The only problem is that some of these prices are negotiated prices reflecting the relative bargaining strengths of the parties rather than a true reflection of opportunity cost.

  - A unit cost per kilometre can be applied and apportioned amount the uses on an NTK basis. Track maintenance and costs charges have stabilised considerably in recent years as older high cost material such as timber sleepers have been replaced by higher quality longer-lived assets and increased mechanisation. There is some variation within individual rail networks as a result of different track standards — mainline or branchline so some of these costs may vary with materials and maintenance regimes and with the amount of usage and wear and tear.
  - Either approach is acceptable however, published rates for CBAs conducted in ARTC controlled territory are recommended.
- **Overhead (operating) costs.** This category covers all operating costs not included in the above three categories. These include operations overheads (scheduling, rostering, driver supervision, depot-related costs); vehicle maintenance overheads (engineering technology services, etc.); head office costs (higher management functions, etc.); and general labour and non-labour overheads (information technology, human resources, insurance, etc.). While overhead cost functions may be expressed in various ways, for simplicity and consistency, they are expressed in the tables as a percentage mark-up on all other operating costs. If the analyst has access to the general ledger, it may be possible to provide a more accurate estimate. Note that the same percentage mark-up is applied for both the base and project cases, this will probably not provide a point of differentiation.
- **Profit margin.** This ‘cost’ category represents the amount a commercial operator expects to be paid to cover interest costs and earn a return on equity capital commensurate with the level of risk. The profit margin has been expressed as a percentage mark-up on the total operating costs (i.e. the sum of the other four cost categories). The ‘normal’ percentage rate in Table 9 is based on Australian and international rail and transport sector experience and benchmarking. The profit component is *not* used in CBA for the purpose of estimating resource costs of train operation because capital costs counted directly in the years they are incurred. However, the profit margin is relevant for estimating market prices for demand forecasting purposes, including forecasting mode share changes.

Notes

In estimating fuel consumption per kilometre the analyst must examine the expected terrain on which the train will operate. A reality check can be obtained by comparing the analyst’s estimates with benchmarks. This should be done taking the expected loads shown in table 8 to derive an estimated fuel consumption per 1000 gross tonne kilometres (’000GTK).

When multiple locomotives are used, the fuel consumption will increase as will the load, so consumption per ’000 GTK will be unchanged.

The analyst is advised to develop their own version of energy costs because of the expected relative volatility of fuel prices over the appraisal period. Issues such as greenhouse emissions, global warming and other factors may have significant influence on fuel availability and price in future years. There may also be increased emphasis on centrally generated electric power.

Locomotives spend a considerable amount of their time idling at terminals or enroute waiting for crossings, signals etc. For example, at coal ports, a nominal two hour window is allowed per train during which energy is consumed. This issue impacts diesel as well as electric locomotives.

6.4.2 Default unit operating costs

The unit cost approach given in Table 10 is intended to reflect generic Australian freight rail cost rates, and would generally be appropriate for economic appraisal of initiatives under consideration. For more detailed appraisal, it would usually be appropriate to make use of bespoke origin-destination point-to-point unit cost information, and to compare this against the cost rates given here. We make the following additional comments on this aspect:

- Where bespoke unit cost estimates are made, these should be checked against the rates given here and any other sources of benchmark costs. This is particularly important given the relatively long appraisal periods typically applied to freight rail projects. Any substantial discrepancies between customised unit cost rates and the rates provided here should be investigated further, as even minor discrepancies may become substantial in the long term.
- In this regard, it is likely to be useful to make reference to benchmarking studies that have been undertaken in Australia and overseas comparing estimated unit costs between similar operations in different jurisdictions.

6.4.3 Joint, common, avoidable and fully distributed costs

Railways are multi-product enterprises and, as such, are characterised by ‘joint’ and ‘common costs’. These are costs for which there is no objective way to attribute causal responsibility to various outputs. The distinction between joint and common costs is that joint costs arise when production of one output necessitates production of another output or outputs in fixed proportions as a technical necessity. For common costs, the proportions can be varied and the outputs are produced together to take advantage of economies of scope. The most obvious example of joint costs and that a trip by a fully loaded train in one direction, the fronthaul, necessitates a return trip, the backhaul, even if there is no freight to carry. Examples of common costs are: a length of track being shared by multiple trains with multiple origins and destinations; and railway workshops servicing many locomotives performing different services. Kolsen (1968)

For charging purposes, the ‘avoidable cost’, sets the lower limit to price. The avoidable cost for an output or group of outputs is the cost that would be avoided if the output or group of outputs was no longer produced by the enterprise, other things held equal. In the fronthaul–backhaul case, the cost of loading and unloading backhaul freight is the minimum charge. If consigners are unwilling to pay the handling costs for the backhaul, the train will return empty. Marketing managers will seek to obtain prices above the avoidable cost of each output so as to contribute to covering the joint and common costs. Thus markets allocate joint and common costs taking into account demand considerations, not only technical factors. For example, freight rates by road and rail tend to higher from Sydney to Perth (the fronthaul) than for the reverse direction (the backhaul) because east-to-west demand for freight transport is greater than west-to-east.

Cost items can be avoidable for groups of outputs and joint or common for individual outputs. For example, the cost of maintaining a branch line is common to individual trains using the line, but avoidable for all trains using the line collectively. If one service using the branch line, was discontinued, most of the cost of keeping the branch line open would remain. If all services using the line were discontinued, the branch line could be closed and all associated costs avoided. Some of corporate overheads could only be avoided if the entire railway closed down.

Fully distributed costs serve as guide to marketing managers as a price to aim for so that each output will make a ‘fair’ contribution to covering joint and common costs. The fully distributed cost for an output comprises the avoidable (or ‘direct’) cost plus shares of all the joint and common (or ‘indirect’) costs for the enterprise allocating according some rule. Activity based costing (ABC) is a fully distributed costing method often used by private enterprises whereby categories of indirect cost are identified, and these costs are allocated to outputs using criteria (often called ‘drivers’) which most closely reflect usage by each output. (CCNCO 1998) The Railways of Australia, National Freight Group2 is a costing convention agreed to by all state railways as an apportionment mechanism between the various cost drivers associated with rail operations based on ABC principles. For almost all rail line haul operations, costs are allocated on the basis of NTK performed. For calculating rail access charges, there is frequently a fixed (flag-fall) and a variable component based on tonnes or NTK. The argument for the fixed component is that a train of any size occupying a slot (assigned train path) requires the same amount of train control and signalling resources.

For CBA purposes, only avoidable costs are relevant because they represent the actual resource costs of providing a particular service or group of services. The allocation of indirect costs to a particular service is, in effect, a bookkeeping entry. For example, an additional train using a length of track or being maintained in a workshop does not increase the indirect costs of the track or the workshop. Therefore, no additional indirect costs should be counted in the CBA even though the railway’s accounting system would allocate a share of the indirect costs to the additional train.

7. Benefits and benefit categories

7.1 ATAP context

A CBA measures net benefits as increases in 'social welfare' of the nation. This can be measured in two equivalent ways (see discussion in Chapter 6 of ATAP Part T2 Cost–benefit analysis):

- As the total increase in willingness-to-pay less the increase in resource costs, or
- As the sum of the sum of the increase in welfare (or net benefits) to the various parties affected (of an initiative as the sum of the following components (IA, 2017):
  - The change in consumer surplus (CS) — user benefits
  - The change in producer surplus (PS) — net benefits to service providers and government
  - The change in third party (externality) effects.

Chapters 6 and 7 of T2 discuss in detail the measurement of the user benefits using the change in willingness to pay less the change in user resource cost, and also the change in consumer surplus (measured with the rule-of-a-half) plus any required resource correction. Table 2 therein provides formulae for estimating user benefits — and apply here.

Chapters 8 and 9 of T2 discuss the measurement of changes in externality effects.

The principles and formulae in Chapters 6 to 9 of Part T2 continue to apply here.

This chapter provides complementary guidance to T2 for use in cost-benefit analyses of rail freight initiatives. Analysts should draw on both of these sources when undertaking an appraisal of an initiative.

The benefits of initiatives that improve rail freight consist of:

- User benefits to:
  - Freight rail users and their customers in the Project Case, which will include users who used the unimproved rail freight service in the Base Case (if it existed)
  - Users attracted from other contestable modes, normally road freight but could be coastal shipping, and
  - Generated rail freight.
- Benefits to those who continue to use alternate freight modes in the Project Case, e.g. reduced traffic congestion to road freight traffic after freight has shifted from road to rail — or, to the extent that additional road travel is generated by the improved traffic conditions, the benefits gained from this additional travel
- Benefits that accrue to the entire community such as reduced environmental pollution and improved safety
- Changes in producer surplus accrued by service providers and governments.

The first two of the benefit categories above are referred to as user benefits. They are estimated here as the change in consumer surplus of rail freight users and customers, with adjustments made to take account of any user and customer misperceptions of the resource costs of their freight.

For a CBA, economic or resource costs need to be used, that is with transfers (taxes and subsidies) excluded from the costs as they represent distributions of costs and benefits rather than net gains to society.

7.2 Initiative types and expected benefits

Tables 11 to 15 summarise the types of initiatives and their expected benefits.

Table 11 Below rail major fixed infrastructure initiatives and potential benefits

Initiative	Potential benefits
New Line/Upgraded line (as opposed rehabilitation to existing standard)	The major impact is improved network capacity. This occurs in several ways and has significant associated effects: • Significant new track in addition to the existing network • Potentially shorter line hauls for some origin destination combinations • Bypass possibility in times of flood/service disruption • Higher capacity — heavier rail etc. allows higher capacity locomotives and wagons • Newer track is of higher standard therefore less prone to breakdown • Lower potential maintenance costs • Decreased frequency and duration of maintenance shutdowns/ in situ speed restrictions — higher network capacity, improved train point to point speeds and reliability • Potential fleet reductions through higher utilisation • Reduced train operating cost — potential for freight rate reductions — improvement to rail's mode competitiveness • Improved access to markets may result in new products e.g. minerals/agriculture developments formerly deemed logistically impractical • Improved safety and damage reduction • Improved amenity — acoustic protection • Improved service quality (that may be valued by customers and may command higher freight rates) • Potential mode shift and replacement of road based line hauls — reduction in costs, accidents, pollution traffic congestion etc.

Table 12 Below rail minor or medium fixed infrastructure initiative and potential benefits

Initiative	Special emphasis benefit areas
New Line	See above
Upgraded Line	See above
New Bridge	Will usually provide for larger capacity rollingstock — greater fleet efficiency and capacity, lower operating costs, reduced maintenance costs, delays, duration and frequency
New Crossing Loop	Improves train reliability and network capacity by removing sectional delays, may permit larger /longer trains
Signal, Telecommunication and Train Control	Improves train safety, reliability and network capacity by removing sectional delays and decreasing train headways

Initiative	Special emphasis benefit areas
Flood immunity/protection	Improves train safety, reliability and network capacity, reduces damage, greater resilience after a flood event
Curve and Grade easing	Improved train speeds and usually trailing loads (train sizes) resulting in more energy efficient locomotive use. Usually decreases maintenance costs because of better track geometry and less wear and tear
Fencing and security, level crossing protection etc	Improves train safety, reliability, speed and network capacity. May provide greater safety for motorists
Electrification	May result in significant fuel and operating cost savings and some environmental benefits. Compliance with emissions reductions targets, reduced bushfire hazard

Table 13 Below rail maintenance projects — restoration to design standard only

Initiative	Potential benefit
Maintenance Fixed Infrastructure	• Newer or cascaded track is of higher standard than what it replaced therefore it is less prone to breakdown/failure • Lower potential maintenance costs • Decreased frequency and duration of maintenance shutdowns/ in situ speed restrictions — higher network capacity, improved train point to point speeds and reliability • Improved safety and product damage reduction • Improved access to markets may result in new products, e.g. minerals/agriculture developments formerly deemed logistically impractical
Repaired Line	As above
Repaired Bridge	As above
Branch line rehabilitation and reactivation	As above

Table 14 Above rail and operational initiatives such as major equipment

Initiatives	Potential benefits
New higher capacity locomotives/wagons	The general aim is to improve line haul efficiency: • Higher capacity trains • Economies of scale — reduced capex, unit costs (labour, fuel, maintenance etc) • Increased train capacity gives higher revenue making potential or potential to remove older lower capacity, higher maintenance units • Improved reliability with newer units — less repair time, better point to point speed and on time reliability • Improved flexibility e.g. common sized coal trains can operate between any mine and port • Equipment standardisation reduces costs of inventory and reduces training of maintenance staff

Table 15 Above and below rail operational and procedural initiatives

Initiative	Potential benefits
Line haul operations	The aims are to improve line haul efficiency, reduce unit costs, promote economies of scale, improve network capacity, resilience and reliability
Revised trailing load limits	Allows for larger train sizes
Revised axleload limits	Allows for larger capacity locomotives and wagons
Revised timetabling	Reduced headways to give more network capacity without compromising safety
Industrial awards e.g. shift lengths	Bigger more productive trains, reduced unit costs, increased competitiveness
Terminals	The aims are higher productivity, capacity and asset utilization with the potential to reduce costs
Fencing and security	Reduce theft, spoilage and trespassers
Materials Handling Equipment	Improve efficiency, safety, damage protection
Yard reconfiguration	Improve efficiency, safety, damage protection
Operating Instructions and Hours	Improve efficiency, safety
Amenity improvements - acoustic barriers	Reduce noise impacts for impacted communities
Amenity improvements — local traffic interface	Improve transit times, reduce waiting times

7.3 Benefits to the industry and its customers

The term 'industry' here refers to train and network (track) operators. The 'customers' are firms who send freight by rail, that is, consignors. In CBA terminology, gains to industry are producers' surplus gains and to customers, consumers' surplus gains.

In the first instance, a benefit will accrue the train operator, the network owner/operator or freight consignors.

The train or network operator will realise cost savings from:

- Faster transits made possible through upgraded routing, grade and curve easing, more powerful locomotives
- Higher payloads:
  - On an individual wagon basis, this is typically achieved by upgrading permissible axleloads and relates to laying heavier tracks or bridge upgrading
  - For whole trains, heavier or more powerful locomotives will improve hauling capacity. Alternatively, more locomotives per train can have the same effect
  - Longer trains will improve productivity and payloads but this is a function of crossing loop size and or duplication, which eases some length constraints
- Improved cycle times — while infrastructure can be a major contributor, improved operations, signalling, coordination and scheduling can also have a major impact. Cycle times are very important for continuous shuttle type movements for commodities such as iron ore and coal

- Track and signal improvements, which reduce track maintenance, downtime, and temporary and permanent speed restrictions, also contribute to faster transits and give operators more versatility in scheduling because of improved on time performance en-route and on arrival
- Improved flood immunity — achievable by bridge replacements or the availability of alternative routes, which improves reliability
- Improved network/route capacity — this can be provided in a number of ways previously identified but duplication on a localised or network-wide basis is a key
- Reduced damage to freight carried, less claims and insurance costs because of smoother track conditions.
- Savings in track maintenance costs.

Freight consignors benefit directly from service quality improvements, which can include:

- More frequent services
- More reliable services, which can translate into less waiting time for pickup and delivery staff and vehicles
- Faster services
- Less damaged products.

Which party ultimately reaps the benefit depends on how access charges that the train operator pays to the network operator/owner and the freight rates paid by the consignor to the train operator change in the project case. A cost saving may be passed on in full, in part or not at all. A service quality improvement may be retained in full by the customer or captured in part or in full by the service provider through a price increase. The outcome will depend on demand and supply elasticities, the bargaining powers and negotiating abilities of large players, and regulatory arrangements.

Assumptions have to be made for the purposes of demand forecasting, benefit estimation and presentation of distributional impacts. Forecasts of diverted and generated freight demand will be affected by how much of the benefits are assumed to be passed on to or retained by consignors.

Where the network operator or train operator reaps a financial gain from an initiative, it can be referred to in a CBA as a 'producers' surplus gain'. It counts as a benefit in a CBA just as a consumers' surplus gain. As the road haulage industry is, for the most part, highly competitive, road operators can be assumed to earn only normal profits in both base and project cases, so there are no producers' surplus gains or losses to be considered.

7.3.1 Estimation methods

As discussed in ATAP Part M1 section 4, these consumers' surplus gains can be calculated in four ways:

- Method 1a: Rule-of-a-half — simple manual method
- Method 1b: Rule-of-a-half — application using a multi-modal demand model
- Method 2: Numerical integration — modified rule-of-a-half method using a multi-modal demand model
- Method 3: Logsum method derived directly from a multi-modal freight model.

Method 1a will generally only be appropriate where an initiative has very limited impacts. In other cases, where demand impacts are large, it is generally necessary to use a multi-modal demand model to establish changes in mode demand that will result from the initiative. In such cases, analysts can use either methods 1b, 2 or 3.

Central to measuring the change in consumer surplus using any of these methods is estimation of the change in generalised cost directly faced by the train operators and indirectly to freight customers and users between the Base Case and Project Case.

Benefits from reduced damage to freight are difficult to quantify. The loss of value to goods caused by the damage is a possible approach.

7.3.2 Roles of methods

The best roles for the four approaches are summarised in Table 16.

Table 16 Role of various approaches for estimating changes in consumer surplus

Method	Best Use	Notes
1a. Rule-of-a-half – simple manual application	Can only be used in simple situations such as improvement to a local service that that does not change the origins and destinations of trips or the mode of transport used.	Cannot be used where an initiative will have substantial effects on demand.
1b. Rule-of-a-half – application using multi-modal demand model	Best used when: • Travel demand changes significantly, including changes in the quantity, mode and location of freight movements • There is a desire for greater transparency by estimating benefits separately from the demand model.	Requires travel demand origin-destination matrices and skims from some form of demand model.
2. Numerical integration — modified rule-of-a-half method using multi-modal demand modal	Best used when: • The initiative involves introduction of a new mode • The demand curve in the region of the change in travel demand is likely to significantly deviate from a straight line • The demand model is not logit-based.	
3. Logsum method derived directly from multi-modal demand model	Can be used when: • The demand model is logit-based • The initiative involves introduction of a new mode • The demand curve in the region of the change in demand is likely to significantly deviate from a straight line	Requires a logit freight demand model

Method 3 (logsum) has been used only to a limited extent in Australia, though it has been used more extensively elsewhere, particularly in the USA. The method is theoretically sound, though its limited use in Australia means that there is a need for practitioners to develop expertise in its use and for decision-makers to gain confidence in its results. Although the rule-of-a-half approximation, and the basic concept of consumers' surplus, are simplifications of the underlying theory, they do retain substantial appeal, in terms of their relative ease of application, reasonable interpretability, and acceptable accuracy (Bates 2003, 36).

The logsum method is especially valuable in the three instances described above, that is:

- where the project involves introduction of a new mode

- where the demand curve is likely to significantly deviate from a straight line
- for large multi-modal and general freight projects where mode share or routing selection arises as a significant issue.

7.3.3 Recommended practice

It is recommended that:

- The rule-of-a-half methods (1a, 1b and 2) continue to be used as the primary methods in practice
- Use of the logsum method (method 3) is acceptable when using a logit discrete choice multi-modal demand model provided that:
  - The user is experienced with using logit models and is aware of the issues associated with logsum calculations (e.g. the logsum from the utility models can be readily estimated and the marginal utility with respect of income is available) — see further discussion in Appendix C of ATAP T2, and
  - Estimates using the rule-of-a-half approach (methods 1a, 1b and 2) also be presented at the same time as cross-checks / sensitivity tests of the reasonableness of the logsum results. This is also a means of developing confidence of decision-makers in the reliability of the logsum method
- Analysts be encouraged to investigate use of the logsum method when using a logit demand model (in line with the above points) as a means for achieving a wider understanding of it, developing capacity for its use, and for increasing the confidence of both practitioners and decision-makers in its results
- A gradual approach be taken to the implementation of the use of the logsum method given its limited use in Australia to date, and that it is likely to be considered complex by a range of practitioners.

7.4 Non user benefits — less freight on roads

Where there is some intermodal contestability, a shift of freight from road to rail as a result of a rail initiative can create benefits for remaining traffic on the road network and to governments as road providers where prices differ from social costs.

Note that many products and hauls are not contestable, being captive to a single mode on efficiency grounds. For example, coal transported from pit to port in trainload quantities will be captive to rail, and short-haul small consignments will always be captive to road.

As ATAP Part T2, Chapter 7 explains, where perceived costs for road users are the same as the marginal social generalised cost in related markets, there are no further benefits to consider. Differences in relation to road transport that might warrant explicit consideration in a CBA can occur in respect of congestion, road maintenance, safety and environmental externalities.

Decongestion benefits can arise in urban areas because lack of congestion charging means that trucks removed from congested roads in the project case generate a positive externality in the form of fewer delays for other vehicles on the same roads. There are unlikely to be any decongestion benefits on non-urban roads. Where freight trains take market share from road, there may be decongestion benefits on roads between the ends of major highways on the outskirts of metropolitan areas and freight distribution centres. Additional trains can lead to higher road congestion costs where they generate additional truck trips for pick up from and deliver to rail terminals in urban areas. The congestion impacts of trucks will vary by time of day. Pick up and delivery trucks are more likely to travel in business hours, or just outside peaks, than at night. ATAP Part M1 Public transport contains detailed information on estimating decongestion benefits.

If the classes of trucks that make fewer trips in the project case are not fully paying for the pavement damage they cause to roads, the savings in road maintenance costs minus the loss of revenue to the government as road provider can be counted as a benefit. At present, charges on trucks to cover road infrastructure costs comprise registration, which can be pro-rated over tonne-kilometres for the present purpose and fuel excise less the fuel tax credit (see ATAP Part PV2). Pavement damage costs will vary by vehicle type and the roads used. More heavily trafficked roads such as major highways are built with stronger pavements and so are more resistant to damage from heavy vehicles compared with less trafficked roads, such as local roads in rural areas.

Although trucks pay for a portion of the costs of road crashes they cause through insurance premiums, the ATAP Guidelines allows the entire cost of crashes avoided to be counted as a benefit. Changes in numbers road crashes by severity level that result from reduced truck use as freight customers shift to rail can be estimated and multiplied by unit crash costs as outlined in Step 8 in ATAP Part T2 on CBA. Default values for unit crash costs are set out in ATAP Part PV2 on parameter values.

Crashes still occur with rail but these are rare compared with truck incidents. Corridor separation greatly reduces the number of accidents involving other transport modes. Level crossings are a notable exception. Nevertheless, where rail safety effects can be estimated, they should be included in the CBA.

Environmental externalities, being unpriced, should be counted. Generally, a shift from road to rail produces a net improvement environmental impacts such as noise, air pollution and greenhouse gas emissions. The environmental cost savings from fewer truck trips less the environmental disbenefits of additional trains should be estimated in the conventional manner set out in Step 9 in ATAP Part T2.

Road parameters are typically applied to the number of road kilometres replaced, which may not be equivalent to the number of rail kilometres generated).

7.5 Combined benefits

Say an initiative reduces train operating costs per tonne for rail from *AC1* to *AC2*, and improves service quality for rail’s customers. An example would be an initiative that raises track speed limits, which reduces train operating costs and transit times. The train operator increases the freight rates it charges from *FR1* to *FR2*, but because of the service quality improvement, generalised or perceived costs for customers fall from *P1* to *P2*. If the combined user costs of transit time, unreliability and service availability are written as *UC*, then $P = FR + UC$.

Rail carries *Q1* tonnes in the base case and *Q2* tonnes in the project case. Part of the increase in rail freight is generated demand, and part is diverted from road transport, $Road\Delta Q$ tonnes.

Combined road congestion costs, environmental externalities and crash costs per tonne carried are *Ext* for rail and *RoadExt* respectively. Rail generates some road congestion costs due to pickup and delivery by road.

Thus:

- reduction in rail operating costs: $AC1 - AC2$
- increase in rail freight rates: $FR2 - FR1$
- reduction in generalised costs for rail customers: $P1 - P2$
- value of the service quality improvement to customers: $UC1 - UC2 = (P1 - FR1) - (P2 - FR2)$
- reduction in rail externalities $Ext1 - Ext2$

- induced rail freight: *Q2 – Q1*
- reduction in road freight: *Road∆Q*

All differences are presented here with the higher value first to make them positive. The expressions derived below still hold for negative quantities. The induced rail freight comprised diverted and generated freight, that is, *Q2 – Q1 = Road∆Q + generated rail freight*.

Truck operating cost, the road freight rate charged, and road pavement damage costs all expressed per tonne are respectively *RoadAC*, *RoadFR*, and *RoadPDC*. The road provider levies a user charge on trucks of *RoadUCh* per tonne carried for pavement damage and it is assumed that there is under-recovery of costs, so *RoadPDC* < *RoadUCh*. Note that this is likely to be the case for very large trucks and less tracked roads with pavements constructed to lower standards. For smaller trucks and major highways, which have stronger pavements, there may be over-recovery of pavement damage costs. Road hauliers are assumed to earn only a normal economic return on capital so *RoadFR = RoadAC + RoadUCh* and there are no producers' surplus changes to consider.

7.5.1 Social welfare approach

Presenting CBA results as the net increase in social welfare, the benefits are the changes in WTP (as measured by the height of the demand curve as a function of generalised cost, *P*, over the quantity change) minus social costs in the rail and road markets.

- **For existing rail freight, *Q1*:**
  - the saving in private costs by rail: *(AC1 – AC2)* × *Q1*
  - the improved service quality benefit to rail users: *(UC1 – UC2)* × *Q1*. A service quality increase means the gap between the generalised (or perceived cost) and the freight rate has fallen, so this is a positive amount. The perceived cost could be defined as including pickup and delivery costs if these are not included in the rail cost and freight rate.
  - reduction in rail externalities *(Ext1 – Ext2)* × *Q1*
- **For induced rail freight, *Q2 – Q1*:**
  - the willingness-to-pay (WTP) gain measured by the area under the demand curve for the change in quality *0.5* × *(P2 + P1)* × *(Q2 – Q1)*.
  - minus the social cost of carrying the induced freight: rail operating costs, externalities and the value to customers of the disutility of transit time, unreliability and other non-price service quality attributes included with generalised costs: *[AC2 + Ext2 + UC2)]* × *(Q2 – Q1)*.
- **For diverted road freight, *Road∆Q*:**
  - the cost saved: *(RoadAC + RoadPDC + RoadExt)* × *Road∆Q*
  - minus the WTP lost: *RoadFR* × *Road∆Q*.

Substituting in the relationship *RoadFR = RoadAC + RoadUCh*, the benefit for diverted road freight can be simplified to *(RoadPDC – RoadUCh + RoadExt)* × *Road∆Q*, which is the avoided under-recovery of pavement damage costs and externalities. User costs for road freight have been ignored because, being an addition to both the full cost incurred by users and the social cost, they cancel out.

It is important to avoid the pitfalls of counting as benefits:

- the saving in road operating costs (*RoadAC*) without deducting the offsetting lost WTP (*RoadFR*), and

- the saving in pavement damage costs (*RoadPDC*) without deducting the offsetting amount trucks pay for road use (*RoadUCh*).

Figure 5 illustrates the benefits for existing and induced rail freight using the social welfare approach. To keep the diagram simple, rail externalities have been omitted. Labels for base case dollar amounts shown by continuous lines are on the left side and labels for project case amounts showed by broken line are on the right. The project case has lower average costs for the railway and lower user costs but there is a small increase in the freight rate.

The benefit to existing freight is the shaded rectangle with a height equal to the reduction in social costs from *AC1 + UC1* to *AC2 + UC2* and a width, *Q1*. From above, the benefit for existing freight is *(AC1 – AC2)* × *Q1* + *(UC1 – UC2)* × *Q1* = *(AC1 + UC1)* × *Q1* – *(AC2 + UC2)* × *Q1*. The benefit to induced freight, *Q2 – Q1*, is the shaded area representing the area under the demand curve less the social cost of producing this output, *AC2 + UC2*.

Figure 5 Rail benefits under social welfare approach

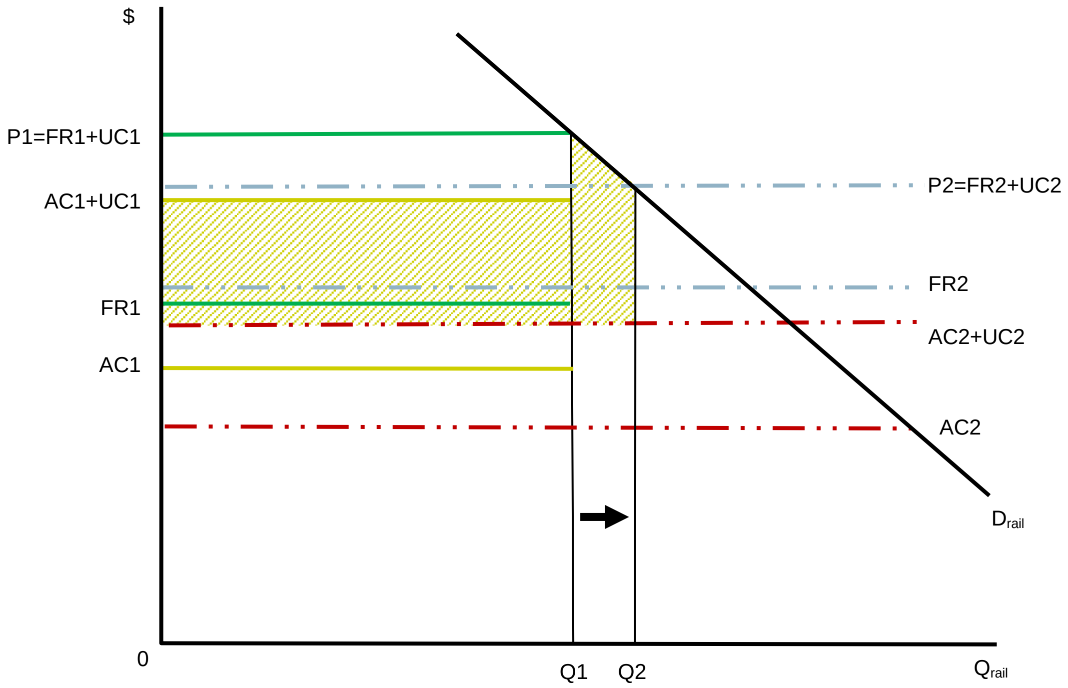

Figure 6 shows the benefit in road haulage market. The demand curve for road haulage shifts leftward reducing the quantity carried. Omitting user costs, users pay the average cost (*AC*) plus the road damage charge (*UCh*), road hauliers incur the average cost (*AC*), the road provider incurs the pavement damage cost (*PDC*) and society in general incurs the externalities (*Ext*). The benefit is the shaded rectangle with a height equal to the difference between the full social cost, *AC* + *PDC* + *Ext*, and the marginal willingness-to-pay each unit of freight that transfers to rail, *AC* + *UCh*.

Figure 6 Benefit in road market

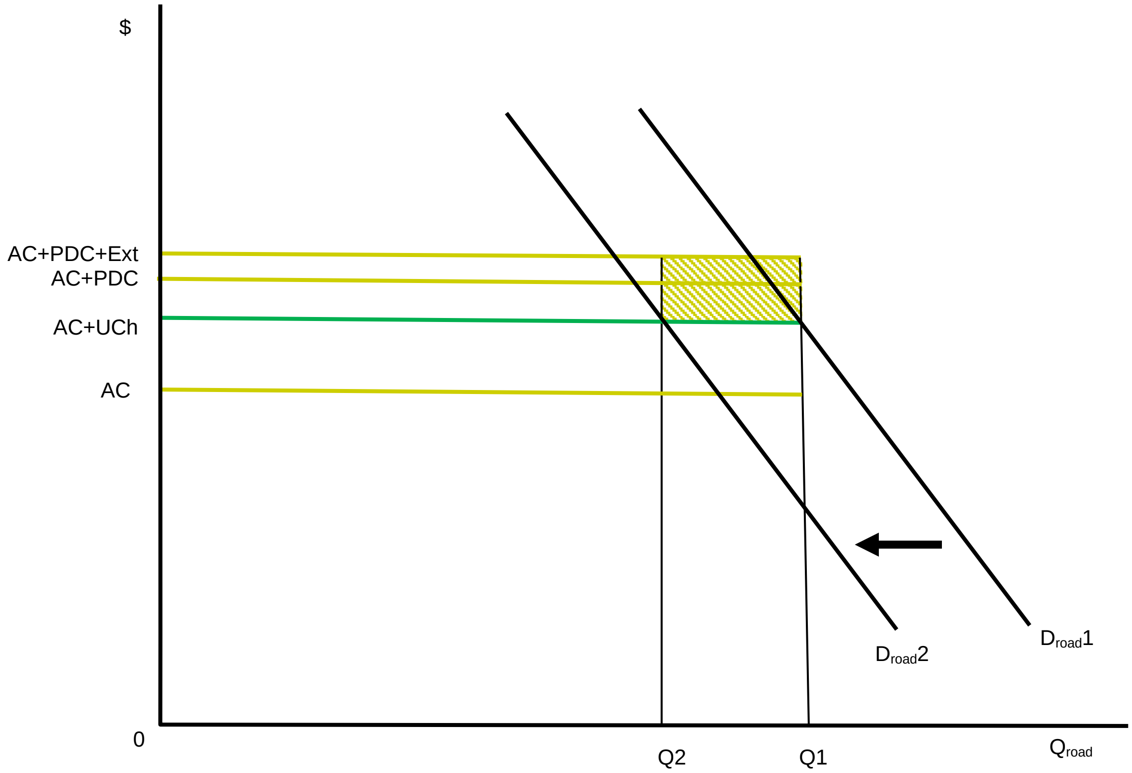

Table 17 summarises the potential benefits under the social welfare approach.

Table 17 Summary of potential benefits under the social welfare approach

Freight component	Benefit	Data needs and issues
Existing freight (freight carried by the same rail service in the base and project cases)	Saving in rail operating costs	Base-case rail freight quantity. Avoidable costs in base and project cases. Costs will usually come from a transport model developed by the analyst.
	Improved service quality (if different between the base and project cases)	Base-case rail freight quantity. Generalised cost and rail freight rates in the base and project cases. Values for non-price service attributes would come from a logit model.
	Reduction in rail externalities (if the rates per tonne of freight differ between the base and project cases)	Base-case rail freight quantity. Unit environmental externality costs and unit crash costs for the base and project cases.
Induced freight (generated and diverted)	Increased WTP	Induced freight quantity and base and project case generalised costs
	Minus increase in social costs comprised of rail operating costs, service quality costs and rail externalities	Induced freight quantity and project case generalised costs, freight rates, rail operating costs, unit costs for rail externalities. See ATAP Part PV5 for rail externality unit costs.
Diverted freight	Under-recovery of road pavement damage costs (if it occurs)	Diverted freight quantity converted to vehicle-km by truck type, registration fees non-rebated fuel excise for each truck class, pavement damage for each truck class for the particular roads affected.
	Saving in road externalities	Diverted freight quantity converted to vehicle-km, unit costs for crashes and environmental externalities. See ATAP Part PV2 for road crash costs and Part PV5 for road externality unit costs, and Part M1 for unit decongestion costs.

7.5.2 Beneficiary approach

Presenting the CBA results by beneficiary, the gains are split between rail customers, operators, the road provider and third parties.

- **Consumers' surplus gain:**
  - the rectangular area for existing traffic, *(P1 – P2),* × *Q1* plus the triangle for induced traffic applying the rule-of-half, *0.5* × *(P1 – P2)* × *(Q2 – Q1)*, combines to equal *0.5* × *(P1 – P2)* × *(Q1 + Q2)*
- **Producers' surplus gain:**
  - revenue minus operating costs in the project case minus the same in the base case, *(FR2 – AC2)* × *Q2 – (FR1 – AC1)* × *Q1*

- **Road provider:**
  - the saving in pavement damage costs minus the loss of revenue from heavy vehicle charges: *(RoadPDC – RoadUCh)* × *Road∆Q*.
- **Third parties:**
  - the saving in rail externalities, *Ext1* × *Q1* – *Ext2* × *Q2*
  - the saving in road externalities, *RoadExt* × *Road∆Q*.

Figure 7 is identical to figure 5 except that the shaded areas show the benefits in the rail market using the beneficiary approach. To simplify the diagram, the *AC* + *UC* curves have been removed since they are not needed with the beneficiary approach. The consumers' surplus gain is the area bounded by the base case and project case generalised costs, *P1* and *P2*, and the demand curve. The producers' surplus gain comprises the areas of three rectangles:

- The increase in freight rates for existing freight, (FR2 – FR1) × Q1
- The saving in costs for existing freight, (AC1 – AC2) × Q1, and
- The surplus earned from induced freight, (FR2 – AC2) × (Q2 – Q1).

These three areas sum to *(FR2 – AC2)* × *Q2* – *(FR1 – AC1)* × *Q1*, the formula given above for the producers' surplus gain.

Figure 7 Rail market benefits under beneficiary approach

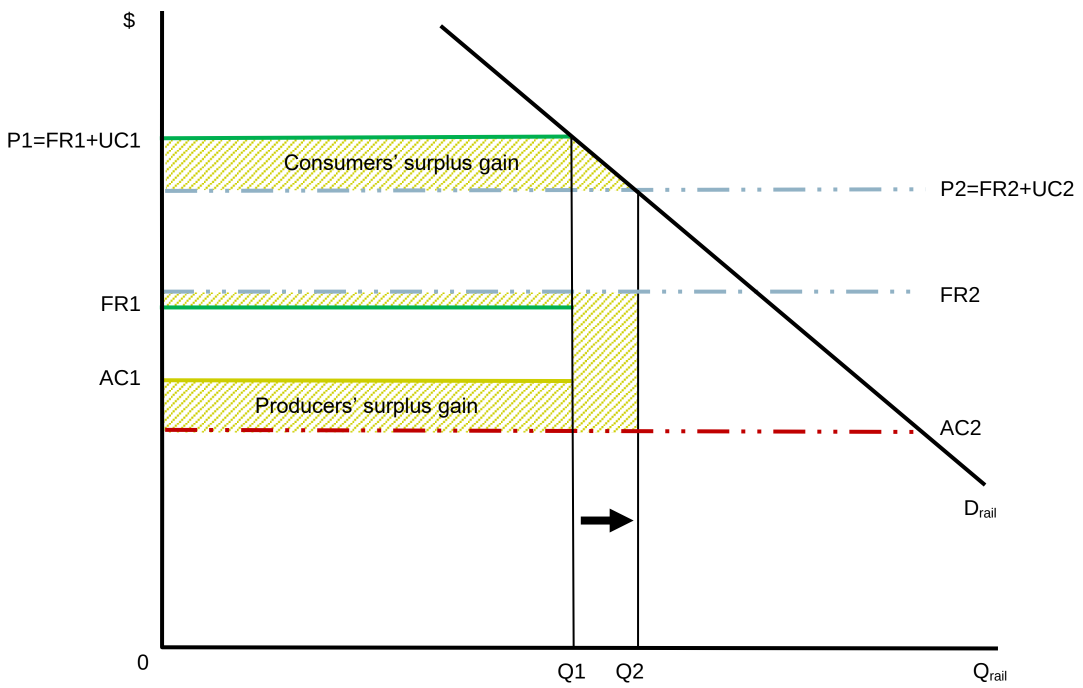

Table 18 summarises the potential benefits by beneficiary.

Table 18 Summary of potential benefits by beneficiary

Beneficiary	Benefit	Data needs and issues
Rail customers, freight consignors	Consumers’ surplus gain	Rail freight quantities and generalised costs in base and project cases. Generalised costs would come from a logit model. If service qualities are identical in the base and project cases, freight rates can be used in place of generalised costs. Application of rule-of-half
Rail operators	Producers’ surplus gain	Rail freight quantities, freight rates and operating costs in the base and project cases. Gross profit (revenue minus operating costs) in the project case minus gross profit in the base case.
Road provider	Saving in road damage costs minus loss of revenue from heavy vehicle charges	Diverted freight quantity converted to vehicle-km by truck type, registration fees non-rebated fuel excise for each truck class, pavement damage for each truck class for the particular roads affected.
Third parties	Saving in rail externalities	Rail freight quantities, unit environmental externality costs and unit crash costs in the base and project cases. (Will be a disbenefit if increases from induced freight outweigh savings for existing freight.) See ATAP Part PV5 for rail externality unit costs.
	Saving in road externalities	Diverted freight quantity converted to vehicle-km, unit costs for crashes and environmental externalities. See ATAP Part PV2 for road crash costs, Part PV5 for road externality unit costs, and Part M1 for unit decongestion costs.

Both the approaches give the same result, that is:

- $\text{Benefit under the social welfare approach} = [(AC1 - AC2) + (UC1 - UC2)] + (Ext1 - Ext2)] \times Q1 + [0.5 \times (P2 + P1) - (AC2 + Ext2 + UC2)] \times (Q2 - Q1) + (RoadPDC - RoadUCh + RoadExt) \times Road\Delta Q$

equals

- $\text{Benefit under the beneficiaries approach} = 0.5 \times (P1 - P2) \times (Q1 + Q2) + [(FR2 - AC2) \times Q2 - (FR1 - AC1) \times Q1] + (RoadPDC - RoadUCh) \times Road\Delta Q + Ext1 \times Q1 - Ext2 \times Q2 + RoadExt \times Road\Delta Q.$

Substituting $UC1 = P1 - FR1$ and $UC2 = P2 - FR2$ into the social welfare approach expression, both expressions expand out to:

- $AC1\ Q1 + Ext1\ Q1 - FR1\ Q1 + 0.5\ P1\ Q1 - 0.5\ P2\ Q1 - AC2\ Q2 - Ext2\ Q2 + FR2\ Q2 + 0.5\ P1\ Q2 - 0.5\ P2\ Q2 + RoadExt\ Road\Delta Q + RoadPDC\ Road\Delta Q - RoadUCh\ Road\Delta Q$

It might be desirable to present CBA results in both ways to confirm that the methodology has been correctly applied.

In the case of a new rail service, there will be zero existing freight and the consumers' surplus benefit will be the area under the demand curve between zero and the quantity carried in the project case above generalised cost. If most of the freight using the new service is diverted from road transport, a logit model can provide a forecast of rails' market share in the project case and an estimate of the consumers' surplus gain using the logsum approach. The logsum approach is explained in ATAP Part T2, Appendices B and C. In particular, Section C7 shows how the logsum approach can be employed to estimate benefits for new modes, services and routes.

In the absence of a logit model, one approach is to estimate the consumers' surplus for rail demand as a function of freight rate rather than generalised cost (Harvey 2002). The road freight rate provides an indicative price at which the rail demand curve intersects the price axis because no freight would be expected to divert to rail if rail charged the same as road. Assuming rail provides a poorer set of service quality attributes compared with road, then as the rail freight rate is reduced below the road freight rate, the consignors who first shift modes would be those who place the lowest value on service quality attributes. As the rail freight rate reduces further, consignors with progressively higher values of service quality would shift from road to rail. For any given pair of road and rail freight rates with RailFR < RoadFR, the marginal consignor shifting to rail would value the difference in service quality between the two modes at RoadFR – RailFR. Intra-marginal shifters would value the service quality difference between zero and RoadFR – RailFR. The rule-of-half might be applied estimating the consumers' surplus area to be 0.5 (RoadFR – RailFR) Q. This implies a linear demand curve. Sensitivity tests might be undertaken for 0.25 (RoadFR – RailFR) Q and 0.5 (RoadFR – RailFR) Q, to allow for convex and concave demand curves respectively. Allowance might also be made for some generated freight to appear as the rail freight rate falls below that for road. The method suggested here is also explained in ATAP Part T2, Section 6.5.

8. Cost–Benefit Analysis methodology

CBA plays a central role in the ATAP appraisal system as explained in ATAP Part F3 Framework. The general features of a transport CBA are set out in ATAP Part T2 CBA. This chapter addresses matters related to the application of CBA that are specific to freight rail initiatives.

8.1 Specifying the Base Case and the Project Case

An appraisal investigates the merit of a proposal relative to some alternative approach, i.e. the Project Case relative to the Base Case. The general features of the Base Case and the Project Case are described in Chapter 1 of ATAP Part T2. It is of note that the Base Case has as much impact on the results of an appraisal as the Project Case, and careful consideration therefore needs to be given to defining and analysing both cases. Particular attention should be given to estimating operating and maintenance costs over the duration of the appraisal period in both the Base Case and the Project Case.

8.1.1 Base Case

The Base Case (see ATAP Part T2 Section 1.6) is the situation that is expected to prevail if the proposed initiative described in the Project Case is not implemented. It typically represents the ‘business-as-usual’ situation and is sometimes referred to as the ‘do-minimum’ situation:

- The Base Case should include a continuation of either the existing services or a variant of these services that is a realistic alternative to proceeding with the initiative considered in the Project Case. All forecast growth should be accommodated by existing infrastructure, road and rail
- The Base Case should include capital and recurrent expenditures needed over the appraisal period. The Base Case should not include significant capital expenditure. Allowance can be made for anticipated changes that might reasonably occur, for example a need to undertake periodic maintenance on existing infrastructure to enable services to continue and a need to add services to cater for rising freight demand, provided the cost is modest and would typically use existing rollingstock assets.
- Estimates of operating and maintenance costs should reflect the costs of sustaining the infrastructure that will be present in the Base Case. It is probable that this infrastructure will be older and have higher unit maintenance costs than would occur in the Project Case.

Where Base Case assets are likely to become technologically obsolete, or to reach the end of their economic life during the appraisal period, allowance should be made in the Base Case for their replacement by assets as similar in function as possible. Railway signalling systems are an example of a type of asset for which technological progress could result in a need to use some updated technology when replacement becomes due.

8.1.2 Project Case

The Project Case is the situation that is expected to occur if the initiative is implemented. Usually there are multiple options available for solving a problem, so more than one Project Case should be assessed. Some matters that are particularly important in the case of freight rail initiatives are:

- A need to take account of the full range of infrastructure associated with the initiative, such as that described in Table 19

- In addition to any infrastructure to be provided as part of the initial investment, there is a need to take account of additional fixed assets and rollingstock that may be required to carry forecast growth in freight rail during the remainder of the appraisal period. Re-investment in rollingstock and other infrastructure that reaches the end of its useful life before the end of the appraisal period also needs to be taken into account
- Project specification is a particular challenge in relation to freight rail 'network initiatives', which can have ramifications on the wider freight rail network. These impacts may not always be readily apparent. The impacts need to be carefully identified, including those that may occur some distance away from the location of the initiative itself, for example, a need to upgrade electricity supply or track capacity in a rail network
- Complementary development needs or plans should be taken into account.

Table 19 Freight rail infrastructure categories

Category	Elements
Systems infrastructure	Management centres such as network control centres; signalling; communications; rollingstock storage and maintenance; fare systems; signage; etc.
Network infrastructure	Rail networks and their infrastructure components: track, rolling stock, etc.
Nodal infrastructure	Freight terminals including off rail logistics and commercial hubs; etc.

The quality of cost estimates (see ATAP Part O1 Cost Estimation) can be improved by breaking down initiative costs in a structured way. This is desirable for three reasons:

- Different assets have different economic lives and therefore different residual values at the end of the appraisal period
- The operating and maintenance costs associated with different elements of infrastructure are likely to vary
- A more detailed breakdown allows the make-up of infrastructure costs to be better understood, particularly for:
  - Minimising the risk that costs are forgotten
  - Enabling attention to be focused on areas of greatest significance to the total costs of the initiative, and
  - Permitting closer attention to be paid to areas where there are uncertainties and risks in estimating the costs of an initiative.

Where possible, work breakdown structures should follow a similar architecture and format to those used in the asset management systems of the organisation that will take ownership of the infrastructure. This has a number of advantages:

- It enables the appraisal to use maintenance schedules and costs that are consistent with those used elsewhere in the organisation (provided, of course, that these are appropriate).
- If the initiative proceeds, the organisation will find it easier to incorporate it into its asset management system.
- It should facilitate post-implementation monitoring by making it easier to access cost information.

Two other matters require careful treatment:

- The Project Case could include non-core improvements that could, at low cost, be implemented in the Base Case.
- There will be occasions where there is some other proposal that is not already ‘funded or committed’ that is not a formal part of the proposed initiative, but which may affect the merits of the initiative being appraised.

In these cases, the appraisal should consider three cases: (a) the Base Case; (b) an Alternative Scheme (the Base Case plus the non-core improvements or the uncommitted proposal); and (c) the Project Case. This allows the merit of the initiatives in the Alternative Scheme and the incremental merit of the additional initiatives in the Project Case to be separately appraised. The aim of this approach is to ensure the costs and benefits of each initiative are separately identified. In this manner, for example, the benefits that could be obtained by making the non-core improvements or uncommitted proposals are benefits that could be obtained without implementing the formal initiative in the Project Case appraised separately, and associated costs and benefits are not attributed to the project.

8.2 Identifying options

The ATAP Framework (see ATAP Part A1 Overview) sets out a general approach to strategic planning and the identification of alternative potential initiatives that addresses identified problems and which then need to be subject to appraisal. This section notes some unique matters related to the identification of problems associated with freight rail that may necessitate an intervention, followed by the identification of potential responses.

8.2.1 Problem identification

Rail operators commonly have a range of performance indicators that show their performance with regard to the demand for freight rail services and the provision of services. Problems that can be identified include under or over capacity, failure to meet peak loads, poor network coverage, indirect routing, uncompetitive add-ons, unreliable on time arrivals etc. Such problems can be identified on a continuing basis by using ‘exception’ reporting of routine statistics and through interrogation of the indicators as part of some specific study.

Identified problems also need to be placed in context, for example to identify relevant intermodal factors, and be related to the transport system objectives.

8.2.2 Option identification

Alternative means for addressing the identified problems then need to be considered. A broad view should be taken to the options, with consideration given to regulatory, governance and operational initiatives as well as capital investment. An initial list of options should be identified, and then screened to identify the options that have the greatest potential.

Considerable care is needed in the case of freight rail to avoid a sole focus on a particular technology or other preferred solution (for example, the gold-plating option of continuously welded rail, but omitting other less costly options).

8.3 Other matters

This section addresses four other matters that are discussed more generally in ATAP Part T2 CBA, but for which some additional, specific comment is needed with regard to the appraisal of freight rail initiatives.

8.3.1 Appraisal period

Section 2.4 of ATAP Part T2 states that It is usual to assume a 30-year life for road initiatives (except bridges, which have much longer lives) and a 50-year life for rail initiatives. Within that appraisal period, freight rail initiatives will have a range of asset components (including various civil infrastructure, electrical and mechanical equipment, and rollingstock) that will have different economic lives. As explained in ATAP T2, that requires:

- Reinvestment of assets whose lives terminate before the end of the appraisal period
- Inclusion of a residual value at the end of the appraisal period, to approximate the remaining benefits generated by those assets that have a life beyond the end of the appraisal period.

8.3.2 Changes in benefits over time

The approach to taking account of changes in benefits over time is described in Chapters 6 to 9 in T2. It covers matters such as the effects of population growth and rising traffic congestion on travel demand and travel conditions in the Base Case and Project Case. There are no specific differences that should be taken into account relating to freight rail initiatives other than the need, if relevant, to take account of ramp-up in freight demand in the Project Case, and hence the ramp-up in benefits that occurs as mode choice changes. Freight demand and mode choice ramp-up is discussed in Section 4.5

8.3.3 Benefit-Cost Ratio

As indicated in Section 10.4 in ATAP Part T2, the benefit–cost ratio (BCR) should be calculated in two different ways:

- With all supply costs incurred by government being included in the denominator (i.e. the ‘cost’), and the consequences of these capital and operating costs included in the numerator (i.e. the ‘benefit’) (BCR1), and
- With only the initial capital (investment) cost being included in the denominator, with all other effects in the numerator (described as benefits that occur after the initiative has commenced operation, noting that some individual effects may be negative i.e. disbenefits) (BCR2).

Both BCR definitions can be used to indicate whether the project has a positive net present value. BCR2 is the appropriate measure for comparison of projects in a capital-constrained environment.

Only BCR1 can be used for initiatives that involve no investment expenditure such as an increase in the quantity of service that is able to use existing fixed infrastructure and rollingstock. For BCR2, the absence of investment costs means a zero denominator, but as the project would not be competing with other projects for investment funds, BCR2 is not required.

9. Performance measurement and monitoring

9.1 Introduction

This section provides material on performance measures ('key performance indicators', KPIs) and their application specific to freight rail initiatives. To remain consistent with other ATAP mode and project specific guidance, this chapter adopts a similar format, philosophy and methodology except tailored to the freight rail perspective. As a result, significant sections of this text are replicated or modified from the other guidance.

It builds on and supplements the more generic material on this topic in other parts of the ATAP Framework Guidelines, principally:

- Part F1: Goals, Objectives and Targets.
- Part F7: Post Completion Review
- Part T6: Benefits Management.

9.2 The Strategic Planning Framework — goals, objectives and targets/ KPIs

The ATAP Framework involves seven steps. Step 1 is concerned with the specification of goals, objectives, targets and associated performance measures (KPIs). Table 20 sets out the definitions used for each of these.

Table 20 ATAP Framework — Terminology

Term	Definition
Goals	Statements that describe the fundamental economic, social and environmental outcomes that a jurisdiction is aiming to achieve through its activities across all sectors (not just transport)
Objectives	Specific statements of outcomes that a jurisdiction is aiming to achieve through its transport system.
Performance indicators and targets	A key performance indicator (KPI) is a measure that enables monitoring of performance in terms of progress towards a specific, defined objective. A target is the desired level of performance for a specific performance indictor. Performance indicators and targets are mechanisms to operationalise objectives.

Source: Paper F1, chapter 2.

9.3 Role and perspectives on performance measures and targets

Performance assessment (relative to targets) is most relevant for two of the steps in the ATAP Framework:

- ***Step 2: Problem identification, assessment and priority setting.*** At this 'before' stage, current (and projected) performance should be measured, and targets set against each objective. This 'gap' analysis will identify problems and deficiencies and point the way towards options that can address these deficiencies.

- ***Step 7: Post-completion review.*** At this 'after' stage, the review should measure the 'after' performance against the targets established earlier, address whether the forecast performance improvements have been achieved, and, if not, identify what further action might be required to enhance performance.

Targets and KPIs should be set for objectives at all planning levels and be consistent and integrated. Each objective should have at least one associated KPI and specific target.

The comparison of targets with performance indicators provides a gap analysis, which shows the extent to which objectives are being met.

Performance can be measured from several different perspectives, specifically:

- **Process:** measures the type of process, policy or activity
- **Inputs:** measure the resources invested in or used by an activity
- **Outputs:** measure the level and extent of activity
- **Outcomes:** measure the end result.

In formulating KPIs and associated targets, the following characteristics are seen as desirable:

- *Be simple and easy to convey*. The language used to express targets and KPIs should be non-technical and straightforward, capable of being understood easily by the public.
- *Relate directly to the identified objectives.* Targets and KPIs need to be formulated carefully to accurately reflect objectives and facilitate problem identification. It should be possible to trace a clear 'pathway' from a target/KPI to a related objective (and back to the high-level goal).
- *Relate to outcomes, not outputs.* Outcomes are better indicators of the effectiveness of an activity. Outputs usually measure the level of activity and not its end result (economic, social and environmental): they should only be used if no appropriate outcome measure is available.
- *Facilitate benefit measurement:* Formulating targets and KPIs in terms of positive outcomes or improvements enables the assessment of the benefit of a specific initiative against its cost.
- *Be measurable from a practical perspective.* The analytical tools, data and/or resources needed to monitor a target or KPI should be readily available at a reasonable cost. This should not preclude the use of 'soft' measures, such as customer and user perceptions. Such measures are often the best means for assessing quality and amenity performance of freight rail services from the user perspective.
- *Reflect recognised performance measures.* Targets/KPIs should incorporate measures that are recognised as reliable and appropriate.

Targets and KPIs are often expressed in terms of:

- *Trends over time* (e.g. % reduction in accident rates or travel times over N years); and/or
- *Performance relative to other jurisdictions* (eg unit costs of operating bus services in an area relative to a recognised regional benchmark rate).

Many jurisdictions will have guidelines for developing targets and KPIs. The 'SMART' criteria are commonly used to guide practitioners in the development of KPIs:

- **S**pecific — well defined and focused.
- **M**easurable — can be measured to track progress.

- **A**chievable — realistic, practical and stretching.
- **R**elevant — directly relate to objectives.
- **T**ime-bound — clear timeframes set for each indicator.

9.4 Potential KPI metrics for freight rail infrastructure proposals

The development of KPI metrics for freight rail initiatives should be provide relevant information to participants in the investment decisions or the operation of the supply chain:

- relevant to government authorities (in roles of funder, regulator)
- relevant to operators (requirements generally specified in operator contract, including targets and related financial and other incentives)
- relevant to users and user organisations (e.g. freight rail user associations, groups representing industry, customers).

Metrics will also often differ between freight rail operations on the basis of:

- Commodity characteristics
  - Physical shape/dimensions
  - Format — powder, solid, liquid, gas
  - Typical consignment size — LCL, container-load, wagonload part trainload, trainload
  - Pack type — unitary (e.g. cars or machinery), break-bulk (e.g. bundled timber or steel), container load, bulk (e.g. grain or mineral), tanker (e.g. bulk fuel or gas), packaged (e.g. drums of fuel or lubricant), refrigerated (e.g. meat and perishables)
  - Materials handling requirements
- Customer requirements
  - Fast transits
  - Product safety and integrity
  - Convenient pickup and delivery time
- Rail operation
  - Alternative routing
  - Type and nature of terrain
  - Quality of track and below rail infrastructure
  - Quality of rollingstock — capacity, reliability, availability of spares
  - Efficiency of Rollingstock — capacity, cost effectiveness
  - Timetabling, scheduling, connections and coordination
  - Terminal equipment and staff competence
  - Physical cost of inputs — equipment, energy, staff etc.
  - Operational standards — headways, load limits, length limits.
  - Network coverage — geographic spread

- Other
  - Entire logistics chain efficiency and coordination
  - Competition from other modes or above rail operators
  - Regulatory compliance — OH&S, enterprise agreements, other legislation,

9.5 Benchmarks and performance assessment

9.5.1 Productivity commission three tier system

Performance benchmarks can be used to understand the efficiency of processes and to promote productivity improvements. In assessing rail performance, there are three classes of performance indicators:

- **Operational performance** — which includes measures of physical process efficiency and the consumption of resources in providing a level of performance and capacity;
- **Comparative input unit rates** — for the resources consumed in the process of providing a level of performance and capacity; and
- **Commercial performance** — quality of service measures, freight rates, etc.

Internal benchmarking is useful if no external comparisons are available. It is important that the comparison contains at least some common aspects such as train size, location, territory, haul length, commodity, volumes etc. Alternatively, it is valid to benchmark using time series information if it is available.

9.5.2 Operational efficiency

Operational performance is concerned with effectiveness and efficiency which can be defined as follows:

- Effectiveness — doing the right things and
- Efficiency — doing things right.

The indicators that can be analysed to assess this performance include:

- Quality of Service:
  - Capacity to handle the available volumes in the designated time
  - Ability to match growth in volumes to capacity
  - Reliability of services; and
  - Loss and damage rates.
- Operating efficiency:
  - Labour productivity and
  - Capital productivity.

It is important here to distinguish between productivity and utilisation. A high degree of utilisation is not a good measure of efficiency and may in fact imply the opposite.

9.5.3 Input efficiency

Key unit costs in freight rail operations include:

- Labour — train crew, terminal crews, supervisor/management costs
- Equipment — rollingstock, materials handling, ITS equipment such as signalling, train control and telecommunications equipment
- Fixed infrastructure — track and alignment, bridges, terminals
- Energy — diesel, electric
- Outsourced functions
- Track maintenance or access regimes.

9.5.4 Commercial efficiency

This type of benchmarking is concerned with comparing:

- Relative costs and prices for inputs
- Comparative consumption of inputs and their associated costs; and
- Regulatory regimes and market structure conditions.

9.5.5 Suggested benchmarks

The following focuses on performance metrics likely to be most relevant in the context of the consideration of freight rail proposals (generally with an infrastructure focus) for which these Guidelines are most relevant.

Table 21 provides an (illustrative) set of KPIs/performance metrics appropriate to a range of investment objectives and associated benefits commonly relevant to freight rail investment proposals.

Table 21 Potential KPIs to support freight rail infrastructure funding requirements

Investment Objective	Benefit sought	KPIs
Increased capacity	Network Capacity Efficiency	Network Throughput Number of train services Gross tonnes Tonnes per km of section Number of train paths available % of theoretical capacity consumed
Improved Productivity	Train Productivity/ Efficiency	Km and tonnes per locomotive Km and tonnes per train Km and tonnes per wagon Cycles per year % of theoretical capacity consumed Average running speed Average train size Average power:weight ratio

Investment Objective	Benefit sought	KPIs
		Average gross:net ratio for round trip Return load ratio% cycle time o line haul % cycle time in terminals
Fleet and Staff Utilisation	Reduced downtime and spares	Percentage downtime Cycle time productivity Spares allocation Average repair time Cycle redundancy % Average fleet age
Infrastructure Cost	Relative cost comparison Linkage between amount of use and capex	Capital and maintenance cost per km/section Cost per 000 GTK Cost per train Cost per tonne
Signalling and Communications	Relative cost comparison	Cost per train Cost per 000GTK
Safety	Relative cost comparison	Incidents per year per section Near incidents per year per section Incidents per 1000 trains Incidents per million train kilometres Incidents per 1000 GTK Level crossing performance
Track Reliability	Reduced downtime	Length and frequency of temporary speed restrictions % of track under speed restrictions Enroute delays % per cycle
Rollingstock Costs	Measures of efficiency, reliability and productivity	Cost per unit (locomotive/wagon) Cost per km Cost per tonne Cost per 000 GTK
Input Unit Costs	Comparative cost structures and local pricing efficiency	Train Crew Cost Ground Crew Cost Energy Cost Track and Equipment Capital Cost Track and Equipment maintenance and servicing Costs
Overall Commercial Performance	Major benchmark of overall performance	Cost per tonne of freight: Rollingstock cost per tonne; Other variable or operating cost per tonne; Overhead cost per tonne; and Access/track charges per tonne Cost per net tonne kilometre of freight: Rollingstock cost per ntk; Other variable or operating cost per ntk; Overhead/fixed cost per ntk and Access/track charges per ntk

Investment Objective	Benefit sought	KPIs
		The above statistics expressed per train tonne kilometre may also be helpful.
Service Performance	Customer satisfaction	% on time arrivals % on time departures % defects/damages
Overhead and Markups	Corporate efficiency	% markup on capital and operating cost

Appendix A Parameter values

The following is provided as a guide to assist in defining and implementing the freight rail appraisal process. The values are indexed to December 2018 prices. They represent indicative parameter values for the rail freight sector in Australia. It is acknowledged that, in some jurisdictions, local knowledge and data may be a better source than the parameter values that are provided here. In the absence of such local information, the parameter values presented here provide a useful benchmark.

A.1 Introduction

It is anticipated that analysts will use a spreadsheet for constructing a train operating cost model as an input into the CBA process. This appendix provides guidance for analysts to develop their own in-house models and to provide benchmarked unit rates based on various rail operations in a number of jurisdictions including Australia, NZ and South Africa. The parameter values provide a consistent basis for comparison between projects and a short cut alternative to analysts developing their own customised models. Because of the diversity of rail operations, geographies and circumstances, analysts are encouraged to tailor their models to their own specific purposes.

The parameter values in this Appendix cover three broad areas:

- Above rail operations
- Below rail operations
- Other

The Appendix also covers ways in which the parameters can be modified by the analyst for customised usage.

A.2 Above rail operations

The major components of a rail freight operational cost model are:

- Capital cost of locomotives and rollingstock
- Crewing and labour costs
- Energy costs
- Locomotive and wagon servicing and repair
- Terminal costs

A.2.1 Capital cost of locomotives and wagons

The rollingstock fleet in Australia contains a significant imported component ranging from fully and partially imported to local assembly from kit parts. There is also a considerable difference in costs depending on the source. Traditional sources such as US, UK and Japan are now being joined by equipment originating in China, India and Europe. For this reason, it is best that the analyst customise their own model based on the latest available information.

It is also important to note that some of the imported Chinese and Indian manufactured units are reportedly considerably less expensive — up to 40% less than US and Western European sourced equipment. The other note of caution is that exchange rates can be volatile especially over the long period of time associated with long term assets such as rollingstock.

Table 22 shows the amortised annual cost of locomotives based on a 25-year economic life, a 30% half-life refit (component change out, CCO) in year 13, and a 5% residual value. The half-life refit is considered a capital cost rather than routine maintenance.

Table 22 Amortised locomotive capital cost ($m, December 2018)

Locomotive type	Upfront capital cost	Discount rate		
		4%	7%	10%
Non-standard diesel 2000hp	6	0.45	0.57	0.72
Non-standard diesel 3000hp	6	0.45	0.57	0.72
Non-standard diesel 4000hp	7	0.52	0.67	0.83
Non-standard diesel 5000hp	8	0.59	0.77	0.95
Non-standard electric 4000hp	7	0.52	0.67	0.83
Standard diesel 2000hp	6	0.45	0.57	0.72
Standard diesel 3000hp	7	0.52	0.67	0.83
Standard diesel 4000hp	8	0.59	0.77	0.95
Standard diesel 5000hp	8	0.59	0.77	0.95
Standard electric 4000hp	7	0.52	0.67	0.83

Source: Cardno estimate based on industry knowledge and a variety of industry sources.

Analysts can undertake the necessary calculations using the following Excel spreadsheet formula:

> =PMT(*rate*,*life_years*,-*capital_cost**(1+*refit_proportion**(1+*rate*)^-ROUNDUP(*life_years*/2,0)-*residual_value_proportion**(1+*rate*)^-*life_years*)

Non-italicised terms are Microsoft Excel functions.

For the $6 million locomotive at the 4% discount rate, the formula is:

> *0.45 =PMT(0.04,25,-6*(1+0.3*(1+0.04)^-ROUNDUP(25/2,0)-0.05*(1+0.04)^-25)*

The same approach can be used for wagons, with the same caveats regarding the point of origin. For Table 23, an economic life of 30 years is assumed, with the half-life refit costs at 30% and residual value at 5% of the original capital cost. The analyst should be aware that there is a considerable amount of legacy rollingstock, much of which is past its economic life.

Table 23 Amortised wagon capital cost ($m, December 2018)

Wagon type	Upfront capital cost	Discount rate		
		4%	7%	10%
Double slot container Wagon	0.150	0.010	0.013	0.017
Triple slot container Wagon	0.180	0.012	0.016	0.020
Double slot well wagon	0.180	0.012	0.016	0.020
Rail tank car - LPG/LNG 80 tonne	0.200	0.013	0.018	0.023
Rail tank car - LPG/LNG 60 tonne	0.180	0.012	0.016	0.020
Mineral Hopper 160 tonne	0.160	0.011	0.014	0.018
Mineral Hopper 120 tonne	0.150	0.010	0.013	0.017
Mineral Hopper 100 tonne	0.150	0.010	0.013	0.017
Mineral Hopper 80 tonne	0.120	0.008	0.011	0.014
Grain/Bulk Commodity Hopper 100 tonne	0.150	0.010	0.013	0.017
Grain/Bulk Commodity Hopper 80 tonne	0.120	0.008	0.011	0.014
Grain/Bulk Commodity Hopper 60 tonne	0.120	0.008	0.011	0.014
Open flat wagon 100 tonne	0.150	0.010	0.013	0.017
Open flat wagon 80 tonne	0.120	0.008	0.011	0.014
Open flat wagon 60 tonne	0.120	0.008	0.011	0.014
Box wagon 80 tonne	0.160	0.011	0.014	0.018
Box wagon 60 tonne	0.140	0.009	0.012	0.016

Table note: As noted above, Chinese and Indian sourced equipment can be procured at considerably lower prices than US, European or Australian sourced equipment. The estimates here are based on Australian sourced wagons. The same caveats regarding exchange rates on imported equipment are also relevant here.

Source: Cardno estimate based on industry knowledge and a variety of industry sources.

A.2.2 Crewing cost

Table 24 summarises the major costs components and conditions for labour. Analysts are advised to provide a local context to suit the specific project since there are a variety of enterprise agreements and industrial awards in operating covering working hours and conditions. In contrast to the capital costs above, this is a bottom-up approach based on an individual train operation that can be replicated depending on the number of trains operated.

Table 24 Train crew cost components (December 2018)

Train operations	Unit	Rate
Train Crew Cost	per hour	$200
Crew members per train	number	1
Maximum hours per shift	hours	10
Semi-skilled labour cost	per hour	$100

Sources: Transport for NSW 2018 Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives 2018, Appendix 4, Cardno Unpublished Consultant's Survey

A.2.3 Energy consumption and cost

Energy consumption and the price of energy is difficult to provide generic estimates therefore a range of values has been set out here. Energy prices are highly volatile and the analyst should use the expected energy consumption rates provided here with the prevailing energy price as a way to estimate train energy costs. There are several ways of estimating consumption based on:

- Type of terrain
- Tractive effort
- Per GTK
- Per km
- Per hour

All of these approaches are acceptable but each has its own strengths and weaknesses. The analyst should strive for consistency in approach. Table 25 summarises litres consumption per locomotive kilometre for diesel electric locomotives (DEL) under a variety of operational conditions.

Table 25 Diesel consumption per locomotive kilometre

Locomotive type	Litres per km			
	Flat	Curvy	Hilly	Mountain
Non standard diesel 1500hp	4.5	5.6	6.8	7.9
Non standard diesel 2000hp	5	6.3	7.5	8.8
Non standard diesel 3000hp	6	7.5	9.0	10.5
Non standard diesel 4000hp	7	8.8	10.5	12.3
Standard diesel 2000hp	5	6.3	7.5	8.8
Standard diesel 3000hp	6	7.5	9.0	10.5
Standard diesel 4000hp	7	8.8	10.5	12.3
Standard diesel 5000hp	7.5	9.4	11.3	13.1

Source: Cardno estimate based on industry knowledge and a variety of industry sources.

Based on a tax free bulk rate of $1.30 per litre, approximate energy cost per locomotive km is summarised in Table 26.

Table 26 Train energy cost ($ per locomotive km, December 2018)

Locomotive type	$ per km			
	Flat	Curvy	Hilly	Mountain
Non standard diesel 1500hp	5.85	7.31	8.78	10.24
Non standard diesel 2000hp	6.50	8.13	9.75	11.38
Non standard diesel 3000hp	7.80	9.75	11.70	13.65

Locomotive type	$ per km			
	Flat	Curvy	Hilly	Mountain
Non standard diesel 4000hp	9.10	11.38	13.65	15.93
Standard diesel 2000hp	6.50	8.13	9.75	11.38
Standard diesel 3000hp	7.80	9.75	11.70	13.65
Standard diesel 4000hp	9.10	11.38	13.65	15.93
Standard diesel 5000hp	9.75	12.19	14.63	17.06

For electric locomotives, energy cost is typically about $0.14 to $0.20 per kWH. Assuming a 3mW locomotive, at 100% effort and travelling at 100kmh, the cost is between $4.2 and $6 per km. This is calculated by multiplying the per hour cost times the energy consumption and dividing by the kilometres travelled.

An alternative way to estimate diesel fuel consumption is based on train type (hence load and tractive effort) and terrain. Table 27 provides a summary of benchmarked consumption rates per thousand GTK for a variety of train types operating in a variety of terrains. For an estimate over mixed terrains, a weighted average based on length of each type of terrain could be used where required.

Table 27 Diesel fuel consumption (litres per thousand GTK)

Train	Flat	Curvy	Hilly	Mountain
Container train	4	6	6	8
General purpose train	4	4.5	5	6
Grain train	5	4.5	5	6
Heavy haul mineral	3	3.5	3.7	5

Source: Cardno estimate based on industry knowledge and a variety of industry sources.

A.2.4 Locomotive and wagon maintenance and servicing

This cost consists of:

- Routine maintenance, day to day and scheduled as opposed to half-life refits which are considered a capital cost item
- Servicing and replenishment, which includes consumables such as lubricants and minor components plus the labour required for removal and installation and testing.

The locomotive charges consist of two parts based on ABC principles:

- A cost per km for items such as wheels, traction motors, etc. whose wear and tear are a function of usage — specifically kilometres travelled and
- A cost per hour for items which are consumed independent of distance travelled.

The two costs are to be used together, not as substitutes for each other. Table 28 summarises those estimated costs.

Table 28 Locomotive maintenance and servicing cost $ per km and per hour (December 2018)

Locomotive Type	Cost per km	Cost per hour
Diesel 1500 - 2000hp	1.3	20
Diesel 2500 - 4000hp	1.3	20
Diesel over 4000hp	1.3	20
Electric 4000hp	1.3	15

Sources: http://www.railpage.org.au/ausrail/99august/msg01312.html

The driver for wagon maintenance is wear and tear based on distance travelled and is independent of load status. Estimated costs per thousand wagon-km are summarised in Table 29.

Table 29 Wagon maintenance and servicing ($ per thousand km, December 2018)

Wagon type	$
Container Flat	70
Bottom Discharge Hopper	125
Box Wagon	100
Rail Tanker	90

Source: Cardno estimate based on industry knowledge and a variety of industry sources.

A.2.5 Terminal costs

The per train cost component of terminals is based on benchmarked throughput rates and does not include lifting charges (for containers). Based on several benchmarks in various locations, a container train up to about 1200 metres will cost about $5000 and for larger trains, $8000 to marshal/shunt/load/unload depending on the complexity of the operation. Many point-to-point trains such as grain or coal have minimal costs outside the train operating costs already counted above on a per hour basis. Allowing two hours of active work and an hour of static (waiting) time per stopover is reasonable for most trains. For coal and grain trains, the other major terminal constraints are capacity of loader and unloader equipment plus headways between trains. Consulting with rail operators is recommended.

A.3 Below rail operations

The main components are:

- Track maintenance and repair
- Signalling, train control
- Track Access Charges.

A.3.1 Track maintenance and repair

Routine track maintenance is regarded as a programmed maintenance schedule often independent of wear and tear over the section. Table 30 summarises high and low annual estimates for a number of different operational scenarios. The driver for this is average volumes in a specific time period (one year). In contrast, the variable track component maintenance is a response to normal wear and tear which is a function of usage — specifically gross tonnes over the section. This is normally estimated on the basis of per thousand gross tonne km as shown in Table 31.

Table 30 Routine/Scheduled Cost ($000 per km pa, December 2018)

Track maintenance	Low	High
Low density branch line	15	25
Secondary line	25	35
Interstate or mainline	25	45
Coal or heavy haul line	40	60
10 year programmed rehabilitation*	10	60

** 10 year Programmed Rehabilitation can also be estimated as a percentage mark up on routine maintenance. A low estimate might be 50% and a high estimate might be 100%. It is important to clarify whether the scope of the rehabilitation is in fact a capital item upgrade or a scheduled maintenance activity.*

Source: Cardno estimate based on industry knowledge and a variety of industry sources.

ARTC reported maintenance expenses of $169.956 million in 2018 which equates to about $20 thousand per track km.[6]

Table 31 Variable track maintenance ($ per thousand GTK pa, December 2018)

Track maintenance	Low	High
Variable track maintenance	$1.50	$3.00

Source: Cardno estimate based on industry knowledge and a variety of industry sources.

The above table is constructed from a variety of sources including TfNSW and is corroborated with Cardno's estimates based on Aurizon data which results in an estimate of $2.2 per 000NTK. For gross to net ratio 80:20 on forward trip, empty for return trip.[7]

[6] Sources: TfNSW (2018) Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives (PGEATII) Appendix 4, https://www.artc.com.au/uploads/Annual-Report-Final-Web-Accessible-Version.pdf

[7] Source: see p18 https://www.aurizon.com.au/~/media/aurizon/files/investors/documents%20and%20webcasts/2018/full%20year%20results/aurizon%20annual%20report%202018.pdf

A.3.2 Access Charges

Access charges typically involve a fixed flagfall component and a variable component. The charges attempt to offer different pricing according to the demands placed on the infrastructure with respect to quality of track, timing of usage, strategic location, type and size of train and competition from other above rail users for the available capacity. Table 32 shows costs for sections under the control of ARTC. The sections are of unequal length hence a simple comparison of the per section cost is misleading.

Care must be taken not to double count access charges and track charges. They are both considered to be the same thing although an access charge will include a profit margin which should be removed from the CBA.

Table 32 ARTC Access Charges 2018

TRACK	EAST - WEST										NORTH - SOUTH					HUNTER VALLEY & INLAND				
	Parkes - Broken Hill	Broken Hil - Crystal Brook	Adelaide - Port Augusta	Port Augusta - Parkeston	Tarcoola - Alice Springs	Port Augusta - Whyalla	Adelaide - Pelican Point	Adelaide - Melbourne	Appleton /Dock Junct - Footscray Rd	Footscray Rd- Appleton Dock	Acacia Ridge - Islington	Tottenham - Macarthur	Macarthur Junct South - Sefton Park	Cootamundra - Parkes Junct	Moss Vale - Unanderra	Maitlanmd - Muswellbrook	Muswellbrook - Merrygoen	Muswellbrook - Werris Creek	Goobang Junction - Werris Creek	The Gap - Boggabilla
All Freight	$	$	$	$	$	$	$	$	$ $		$	$	$	$	$	$	$	$	$	$
VARIABLE PRICE PER '000 GTK	**4.286**	**4.29**	**3.287**	**3.287**	**6.158**	**5.543**	**4.841**	**3.676**			**3.830**	**3.012**	**5.787**	**4.218**	**4.845**	**4.081**	**3.601**	**4.081**	**2.683**	**2.773**
FLAGFALL PRICE per TRAIN KM																				
Passenger	1.841	1.841	4.507	4.507	5.531			2.773												
Express Freight	1.204	1.204	4.267	4.267				2.230				1.267	4.076	1.267						
Regular Freight	1.281	1.281	4.248	4.248	5.134	2.857	3.043	2.587	52.098	22.314	2.085	2.020	8.964	1.671	1.230	5.712	5.843	4.977	0.647	0.590
Super Freight	1.182	1.182	4.237	4.237	5.134	2.857	3.043	2.280	52.098	22.314	1.107	1.198	3.863	1.141	1.198	0.516	0.559	0.516	0.115	0.590
Standard Freight	0.602	0.602	3.021	3.021	3.764	2.065	2.531	2.169	52.098	22.314	0.982	0.740	3.411	0.503	0.619	0.516	0.504	0.516	0.097	0.590
Heavy Freight *																				
VARIABLE PRICE PER '000 GTK	**5.208**	**5.208**	**3.993**	**3.993**	**7.484**	**6.738**	**5.882**	**4.469**			**3.830**	**5.843**		**8.185**	**7.793**					
FLAGFALL PRICE per TRAIN KM	1.558	1.558	5.164	5.164	6.240	3.473	3.700	3.146			2.085	2.020		1.671	1.230					
Express Passenger																				
VARIABLE PRICE PER '000 GTK	**4.227**										**3.781**	**2.984**			**4.777**	**4.026**		**4.026**	**2.646**	**2.517**
FLAGFALL PRICE per TRAIN KM	2.136										2.258	2.422			2.175	2.131		2.150	2.153	1.928

Adhoc Grain																				
VARIABLE PRICE PER '000 GTK	**4.286**	**4.286**	**3.287**	**3.287**	**6.158**	**5.543**	**4.841**	**3.676**			**3.830**	**3.187**	**5.787**	**4.218**	**4.845**	**4.081**	**3.601**	**4.081**	**2.683**	**2.773**
FLAGFALL PRICE per TRAIN KM	0.602	0.602	3.021	3.021	3.764	2.065	2.531	2.169	52.098	22.31 4	0.982	0.784	3.411	0.503	0.619	0.516	0.504	0.516	0.097	0.590

FLAGFALL APPLICATION

FLAGFALL	TRAIN TYPE AND DESCRIPTION	EXAMPLE TRAINS (To be used as a guide only)
Express Passenger	Max train speed above 115kph /Max Axle Loading up to 19T	XPT, Intra Urban Passenger, Intra State Passenger
Passenger	Max train speed 115kph /Max Axle Loading up to 19T	Long Distance Passenger
Express Freight	Max train speed 115kph /Max Axle Loading up to 20T	Express Freight
Regular Freight	Max train speed 80kph / Max Axle Loading up to 23T / Length to corridor standard max	Scheduled Services including Steel, Cement, Concentrates Limestone, Minerals
Heavy Freight	Max train speed 80kph / Max Axle Loading up to 25T / Length to corridor standard max	Limestone , Minerals
Superfreight	Max train speed 110kph / Max Axle Loading up to 21T / Length up to corridor standard max	Intermodal, Land Bridging
Standard Freight	Max train speed 80kph / Max Axle Loading up to 23T / Length to corridor standard max	Non Scheduled services excluding Grain
Adhoc Grain	Max train speed 80kph / Max Axle Loading up to 23T / Length to corridor standard max	Non Scheduled Grain services

Source: https://www.artc.com.au/uploads/Access-Charges-effective-1-July-2018.pdf

For most container trains and ad hoc grain trains on most of the ARTC corridors, the variable price per thousand GTK is between $3 and $6, depending on the corridor. Very short sections or low density routes tend to attract higher charge. Rates for heavier trains, e.g. interstate steel and heavy industrial products are charged at a higher rate. Ad hoc grain trains receive a preferential flagfall charge compared with most container trains.

A.4 Other operations

These costs represent a two-part mark up. The first is a mark-up on all above and below rail costs, the second is a mark-up on all above and below rail costs plus the operational mark-up. The estimates are summarised in Table 33.

Table 33 Other costs

Item	Low	High
Operational mark-up - operations, supervision, train control, etc.	5%	10%
Corporate mark-up — profit and head office administration, finance, marketing, etc.	15%	20%

Source: Cardno estimate based on industry knowledge and a variety of industry sources.

Table 34 summarises the expected economic life of major below rail infrastructure assets.

Table 34 Economic life of above and below rail infrastructure (years)

Item	Central	Low	High
Locomotives	30	25	50
Wagons	25	20	30
IT control systems	5	4	10
Signals and communications	15	10	20
Earthworks	100	100	150
Bridges	40	40	120
Tunnels	100	100	100
Culverts	100	100	120
Steel rail	100	100	100
Turnouts	12	10	20
Ballast	60	60	60
Sleepers timber	20	20	20
Sleepers concrete	50	50	50

Source: Cardno estimate based on industry knowledge and a variety of industry sources.

Appendix B List of relevant abbreviations and terms

Abbreviation/ Acronym	Meaning
ABC	Activity Based Costing
Above rail	Refers generally to train operations and activity occurring above the rail
AC traction	Alternative Current Traction
ARRDO	Australian Roads Research and Development Organisation
ARTC	Australian Rail Track Corporation
Aurizon	formerly QRNational - an above rail operator
Below rail	Refers to the formation, sleepers, rail and signalling which support train operations
BITRE	Bureau of Infrastructure Transport and Regional Economics
Capex	Capital Expenditure
Car/Carriage	Conventionally used for conveying passengers as opposed to freight in wagons. Exceptions are tank cars
CCO	Component change out
CIF	Cost, Insurance and Freight
Consist/Train consist	The configuration of a train including locomotive and wagon combinations
COPEX	Capitalised Operating Expenditure
CPI	Consumer Price Index
DC	Distribution Centre
DC (traction)	Direct Current Traction
Diverted Traffic	Freight that changes routes but still travels between the same origin and destination pair.
DORC	Depreciated Optimised Replacement Cost
DTC	Direct Traffic Control is a non-signalled absolute block safe working train movement control system
EC	Electric Energy Component
EGTK	Electric Gross Tonne Kilometres
FCL	Full Car/Container Load
FEU	Forty foot Equivalent Unit (sea freight container) — a 12 metres container
First Mile - Last Mile	The extreme ends of a logistics chain, not the line haul
FMM	Freight Movement Model
FOB	Free On Board
FY	Financial Year
GC	Generalised Cost
Generated Traffic	New traffic which formerly did not exist but now occurs as a result of the project.

Abbreviation/ Acronym	Meaning
GTK	Gross Tonne Kilometre - a measure of transport task, like NTK but includes tare mass
Hazchem	Hazardous Chemical
HML	High Mass Limit
Hopper	Open high sided wagon suitable for bulk minerals, grain, powder, solids
HPV	High Productivity Vehicle - B-double or larger combination
HV	Heavy Vehicle
IA	Infrastructure Australia
IBCR	Incremental Benefit Cost Ratio
ICT	Information and Communication Technology
IMEX	Import/Export (Containers) Refers to Container Movements
Induced freight	Sum of generated and diverted freight
ITS	Intelligent Transport Systems
JIT	Just in time
LCL	Less than Car/Container Load - small quantities of freight
LCV	Light Commercial Vehicle
Locomotive	Unit providing tractive effort for propulsion of a train
LOS	Level Of Service
LV	Light Vehicle
Marshalling	The activity of forming up a train
Mt	Million Tonne
mtpa/MTPA	million tonnes per annum
MVKT	Million Vehicle Kilometres Travelled
NA	Not Available
Natural Growth	The growth associated with population and other socio-political and economic issues which will occur whether or not a project proceeds.
NT	Net Tonnes
NTK	Net Tonne Kilometre - a measure of transport task, mass x distance travelled
O&M	Operating & Maintenance Cost
OD or O-D	Origin and Destination
OHTE	Overhead Tractive Energy/Effort
OPEX	Operational Expenditure
PA	Per Annum
PCE	Passenger Car Equivalent
PCU	Passenger Car Equivalent Unit
Pit to Port	The entire landside logistics chain for export minerals and ores
PN	Pacific National - an above rail operator
PUD	Pick-up and delivery

Abbreviation/ Acronym	Meaning
PV	Present Value - current value of a discounted future value
QR	Queensland Rail Limited
RCS	Remote Control Signalling where train movements are controlled by displayed colour light signals
Rollingstock	Locomotives and wagons
Shunting	Activity of repositioning rollingstock within a terminal
Slot — train slot	A space in a train timetable where a train can be operated.
T	Tonne
TAL or tal	Tonne Axle Load
Tare	Empty Vehicle Mass
TEU	Twenty foot Equivalent Unit (sea freight container) - a 6 metres container
TSC	Transport Services Contract (rail freight services)
TSC	Transport Services Contract
VHT	Vehicle Hours Travelled
VKT	Vehicle Kilometres Travelled
Wagon	Rollingstock to carry freight
WTP	Willingness to Pay

Appendix C CBA result formulas

General

All benefits and costs in each future year of the appraisal period are discounted back to the base year.

The summation of all annual discounted present values of a stream of benefits or costs is called the ‘present value’ of that stream.

See ATAP Part T2, Chapter 10 for more detail on CBA results formulas listed here.

Net present value (NPV)

- The NPV of an initiative is the difference between the discounted stream of benefits and the discounted stream of costs. The NPV is given by:

$$NPV = \sum_{t=0}^{n} \frac{B_t - OC_t - IC_t}{(1+r)^t}$$

where:

- t is time in years
- n is number of years of the appraisal period
- r is the discount rate
- B_t is benefits in year t
- OC_t is infrastructure operating costs in year t
- IC_t is investment costs in year t.

A positive NPV means that the initiative represents an improvement in economic efficiency compared with the Base Case.

Benefit cost ratio (BCR)

There are two alternative definitions of BCR depending on whether one puts infrastructure operating costs in the numerator or the denominator.

$$BCR1 = \frac{PV(B)}{PV(OC + IC)}$$

$$BCR2 = \frac{PV(B - OC)}{PV(IC)}$$

$$where\ PV(x) = \sum_{t=0}^{n} \frac{x_t}{(1+r)^t}$$

A BCR greater than one implies a positive NPV.

Incremental BCR

The incremental BCR (IBCR) is defined as:

$$IBCR = \frac{PV(B_2 - OC_2) - PV(B_1 - OC_1)}{PV(IC_2) - PV(IC_1)}$$

where the subscripts represent options 1 and 2, and option 2 has the greater investment cost. The IBCR is well-suited for comparing options involving different scales of initiative. Increases in the scale of initiative are worthwhile as long as the IBCR for each scale exceeds one.

Appendix D Types of Initiative and Appraisal Guidance

This section covers:

- Potential projects based on performance outcomes
- Potential projects based on infrastructure or operational/process changes
- Initiative Appraisal Guidance.

Potential projects based on performance outcomes

To improve running time/operational performance, e.g.

- New track or loops e.g. to improve geometry
- New bridges and structures — to improve clearances, axleloads, capacity
- New signalling and telecommunications reduced headways and delays,

To improve reliability/operational performance, e.g.

- Upgraded track or loops - e.g. timber sleeper replacement
- Bridges and structures — to reduce maintenance downtime, frequency and cost
- New signalling and telecommunications to improve reliability and capacity

Potential projects based on infrastructure or operational/ process changes

- New crossing loop or duplication
- New higher capacity bridge
- Improved tunnel clearances
- Flood proofing/mitigation
- New higher power locomotives
- Higher capacity wagons
- Electrification
- Branch line rehabilitation and reactivation
- Relocation of freight terminal
- Alteration of operational hours at terminals
- New container handling equipment

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