Transport for NSW

Freight Benefit Guidelines

August 2022

NSW GOVERNMENT

transport.nsw.gov.au

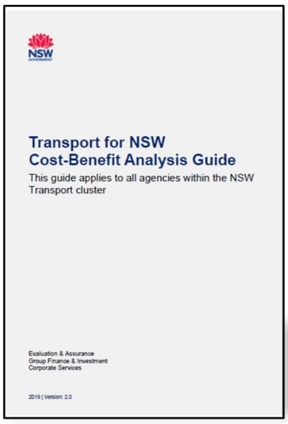
Table of Contents

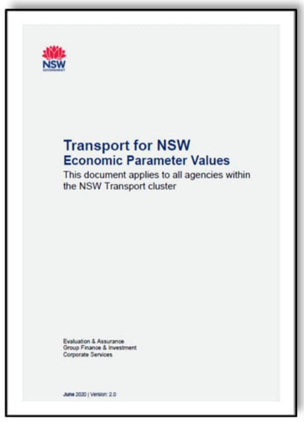
1 Introduction

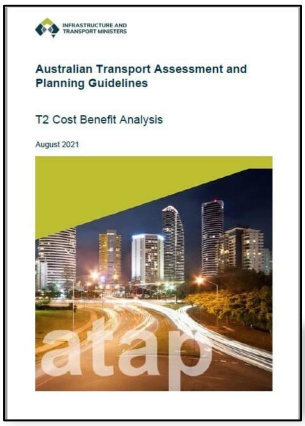
This document aims to assist economic and project development professionals (or ‘practitioners’) in identifying benefits related to freight initiatives. This will enhance the way in which freight benefits are captured in economic appraisals across the NSW Transport Cluster. The Freight Benefit Guidelines (or ‘Guidelines’):

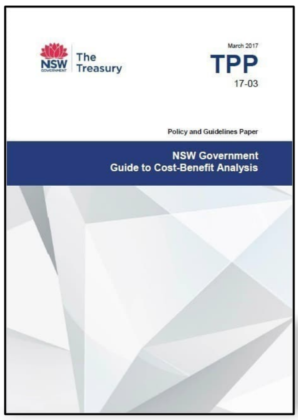
- Outline the supply chain context in which freight benefits should be considered;
- Identify economic benefits that can be derived from freight initiatives and maps these to outcomes in TfNSW’s 10 year blueprint;[1]
- Outlines, for each freight benefit category:
    - The underlying problems or constraints that could be addressed by new initiatives;
    - The types of initiatives that could deliver freight benefits;
    - TfNSW outcomes that can be achieved with each benefit;
    - Guidance for practitioners in monetising each benefit.

This Guideline has been informed by consultations with Government and industry. It is intended to support, complements and enhances the existing guidelines for cost benefit analysis in NSW (the main guidelines are shown below[2]). Where a specific approach is provided by TfNSW, it should take precedence over other guidance when assessing NSW freight projects.









1.1 Why have specific guidance for freight?

An economic appraisal assesses the incremental costs and benefits of an initiative. It provides evidence to aid sound investment decision making. Cost-benefit analysis (CBA) is the preferred evaluation method of the NSW Government and the NSW Transport cluster. It is required to support funding proposals, and aims to measure the

---

1 TfNSW, *Connecting to the future: our 10-year blueprint*, accessed June 2022.
2 Practitioners should also refer to ATAP Guidelines M3: Freight Rail, ATAP’s National Guidelines for Transport System Management in Australia (NGTSM), ATAP-04 Flood Resilience Initiatives, ATAP-08 Land Use Benefits and other guidelines cited within this document.

economic, social and environmental impacts of a decision on the NSW community, individuals, firms and the government. CBAs may consider the qualitative and quantitative impacts of freight initiatives.

While there is extensive guidance on preparing economic appraisals, they are predominantly focused on passenger transport initiatives. The guidance for assessing freight projects is currently limited, particularly with respect to rail. A more comprehensive approach for evaluating freight initiatives will allow road and rail infrastructure projects to be more meaningfully assessed.

1.2 When to consider freight benefits

Freight benefits can emerge from a range of infrastructure and non-infrastructure initiatives. While these initiatives may be predominately freight focused, freight benefits can also emerge as secondary benefits from other projects, that may be traditionally considered as "non-freight" initiatives. For example, a metropolitan road project may also act as a key freight corridor, providing freight forwarders in regional areas with more efficient access to ports.

This emphasises the need to carefully consider supply chains, freight demand and the potential interaction of the proposed initiative with these factors, to ensure that the full spectrum of benefits (freight and non-freight) are captured in a CBA. This is not just a consideration during the benefit mapping phase but, more importantly, during the options identification stage, as it is critical to ensure that options are capable of unlocking constraints in the existing freight supply chains. Upstream and downstream constraints may require additional initiatives at other points along the supply chain to unlock the benefits of a project.

The freight benefits to be identified may apply to various customers across the supply chain. These include:

- Benefits for freight customers: These are the typical freight specific initiatives that support the rail freight industry (for example, TAL upgrades to the rail freight network, enabling longer heavier and higher trains to operate) and the road freight industry (for example, improved bypasses, new lanes on key highways, or higher capacity bridges to support heavy vehicles);
- Benefits for non-freight customers: initiatives can also benefit non-freight customers (e.g., those customers using passenger services or personal travel by road, the wider community benefiting from reduced externalities). For example, dedicated freight lines may enable additional passenger services on what were previously shared networks[3];
- Benefits from policy or non-infrastructure changes: These benefits stem from regulatory initiatives that could positively affect the freight industry. Examples of these initiatives include: , changes to access regimes, changes to freight train curfews on shared networks, changes to port window arrangements;
- Benefits from non-freight focused initiatives: Practitioners should consider whether projects designed with a focus on non-freight customers may result in benefits for the freight industry. For example, a metropolitan road project may result in benefits for commuters, but other benefits may also emerge for the freight industry as a result of the project, including reduced vehicle operating costs (e.g., as a result of the project supporting use of high productivity vehicles), shorter routes for heavy vehicles, freight travel time savings and resilience benefits resulting from corridor optionality.

1.3 Identifying appropriate benefits

The identification of freight benefits should start at the Investment Logic Mapping (ILM) stage and be carried through the project lifecycle.[4] Projects, programs and strategies should focus on addressing problems and opportunities, with key outcomes in mind. Understanding the existing problems or opportunities that the initiative is seeking to address allows for outcomes and benefits to be clearly articulated and communicated since early stages of the project .

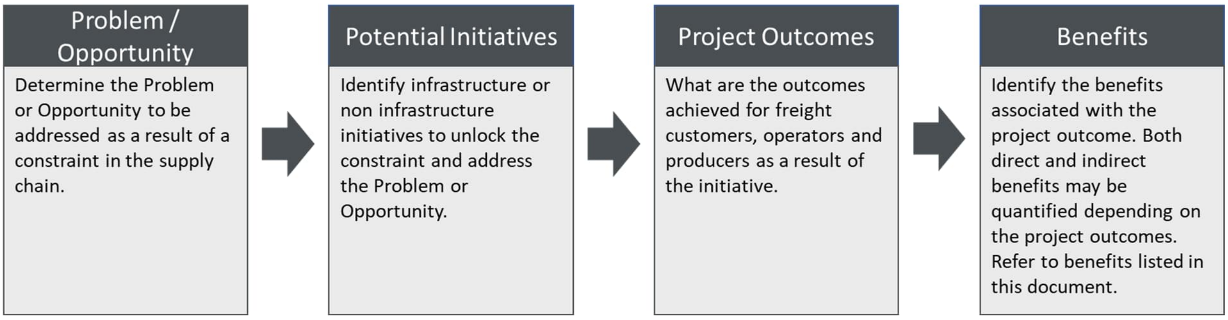
An ILM is a visual representation of the drivers, outcomes and benefits of a strategy, program or project. The ILM tool assists with early benefit and outcome relationship mapping and supports strategic alignment for future prioritisation. Figure 1 outlines the steps involved in developing an ILM.

---

[3] It should be noted that whilst these Guidelines recognise impacts to non-freight customers, the focus of these guidelines is to present methodologies that directly relate to freight initiatives. For example, impacts on the passenger network will have to be assessed with consideration of existing methodologies and guidance as per TFNSW Cost Benefit Analysis Guide and Economic Parameter Values.

[4] Refer to TfNSW's *Cost-Benefit Analysis Guide*, page 23 for further details on developing an ILM.

Figure 1 ILM process



Source – EY

Freight benefits are generally measured directly at the source. This is intended to remove the risk of double counting. If, for example, rail or road operators perceive operating cost savings as a result of a project, they may pass some of those cost savings onto their customers. The effect of these cost savings is typically transferred throughout the supply chain and the economy in the form of lower prices. This however if the same effect just passed on several times, as such measuring it at different nodes of the supply chain will result in double counting.

Additionally, it should be noted that the consideration of distributional effects within the freight context becomes more difficult due to the commercial nature of the relationships within the supply chain. As such, there are a number of factors or costs that the practitioner may not be able to observe (e.g. profit margins, overheads, contractual obligations), which may affect the extent and number of beneficiaries from a freight initiative. The Australian Transport Assessment and Planning (ATAP) Guidelines note that the benefits distribution will depend on the demand and supply elasticities, commercial considerations, and regulatory arrangements.[5]

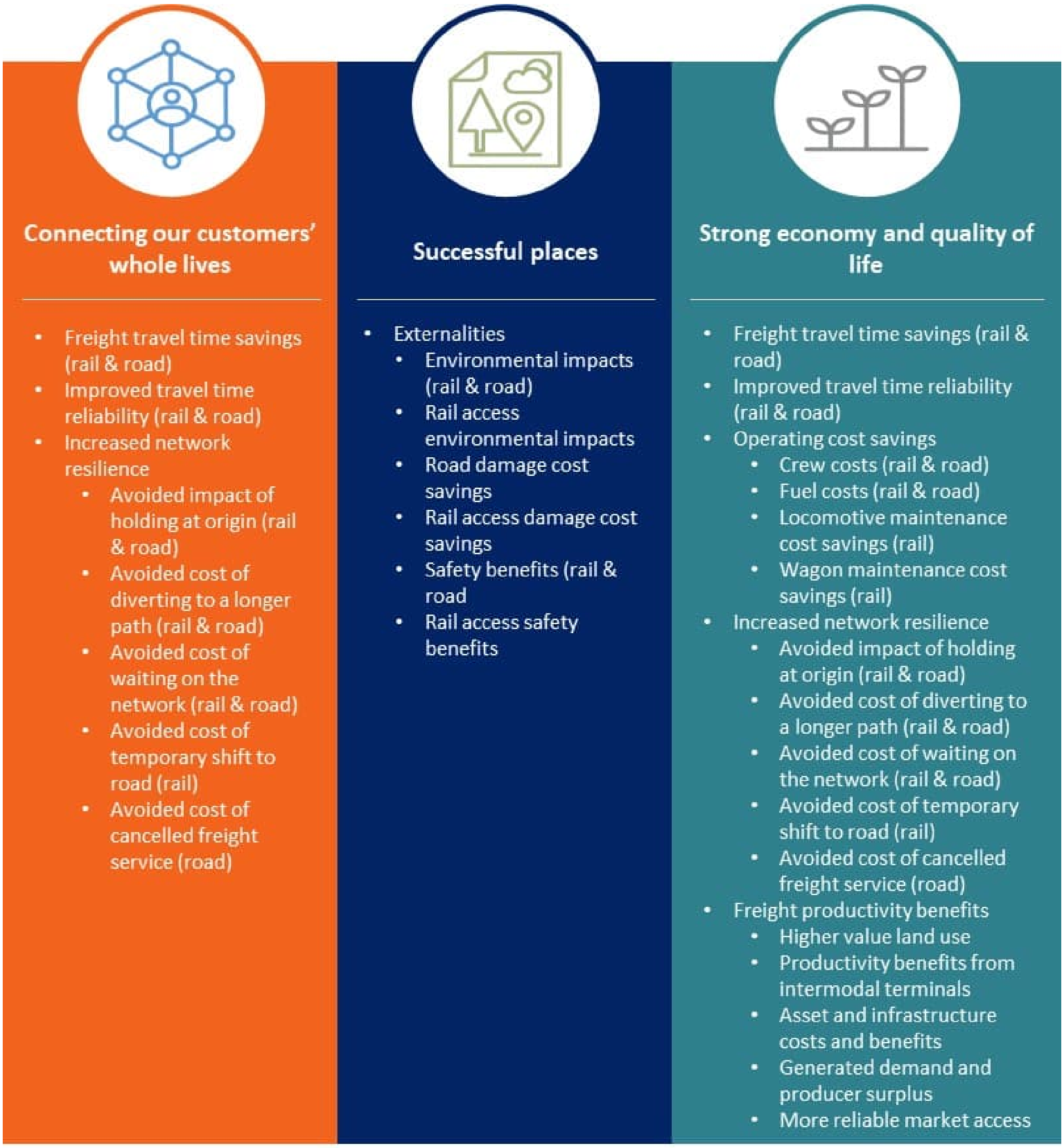
Freight benefits covered in this Guideline include the following categories, disaggregated in more detailed in Figure 2:

- Travel time savings (chapter 2);
- Travel time reliability (chapter 3);
- Operating cost savings (chapter 4);
- Network resilience (chapter 5);
- Externalities (chapter 6)
- Safety benefits (chapter 7);
- Freight productivity benefits (chapter 8).

The freight benefits outlined in this Guideline are aligned with the outcomes in TfNSW's *Connecting to the future – Our 10 Year Blueprint.* The blueprint identifies the desired outcomes, ambitions and strategic priorities between 2019 and 2029. The freight benefits in this Guideline are mapped across three key TfNSW outcomes, as outlined in Figure 2.

[5] Australian Transport Assessment and Planning Guidelines, *M3 Freight Rail*, August 2021, page 40.

Figure 2 Freight benefit alignment to TfNSW 10 Year Blueprint



1.4 Demand and supply chain considerations

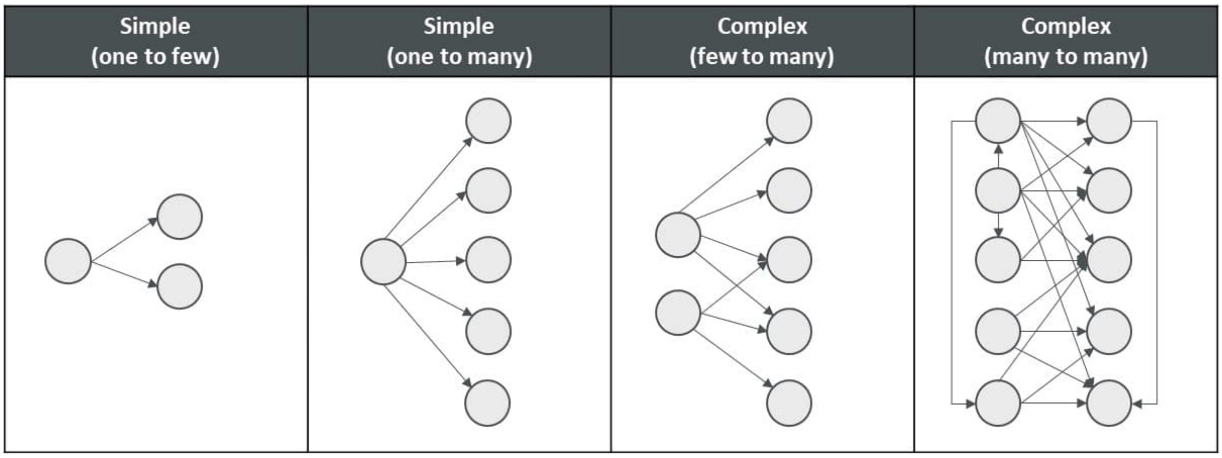
The process of quantifying freight benefits across supply chains should be applied methodically:

- Beginning with an understanding of the relevant supply chains and commodities that are supported by the proposed initiative;
- Progressing to an analysis of the total demand task and the potential changes to the relevant supply chain(s); and
- Concluding with benefits mapping for the relevant supply chains, to identify the specific benefits that could be enabled by an infrastructure or non-infrastructure initiative. This analysis should consider whether additional initiatives are required to unlock constraints upstream or downstream in the supply chain.

A summary of supply chain considerations is available in section 9. Supply chains are the structural networks that facilitate the production and delivery of goods and services to end-users. Freight benefits result from infrastructure and non-infrastructure initiatives that improve the productivity, safety and efficiency of supply chains, by reducing or eliminating constraints, and/or costs. Commodities tend to have unique supply chains, with specific links between producers, freight nodes and end consumers. Therefore, the benefits associated with an initiative should account for its unique supply chain context.

A stylised example of the relationship between producers, freight nodes and consumers is outlined in Figure 3. It is important to note that this is a simplified example of supply chains, and is therefore not intended to account for all supply chain types and factors that may affect them. Depending on market factors, the movement of a single commodity type may be facilitated through multiple supply chain types. Practitioners should also consider other factors beyond nodes when understanding supply chains. For example, price changes may affect the supply of a commodity which, in turn, will affect the demand for freight transport.

Figure 3 Stylised example of relationship between producers, freight nodes and consumers



Source – Neil Matthews Consulting

Freight transport is considered a derived demand, as it is an input into the production of final goods that are demanded by consumers.[6] As such, freight transport is not demanded for its own sake.[7] Freight transport operators and other transport intermediaries[8] intervene in these supply chains to connect producers and consumers. In contrast to public transport, freight transport providers are influenced by profit motives and competition (for example, by acquiring assets that are not easily replicated, such as intermodal terminals (IMTs), ports and rollingstock).

Practitioners should be aware of the major supply chains in NSW, to appropriately consider the impact of a freight initiative. This will allow them to develop a deeper understanding of the linkages across the supply chain, the interdependencies of each supply chain, who the key project stakeholder groups will be, and what barriers there might be to realising benefits upstream and downstream.

Infrastructure and non-infrastructure freight initiatives will result in economic benefits when they affect pricing structures for freight operators and intermediaries. The effects will vary across supply chains, as some can be relatively simple to identify (e.g., coal) and others more complex (e.g., container freight), involving the use of different modes, transfers, and interfaces.

As previously noted, the ability to realise benefits within supply chains will depend on commercial decisions in many cases. Where the realisation of benefits requires additional investment or operational changes, practitioners should consider the extent to which potential benefits will be realised.[9] For example, the benefits of an increase in tonne axle loads (TAL) ,enabling longer, heavier and higher trains to run on a rail line,) will depend on operators having access to a fleet of locomotives and wagons capable of 25 TAL.

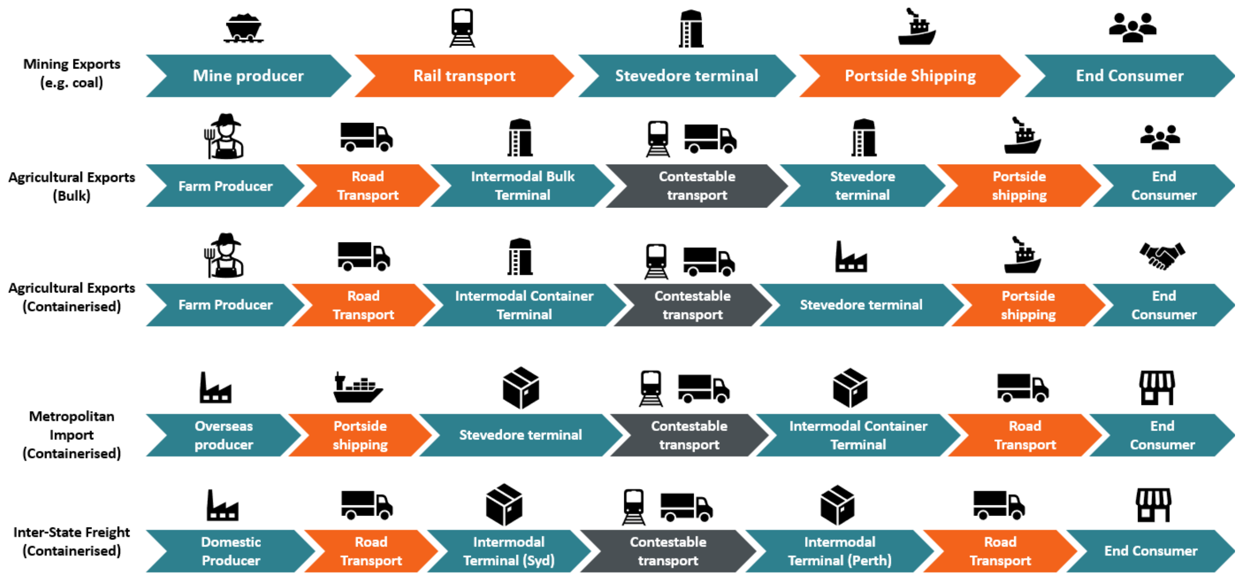
Figure 4 illustrates some of the key supply chains in NSW, noting that the focus of this report is on supply chain benefits arising from land transport initiatives.[10] It is important to note that the supply chains listed in this

---

[6] It should be noted that there is some academic discussion on this point. Rodrigue (2006) *Challenging the Derived Transport Demand Thesis: Issues in Freight Distribution* notes that while this assumption is reflected in the conventional literature, recent developments in logistics and supply-chain management have shown that the functions of production, consumption, and transportation have become embedded to the point that it is difficult to separate them.
[7] Infrastructure and Transport Ministers, *Australian Transport Assessment and Planning Guidelines: M3 Freight Rail*, August 2021, page 10.
[8] Intermediaries can be defined as firms that act as handlers of freight that connect different segments of the supply chain. These include, for example, intermodal terminal, freight forwarders, storage and packing facilities, etc.
[9] Practitioners should account for any reliance on other investments or activities to fully realise benefits by identifying interdependencies when developing the Investment Logic Map and Benefits Realisation Management Plan. Approaches such as a benefits ramp up should also be considered, where relevant to the unique aspects of the supply chains.
[10] Note that this figure does not capture all the supply chains in NSW, for example, it does not show intrastate movements, which represent a portion of the freight task. Instead, its intent is to illustrate some key examples. Practitioners should consider the unique characteristics of the supply chains, as they relate to their projects.

figure are conceptual examples only, to highlight the importance of considering the supply chain context of an initiative. It is not intended to be an exhaustive illustration of all supply chains in NSW.

Figure 4 Conceptual examples of supply chains



Source – EY

When quantifying and monetising the benefits of specific initiatives, practitioners should also consider the impact of supply chains that interact with passenger networks. This is because the impacts on these networks could be far more significant compared to incidents in freight dedicated or remote parts of the network. For example, freight trains carrying exports to Port Botany are required to use the shared freight-passenger network for the final parts of their journey. Breakdowns of freight trains in this specific part of the network could impact passenger services and cut off pathways for other freight trains heading to Port Botany during an outage, creating significant scheduling conflicts and potential delays. Additionally, this impact is more significant in metropolitan areas, due to the frequency of passenger services.

To further support understanding of supply chains and a list of potential sources for data collection is available in Section 9 Appendix A: Supply Chain Considerations Summary.

1.5 Considerations for practitioners when using this Guideline

The table below summarises other specific considerations that practitioners will have to consider when evaluation and estimating freight benefits.

Freight specific approaches	The approaches outlined in this Guideline are bespoke in some cases, as they cater for the unique characteristics of freight supply chains. Benefits estimation for freight is often more complex than assessing vehicle movements or kilometres travelled. Practitioners may need to account for specific supply chain characteristics when assessing demand or estimating the impact of the project on supply chains. Supply chains may be unique due to factors such as the commodity type, the interaction with intermodal terminals and the first and last mile (i.e., pick-up and delivery) required to move goods from point A to point B.[11]
Rule of half (RoH)	Consistent with the consumer surplus approach, practitioners will need to consider whether rule-of-half should be applied when estimating user benefits. For freight projects, this consideration should be made where there is induced demand in the project case. As defined by ATAP, induced demand includes the sum of the following:[12]

[11] Refer to page 14 of ATAP's *M3 Freight Rail* for a description of the additional costs that can result from these supply chain factors.
[12] Australian Transport Assessment and Planning Guidelines, *M3 Freight Rail*, August 2021, page 6.

	• Diverted demand: travel that switches from one mode, route, time of day, origin or destination as the result of an initiative;[13] • Generated: Altogether new travel resulting from an initiative. In cases where there is either diverted or generated demand in the project case, the rule-of-half should be applied to benefits that are linked to an operator's willingness to pay (i.e. use the RoH when demand is modelled based on a multi-modal, multi-commodity freight network, rather than commercial decisions for discreet supply chains). These include freight travel time savings and operating cost savings. Practitioners should carefully consider the application of rule-of-half, depending on the nature of freight demand modelling completed for the project (e.g., rule of half would not be applied in cases where a logit model can be used to estimate a consumer surplus gain using a LOGSUM approach). Guidance on applying rule-of-half for the benefits associated with parallel infrastructure[14] (e.g., vehicle operating cost savings due to road freight volumes shifting to rail) can be found in TfNSW's *Technical Note on Calculating Road Vehicle Operating Costs.* The application of rule-of-half will depend on the nature of the road traffic modelling that has been performed.
Value of freight time (rail)	The value of freight time is linked to the timely delivery of freight commodities, and is distinct from the parameters that are linked to the value of driver or passenger time. As such, the parameter is reflected in tonne hours, and is reflective of the time taken to complete the freight task. There are several parameters included in this Guideline, sourced from academic literature. While these parameter values may be a suitable proxy for valuing projects that improve cycle times,[15] they cannot be used to differentiate between different commodity types, or different producer or customer preferences. These enhancements would need to be the product of future statistical studies.
Network capacity	The capacity of the road and rail network will be a key driver of mode share. Projects that support increased throughput (e.g., TAL upgrades) can be expected to encourage increased use of a particular mode, where that mode is cost competitive. In this context, practitioners should consider the entire supply chain when developing project options and mapping benefits. Projects that improve the freight rate may not result in benefits being realised where there is a capacity constraint upstream or downstream that has not been addressed in the proposed scope of the initiative.
Avoiding double counting	Practitioners must carefully consider whether their selected benefits and approaches results in double counting. Specifically: • Rail operating cost savings should be monetised using the methodologies in this Guideline for crew cost savings, fuel cost savings, wagon cost savings and locomotive cost savings. The distributional impacts of these cost savings (i.e., secondary flow-on impacts to producers or consumers) should not be counted, as these impacts have already been quantified by measuring benefits close to their source; • When quantifying network resilience impacts for a road or rail project (i.e., due to an avoided need for route diversions), practitioners should ensure that the benefits for impacted trips are not double counting benefits monetised for core project flows. • Where road or rail trips are assumed to be impacted by incidents in the base case (e.g., due to flooding), network resilience benefits should be quantified for these flows, and road and rail benefits should not be calculated for those

[13] The application of rule-of-half for freight demand changing routes in the project case should be carefully considered. Freight flows are often determined by access arrangements, and are therefore not a behavioural decision made by operators (particularly for existing rails services). In these circumstances, practitioners may choose to claim full benefits.
[14] Parallel infrastructure is the alternative infrastructure that can be used for the freight task. This infrastructure would be ancillary to the infrastructure being considered for an upgrade by the practitioner, and would not be upgraded in the project case. For example, if a project considered upgrading a rail freight line, the parallel infrastructure would be the road network that could be used by freight operators to move between the same origin and destination.
[15] Cycle times include the time spent loading, unloading and travelling from origin to destination (including the empty train's trip back to the origin).

	impacted flows in other benefits streams, as this would result in double counting.
	• Rail reliability benefits can be bespoke, as improved reliability can be the result of:
	  o Increased network capacity that supports timetabling flexibility and on-time running;
	  o Harmonisation of inter-network standards and/or signalling that improves the interfaces between networks;
	  o Dedicated freight networks that reduces the reliance on shared networks which prioritise passenger journeys.
	• Road reliability will be reliant on similar factors, including reduced congestion, which could provide more consistent journey times.
	• Reliability benefits could therefore be quantified as:
	  o Reduced variance in actual arrival times, relative to scheduled arrival times. This would also cover the impact of network incidents on cycle times, outlined in section 5, and should therefore not be used in conjunction with the approaches outlined in this section for those benefits;
	  o Increased mode share over the medium to long term (i.e., as the particular mode is viewed as being consistently more reliable). However, practitioners should consider the extent to which mode share has already been assumed in benefits analysis (i.e., whether further mode share from improved reliability is justified).

Demand modelling	Detailed traffic demand modelling for freight projects may not always be available nor required t from TfNSW's Advanced Analytics and Insights (AAI) team. For smaller and more bespoke projects, practitioners may use more simplified road and rail O-D inputs (i.e., without detailed traffic modelling). This is typically the case for regional projects, such as upgrades to rail branch lines or regional freight corridors. Additionally, consideration needs to be given to freight demand units of measurement. Whilst freight demand could be measured differently (e.g., tonnes, TEUs) depending on the context and data availability, this Guideline has adopted tonnes (per annum) as the headline unit of measurement for benefits calculations. The practitioner will be required to perform the necessary conversions to apply the calculations presented in this Guideline.
The need to consider the application of a 'ramp up' in benefits modelling	Practitioners should consider the lead-in investment time for new above rail assets, as it tends to be much higher than road due to a higher investment risk, higher upfront capital requirements and the commissioning of new assets by network operators. Where an infrastructure improvement allows higher TAL on a rail line, fleet rationalisation towards a higher capacity fleet (e.g., a fleet of trains with 25 TAL capacity) may be required to fully realise benefits. To cater for these delays, practitioners should consider the timeline of their project, other related projects, and whether a ramp-up should be applied in an economic appraisal. Operational benefits resulting from a shift to rail may occur within a ramp up period. Where an improvement will result in a mode shift from road to rail, it may take time for rail to gain market share from road. A ramp up period should be considered based on experience and consultation with industry.[16]

[16] The ATAP Guidelines *M3 Freight Rail*, 2020 Section 4.6 provides details on using a demand ramp-up.

2 Freight travel time savings

Freight travel time savings represent the willingness to pay for commodities to be delivered sooner. In a freight context, this may be due to a number of factors including, but not limited to:

- The ability to better manage inventory;
- Customers wanting to receive the good or product sooner;
- Being able to meet time sensitive demands;
- The perishability of the goods (e.g., fresh produce); or
- Being able to put the product or commodity to work sooner.

Freight travel time parameter values are derived in existing literature by surveying supply chain participants and presenting them with several choices, to understand their time preferences. While, in reality, there may be some differences in the value of freight time for different commodities, the parameter values found in current literature were not developed to this extent. Further studies may be required to produce freight travel time parameter values that reflect the differences in the freight value of time for different commodities. Benefits related to freight travel time savings will be considered for rail and road respectively in the following sub sections.

2.1 Rail freight travel time savings

Rail travel time savings refer to the benefits associated with shorter "cycle times", due to a freight initiative. Cycle times and reliability are the key considerations in this context, as they represent the entire trip (including loading and unloading), rather than a segment of the journey. This is an important consideration when measuring travel time savings for rail, as faster transit times along a part of the journey may not result in reductions in overall cycle times where there are upstream and downstream constraints (for example, delayed entry into shared metropolitan networks, which can lead to unexpected dwell times for freight trains). Practitioners should also consider that initiatives that result in rail freight travel time savings may also result in travel time savings for passenger networks (where those networks are shared between freight and passenger trains). These benefits can be considered using existing guidelines published by TfNSW.

Freight travel time savings tend to be valued by multiplying the incremental time savings for the freight task by the value of freight time. The value of time is generally derived as a willingness to pay metric that represents the marginal rate of substitution between travel time and cost.[17] The value of freight time is therefore distinct from the direct operating costs (i.e., resource costs) of freight train operations.

While freight travel time parameters in existing literature do not appear to differentiate between commodity types, stakeholder consultations indicated that the value of time may be commodity specific. Generally, bulk commodities were not viewed by industry stakeholders as being particularly time sensitive. Therefore, freight travel time savings tend to result in modest benefits, compared to "mass-based" benefits (i.e., those benefits linked to initiatives that enable higher-capacity trains to operate). Where a commodity is time sensitive, industry stakeholders indicated that they tend to opt for the mode that provides them with the best reliability, to ensure the timely completion of the freight task.

2.1.1 What are the problems or constraints associated with freight rail travel times?

The key problems or constraints related to freight rail travel times include:

- Shortages in passing loops that are strategically positioned across the network, that would otherwise reduce headways and provide scheduling flexibility;
- Non-infrastructure constraints such as access regimes (that create restrictions on the periods in which freight trains can enter shared networks), port window booking arrangements, constraints as loading and unloading sites (such as curfews);
- Speed restrictions for specific rail lines, due to the condition of below rail assets or other factors (such as overgrown vegetation or changes to engineering standards over time that increase sighting distance);
- Network reliability issues that require operators to increase buffer times or cancel services;
- Other infrastructure (e.g., location of crew depots and servicing locations, main-line loading sites, length of rail sidings to support efficiency loading and unloading);

[17] Examples of studies that use willingness to pay for the measure include Melbourne-Brisbane Inland Rail Alignment Study, July 2010.

- Operational issues including lack of crossover opportunities and bi-directional signalling.

2.1.2 What are the interventions that can support travel time improvements?

There are several interventions that may support travel time improvements:

- New rail paths that reduce the required service distance. These paths can be created via new motorised connections between existing lines (which may reduce service distance by avoiding the need for trains to travel to other parts of the network for shunting) or greenfield rail lines which provide more direct pathways between a given origin and destination (or which separate freight trains from shared networks);
- Improved below rail infrastructure (e.g., upgrading to higher tonne axle loads) to enable increased speed limits within train operating conditions;
- Non-infrastructure solutions that enable increased speed limits (e.g., Train Operating Conditions (TOC) waiver);
- Greater cant to enable higher speeds through curves;
- Port shuttle services to support Inland port facilities;
- Motorising turnouts to decrease time at intersections and loops;
- Additional passing loops strategically positioned in congested parts of the network to allow for additional train paths, potentially reducing cycle times due to improved scheduling;
- Motorisation of turnouts to reduce crew walking times, leading to a more efficient use of passing loops;
- Non infrastructure improvements that may improve scheduling (e.g., improved data and train monitoring);
- Improved port-side capacity to provide additional loading windows;
- Changes to port window booking arrangements to improve efficiency, (for example, higher penalties for unused windows, and use of intermodals to save shunting time at the port);
- Improved interfaces with ports (for example, through the use of IMTs in metropolitan areas) to streamline operations, such as through breaking up longer trains to align with port-side siding lengths;
- Additional holding roads close to the Sydney Metropolitan Network to stow freight trains for pre-peak positioning;
- Improved interoperability between different rail networks including through the harmonisation of signalling, safety, scheduling and operating standards to improve the interfaces between networks and prevent cycle time delays.

Practitioners should consider initiatives in the context of the supply chain. An initiative may provide benefits for a certain part of the freight journey, but these benefits may not be fully realised due to upstream or downstream constraints.

2.1.3 What are the outcomes associated with travel time savings?

The matrix below provides some example outcomes related to the problem or constraint listed in section 2.1.1 and maps these against relevant benefits and the relevant objectives in *Connecting to the Future – Our 10 Year Blueprint*.[18]

Outcome	Benefits	Alignment with 'Connecting to the Future' Outcomes
Improved scheduling flexibility	• Rail freight travel time savings	<u>Connecting our customers whole lives</u> • Safe, seamless journeys for people and goods <u>Strong economy and quality of life</u> • Quality assets and efficient networks, managed at the right price • Transport investments and solutions that serve the people of NSW • Strong economy and quality of life
Faster journey times that allow for goods to be delivered to customers sooner		<u>Connecting our customers whole lives</u> • Safe, seamless journeys for people and goods <u>Strong economy and quality of life</u> • Quality assets and efficient networks, managed at the right price

[18] Transport for NSW, *Connecting to the future – Our 10 year Blueprint*, 2019

2.1.4 Guide to quantifying benefits

The approach for valuing freight travel time savings focuses on the willingness to pay for freight commodities to be delivered in a shorter time period. In order to capture this value, the parameters sourced from existing literature are expressed in tonne hours. Given that the parameters listed below would result in a relatively wide range of results for freight travel time savings, practitioners should consider using the alternative 1 figure in their core results, and including alternative 2 as a sensitivity.

Benefit	Demand inputs	Transformations	General formula and parameter value
Rail freight travel time savings: Due to improved speed or distance to freight destination	• Base and project case tonnage, by O-D pair • Base and project case loaded journey times, by O-D pair (loading time, travel time for loaded trains, unloading time)	• N/A	Freight travel time savings ($/year) = (base case tonnes/year + project case tonnes/year)/2 x loaded train travel time savings (hr) x value of freight time ($/tonne hr)[19] Value of freight time • Alternative 1:[20] $1.06 (FY2022/tonne hour) • Alternative 2:[21] $1.60 (FY$2022/tonne hour) Net Tonnes • The weight of the commodity loaded on the freight train Loaded train travel time saving: • Rail travel time savings benefits should be calculated for the loaded direction only to ensure that benefits are assigned to the freight commodity, rather than the full cycle time, which includes travel time for empty trains. Empty trains do not hold commodities, and are therefore not time sensitive.

[19] Rule-of-half for induced demand is accounted for in this formula by taking the average of base and project case demand.
[20] ARTC '*Melbourne-Brisbane Inland Rail Alignment Study*', NSW Government, 2010, parameter has been escalated at 2.5% per annum from 2010 to FY2022.
[21] Mary R Brooks, Sean M Puckett, David A Hensher & Adrian Sammons, *Understanding Mode Choice Decisions: A Study of Australian Freight Shippers*, 2012, parameter has been escalated at 2.5% per annum from 2012 to FY2022. Note, this study estimated a value of time of $25.03/hr from surveys regarding a 20 tonne freight shipment. This infers a value of freight time of $1.25/tonne hour, or $1.60/tonne hour when escalated to be in FY2022 terms.

2.2 Heavy Vehicle freight travel time savings

Road freight travel time savings refer to the benefits of faster travel times for freight vehicles. Similar to rail freight travel time savings, this benefit relates specifically to the time value of freight commodities, and should therefore be focussed on loaded trips for road freight vehicles. Freight travel time savings are distinct to user travel time savings and should therefore be considered separately.[22]

2.2.1 What problems or constraints are related to road freight travel time?

The key problems or constraints that relate to road freight travel time include:

- Route choice is often not optimised or well planned by heavy vehicle operators, due to data limitations;
- Steep grades and road geometry for heavy vehicles (limiting speeds);
- Level crossings;
- Travel through regional towns reducing average speed limits for freight trips;
- Limited overtaking opportunities;
- Infrastructure constraints, preventing potentially more efficient pathing for heavy vehicles (e.g., narrow bridges, load limited bridges);

2.2.2 What are the interventions that can support road freight travel time improvements?

Interventions that could support improvements in road freight travel time include:

- New or upgraded infrastructure (e.g., a new lane added to motorway or upgrading of a rail line) to increase capacity and reduce congestion;
- Passing opportunities (e.g., overtaking lanes);
- Signal coordination strategy to enable faster travel along a corridor (e.g. smart motorways);
- New technology solutions (e.g., use of telematics);
- Provision of real-time information for better journey planning.

2.2.3 What are the outcomes associated with travel time benefits?

The matrix below provides some example outcomes related to the problem or constraint listed in section 2.2.1 and maps these against benefits and the relevant objectives in *Connecting to the Future – Our 10 Year Blueprint*.[23]

Outcome	Benefits	Alignment with 'Connecting to the Future' Outcomes
More efficient freight operations that will reduce costs for producers, operators and customers	• Road freight travel time savings	Connecting our customers whole lives • Safe, seamless journeys for people and goods Strong economy and quality of life • Quality assets and efficient networks, managed at the right price • Transport investments and solutions that serve the people of NSW • Strong economy and quality of life
Increased utilisation of higher productivity vehicles, to support faster deliveries to customers		

[22] User parameters (from the perspective of businesses) can be used to capture these time benefits separately. Refer to section 2.2.4 for a worked example.
[23] Transport for NSW, *Connecting to the future – Our 10 year Blueprint*, 2019

2.2.4 Guide to quantifying benefits[24]

There are two approaches that can be used by practitioners to monetise road travel time improvements as a result of a freight project:

- The value of freight time, which is expressed in terms of the tonne hours required for the freight task in the base and project case.
- The value of road travel time for freight vehicles, using Table 3 of TfNSW's Economic Parameter Values and the vehicle hours travelled in the base and project case;

The two methods (summarised below) are supplementary, and should be selected by the practitioner on the basis of available demand inputs. Using both methods in the same CBA should be avoided, as this could lead to the double counting of benefits.

Benefit	Demand inputs	Transformations	General formula and parameter value
Road freight travel time savings: Due to increased speed or reduced distance between origin and destination	• Base and project case tonnage, by O-D pair • Base and project case travel times (loaded direction)	• N/A	Freight travel time savings ($/year) = (base case tonnes/year + project case tonnes/year)/2 x loaded vehicle travel time savings (hr) x value of freight time ($/tonne hr)[25] Value of freight time • Alternative 1:[26] $1.06 (FY2022/tonne hour) • Alternative 2:[27] $1.60 (FY$2022/tonne hour) Net Tonnes • The weight of the commodity loaded on the heavy road vehicle. Loaded truck travel time saving: • Road freight travel time savings benefits should be calculated for the loaded direction only to ensure that benefits are assigned to the freight commodity, rather than the full cycle time, which includes travel time for empty trains. Empty trucks are assumed not to hold commodities, and are therefore not time sensitive.

[24] Note, the methods summarised in this section are specific to freight travel time. Practitioners may wish to also consider the value of occupant/driver time if this is appropriate in the context of their project. Refer to TfNSW's *Economic Parameter Values 2020,* tables 3, 4 and 5 for further details on total values of travel time per vehicle hour (which account for occupancy rates, values per occupant and the value of freight).

[25] Rule-of-half for induced demand is accounted for in this formula by taking the average of base and project case demand.

[26] ARTC '*Melbourne-Brisbane Inland Rail Alignment Study*', NSW Government, 2010, parameter has been escalated at 2.5% per annum from 2010 to FY2022

[27] Mary R Brooks, Sean M Puckett, David A Hensher & Adrian Sammons, *Understanding Mode Choice Decisions: A Study of Australian Freight Shippers,* 2012, parameter has been escalated at 2.5% per annum from 2012 to FY2022.

Benefit	Demand inputs	Transformations	General formula and parameter value
Road travel time savings (value of time by vehicle type):[28]Due to increased speed or reduced distance between origin and destination	• Base and project case travel times (loaded direction) • Average net vehicle capacity • Freight tonnage by O-D pair	• Net tonnes per loaded heavy vehicle (e.g. B-double) by O-D pair[29] • Required trips per annum = net tonnes/net vehicle carrying capacity • Average travel time saving per trip (loaded and unloaded direction)	Road travel time savings ($/year) = (Number of trips base case + project case (trips/year))/2 x vehicle travel time savings per trip (hr/trip) x value of time for heavy-vehicles ($/vehicle hr)[30]

[28] Parameter values for travel time can be found by vehicle type in TfNSW's *Economic Parameter Values 2020*, table 3.
[29] Note: Practitioners can source carrying capacity information for heavy vehicles from the National Heavy Vehicle Regulator's mass and dimension limits (https://www.nhvr.gov.au/files/201607-0116-mass-and-dimension-limits.pdf), adjusted for tare vehicle weights to derive net tonnes using industry sources such as: Road Transport Weight Limits | MTF Logistics Services Sydney
[30] Note: depending on the granularity of demand outputs, practitioners may be required to repeat this calculation for each vehicle type to account different values of travel time. Parameter values for freight ($/vehicle hour) can be found in Table 3 of *TfNSW's Economic Parameter Values 2020*.

3 Travel time reliability

Travel time reliability in freight refers to the certainty with which freight moves between an origin and destination within an expected time period. This is distinct from network resilience, which is related to the impact of unexpected incidents on supply chains. Reliability can play a significant role in mode choices. Consistently poor reliability is likely to disrupt supply chains and result in the use of alternative modes that are viewed as being more reliable.

3.1 Rail reliability benefits

Rail reliability can be a significant factor in the mode choice of operators. Reliable rail networks allow port windows to be met within their scheduled time period, reduce unexpected dwell times on the network and reduce the need for buffer time requirements. The reliability of a network may also affect the investment decisions of users, as unreliable rail operations may necessitate additional storage across supply chains to support higher inventory levels.

Case Study: Reliability of accessing Port Botany through a shared network[31,32,33]

Rail access and reliability of freight trains travelling to Port Botany is an ongoing challenge for freight operators. Freight trains must transit through the Sydney Trains network to reach Port Botany but are subject to limited paths, as priority is given to passenger trains in peak periods.[34]

Other networks that are traversed to reach Port Botany include the Northern Sydney Freight Corridor and Illawarra line. The Northern Sydney Freight corridor is designed to cater to forecast growth of interstate container freight until Inland Rail is operational. However, the Illawarra line is facing increasing demand for passenger services, which will reduce the capacity for freight on the line.

Trains from regional NSW may need to traverse several networks (such as ARTC and CRN) before reaching the Sydney Trains network, which can reduce the reliability of services. Stakeholders indicated that missed windows into the shared network can lead to considerable delays in cycle times.

Construction of optimally placed passing loops can help to increase the options for the network controller to maintain network reliability. This will have additional benefits by allowing a freight service to depart its point of origin later and reduce its overall cycle time to east coast ports.

3.1.1 What are the problems or constraints associated with poor rail reliability?

The key problems or constraints related to reliability:

- Shared networks with frequent passenger rail services can reduce reliable rail operations through metropolitan networks, in their path towards east coast ports;
- Missed pathing windows, as a result of interoperability issues, result in significant delays, as well as upstream and downstream supply chain impacts;
- Negotiating movements between different networks with different operating conditions may present uncertainty for some operators and restrict the ability to monitor reliability issues (CRN, ARTC, Sydney Trains network).

3.1.2 What are the interventions that can support rail reliability improvements?

There are several interventions that may support reliability improvements for rail freight:

- Dedicated freight paths (i.e. separation of freight and passenger services) and increased pathing availability for freight;
- Consistent regulation and standards across networks (e.g., definition of 'late trains') between networks;
- Data sharing between various parties in the supply chain (e.g., CRN, ARTC, Sydney Trains, Stevedores, NSW Port Authority, TfNSW) to improve reliability monitoring capability.

31 Stakeholder consultation identified several issues with reliability and the current rail paths to Port Botany.
32 Audit Office of New South Wales, *Rail freight and Greater Sydney, 2021* [link].
33 ARTC, *2015-2024 Sydney Metropolitan Freight Strategy, 2015* [Link]
34 Note: in accordance with the *Transport Administration Act 1988 No 10* (NSW), priority is given to passenger services in the NSW rail network.

3.1.3 What are the outcomes associated with rail reliability improvements?

The matrix below shows the outcomes related to the problem or constraint listed in section 3.1.1 and alignment against relevant benefits and the relevant objectives in *Connecting to the Future – Our 10 Year Blueprint*.[35]

<table>
<tr><th>Outcome</th><th>Benefits</th><th>Alignment with ‘Connecting to the Future’ Outcomes</th></tr>
<tr><td>Improved rail reliability and on-time running for regional and metropolitan trains</td><td rowspan="2">• Improved rail travel time reliability</td><td><u>Connecting our customers whole lives</u>
• Safe, seamless journeys for people and goods</td></tr>
<tr><td>More seamless interaction between networks, supporting improved rail reliability and on-time running for regional freight</td><td><u>Connecting our customers whole lives</u>
• Safe, seamless journeys for people and goods
<u>Strong economy and quality of life</u>
• Quality assets and efficient networks, managed at the right price</td></tr>
</table>

[35] Transport for NSW, *Connecting to the future – Our 10 year Blueprint*, 2019

3.1.4 Guide to quantifying benefits

There are two options for quantifying reliability benefits:[36]

- The standard deviation approach, which considers the improvement in the standard deviation of travel times (against scheduled or planned times) in the base or project case, and then applies a value of reliability time ($/hr). Given that TfNSW's *Economic Parameter Values* recommend that lost time due to poor reliability be treated as equal to lost travel time, standard values of time per vehicle class could be applied in the absence of more specific values for reliability time being developed.[37]
- TfNSW's *Economic Parameter Values* recommends the use of a buffer time method, which treats the buffer times built into a journey (due to travel time variability) as being equally as costly as the time spent travelling;

The two methods (summarised below) are supplementary and should be selected by the practitioner on the basis of available demand inputs. Using both methods in the same CBA should be avoided, as this would result in the double counting of reliability benefits.

Benefit	Demand inputs		Transformations		General formula and parameter value
Improved rail travel time reliability – standard deviation method: due to improvements in pathing, access regulation or data sharing resulting in improvements in consistency of trips	Data for loaded freight train travel times, base and project case	→	Calculate the standard deviation of loaded freight train travel times, base and project case	→	Value of improved rail travel time reliability ($/year) = Incremental change in standard deviation of freight travel time between base and project case (hr/year) x value of reliability time ($/hr)[38]
Improved rail travel time reliability – buffer time method: due to improvements in pathing, access regulation or data sharing resulting in improvements in consistency of trips	Tonnes by O-D pair Cycle times Buffer time	→	N/A	→	Value of improved rail travel time reliability ($) = (Net tonnes by rail base case + project case (tonnes/year))/2 x Buffer time (hr)[39] x (1- ▲service reliability (%)) x value of freight time ($/tonne hr)[40] Net Tonnes • The weight of the commodity loaded onto the train

[36] Some operators may also be impacted by an inability to access port windows. Stakeholders indicated that there are often challenges in obtaining port windows, as other operators book multiple windows to cater for reliability issues, regardless of whether all those windows are ultimately used. This often leads to lost port-side utilisation, and lost rail freight service capacity for operators. Practitioners may assess these impacts on a case by case basis with project-specific data, given that the impacts are likely to be operator and supply-chain specific.
[37] A specific parameter value for "reliability time" is not available at this stage. A willingness to pay study would be required to determine the value attributed for this time. Current TfNSW *Economic Parameter Values* recommends treating travel time variability as being equally as costly as time spent travelling.
[38] Ibid.
[39] Note, this buffer time may not be consistent between networks. Practitioners should consider the buffer times used by operators in their freight journeys to allow for on-time arrival.
[40] Rule-of-half for induced demand is accounted for in this formula by taking the average of base and project case demand.

3.2 Road reliability benefits

Road reliability benefits are a result of unexpected deviations in the consistency or dependability of road freight travel times. When there are unexpected variances in travel time, this can impact trip planning and downstream activities. This is particularly critical for supply chains with limited access to intermodal terminals, ports and suppliers.

3.2.1 What are the problems or constraints associated with road reliability?

- Insufficient heavy vehicle rest areas or rest area capacity impacting real-time route planning;
- Lack of network capacity, resulting in congestion and unexpected increased in road travel times;
- Lack of take up of higher productivity vehicle access that would otherwise help to ease congestion and improve travel time reliability for road freight operators;
- Lack of real-time information for journey planning;
- Road unloading windows at Port Botany are determined by the vehicle booking system, with reliability issues impacting arrival times and therefore potentially resulting in 'no-show' fees;
- Network congestion, leading to lower speeds than planned;
- Delays, or significant wait time at rail level crossings;
- Uncoordinated traffic signals along road corridors, causing delays.

3.2.2 What are the interventions that can support road reliability improvements?

- Additional road infrastructure capacity – reducing road congestion and decreasing delays;
- Improved incident detection, management processes or technology like artificial intelligence (AI) and Internet of Things (IoT) e.g., Smart Motorways;
- Improved incident management and re-routing – allows vehicles to quickly select the next optimal route to destination;
- Infrastructure improvements to enable high productivity vehicle usage – supporting higher capacity vehicles to fulfil the movement task with less trips, resulting in less congestion and delays;
- Investments in infrastructure that can improve safety outcomes for heavy vehicle road users (e.g., emergency lanes, road widening, rest areas);
- Removal of rail level crossings or other at grade conflicting movements;
- Separation of the passenger and freight networks (e.g., truck-only lanes).

3.2.3 What are the outcomes associated with improved road reliability?

The matrix below provides some example outcomes related to the problem or constraint listed in section 3.2.1 and maps these against relevant benefits and the relevant objectives in *Connecting to the Future – Our 10 Year Blueprint*.[41]

Outcome	Benefits	Alignment with 'Connecting to the Future' Outcomes
Improved route time and reduced uncertainty for heavy vehicle operators	• Improved road travel time reliability	Connecting our customers whole lives • Safe seamless journeys for people and goods Strong economy and quality of life • Quality assets and efficient networks, managed at the right price
Increased resilience of road assets to natural disasters		Connecting our customers whole lives • Safe, seamless journeys for people and goods Strong economy and quality of life • Quality assets and efficient networks, managed at the right price • Transport investments and solutions that serve the people of NSW • Strong economy and quality of life

[41] Transport for NSW, *Connecting to the future – Our 10 year Blueprint*, 2019

Outcome	Benefits	Alignment with 'Connecting to the Future' Outcomes
Increased highway capacity, reducing road congestion and supporting on-time running		<u>Connecting our customers whole lives</u> • Safe, seamless journeys for people and goods <u>Strong economy and quality of life</u> • Quality assets and efficient networks, managed at the right price
Reduced operating time delays		

3.2.4 Guide to quantifying benefits

There are two options for quantifying benefits. As outlined in section 3.1.4, these approaches are supplementary and should be selected based on the demand inputs available. Practitioners should avoid using both methods in the same CBA to quantify reliability benefits, as this would lead to double counting.

Benefit	Demand inputs	Transformations	General formula and parameter value
Improved road travel time reliability – standard deviation method[42]	Data for loaded freight vehicle travel times, base and project case	Calculate the standard deviation of loaded freight vehicle travel times, base and project case	Value of improved road travel time reliability ($) = Incremental change in standard deviation of loaded travel time between base and project case (hr) x value of reliability time ($/hr)[43]
Improved road travel time reliability – buffer time method	Tonnes by O-D pair Loaded travel time Buffer time	N/A	Value of improved road travel time reliability ($) = (Net tonnes by road base case + project case (tonnes/year))/2 x Buffer time (hr) x (1- ▲service reliability (%)) x value of freight time ($/tonne hr)[44] Net Tonnes • The weight of the commodity loaded onto the freight vehicle

[42] Note, this approach is similar to that described as the 'network model' in *ATAP's Road Reliability Measurement – Research Report*. Practitioners may also consider using other methods outlined in this research report, including the 'link model' and 'route model'. The practitioner may consider use of one of those methods in their CBA, depending on the modelling and demand information that is available.

[43] A parameter value for the value reliability time is not available at this stage, a willingness to pay study is required to determine the value attributed.

[44] Rule-of-half for induced demand is accounted for in this formula by taking the average of base and project case demand.

4 Operating cost savings

Benefits resulting from operating cost savings for both road and rail freight are well established in existing studies and guidelines. A focus is placed on quantifying direct benefits for operators, as the operating cost impacts of freight network improvements are often measurable based on industry data and benchmarks. The distribution of benefits between producers, operators and customers will depend on commercial factors, elasticity of demand and competition. Therefore, the distributional effects of freight benefits is not the focus of CBAs in cases where the benefits have already been quantified at their source.

4.1 Rail operating cost savings

Rail operating cost savings refer to the reductions in the costs associated with running freight train services (i.e., above rail costs), as a result of improvements to below rail infrastructure.

Case Study; Upgrading below rail infrastructure to 25TAL Junee to Griffith[45,46]

Through the Transport for NSW Fixing Country Rail program, the Junee to Griffith rail line was upgraded from 20 TAL to 25 TAL capacity. The project included upgrades to the below rail infrastructure across 174 kilometres of rail line, including re-railing of the line.

The TAL upgrade will allow operators to run longer and heavier trains, improving the efficiency and productivity of rail operations, as the freight task can be completed with fewer services. The upgrade could also support mode shift from road to rail for trips towards east coast ports, if the rail operating cost savings make rail more competitive than some existing road movements in the freight catchment.

4.1.1 Drivers of rail operating cost savings

Above rail costs are those costs incurred to provide and operate train services. They include, but are not limited to:

- Crew costs;
- Fuel costs;
- Locomotive maintenance costs;
- Wagon maintenance costs.

Operational benefits result from mass [47]and/or cycle time improvements. Mass improvements from below rail infrastructure upgrades increase the net carrying capacity of freight trains, due to improved track specifications that support longer, higher (i.e., double-stacked) and heavier trains. This leads to a more productive and efficient freight network. Time and distance improvements can also reduce operating costs (e.g., reduced crew costs), but generally to a lesser extent compared to mass improvements. Below Rail infrastructure improvements include, but are not limited to:

- Upgrades to track capacity (i.e., higher tonne axle loads) to support longer, higher and heavier trains;
- New connections to create new trains paths and reduce service distance;
- New passing loops to improve train pathing and scheduling on existing routes;
- Increasing the fuel efficiency and resilience of locomotives.

4.1.2 What problems or constraints are associated with the operation of freight rail services?

Efficient and productive freight train operations tend to be constrained by:

- The condition of below rail assets. For example:
  - TAL restrictions may require light loading of trains or disincentivise investment in a higher capacity fleet, increasing the required number of services for a given freight task;

---

[45] Transport for NSW, *Junee to Griffith Rail Project Fast Tracks Freight, 2021 [*link*]*
[46] Rail Express, *$60m in efficiency upgrades for Junee-Griffith rail corridor*, 2018 [Link]
[47] Note: as outlined in section 2.1, mass-based benefits result from initiatives that support the operation of higher capacity trains.

- Inconsistent TAL restrictions across the rail network increases fleet management costs for rail operators, as new (and higher spec) locomotives cannot operate on lower TAL lines. This often means that operators must retain and maintain old locomotives to continuing performing their services;
- The condition of some branch lines may require significant speed restrictions for trains, in accordance with published train operating conditions (TOC);
- The grading of particular sections of the network (e.g., Blue Mountains line) which increases fuel and locomotive costs for freight services.

- Intermodal terminal access arrangements, loading constraints and required upstream road movements (which may currently be constrained by a lack of coordination between intermodal terminal operators and heavy vehicle operators);
- Mode changes required along supply chains that result in double handling of freight (e.g., pick-up and delivery costs for container freight, after a rail trip to an intermodal terminal).

4.1.3 What are the interventions that can result in operating cost savings?

The following interventions are likely to lead to operating cost savings:

- Upgrades to below rail assets (e.g., higher TAL to support heavier, longer and higher trains);
- New or upgraded bridges to allow for higher TAL;
- Streamlined approval processes to reduce delays in the accreditation of new locomotives, that are more fuel efficient and less prone to breakdowns;
- Lengthening crossing loops to support efficient pathing of longer trains;
- Strategic placement of intermodal terminals to reduce upstream road movements;
- Greenfield rail lines that provide more direct paths to east coast ports;
- Improving access arrangements and coordination between Sydney Trains, UGL Linx and ARTC.

4.1.4 What are the outcomes associated with train operating improvements?

The matrix below provides some example outcomes related to the problem or constraint listed in section 4.1.2 and alignment to relevant benefits and objectives in *Connecting to the Future – Our 10 Year Blueprint*.[48]

<table>
<tr><th>Outcome</th><th>Benefits</th><th>Alignment with 'Connecting to the Future' Outcomes</th></tr>
<tr><td>Increased throughput due to longer and heavier trains</td><td rowspan="2">• Fuel cost savings
• Crew cost savings
• Locomotive maintenance cost savings
• Wagon maintenance cost savings</td><td><u>Connecting our customers whole lives</u>
• Safe, seamless journeys for people and goods

<u>Strong economy and quality of life</u>
• Quality assets and efficient networks, managed at the right price
• Transport investments and solutions that serve the people of NSW
• Strong economy and quality of life</td></tr>
<tr><td>Reduced above rail operating costs due to more efficient train operations</td><td><u>Strong economy and quality of life</u>
• Quality assets and efficient networks, managed at the right price</td></tr>
</table>

48 Transport for NSW, *Connecting to the future – Our 10 year Blueprint*, 2019

4.1.5 Guide to quantifying benefits[49]

The benefits outlined below for operating cost savings are calculated in both the loaded and unloaded direction. This is because rail operating costs savings relate to the resource cost of trains, which are incurred by operators regardless of whether the trains are loaded or empty. Benefits are linked to either the total kilometres travelled, changes in cycle time (capturing both the loaded and unloaded direction) or changes in total GTK.

Benefit	Demand inputs	Transformations	General formula and parameter value
Fuel cost savings: due to a reduction in fuel costs from a reduction in the total gross tonne kilometres travelled.	Freight demand volume (tonnes), by O-D pair Consist weight[50] Net train capacity	Convert freight demand by O-D pair into gross tonne kilometres (GTKs) Total GTK = GTK loaded direction + GTK empty direction Loaded direction: (*consist weight (tonnes)* + *net train capacity (tonnes))*service distance (km)*required services per annum* Empty direction: (*consist weight (tonnes) * service distance (km)*required services per annum*	Fuel cost savings for existing demand ($/year) = Gross tonne kilometres saved for existing demand (GTK/year) x Fuel consumption (Litres/GTK) x Fuel price ($/Litre) Fuel cost savings for induced demand ($/year) = Gross tonne kilometres saved for induced demand (GTK/year) x 0.5 x Fuel consumption (Litres/GTK) x Fuel price ($/Litre) • Fuel price: bulk tax free rate of $1.30 per litre[51] • Fuel consumption rate: Refer to Table 27 of ATAP Guidelines M3[52] Dual directional benefits: • Fuel cost savings are calculated in both the loaded and unloaded direction, to ensure that the cost savings are accurately captured. For example a new rail path that decreases the distance will decrease the total GTK (in the loaded and unloaded direction).

[49] Note, the formulas in this section assume that there is a rail path available in both the base and project case. As outlined in ATAP: M3 Freight Rail (page 50) and ATAP: T2 Cost Benefit Analysis (page 42), where there is a new rail freight service in the project case (i.e., from a greenfield development) for an O-D pair that could only be serviced by road in the base case, consumer surplus gains should be estimated by comparing rail freight rates in the project case with road freight rates in the base case. Practitioners should consult the ATAP guidelines for further details.

[50] Consist refers to the locomotives and wagons in a train.

[51] Note: a tax free bulk rate of $1.30 per litre is cited on page 65 of the *Australian Transport Assessment and Planning Guidelines: M3 Freight Rail*. However, the ATAP Guidelines also recommend that the prevailing energy price should be used to estimate train energy costs. EY analysis of the average cost of diesel between 2007 and 2021 [link], net of excise [link] and escalated to FY$2022, indicates a bulk tax-free rate of $1.24 per litre.

[52] See Table 27 of the *Australian Transport Assessment and Planning Guidelines: M3 Freight Rail* for fuel consumption rates per thousand GTK, according to train and terrain types. An analysis of a range of open source information including; Aurizon 2021 sustainability report, Canada National Railway published statistics (converted), American Freight Rail Operator CSX, Pacific National Road vs Rail Case Study – Sydney to Brisbane, Pacific National Road vs Rail Case Study – Penola to Portland indicated an average fuel consumption rate of approximately 5L/'000 GTK.

Benefit	Demand inputs	Transformations	General formula and parameter value
Crew cost savings: due to a reduction in the total crew hours required to complete the freight task.	Freight demand volume (tonnes), by O-D pair Average crew per shift, by O-D pair (#) Cycle times, by O-D pair	Convert freight demand by O-D pair into net tonne kilometres (NTK): *Net train capacity (tonnes)*service distance (km) * 2*	Crew cost savings for existing demand ($/year) = Base case demand (tonnes) x ▲Cycle time (hr) x Number of crew (crew) x Crew hrs (hr/shift) / Footplate hrs (hr/shift) / ▲Net train capacity (tonnes) x Crew costs ($/crew /hr) Crew cost savings for induced demand ($/year) = (project case tonnes – base case tonnes)/2 x ▲Cycle time (hr) x Number of crew (crew) x Crew hrs (hr/shift) / Footplate hrs (hr/shift) / ▲Net train capacity (tonnes) x Crew costs ($/crew /hr) • Footplate hours:[53] 6 hours per shift • Crew hours:[54] 7.6 hours/shift • Crew cost:[55] $182.13 (FY$2022/individual crew hour) Dual directional benefits: Crew cost savings are calculated for cycle times (both unloaded and loaded direction), to ensure that the cost savings are accurately captured. For example, a new shorter rail path that decreases the cycle times, and therefore decreases total crew hours in both directions.
Locomotive maintenance cost savings: due to a reduction in the total kilometres travelled by locomotives on a freight train.	Freight demand volume (tonnes), by O-D pair	Calculate locomotive kilometres by O-D pair: *number of required trips (#) x service distance (km) x number of locomotives (#) * 2*	Locomotive maintenance cost savings for existing demand ($/year) =▲ locomotive kilometres for existing demand x Locomotive maintenance costs ($/km) Locomotive maintenance cost savings for induced demand ($/year) =▲ locomotive kilometres travelled for induced demand x 0.5 x locomotive maintenance costs ($/km) • Locomotive maintenance:[56] $2.13 (FY$2022/km) Dual directional benefits: Locomotive maintenance savings are calculated for both unloaded and loaded direction, to ensure that the cost savings are accurately

[53] Source: Neil Matthews Consulting (NMC). Footplate hours are the number of hours spent by crews operating trains (i.e., the 'productive' time in a shift), not the entire shift. It is calculated as the shift hours less the time spent boarding, onboarding and following safety procedures.
[54] Source: Neil Matthews Consulting (NMC). Crew hours represent the total average hours in a shift.
[55] Transport for NSW, *Economic Parameter Values*, Table 69 escalated to FY$2022 at 2.5% per annum
[56] Transport for NSW, *Economic Parameter Values, Table 69, escalated from 2019 to 2022 at 2.5%*

Benefit	Demand inputs	Transformations	General formula and parameter value
			captured. For example, a new shorter rail path that decreases the locomotive kilometres travelled in the loaded and unloaded directions.
Wagon maintenance cost savings: due to a reduction in the total kilometres travelled by wagons on a freight train.	Freight demand Volume and OD pairs	Calculate wagon kilometres by O-D pair: *number of required trips (#) x service distance (km) x number of wagons (#) * 2*	Wagon maintenance cost savings for existing demand ($/year) = ▲wagon kilometres travelled for existing demand x Wagon maintenance costs ($/km) Wagon maintenance cost savings ($/year) =▲ wagon kilometres travelled for induced demand x 0.5 x wagon maintenance costs ($/km) • Wagon maintenance:[57] $0.08 ($FY2022/km) Dual directional benefits: Wagon maintenance savings are calculated for both unloaded and loaded direction, to ensure that the cost savings are accurately captured. For example, a new shorter rail path that decreases the wagon kilometres travelled in the loaded and unloaded directions.

[57] Transport for NSW, *Economic Parameter Values*, Table 69, *escalated from 2019 to 2022 at 2.5%*

4.2 Road vehicle operating cost savings

Vehicle operating costs (VOC) refer to the fuel, tyre and maintenance costs that are required to operate freight vehicles. These costs are influenced by the condition of roads and the speed of travel.

4.2.1 What problems or constraints lead to higher VOC?

- Poor pavement conditions and steep grades of road freight corridors;
- Road congestion, leading to lower average speeds and stop-start travel conditions;
- Infrastructure constraints limiting the use of high productivity vehicles along some road corridors, necessitating the use of longer alternative routes;

4.2.2 What are the interventions that can support VOC savings?

- Freight bypasses to avoid congested routes and town centres, leading to reduced travel distance and higher speeds;
- Rail network upgrades to support mode shift, reducing the number of road freight movements;
- Use of higher productivity vehicles (e.g., in line with performance based standards);
- Road infrastructure upgrades:
    - Widening of roads to allow higher capacity vehicles to complete the freight task (reducing the required number of trips per annum);
    - Re-sealing to improve road quality and support increased speeds.

4.2.3 What are the outcomes associated with VOC savings?

The matrix below provides some example outcomes related to the problem or constraint listed in section 4.2.1 and alignment to relevant benefits and objectives in *Connecting to the Future – Our 10 Year Blueprint*.[58]

<table>
<tr><th>Outcome</th><th>Benefits</th><th>Alignment with ‘Connecting to the Future’ Outcomes</th></tr>
<tr><td>Higher speeds on key road freight corridors</td><td rowspan="3">• Reduced road VOC</td><td rowspan="3"><u>Connecting our customers whole lives</u>
• Safe, seamless journeys for people and goods

<u>Successful places</u>
• Protecting and enhancing communities and their environments

<u>Strong economy and quality of life</u>
• Quality assets and efficient networks, managed at the right price
• Transport investments and solutions that serve the people of NSW
• Strong economy and quality of life
•</td></tr>
<tr><td>Mode shift from road to rail, reducing the required number of road movements per annum</td></tr>
<tr><td>More free flowing road freight journeys across key road freight corridors (i.e., less congestion and stop-start movements)</td></tr>
</table>

4.2.4 Guide to quantifying benefits

TfNSW recommends one of four approaches to estimating VOC savings. Detailed guidance on the method for calculating VOC savings, including the required data, is provided in the *Technical Note on Calculating Road Vehicle Operating Costs*.[59]

---

[58] Transport for NSW, *Connecting to the future – Our 10 year Blueprint*, 2019
[59] Transport for NSW, *Technical Note on Calculating Road Vehicle Operating Costs*, June 2020 (refer to Section 3).

5 Network resilience

The ability of transport infrastructure to withstand incidents, such as adverse weather and climate impacts, fires, and other vulnerabilities, is of importance to the viability of the freight network. Resilience is the benefit of having a network that can cater for incidents and outages, allowing freight supply chains to continue to function, despite an incident occurring. It is distinct from safety impacts, such as the direct costs associated with road and rail crashes, and instead focusses on the second-round impacts to other road and rail operators in the supply chain.

5.1 Rail incident delays cost savings

Rail incidents can be defined as any occurrence that disrupts the day-to-day operation of the rail freight network. This includes crashes, derailments, breakdowns, flooding and fires.

Rail incidents result in a part of the rail network being unusable for a period of time. These are distinct from rail reliability issues, which impact day-to-day operations on a regular basis (i.e., in cases where there has not been a network outage). When considering infrastructure improvements that will reduce the likelihood of an incident, it is important for practitioners to consider the type of incident, its grade of severity, and the frequency of its occurrence. Typical supply chain responses for a range of rail incidents are included in the figure below.

Expected supply-chain responses	Incidents measured in hours	Incidents measured in days	Incidents measured in weeks
Incidents that occur rarely	Short-run operational impacts (e.g., holding trains back, waiting in passing loops)	Short-run operational impacts (e.g., holding trains back, waiting in passing loops, cancelled paths)	Supply-chain diversions to other routes, modes, times
Incidents that occur sometimes	Short-run operational impacts (e.g., holding trains back, waiting in passing loops)	Supply-chain diversions to other routes, modes, times, cancelled paths	Long-run business impacts such as increased inventory
Incidents that occur frequently	Supply-chain diversions to other routes, modes, times (alternatively, 'unreliable' mode is not used due to ongoing reliability issues)	Supply-chain diversions to other routes, modes, times or cancelled paths (alternatively, 'unreliable' mode is not used due to ongoing reliability issues)	Long-run business impacts such as increased inventory

Existing parameters and CBA frameworks for incidents tend to focus on the direct economic impact of crashes and derailments, as opposed to the broader supply chain impacts. Other costs and supply chain impacts are not quantified in existing crash cost parameters. This section focuses on methods to quantify these other costs and supply chain impacts, and is distinct from the safety benefits in section 7.

Case Study: Flooding of the Nullarbor[60,61,62,63,64]

In January 2022, the Nullarbor plains experienced flooding, damaging rail paths between South Australia, Western Australia and the Northern Territory. Significant weather effects caused washout along the track and impacted the delivery of goods to the west coast. This event was particularly significant due to damage to the alternative road networks between the east and west coasts of Australia, compounding the supply chain effects. The rail line was shut for three weeks while ARTC worked to repair the damage including use of more than 50,000 tonnes of ballast and rock utilised in the repair and more than 100 staff.

As a result of the flooding significant supply chain issues occurred with supermarket struggling to stock essentials. Even as the rail connection was re-established a significant backlog of freight resulted. Some retailers contracted shipping lines to deliver containers of food, supermarkets were forced to introduce purchase limits and emergency supplies were sent from SA to WA by road.

Case Study: Western rail line outages[65,66,67,68]

Rail access on the Main West Line across the Blue Mountains into Sydney has been affected by major weather events on several occasions. Recent incidents of closure include:

- *A sink hole in early 2022 resulting in line closure between Emu Plains and Lithgow for three weeks while almost 200 staff worked to repair the damage;*
- *Bushfires in December 2019 caused significant damage to track causing closure between Mount Victoria and Lithgow. This was compounded by damage caused by heavy rain in February 2020 and a resulting landslip resulting in damage between Springwood and Mt Victoria. Parts of rail line through the Blue Mountains were closed for several months while damage was repaired.*

Extreme weather conditions such as the above that damage track significantly affect freight movements into Port Botany where the western rail line is shut for extended periods of time as track is rebuilt. Freight can either be diverted to a much longer route into Port via Cootamundra, or a temporary mode shift to road may occur to complete the freight task.

5.1.1 What are the causes, problems or constraints related to freight rail incidents ?

The key problems and causes associated with rail freight incidents include:

- Flooding, storms or other natural disasters damaging below rail assets or blocking rail lines;
- Bushfires, affecting key infrastructure and making lines non-operational for a period of time;
- Rail incidents at level crossings increasing travel time;
- Rail derailments;
- Locomotive break downs.

A rail incident occurs within a wider supply chain and network, and is likely to result in upstream and downstream impacts to producers and to end users. Effects of a rail incident to the wider supply chain include:

- Infrastructure damage as a direct result of the incident;
- Network impacts due to rail paths being unusable for a period of time;
- Diversion costs for services using affected pathways;
- Potential affect to customer network, where shared networks are used (e.g., on path to Port Botany);
- Downstream impacts:
  - Missed delivery schedules;
  - Missed vessel windows at east coast ports, resulting in significant revenue impacts for operators;

[60] Guardian, *Flooding cuts off key railway supply routes in central Australia*, 2022, [Link]
[61] ABC News, *Australian Rail Track Corporation says line closed between SA, WA and NT due to heavy rain in outback*, 2022, [Link]
[62] 9 News, *Trans-Australian railway line re-opens after severe flood damage, 2022* [Link]
[63] ARTC, *South Australia flooding and track closure – update, 2022* [Link]
[64] Inner west review, *WA freight 'backlog' as rail link restored, 2022* [Link]
[65] Transport for NSW, *Getting freight back on track over the Blue Mountains, 2022* [Link]
[66] Rail Express, *Weather destruction is flooding NSW network with repairs, 2020* [Link]
[67] Western Sydney Business Access, *Getting freight back over Blue Mountains, 2022* [Link]
[68] 9 News, *Commuters urged against travel to the Blue Mountains as roads and train lines face severe damage, 2022* [Link]

- Spoilage or loss of affected commodities.[69]

5.1.2 What are the interventions that can support rail incident delays cost savings?

There are several interventions that can support rail incident delay cost savings. These infrastructure improvements should be considered in the context of the supply chain. Examples of interventions that may help to avoid delay costs include:

- Optionality and alternative paths, separating freight and passenger services and/or providing more efficient diversion routes for freight rail services;
- Improved resilience of existing lines (e.g., new or upgraded rail bridges in problem flooding areas on the network);
- Improved incident response times to shorten delays;
- Passing loops on congested lines in strategic locations, to improve pathing;
- Shared network data and real time updates to allow for improved route planning (where optionality exists);
- Increased inventory storage and buffer in operational timetables, to support any shift away from just-in-time to just-in-case freight.

5.1.3 What are the outcomes associated with rail incident delay cost savings?

The matrix below shows some example outcomes related to the problem or constraint listed in section 5.1.1 and alignment to relevant benefits and objectives in *Connecting to the Future – Our 10 Year Blueprint*.[70]

Outcome	Benefits	Alignment with 'Connecting to the Future' Outcomes
Improved resilience of rail assets during incident periods, resulting in fewer line closures and disruptions Improved pathing optionality for rail freight services during network outages	• Avoided impact of holding at origin • Avoided cost of diverting to a longer path • Avoided cost of waiting on the network • Avoided cost of temporary shift to road (i.e., due to an increase in the number of road trips to temporarily replace rail trips)	Connecting our customers whole lives • Safe, seamless journeys for people and goods Strong economy and quality of life • Quality assets and efficient networks, managed at the right price • Transport investments and solutions that serve the people of NSW

[69] For significant derailments, there is likely to be a cost associated with the loss or damage of the commodity transported, as well as damage costs to the locomotives and/or wagons. However, a standard method of valuing the loss incurred is challenging, as the cost will depend on both the commodity transported and the type of locomotive and wagon used. Direct crash cost parameters for rail can be sourced from TfNSW's Economic Parameter Values.
[70] Transport for NSW, *Connecting to the future – Our 10 year Blueprint*, 2019

5.1.4 Guide to quantifying benefits

The below process map demonstrates a guide to quantifying selected resilience benefits from avoided incidents.

Benefit	Demand inputs	Transformations	General formula and parameter value
Avoided impact of holding train at origin: due to a reduction in incident frequency or length	• Historical incident data • Rail tonnes affected, by O-D pair • Probability of incident prevention or mitigation by project	• Determine probability of incident occurring • Determine average delay time during incident period • Refine affected rail tonnes	Impact of holding at origin = Reduction in incident probability x avoided delay time (hr/incident) x (Net Tonnes by rail base case + project case (tonnes/year))/2 x Value of Freight Time ($/tonne hour) Reduction in incident probability • Probability of incident (base case) – Probability of incident (project case) • E.g., in the base case, 5% (P=0.05)[71] or 1 in 20 years. In the project case 3% (P=0.03) or 1 in 33 years • Reduction in Incident Probability = 0.05 – 0.03 = 0.02 (or 2%) Value of freight time • Alternative 1:[72] $1.06 (FY$2022/tonne hour) • Alternative 2:[73] $1.60 (FY$2022/tonne hour)

[71] Note: where benefits are quantified for avoided diversions for impacted trains, benefits should not be quantified elsewhere in a CBA for those impacted flows, to avoid double counting.
[72] ARTC '*Melbourne-Brisbane Inland Rail Alignment Study*', NSW Government, 2010.
[73] Mary R Brooks, Sean M Puckett, David A Hensher & Adrian Sammons, *Understanding Mode Choice Decisions: A Study of Australian Freight Shippers*, 2012, parameter is escalated from 2012 to 2022 at 2.5%

<table>
<tr><th>Benefit</th><th>Demand inputs</th><th>Transformations</th><th>General formula and parameter value</th></tr>
<tr><td>Avoided cost of diverting to a longer path: due to a reduced need to divert or a shorter diversion</td><td colspan="3">Valuing the avoided costs in the project case if it reduces the distance of the diversion route. The key inputs for the Practitioner to consider are the frequency of incidents, and the number of affected trips.

For example, if there is an incident along a route that causes a diversion onto a new (proposed) line, there will be an additional benefit defined as the incremental operating cost saving from using the new diversion during the incident period, instead of the existing (longer) diversion. To quantify this benefit, practitioners should:

• Identify the rail operating cost saving that results from using the shorter or higher capacity rail diversion (refer to section 2.1.4 for these methods);
• Apply the above incremental operating cost savings to an assumed number of freight services that would be required to divert per annum, due to rail incidents.

This method could also be applied where an initiative reduces the frequency of incidents (by reducing the probability of an incident occurring) or the number of affected trips (by reducing the length of the interruption).

The rule-of-half should be considered where there are new trips in the project case as a result of the improved network resilience supported by the project.</td></tr>
<tr><td>Avoided cost of waiting on the network: due to a reduction in incident frequency or length</td><td colspan="3">A wait on network decision will occur if an operator determines that it is more beneficial to wait (for example, in a passing loop), instead of diverting or waiting at the origin. This is the same calculation as the hold at origin formula, as the decision will result in an increased cycle time due to the delay. Refer to impact of holding at origin.

The rule-of-half should be considered where there are new trips in the project case as a result of the improved network resilience supported by the project.</td></tr>
</table>

Benefit	Demand inputs	Transformations	General formula and parameter value
Avoided cost of temporary shift to road: due to a reduction in incident frequency or length	• Change in probability of rail freight task temporarily shifting to road during an average incident, base and project case • Length of average incident (hrs), base and project case • Average number of incidents per annum (#), base and project case • Demand volume affected • OD pairs affected and route taken	Vehicle kilometres travelled (VKT) due to temporary mode shifts during average annual incident periods, base and project case.[74]	Road operating costs and externalities in base case – project case VOC (resource and perceived) = Vehicle Kilometres Travelled by road (km) x Operating Costs ($/km) Refer to Transport for NSW 2020 Economic Parameter Values table 12 and 13 for resource and perceived VOC respectively Road crash costs = Vehicle Kilometres Travelled by road (km) x Accident Costs ($/km) Freight road safety value ($FY2022/VKT): • Urban:[75] $0.08 • Rural:[76] $0.04 Road environmental impacts = Vehicle Kilometres Travelled by road (km) x Externality Costs ($/km) Refer to Transport for NSW 2020 economic parameters table 39 and 40 for Urban and Rural externality costs respectively by Heavy Vehicle size. Road damage costs = Vehicle Kilometres Travelled by road (km) x Cost of Road Damage ($/km) Refer to Transport for NSW 2020 Economic Parameter Values table 48 for cost of road damage by Heavy Vehicle type.

Practitioners may also consider the impact of cancelled freight paths. Monetising the benefit of reduced rail freight service cancellations is complex, as the impacts are highly specific to commodity types and their specific supply chains. However, practitioners could consider the following approaches to value the benefit of initiatives that reduce the need to cancel rail freight paths:

- Avoided costs for sellers: these costs could include temporary IMT storage costs, delayed or lost revenue, spoiled goods (particularly relevant for some general freight items);

[74] Base Case and Project Case differences will account for the difference created by the infrastructure improvement which could be the length of an average incident and/or the frequency of an incident.
[75] Transport for NSW *Economic Parameter Values*, Table 25, 2020
[76] EY analysis based on Transport for NSW *Economic Parameter Values*, Table 25, 28 & 29, 2020

- Avoided costs for operators: these costs could include lost revenue due to cancelled services (which may need to be absorbed by operators, depending on the contractual arrangements that are in place); lost utilisation of rollingstock;
- Avoided costs for consumers: these could include reduced consumer welfare during the incident/outage period due to empty shelves and less product choice; increased search costs for customers (e.g., transportation and lost time) due to the need for visits to several businesses to locate preferred goods.

Careful consideration should be given to avoid double counting of benefits.

5.2 Heavy Vehicle incident delays cost savings

Road incidents can be defined as any occurrence that disrupts the day-to-day operation of the road freight network. This includes, but is not limited to, crashes, breakdowns, flooding and fires that prevent heavy vehicles from operating along their preferred route.

For heavy vehicle incidents, existing parameters and CBA frameworks tend to focus on the direct economic impact of crashes, as well as the damage to property and/or road infrastructure.[77] Broader supply chain impacts from heavy vehicle incidents tend not to be quantified, given that the road network tends to be more flexible than rail in responding to an incident, with the exception of extreme incidents.

Case Study; 2019-20 bushfires and road closures[78,79,80,81,82]

Bushfires in December 2019 caused significant road closures in NSW that affected freight movement. Significant interruptions to freight operations occurred in mid-December when the Great Western Highway was closed at Blackheath to enable backburning, closing one of the main routes west of Sydney and into the blue mountains.

Later in the month fires damaged 880 kilometres of state roads, and 150 kilometres of local road with significant impact to major arterial roads such as Kings Highway, Oxley Highway, Gwydir Highway and Princess Highway. The length of road closures varied depending on fire severity, with some closed access for over a week. These significant closures affected not only general travel but also freight, and regional town's ability to receive commodities including supermarket restock and fuel. Freight operators experienced significant delays during the fires with some companies needing to cancel deliveries to parts of the state due to lack of access. While diversion routes are often possible with an incident or crash, the scale of fires and resulting road closures in December 2019 through January 2020 meant significant portions of regional NSW were not accessible for road freight operators.

Case Study; Flood resilient bridge built in Brisbane[83,84]

The Brisbane City Council replaced an existing 90 year old timber bridge in with a new higher, concrete 'flood resilient' bridge May 2022. Construction included significant improvements to the drainage infrastructure surrounding the bridge. Council records indicate that the previous bridge flooded on average every 2 to 5 years, the new bridge and drainage upgrades are intended to improve the resilience of the road network. The upgrades will also support heavier vehicles using the road in more direct routes, the old structure limited vehicle access to 22.5 tonnes.

5.2.1 What are the causes, problems or constraints related to Heavy Vehicle incident delay costs?

The key problems, causes and constraints related to heavy vehicle incident delays include:

- Natural disasters: Flooding, storm, fire or other natural disaster - blocking major roads or bridges;
- Common vehicle crash causes (i.e., speeding, fatigue, drink driving, phone usage);
- Heavy-vehicle break downs;
- Unsafe and/or poorly maintained roads or bridges.

5.2.2 What are the interventions that can support Heavy Vehicle incident delay cost savings?

The following interventions are likely to lead to heavy vehicle incident delay cost savings:

- Optionality and alternative route allowances that support heavy vehicle usage – including road durability and routes that are suitable for higher productivity vehicles;
- Improved incident management and re-routing to allow vehicles to quickly select the next optimal route to destination (e.g., through improved technology to detect incidents, dispatch a response and manage diversions);
- Increased number of lanes on key road corridors;

---

77 For example, the 2010 study *Social Cost of Road Crashes* by BITRE [link]
78 NSW Government, *How Transport for NSW has adapted to change*, n/d copyright 2022 [Link]
79 ABC, *NSW bushfires destroy almost 1,000 homes as Christmas travel limited by road closures*, 2019 [Link]
80 Air Road, *14/01/20: Delays due to Bushfires, 2020 [Link]*
81 Daily Mail, *Australia's 'apocalyptic' bushfire towns go into 'panic stations' as supermarket shelves are cleared, petrol stations run dry, water supplies are contaminated and communities struggle without power, 2020* [Link]
82 Blue Mountain Gazette, *Great Western Highway to close at Blackheath, 2019* [Link]
83 Brisbane City Council, *Gresham Street Bridge replacement project – Ashgrove*, 2022, [Link]
84 Tony Moore, Brisbane Time, *New flood-resilient bridge opens in west Brisbane* [Link]

- Turn around points with a Variable Message Sign (VMS) providing b-triples with an opportunity to change route following the occurrence of an incident;
- Data collection (including motor way tracking) and real time update of freight operators allowing for early diversion, and reduced risk of incidents. Including:
    - Automatic speed change signs on motor ways to prevent additional damage;
    - Faster incident response and clearing time;
    - Automatic speed reduction in poor weather or congestion.
- Increased safety initiatives to reduce number of incidents:
    - Increased and optimally placed heavy vehicle rest stops;
    - Initiatives to support safe length of driving times;
    - Adequate lane width along Heavy Vehicle freight routes;
    - Initiatives to support improved visibility.

5.2.3 What are the outcomes associated with Heavy Vehicle incident delay cost savings?

The matrix below shows the outcomes related to the problem or constraint listed in section 5.2.1 and alignment to relevant benefits and objectives in *Connecting to the Future – Our 10 Year Blueprint*.[85]

Outcome	Benefits	Alignment with 'Connecting to the Future' Outcomes
Increased resilience of road paths and highways during natural disasters, reducing the occurrence and length of disruptions	• Avoided cost of holding at origin • Avoided cost of diverting to a longer road route • Avoided cost of waiting on network • Avoided cost of cancelled road freight service	<u>Connecting our customers whole lives</u> • Safe, seamless journeys for people and goods <u>Strong economy and quality of life</u> • Quality assets and efficient networks, managed at the right price • Strong economy and quality of life
Reduced interruption from heavy vehicle crashes and breakdowns, through a more responsive road network		<u>Connecting our customers whole lives</u> • Safe, seamless journeys for people and goods

[85] Transport for NSW, *Connecting to the future – Our 10 year Blueprint*, 2019

5.2.4 Guide to quantifying benefits

The below process map demonstrates a guide to quantifying benefits.

Benefit	Demand Inputs	Transformations	General formula and parameter value
Avoided cost of holding truck at origin: due to a reduction in incident frequency or length	• Historical road incident data • Road tonnes affected • Probability of prevention	• Determine probably of incident occurring • Determine average delay time • Refine affected rail tonnes	Impact of holding at origin[86] = Reduction in incident probability (between base and project case)[87] x avoided delay time (hr) x (net tonnes by road base case + project case (tonnes/year))/2 x value of freight time ($/tonne hour) Reduction in Incident Probability • *Refer to section 5.1.5* Net Tonnes by Road • *Refer to section 5.1.5*
Avoided cost of diverting to a longer road route: due to a reduced need to divert or a shorter diversion	A diversion occurs where an operator determines it is more beneficial and also possible to take a longer route, instead of waiting at the origin or at a point along the journey. The project case benefit is therefore the vehicle operating costs, road crash costs and road environmental impacts avoided due to either a reduced need for road operators to divert to a longer journey or a shorter diversion path made available (or both). Refer to section 5.1.5 for a discussion of these avoided costs and approaches. To quantify this benefit, practitioners should: • Identify the vehicle operating cost savings that result from using the shorter or enhanced (e.g., higher speed) road diversion; • Apply the above incremental operating cost savings from the new or improved diversion to an assumed average number of road freight services that would be required to divert per annum. The assumed average number of diversions in the project case would need to be adjusted for resilience improvements that result from the road project. The rule-of-half should be considered where there are new trips in the project case as a result of the improved network resilience supported by the project.		
Avoided cost of waiting on network: due to a reduction in incident frequency or length	A decision to wait on the network, will occur if an operator determines that it is more beneficial to wait as opposed to diverting or waiting at the origin, or if it is not possible for heavy vehicles to turn around and head in another direction. This is the same calculation that used to quantify the cost of holding at the origin, albeit with a different average delay time. The rule-of-half should be considered where there are new trips in the project case as a result of the improved network resilience supported by the project.		

[86] Alternatively, practitioners could quantity this benefit using the value of time for freight vehicles (expressed in $/hr) contained in TfNSW's *Economic Parameter Value 2020*, provided that the number of impacted trips and total improvement to travel times (due to avoided holding times) can be ascertained.
[87] Note, where resilience benefits are quantified for impacted road flows, benefits should not be quantified elsewhere in a CBA for the same flows, as this would lead to double counting.

Benefit	Demand Inputs	Transformations	General formula and parameter value
Avoided cost of cancelled road freight service: due to a reduction in incident frequency or length	The potential methodologies for valuing the benefits of reduced road freight service cancellations would be consistent with those outlined for rail (see section 5.1.4). However, the magnitude of impacts may differ, as road network outages tend to be shorter than those experienced on the rail freight network. Further, there are similar complexities to quantifying these benefits, as is outlined in the rail freight section. The rule-of-half should be considered where there are new trips in the project case as a result of the improved network resilience supported by the project.		

6 Externalities

Externalities refer to the flow on impacts experienced by society more broadly, rather than by direct road and rail users. This means that externalities cover a broad range of potential impacts, some examples of which are outlined below.

Outcome	Benefits	Alignment with 'Connecting to the Future' Outcomes
Reduced environmental costs from freight activity, leading to improved amenity for the people of NSW.	• Reduced rail environmental impacts • Reduced road environmental impacts • Reduced rail access environmental impacts • Road damage cost savings	Successful places • Integrated, resilient and accessible transport networks and places • Protecting and enhancing communities and their environments

6.1 Reduced rail environmental impacts

Rail environmental impacts are the environmental externalities generated by rail freight operations. Benefits result from a reduction in Gross Tonne Kilometres (GTKs), or from more freight being transported through rural as opposed to urban areas. These include reductions in air and noise pollution, greenhouse gas emissions and urban separation.

Rail environmental benefits can be calculated using the parameters outlined in TfNSW's Economic Parameter Values 2020, specifically Table 42 and 43, and the following formula:

Rail environmental impacts ($) =(Gross Tonne Kilometres (GTK) $_{base}$ *- Gross Tonne Kilometres (GTK)* $_{project}$*) x Rail environmental impact ($/GTK)*

6.2 Reduced road environmental impacts

Projects that affect the number of freight vehicles on roads, or travel speeds, will have environmental impacts. This is due to:

- Increased air pollution: urban road projects that reduce the level of congestion, and increase the flow of traffic, can help to reduce the impacts of pollution. This is predominately an urban issue due to higher population density.[88] Refer to section 6.1 and Table 35 of TfNSW's Economic Parameter Values 2020 for further details.
- Increased greenhouse gas emissions: the global impact associated with vehicle kilometres (due to vehicle emissions), meaning that the same impacts are experienced, regardless of whether road travel occurs in regional or urban areas. Refer to section 6.1 and Table 35 of TfNSW's Economic Parameter Values 2020 for further details.

Road environmental impacts can be calculated using the parameters outlined in TfNSW's Economic Parameter Values 2020, specifically Table 39 and 40 (for urban and rural respectively) and the following formula:

*Road environmental impacts ($) = (Vehicle Kilometres travelled (VKT) (by road)*$_{base}$ *- Vehicle Kilometres travelled (VKT) (by road)*$_{project}$*) x Externality costs ($/VKT)*

6.3 Reduced rail access environmental impacts

Upstream road movements towards rail infrastructure (e.g., towards a rail siding or an intermodal terminal) generate environmental externalities for third parties and the broader community. Environmental impacts per Vehicle Kilometre Travelled (VKT) can be calculated using the parameters outlined in TfNSW's Economic Parameter Values 2020.[89] Externalities captured in parameter values include:

- Air pollution;
- Greenhouse gas emissions;
- Noise and water pollution;

[88] TfNSW, *Economic Parameter Values 2020*
[89] Refer to tables 39 and 40 for urban and rural parameters respectively.

- Nature and landscape;
- Urban separation; and
- Upstream and downstream costs.

Benefits may result from infrastructure projects that improve the efficiency of upstream road movements (e.g., improved traffic flow from a producer to intermodal terminal, due to a road resealing that enables higher speeds for heavy vehicles) or reduces the length of the upstream road movements (e.g., new or improved rail access point closer to the origin of freight).

Rail access environmental impacts ($) = (Vehicle Kilometres travelled (VKT) (by road to access rail)$_{base}$ - Vehicle Kilometres travelled (VKT) (by road to access rail)$_{project}$) x Externality costs ($/VKT)

7 Safety benefits

Safety benefits result from the reduced damage to infrastructure (used by other freight and non-freight users) and also the reduced cost of road and rail crashes.

Outcome	Benefits	Alignment with 'Connecting to the Future' Outcomes
Safer movement of freight commodities across NSW, reducing the potential impact of crashes on freight and non-freight users.	• Rail safety benefits • Road safety benefits	Connecting our customer's whole lives • Safe, seamless journeys for people and goods

7.1 Road damage cost savings

Road damage cost savings result from a reduction in the damage caused by heavy vehicle movements. This could be a result of end-to-end road journeys or upstream/downstream road journeys from an intermodal terminal or rail siding to an end customer (i.e., rail access). This benefit may be realised in the case where an infrastructure initiative reduces the distances travel for O-D pairs or reduces the need for travel via longer routes during an incident. The reduction in road kilometres travelled will reduce the wear and tear on the existing road network. Practitioners should refer to table 48 of the TfNSW Economic Parameter Values 2020 for road damage cost parameters and the following formula:

Road damage cost saving benefits ($) =(Vehicle Kilometres Travelled (VKT) (by road) $_{base}$ - Vehicle Kilometres Travelled (VKT) (by road) $_{project}$) x cost of road damage ($/VKT)

7.2 Rail safety benefits

Rail safety benefits result from a reduction in Gross Tonne Kilometres (GTK) for rail journeys, which reduces the likelihood of rail freight crashes. Parameter values are currently limited in this area. Practitioners may consider use of the 0.04 cents/NTK parameter published in the Inland Rail Alignment study.[90]

7.3 Road safety benefits

Road safety benefits arise from a reduction in vehicle kilometres travelled (VKT) on the road network, which reduces the probability of heavy vehicle crashes. This could be a result of end-to-end road journeys or upstream/downstream road journeys from an intermodal terminal or rail siding to an end customer (i.e., rail access). TfNSW's cost benefit analysis guidance provides detailed parameters for road in two key forms:

- Average crash costs by road type (urban) where detailed crash data is not available (table 25)
- Costs per casualty and per crash (urban and rural), broken down by accident type (table 26)

When using the average crash costs by road type the following formula can be used:

Road safety benefits ($) =(Vehicle Kilometres Travelled (VKT) (by road) $_{base}$ - Vehicle Kilometres Travelled (VKT) (by road) $_{project}$) x Accident costs ($/VKT)

Detailed road safety analysis can be undertaken using the Road User Movement (RUM) codes, and Inclusive WTP costs. The Safer Roads team in the Centre for Road Safety maintains a model that calculates road safety benefits and costs for road infrastructure projects. The Safer Roads team also maintains the Crash Reduction Factor matrix that records the literature based crash reduction or increase factors of individual road safety countermeasures, by RUM code.

[90] ARTC, *Melbourne-Brisbane Inland Rail Alignment Study*, Final Report, July 2010, page 90.

8 Freight productivity benefits

Freight productivity benefits refer to the market related impacts that result from a new freight project. These are distinct from the benefits for road and rail operators, and instead refer to the productivity improvements that could be delivered to the economy more broadly in terms of improved land use, labour supply, producer surplus and market access opportunities.[91]

Outcome	Benefits	Alignment with 'Connecting to the Future' Outcomes
A more productive freight network, improving economic outcomes for the people of NSW.	• Land use impacts • Productivity benefits from intermodal terminals • Asset and infrastructure costs/benefits • Generated demand/producer surplus • More reliable market access	Strong economy and quality of life • Quality assets and efficient networks, managed for the right price • Transport investments and solutions that serve the people of NSW

8.1 Land use impacts

A change in land use will generate economic benefits if the new infrastructure project unlocks the supply of higher value land, by reducing a constraint on the supply of that land. ATAP defines land-use benefits as being applicable where:[92]

- The project is expected to result in significant land-use change; and
- There are market imperfections in the land-use market so that prices differ from marginal social costs; or
- There are feedback effects between land use and the transport network.

Examples of freight projects which could result in land use changes include:

- A new intermodal terminal, which could unlock land use benefits if the project has a direct rail connection to an east coast port, which may offer a shuttle service to unlock higher-value industrial land due to the productivity benefits of the terminal's location;
- A new freight line resulting in freight traffic switching from a shared network to dedicated freight infrastructure, allowing for additional passenger services on the previously shared network. The resulting additional passenger services may unlock additional capacity where a supply constraint previously existed;
- Road freight corridors in metropolitan areas which induce investment in warehousing.

The steps to be taken in estimating land-use benefits are outlined on pages 23-29 of ATAP's land-use guidelines.[93]

8.2 Productivity benefits from intermodal terminals

Practitioners should consider the extent to which other productivity benefits emerge due to the construction of intermodal terminals in conjunction with other freight initiatives.[94] These benefits could include:

- Freight agglomeration benefits: due to the improved connectivity and accessibility of people and businesses from a decrease in the cost of travel. Business travel times will bring firms closer to each other, their suppliers and consumers, and facilitates knowledge and information exchanges;
- Labour supply benefits: reductions in the generalised costs of travel can have an impact on an individual's employment decisions. As the cost of travel to and from work can be reduced through travel time savings, individuals may choose to enter the labour market or increase their working hours;

[91] Given that these benefits only tend to arise in very specific circumstances, careful consideration needs to be given to their presentation and reporting. As a general rule, these benefits should be excluded from central BCR and NPV calculations to the extent that there is a degree of uncertainty around the realisation of these benefits.

[92] Australian Transport Assessment and Planning Guidelines, *O8 Land-use benefits of transport initiatives,* page 4.

[93] Australian Transport Assessment and Planning Guidelines, 08 Land-use benefits of transport initiatives, pages 23-29.

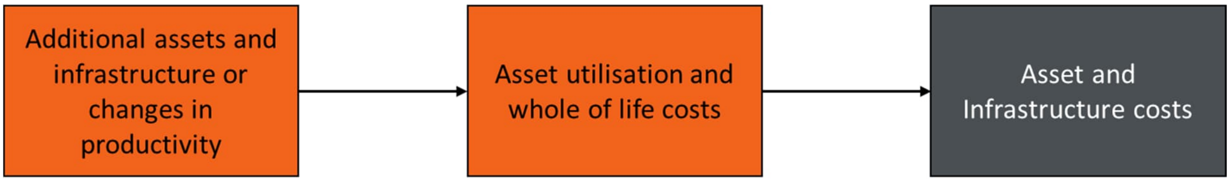
[94] Refer to TfNSW's *Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives: Transport Economic Appraisal Guidelines* for further details on methods that can be used to quantify wider economic benefits in CBAs.

- Labour productivity benefits: the benefit of matching workers with the most relevant job opportunities. The development of an intermodal terminal may drive higher value add per worker, thereby delivering higher taxation revenue.

8.3 Asset and infrastructure costs/benefits

Asset and infrastructure impacts are based on the cost to industry of investing in additional infrastructure to manage reliability and/or operational factors. The asset and infrastructure analysis uses the process outlined in Figure 5 to determine the infrastructure cost to the rail freight industry to cater for reliability and/or operational factors. Practitioners could inform their assumptions on asset and infrastructure investment requirements with industry consultation. The information to support this benefit may be difficult to locate for all projects, and is likely to be highly operator and supply-chain specific, practitioners should consider whether relevant information is available to quantify this benefit.

Figure 5 Asset and infrastructure costs



Source – George Stanley Consulting

Asset and infrastructure costs can be separated into two categories:

- Rolling stock: locomotive and wagon rollingstock capital costs would be based on industry estimates;
- Storage and handling: changes in storage and handling or warehousing requirements as a result of a project investment could be identified. Freight customers may alter their storage space in response to supply chain factors, which has an economic value.

8.4 Benefits arising from generated demand (producer surplus)

Improved logistics can materially improve supply chain costs and encourage producers to increase their production in new or existing markets. Where this occurs, a freight project would have resulted in a producer surplus or generated demand.

The measure of this benefit should follow the usual assessment of producer surplus. To avoid double counting, the production should be net additional, the reorganisation of existing freight volumes, for example, as a result of mode shift. The net production impacts should be specifically linked to the infrastructure project being considered by the practitioner.

Practitioners would be required to undertake industry analysis, specific to their project, to estimate the producer surplus of the following formula can be used:

$$\text{Producer surplus, by commodity or industry} = (\text{tonnes}_{project} - \text{tonnes}_{base}) \times (\text{production value (\$/tonne)} - \text{production cost(\$/tonne)})$$

8.5 More reliable market access

Improved reliability of the freight rail network can also allow producers to be more responsive to market demands. This is particularly the case for containerised grain, as it tends to achieve a higher price per tonne for farmers and freight forwarders due to serving niche markets. These niche markets can develop for a range of reasons, including demand for speciality types of grain to satisfy a particular processing product or where buyers do not need to purchase bulk shiploads volumes of grain for their processing activities (and are prepared to pay a premium for containerised grain).

In these circumstances, and others where market factors drive a premium in the price of goods, operators and freight forwarders will benefit from a freight network that is reliable and can allow them to quickly respond to changes in market conditions. To the extent that a new freight project would support increased production in these market circumstances, the method for calculating this benefit is the same as the producer surplus benefit outlined in section 8.4, with adjustments in production values to account for international demand and commodity pricing.

9 Appendix A: Supply Chain Considerations Summary

Consideration of the entire supply chain will ensure that all potential costs and benefits are captured in the analysis. This process will promote a better understanding of supply chains, demand analysis, and benefits estimation and realisation. The diagram below outlines the supply chain considerations that practitioners should consider for road and rail projects impacting freight.

Supply chain understanding

Having a strong understanding of supply chains is vital to ensuring that all project benefits are identified and quantified. Even for non-freight projects, practitioners should consider the part of the supply chain that interacts with the project, and if it might lead to any freight benefits. For all types of projects, practitioners should consider the following:

- What type of supply chains will be affected?
    - *e.g., Interstate, Intrastate, Metropolitan IMEX, Agricultural Bulk/Containerised, Coal, Steel, Agricultural (bulk and containerised), Mining Exports, direct road movements from producer to customer.*
- Where does the project sit within the supply chain?
    - *e.g., upgrading an intermodal bulk terminal to have greater storage may be constrained by the roads leading to the intermodal from the farm, and the rail payload capacity leaving the intermodal.*
    - *e.g., upgrading an access road to support road-trains accessing a grain silo may be constrained by roads upstream that do not support road-trains.*
    - *e.g., upgrading a metropolitan road may enhance the 'last mile' of the freight movements into an east coast port.*
- What types of commodities are involved?
    - *e.g., a coal supply chain will be less substitutable than most other supply chains due to the size of the freight movements.*
    - *e.g., refrigerated goods may be more suitable to road, and may therefore be more likely to benefit from a road improvement*
- How is the commodity moved within different supply chains?
    - *e.g., a rail upgrade may increase reliability for the journey to Port – which may reduce additional window purchase costs at the Landside Container Terminal;*
    - *e.g., a road upgrade such as a dedicated freight lane for heavy vehicles may improve the 'last mile' of travel into an east coast port.*
- Who are the key participants across the supply chain?
    - *i.e., supply chains can involve road, intermodal and rail components in moving goods from a consumer to a producer.*
- For the affected freight movement, what was the previous supply chain movement (i.e., how was it received) and what is the next freight movement (i.e., is this the last mile movement, or if not, how will it get to the end consumer)?
    - *e.g., a project may improve the prior freight movement, but if the next freight movement is congestion constrained then benefits realisation will be affected.*
    - *e.g., if the supply chain includes a last-mile leg, the impacts of an incident may be far worse compared to a similar incident on a CRN line.*

Total demand in freight catchment & contestability

After practitioners develop an understanding of the supply chains that will be impacted by the project, they should quantify the demand and associated road and rail mode share.

- What is total demand in the catchment area?
    - *i.e., a top-down understanding of the demand task will ensure that quantifiable freight benefits are broadly consistent with the way supply chains operate for different commodities in NSW.*

- What do those key supply chains look like in the medium term?
  - *i.e., how likely are the benefits associated with supply chains that are experiencing long-term decline and will benefits be amplified by increasing demand for new supply chains.*
- What is the mode-share in the catchment area?
  - *i.e., what is the mode share of that demand in both the base and project case?*

Ability to realise benefits

Understanding the extent to which benefits can actually be realised is critical in the analysis of freight projects. Practitioners should consider:

- What are factors across the supply chain that might hinder benefits realisation?
  - *e.g., a silo/storage facility operator may be capacity constrained by staffing levels as opposed to the quality of the underlying infrastructure*
  - *e.g., the benefits associated with improving below rail assets to allow a TAL increase may not be realised if operators do not have sufficient rolling stock to support greater payloads, or if road is still viewed as a more cost-effective option for a particular commodity and O-D pair.*
  - *e.g., access arrangements on shared networks, or Port Window booking arrangements may affect benefits realisation from upstream infrastructure improvements*
  - *e.g., rail path hoarding to cater for rail reliability issues*
  - *e.g., traffic count data for a road project may be unreliable, unrepresentative or unavailable when quantifying the benefits of movements along the road.*
- *To the extent that there is substitutability, what are the effects of the infrastructure project on the substitute?*
  - *e.g., a new rail line may induce rail demand, increasing congestion at east coast ports.*
  - *e.g., a highway upgrade may improve part of a freight journey, but lead to increased congestion at entry and exit points to the road.*

10 Appendix B: Freight demand and supply chain information

Datasets available on NSW Government Open Data Hub

- *Freight Forecast:* Demand Forecast for NSW by commodity and SA3;
- *Use of Rail Freight:* Containers leaving or arriving at Port Botany on rail;
- *Road Safety:* Statistics relating to fatalities and serious injuries from crashes involving heavy and light trucks;
- *Rail Freight Access:* The number of paths available for freight at key locations within the Sydney Metropolitan Network;
- *Rail capacity:* TAL capacity of operational lines across NSW;
- *Port Botany Efficiency:* Operational data for Port Botany;
- *Port Botany:* Monthly data on performance of various operational aspects within Port Botany;
- *Port Kembla:* Monthly data on imports and exports in tonnes from Port Kembla;
- *Port of Newcastle:* Monthly data on imports and exports in tonnes from the Port of Newcastle;
- *Kingsford Smith Airport:* Monthly data on import and export volumes at Kingsford Smith Airport;
- *NSW Port Botany Load Discharge Ratio Statistics:* Monthly data from September 2019- January 2022. Use Port Botany data for data after February 2022;
- *Empty Container Park Capacity and Utilisation:* Monthly utilisation of operational capacity at selected Empty Container Parks (ECPs) in Sydney;
- *NSW Road Crash Data 2016-2020:* general crash information across NSW.

Office of National Rail Safety

- Network safety statistics, key occurrences, occurrences relating to national priorities, and industry drug and alcohol testing.

Sydney Trains

- Sydney trains holds a record of incidents and breakdowns on the network, which may be available to practitioners upon request.

The CSIRO

- The Transport Network Strategic Investment Tool (TraNSIT) provides detailed map of routes and costings across Australia's agricultural and forestry supply chain. CSIRO can be contacted for access to the tool.

The Australian Bureau of Statistics

- Agricultural commodity data may provide context of volumes of commodities and origin.

Transport for NSW (data may be available for specific project teams, upon request):

- Dashboard of data on freight transport, including road and rail incident data:
- Advanced Analytics and Insights (AAI) data on several main highways in specific locations across NSW, including data on network speeds, traffic volumes, and journey time;
- Heavy Vehicle data including breakdown duration and volume;
- INX collision data for public busses across NSW;
- Strategic Freight Model outputs, noting that these models are high-level (by SA3) and cannot be used to predict the mode shift impacts that result from a freight project;
- Historical data of flood impacts on road projects;
- Forecast tonnages on major highways across NSW.

The Safer Roads team in the Centre for Road Safety

- The Safer Roads team in the Centre for Road Safety maintains a model that calculates road safety benefits and costs for road infrastructure projects. The Safer Roads team also maintains the Crash Reduction Factor matrix.

11 Appendix C: Rail case study

Hypothetical project description[95]
Suppose a project entailed upgrading a rail freight line's capacity from 20TAL to 25TAL on a part of the CRN that interfaces with Inland Rail, improving load capacity and speed.[96]   This would involve strengthening and/or replacing below rail infrastructure such as the sleepers, ballast and formation. This project would support longer and heavier trains, at higher speeds (and in this case, it is assumed shorter cycle times in the absence of upstream or downstream constraints), and improved interoperability with Inland Rail (which is currently limited to 25TAL).

Investment Logic Mapping
The investment logic map below outlines the key problems, outcomes and benefits associated with the project.

Problem/Opportunity	Project outcomes	Benefits[97]
This line does not currently support interoperability with Inland Rail, leading to less efficient rail operations, and disincentivising fleet rationalisation	Heavier and longer trains support more efficient operations and interoperability with Inland rail	Crew cost savings, fuel cost savings, locomotive cost savings, wagon cost savings

Quantifying benefits
Data gathering

After conducting their research, the practitioner would derive the following information (note, the below is for illustrative purposes only and may not accurately reflect the outcomes of this project or specific parameter values if implemented in practice):

- The total freight demand is 500,000 tonnes per annum in the base case and 600,000 tonnes per annum in the project case. Induced demand as a result the project is 100,000 tonnes;
- The average train length is 2 locomotives and 40 wagons in the base and project case;
- The rail line being upgraded is 300kms in length;
- The existing demand, requires 230 rail services per annum in the base case, compared to 172 in the project case.
- Induced demand is a product of diversion from road freight. However, if in the base case this induced demand would have used the existing rail line (without the upgrade), 45 rail services per annum would be required. In the project case, only 34 services per annum are required.
- The average cycle time is 17 hours in the base case, compared to 15 hours in the project case; resulting in a 2 hour saving due to the project.
- The net train capacity increases from 2200 tonnes in the base case to 2900 tonnes in the project case, as a result of a TAL upgrade which supports higher net carrying capacity of trains;
- Gross weight per loaded service is 3,500 tonnes in the base case and 4,200 tonnes in the project case;
- Gross weight per empty service is 1,280 tonnes in the base case and project case.
- There is an average of 2 crew per shift;
- Footplate hours are 6 hours per shift;
- Crew hours are 7.6 hours per shift;
- Crew cost is equal to $182/hour;
- Fuel price: $1.30/Litre;
- Fuel consumption rate: 5 Litres/'000 GTK, based on the diesel consumption of a grain train on flat terrain;
- Locomotive maintenance costs: $2/locomotive km;

[95] Note: example benefits calculations are for the first project year only, for illustrative purposes. The practitioner, in consultation with the freight demand estimator, will have to forecast benefits over the appraisal period. Discounting of benefits profile should rely on prescribed discount rates as per TfNSW Cost Benefit Analysis Guide.
[96] Note that projects that relate to TAL upgrades may not necessarily result in improved speed. This is just an illustrative example in which a TAL upgrade unlocks the possibility of increasing travel speeds that will not occur in the base case.
[97] Note: for simplicity, mode shift benefits (i.e., for parallel infrastructure) have not been considered in this illustrative example. Refer to ATAP T2, chapter 7 for further details on the approach used to assess benefits on parallel infrastructure as a result of mode shift.

- Wagon maintenance cost: $0.08/locomotive km.

Crew cost savings

Crew cost savings for existing demand ($/year)

> = Base case demand (tonnes) x ▲Cycle time (hr) x Number of crew (crew) x Crew hrs (hr/shift) / Footplate hrs (hr/shift) / ▲Net train capacity (tonnes) x Crew costs ($/crew /hr)

= 500,000 tonnes x 2 hours x 2 crew x 7.6 hrs/6 hrs/700 tonnes x $182/hour

=$658,667

Crew cost savings for induced demand ($/year)

> = (project case tonnes – base case tonnes)/2 x ▲Cycle time (hr) x Number of crew (crew) x Crew hrs (hr/shift) / Footplate hrs (hr/shift) / ▲Net train capacity (tonnes) x Crew costs ($/crew/hr)

=(600,000 tonnes – 500,000 tonnes)/2 x 2 hours x 2 crew x 7.6 hrs/6 hrs/700 tonnes x $169/hour

=$65,867

Fuel cost savings

Fuel cost savings for existing demand ($/year)

> = Gross tonne kilometres saved for existing demand (GTK/year) x Fuel consumption (Litres/GTK) x Fuel price ($/Litre)

Base case GTK for existing demand

=(gross weight per loaded service x service distance x required services per annum) + (gross weight per empty service x service distance x required services per annum)

=((3,500 x 300 x 230) + (1,280 x 300 x 230))/1,000

=329,820 (‘000 GTK)

Project case GTK for existing demand

=(gross weight per loaded service x service distance x required services per annum) + (gross weight per empty service x service distance x required services per annum)

=((4,200 x 300 x 172) + (1,280 x 300 x 172))/1,000

=282,768 (‘000 GTK)

▲Total GTK= 329,820 (‘000 GTK) – 282,768 (‘000 GTK) = 47,052 (‘000 GTK)

Incremental benefit for existing demand = 47,052 (‘000 GTK) x 5L/’000 GTK x $1.30/Litre = $305,838

Fuel cost savings for induced demand ($/year)

> = Gross tonne kilometres saved for induced demand (GTK/year) x 0.5 x Fuel consumption (Litres/GTK) x Fuel price ($/Litre)

=(gross weight per loaded service x service distance x required services per annum) + (gross weight per empty service x service distance x required services per annum)

Base case GTK for induced demand

=((3,500 x 300 x 45) + (1,280 x 300 x 45))/1,000

= 64,530

Project case GTK for induced demand

=((4,200 x 300 x 34) + (1,280 x 300 x 34))/1,000

= 55,896

▲Total GTK= 64,530 (‘000 GTK) – 55,896 (‘000 GTK) = 8,634 (‘000 GTK)

Incremental benefit for induced demand = 8,634 (‘000 GTK) x 0.5 x 5L/’000 GTK x $1.30/Litre = $28,061

Locomotive maintenance cost savings

Locomotive maintenance cost savings for existing demand ($/year)

> =▲ locomotive kilometres for existing demand x Locomotive maintenance costs ($/km)

Base case kms

=230 required trips per annum x 300km service distance x 2 (return trip) x 2 locomotives

=276,000km

Project case kms

=172 required trips per annum x 300km service distance x 2 (return trip) x 2 locomotives

= 206,400km

Incremental benefit for existing demand = (276,000km – 206,400km) x $2/km = $139,200

Locomotive maintenance cost savings for induced demand ($/year)

> =▲ locomotive kilometres travelled for induced demand x 0.5 x Locomotive maintenance costs ($/km)

Base case kms (for induced demand volumes)

= 45 required trips per annum x 300 km service distance x 2 (return trip) x 2 locomotives

= 54,000km

Project case kms (for induced demand volumes)

= 34 required trips per annum x 300 km service distance x 2 (return trip) x 2 locomotives

=40,800km

Incremental benefit for induced demand = (54,000 km – 40,800km) x 0.5 x $2/km = $13,200

Wagon maintenance cost saving

Wagon maintenance cost savings for existing demand ($/year)

> = ▲wagon kilometres travelled for existing demand x Wagon maintenance costs ($/km)

Base case kms travelled for existing demand

=230 required trips per annum x 300km service distance x 2 (return trip) x 40 locomotives

= 5,520,000 km

Project case for existing demand

=172 required trips per annum x 300km service distance x 2 (return trip) x 40 wagons

= 4,128,000 km

▲wagon kilometres travelled for existing demand = 5,520,000 km – 4,128,000km = 1,392,000km

Wagon maintenance cost savings for existing demand = 1,392,000 x $0.08/km = $111,360

Wagon maintenance cost savings for induced demand ($/year)

> = ▲wagon kilometres travelled for induced demand x 0.5 x Wagon maintenance costs ($/km)

Base case kms travelled for induced demand

=45 required trips per annum x 300km service distance x 2 (return trip) x 40 locomotives

= 1,080,000 km

Project case for induced demand

=34 required trips per annum x 300km service distance x 2 (return trip) x 40 wagons

= 816,000 km

▲wagon kilometres travelled for induced demand = 1,080,000 km – 816,000 km = 264,000km

Wagon maintenance cost savings for existing demand = 264,000km x 0.5 x $0.08/km = $10,560

12 Appendix D: Road case study

Hypothetical project description
The project entails the construction of a new road bypass. The project would provide a more direct path for heavy vehicles compared to the existing road corridor, by avoiding several townships, providing distance and time improvements for selected origin-destination pairs. The quality of the new road will support faster average speeds for heavy vehicles compared to the existing route.

Investment Logic Mapping

The investment logic map below outlines the key problems, outcomes and benefits associated with the project.

Problem/Opportunity	Project outcomes	Benefits
The existing pathway is highly congested and passes through some townships, reducing the average speeds for operators	A freight bypass will reduce the travel distance, avoid townships and enable higher speeds	Reduced vehicle operating costs, freight travel time savings, road travel time savings (user benefit) and externalities

Quantifying benefits

Data gathering

Assume that the practitioner derives the following demand and supply chain information (note, this is for illustrative purposes only and may not accurately reflect the outcomes of this project if implemented in practice):

- 500,000 tonnes per annum of containerised goods are moved via the current road pathway under the base and project case, which is assumed to comprise of 16,628 B-double movements.[98]
- Under the project case, the distance travelled from origin to destination will decrease by 30kms (from 130km to 100km);
- B-doubles are assumed to travel at an average speed of 70km/h along the path in the base case, compared to 90km/h in the project case (along the new bypass route). The resource VOC for a B-double travelling at an average speed of 70km/hr is $1.77/km and $1.70/km for a B-double travelling at 90km/hr;[99]
- Under the project case, travel times will decrease by 0.75 hours;[100]
- The value of freight time is assumed to be $1.06/tonne hour;
- The value of travel time for B-doubles is assumed to be $36.21/vehicle hr;[101]
- The practitioner assumes that there are 300 operating days in a year;
- According to TfNSW Economic Parameters, the road damage cost for a B-double is $0.27/km;[102]
- According to TfNSW Economic Parameters, the total environmental cost in urban areas for a B-double is 1.40/km;[103]
- According to TfNSW Economic Parameters, freight safety benefits in urban areas are: $0.08/km.[104]

---

98 Assumes a net weight of 30 tonnes per b-double, based on data from the National Heavy Vehicle Regulator (https://www.nhvr.gov.au/files/201607-0116-mass-and-dimension-limits.pdf) and MTF Logistics (Road Transport Weight Limits | MTF Logistics Services Sydney).

99 Transport for NSW *Economic Parameter Values* 2020, Table 12 and Table 13. Parameter values have been escalated from 2019 to 2022 at 2.5% per annum. Costs are presented in 10km/hr increments and the band within 10km/hr above has been used where indicative speed is not divisible by 10.

100 This is based on an average speed of 70km/hr in the Base Case for a 130km trip and 90km/h in the Project Case for a 100km trip.

101 Transport for NSW *Economic Parameter Values* 2020, Table 3 (B double parameter value, non-urban freight vehicle), page 11. The 2019 value of $33.62/vehicle hour has been escalated by 2.5% per annum to be expressed in 2022 terms.

102 Transport for NSW *Economic Parameter Values* 2020 Table 48. Note: parameter values have been escalated by 2.5% per annum from 2019 to 2022.

103 Transport for NSW *Economic Parameter Values* 2020 Table 39. Note: parameter values have been escalated by 2.5% per annum from 2019 to 2022 at 2.5% per annum. Parameter for 'articulated trucks' have been used. They include air pollution, GHG emissions, noise, water pollution, nature & landscape and urban separation. Both the base case and project case are assumed to be located in urban areas.

104 Transport for NSW *Economic Parameter Values* 2020 Table 25. Note: parameter values have been escalated by 2.5% per annum from 2019 to 2022. Numbers are expressed in million vehicle kilometres travelled (mvkt) but are converted to kms for this example.

Reduced vehicle operating costs from increased speeds and reduced distances

Vehicle Operating Cost savings

= Vehicle Kilometres Travelled (VKT) x Resource VOC ($/VKT)[105]

Base case

= (number of trips per annum x kilometres per trip x 2)[106] x Resource VOC

= (16,628 trips x 130 km x 2) x $1.77/km

= 4,323,280km x $1.77/km

= $7,652,206

Project case

= (number of trips per annum x kilometres per trip x 2) x Resource VOC

= (16,628 trips x 100km x 2) x $1.70/km

= 3,325,574km x $1.70/km

= $5,653,520

Incremental benefit = $7,652,206 - $5,653,520 = $1,998,686

Time benefits from shorter and faster journeys

Approach 1: Freight travel time savings[107]

= Net tonnes by road (tonnes/year) x loaded vehicle travel time savings (hr) x value of freight time ($/tonne hr)

= 500,000 tonnes x 0.75 hrs travel time saving (loaded direction) x $1.06/tonne hr

= $397,500

Approach 2: Road travel time savings (value of travel time for urban freight vehicle)[108]

= Number of trips per annum (trips/year) x travel time savings per trip (hr) x 2 x value of road travel time (b doubles) ($/vehicle hr)

=16,628 x 0.75 hrs x 2 x $36.21/hr

=$903,150

Externality benefits from shorter and faster journeys

Road damage cost savings

= Vehicle Kilometres Travelled (VKT) x cost of road damage ($/VKT)

Base case

= (service distance x number of trips per year x 2) x cost of road damage

= (130km x 16,628 trips x 2)[109] x $0.27/km

= $1,167,286

Project case

= (service distance x number of trips per year x2) x cost of road damage

= (100km x 16,628 trips x 2) x $0.27/km

= $897,912

Incremental benefit = $1,167,286 - $897,912 = $269,374

---

105 Transport for *NSW Technical Note on Calculating Road Vehicle Operating Costs*, 2020. Refer to approach 1: Change in resource costs.
106 Multiplying by 2 accounts for the return journey.
107 Loaded trips only.
108 Accounts for trips in both directions as parameter values are based on business time.
109 Multiplying by 2 to account for return trips.

Environmental impacts

= Vehicle Kilometres travelled (by road) (VKT) x Externality costs ($/VKT)

Base case

= (service distance x number of trips per year) x environmental externality cost

= (130km x 16,628 trips x 2)[110] x $1.40/km

= $6,052,592

Project case

= (service distance x number of trips per year x 2) x environmental externality cost

= (100km x 16,628 trips x 2) x $1.40/km

= $4,655,840

Incremental benefit = $6,052,592 - $4,655,840 = $1,396,752

Road safety benefits

= Vehicle Kilometres Travelled (VKT) (by road) x Accident costs ($/VKT)

Base case

= (service distance x number of trips per year) x road safety benefits

= (130km x 16,628 trips x 2) x $0.08/km

= $345,862

Project case

= (service distance x number of trips per year) x road safety benefits

= (100km x 16,628 trips x 2) x $0.08/km

= $266,048

Incremental benefit = $345,862 - $266,048 = $79,814

[110] Multiplying by 2 to account for return trips

13 Appendix E: Resilience case study

Hypothetical project description

The project entails the construction of new bridges and other road infrastructure to improve flood resilience

The project would improve bridge and road infrastructure, compared to the existing corridor, which would reduce the frequency of road closures during periods of heavy rainfall.

Investment Logic Mapping

The investment logic map below outlines the key problems, outcomes and benefits associated with the project.

Problem/Opportunity	Project outcomes	Benefits
Due to several low-level bridges on the current road path, 15% of the current road freight task is impacted due to flooding each year, and must divert to a relatively longer pathway	A freight bypass that would lead to a reduction in impacted road freight services (thereby reducing the need for diversions).	Avoided increase in vehicle operating costs, freight travel time, road travel time (user benefit) and externalities

Quantifying benefits

Data gathering

After researching, assume that the practitioner derives the following demand and supply chain information (note, this is for illustrative purposes only and may not accurately reflect the outcomes of this project if implemented in practice):

- 650,000 tonnes per annum of containerised goods are moved via the current road pathway under the base and project case, which is assumed to comprise of 21,667 B-double movements.[111]
- B-doubles are assumed to travel at an average speed of 70km/h along the path in the base and project case;
- The value of freight time is assumed to be $1.06/tonne hour;
- The value of travel time for B-doubles is assumed to be $36.21/vehicle hr;[112]
- The practitioner assumes that there are 300 operating days in a year;
- On average, under the base case, flooding impacts 15% of total road freight trips per annum, requiring operators to use a diversion path that is 50km longer at an average speed of 70km/hr. In the project case, only 2% of total road freight trips per annum are expected to be impacted by flooding;[113] Additional travel time due to the diversion = 50km ÷ 70km/hr = 0.71hrs
- The resource VOC for a B-double travelling at an average speed of 70km/hr is $1.77/km;[114]
- According to TfNSW Economic Parameters, the road damage cost for a B-double is $0.27/km;[115]
- According to TfNSW Economic Parameters, the total environmental cost in urban areas for a B-double is 1.40/km;[116]

---

[111] Assumes a net weight of 30 tonnes per b-double, based on data from the National Heavy Vehicle Regulator (https://www.nhvr.gov.au/files/201607-0116-mass-and-dimension-limits.pdf) and MTF Logistics (Road Transport Weight Limits | MTF Logistics Services Sydney).

[112] Transport for NSW *Economic Parameter Values* 2020, Table 3 (B double parameter value, non-urban freight vehicle), page 11. The 2019 value of $33.62/vehicle hour has been escalated by 2.5% per annum to be expressed in 2022 terms.

[113] Note: practitioners would need to produce evidence to support the % change in expected impacts between the base and project case. This may be based on operational modelling, stakeholder consultations or other sources.

[114] Transport for NSW *Economic Parameter Values* 2020, Table 12 and Table 13. Parameter values have been escalated from 2019 to 2022 at 2.5% per annum. Costs are presented in 10km/hr increments and the band within 10km/hr above has been used where indicative speed is not divisible by 10.

[115] Transport for NSW *Economic Parameter Values* 2020 Table 48. Note: parameter values have been escalated by 2.5% per annum from 2019 to 2022.

[116] Transport for NSW *Economic Parameter Values* 2020 Table 39. Note: parameter values have been escalated by 2.5% per annum from 2019 to 2022 at 2.5% per annum. Parameter for 'articulated trucks' have been used. They include air pollution, GHG emissions, noise, water pollution, nature & landscape and urban separation. Both the base case and project case are assumed to be located in urban areas.

- According to TfNSW Economic Parameters, freight safety benefits in urban areas are: $0.08/km.[117]

Reduced vehicle operating costs from improved network resilience

Vehicle Operating costs

= Vehicle Kilometres Travelled (VKT) x Resource VOC ($/VKT)

Base case (15% of trips are affected)

=(number of trips per annum x percentage of trips diverted x 2)[118] x additional kilometres per diverted trip x Resource VOC

= (21,667 trips x 15% x 2) x 50km x $1.77/km

=4,988 trips x 50km x $1.77/km

= $575,259

Project case (2% of trips are affected)

=(number of trips per annum x percentage of trips diverted x 2) x additional kilometres per diverted trip x Resource VOC

= (21,667 trips x 2% x 2) x 50km x $1.77/km

= 665 trips x 50km x $1.77/km

= $76,701

Incremental benefit = $575,259- $76,701 = $498,558

Time benefits from improved network resilience

Freight travel time savings

= Net tonnes by road (tonnes/year) x loaded vehicle travel time savings (hr) x value of freight time ($/tonne hr)

Base case

= (total tonnes x percentage impacted) x loaded vehicle travel time when diverted x value of freight time

= (650,000 tonnes x 15%)[119] x 0.71 hrs x $1.06/hr

= $73,379

Project case

= (total tonnes x percentage impacted) x loaded vehicle travel time when diverted x value of freight time

= (650,000 tonnes x 2%) x 0.71 hrs x $1.06/hr

=$9,784

Incremental = $73,379 - $9,783 = $63,596

Road travel time savings (b double, per vehicle hour)

= Number of trips x travel time savings per trip (hr) x value of road travel time ($/vehicle hr)

Base case

= (number of annual trips x percentage impacted) x travel time when diverted x value of road travel time

= (21,667 x 15%)trips x 0.71hrs x 2 x $36.21/hr

= $167,112

---

[117] Transport for NSW *Economic Parameter Values* 2020 Table 25. Note: parameter values have been escalated by 2.5% per annum from 2019 to 2022. Numbers are expressed in million vehicle kilometres travelled (mvkt) but are converted to kms for this example.
[118] Multiplying by 2 to account for return journeys. This assumes that the alternate route is used for return journeys during an incident, however this would need to be confirmed by the practitioner on a case by case basis.
[119] This assumes that the freight task is completed by the same vehicle class (i.e., B Doubles). A more granular approach may be required if multiple vehicle classes are used.

Project case

= (number of annual trips x percentage impacted) x travel time when diverted x value of road travel time

= (21,667 x 2%)trips x 0.71hrs x 2 x $36.21/hr

= $22,282

Incremental benefit = $167,112 - $22,282 = $144,830

Externality benefits from improved network resilience

Road damage cost savings

= (Vehicle Kilometres Travelled (VKT)) x cost of road damage ($/VKT)

Base case

= (diversion distance x number of trips per year x percentage of trips affected) x cost of road damage

= (50km x 21,667 trips x 15% x 2)[120] x $0.27/km

= $87,751

Project case

= (diversion distance x number of trips per year x percentage of trips affected) x cost of road damage

= (50km x 21,667 trips x 2% x 2) x $0.27/km

= $11,700

Incremental benefit = $87,751 - $11,700 = $76,051

Environmental impacts

= Vehicle Kilometres travelled (by road) (VKT) x Externality costs ($/VKT)

Base case

= (diversion distance x number of trips per year x percentage of trips affected) x environmental externality cost

= (50km x 21,667 trips x 15% x 2) x $1.40/km

= $455,007

Project case

= (diversion distance x number of trips per year x percentage of trips affected) x environmental externality cost

= (50km x 21,667 trips x 2% x 2) x $1.40/km

= $60,668

Incremental benefit = $455,007 - $60,668 = $394,339

Road safety benefits

= Vehicle Kilometres Travelled (VKT) (by road) x Accident costs ($/VKT)

Base case

= (diversion distance x number of trips per year x percentage of trips affected) x road safety benefits

= (50km x 21,667 trips x 15% x 2) x $0.08

= $26,000

Project case

= (diversion distance x number of trips per year x percentage of trips affected) x road safety benefits

= (50km x 21,667 trips x 2% x 2) x $0.08

= $3,467

Incremental benefit = $26,000 - $3,467 = $22,533

[120] Multiplying by 2 to account for return trips. This assumes that the freight vehicles would be required to use the alternative route on a return trip during an incident, but this would need to be confirmed by the practitioner.