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It's All Good: Considering negatives in the cost-benefit analysis framework

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Abstract

Cost-Benefit Analysis is an effective tool for assessing the positives and negatives of transport infrastructure proposals. While most assessments accurately capture the benefits and costs, a project's dis-benefits[1] are often excluded when assessing its economic merit. The exclusion of dis-benefits has the potential to lead to the sub-optimal allocation of resources and ultimately result in smaller scale or non-typical solutions being overlooked. If greater consideration was given to capturing the negative impacts of a project, through potential harm or damage, we would expect to see a shift in the way infrastructure solutions are analysed, resulting in greater alignment with desired outcomes of economic assessments.

1.Introduction

Cost-Benefit Analysis (CBA) is an effective tool for assessing the positives and negatives of transport infrastructure proposals. Agencies at both the State and Federal levels typically require CBAs to be undertaken on transport infrastructure projects as part of the Business Case development process. There is significant literature on the method to be used when undertaking CBAs on transport infrastructure, particularly in the road space. This is supported by detailed guidance on how the inputs to a CBA should be estimated, the parameter values to be used in the CBA and how outputs should be presented and interpreted.

While most assessments accurately capture the benefits and costs, dis-benefits such as delays during construction and the environmental impacts of construction materials are often excluded when assessing the economic merit of a project. This is driven by a range of factors, such as optimism bias, directives from project proponents, the desire to 'sell' a project and the competitive nature of public funding amongst others.

This paper will present an overview of the existing guidance in Australia and New Zealand, discuss which dis-benefits are routinely considered and which potentially should be, the problems with including dis-benefits in practice and present recommendations for how dis-benefits may be incorporated more regularly.

Academic literature covers the importance of considering both positive and negative benefits when making decisions. However, this paper has been developed with a focus on the way CBAs are conducted in practice, rather than on the research surrounding their inclusion. It can be generally agreed that the inclusion of dis-benefits would improve the accuracy of CBAs, so this paper attempts to identify the factors which limit their inclusion in practice and to encourage discussion on this topic so that all transport CBAs in Australasia consider dis-benefits similarly.

[1] Disbenefits are negative consequences to the public that work to reduce the total benefits of a project as opposed to the costs of the project to government which are included in the cost line of the benefit cost ratio.

2. Existing guidance

Guidance in Australia and New Zealand mentions the inclusion of dis-benefits or negative benefits to varying degrees. In almost all cases, the methodology components of the guidelines include recommendations to include 'all benefits' or 'both positive and negative benefits'. However, benefit quantification and monetisation guidance are only provided for impacts which are typically positive.

The table below contains a summary of how negative benefits or dis-benefits are discussed in the current guidelines

Table 1: Existing guidance on dis-benefits / negative benefits

Guideline	Discussion
Infrastructure Australia Guide to Economic Appraisal (Infrastructure Australia, 2021)	• Description of any significant positive or negative environmental externalities of the project. • Description of any significant positive or negative social impacts of the project • Negative externalities, such as congestion due to induced demand • Negative WEBs • Land use changes • Environmental impacts from reclamation of coastal areas
Transport for NSW Cost-Benefit Analysis Guide (Transport for New South Wales, 2019)	• Increase car use leads to negative environmental impacts
NSW Govt: Coastal Management Options (State of NSW and Office of Environment and Heritage, 2018)	• Amenity and recreation values • Negative externalities may include impacts on environmental values (e.g., increased pollution, reductions in native vegetation); social values (e.g., impact on heritage values, reduced social cohesion); and economic values (e.g., travel time increases; increases in death/injuries that lead to lower workforce output).
UK Green Book (Her Majesty's Treasury, 2020)	• Collateral effects (both positive and negative) may result from an intervention and unintended consequences may occur as a result • Negative impacts to place
Waka Kotahi (Waka Kotahi: New Zealand Transport Agency, 2020)	• Negative impacts associated with congestion • Negative impacts associated with PT demand increases (left behind, standing) • Disruption costs to existing users of walking and cycling facilities during the implementation of new or improved facilities must be included in the evaluation as a disbenefit • Note that the benefit calculations should include any negative impacts (disbenefits) during implementation/construction.

These guidelines make it clear that practitioners should consider negative impacts, however, in contrast to the guidelines on benefits, they typically lack details of which dis-benefits should be included or how they should be monetised. For example, the Infrastructure Australia Guide to Economic Appraisal (Infrastructure Australia, 2021) includes disruption costs over the evaluation period and negative social impacts, but parameter values provided in guides such as the Australasian Transport Assessment and Planning guidelines do not provide specific values readily available for use in assessments. An exception is the Waka Kotahi Monetised Benefits and Costs Manual which does explicitly list dis-benefits which should be captured in economic appraisals.

Outside of economic guidance, there is an increasing body of literature on sustainability and social impacts. For example, governments in Australia report on Environment, Social and Governance (ESG) targets, the financial sector is developing sustainable finance strategies such as the taskforce for climate-related financial disclosures (TCFD) and risk assessments capture sustainability risks. The push to a whole of system approach to infrastructure has impacted how business cases are developed, but this is not always realised in the associated economic analyses.

The inclusion of more guidance on dis-benefits could facilitate more accurate prioritisation of options. It could also improve sections of typical Business Case development frameworks, such as the consideration of non-infrastructure solutions, innovative construction techniques and options which add value outside of the traditional CBA frameworks. This is discussed in more detail in the following stages.

3. Dis-benefits for consideration

3.1. Overview

Dis-benefits are often considered in CBAs, whether that be explicitly or implicitly. This paper will focus on those which are only occasionally included or rarely included. The table below provides a summary of the most relevant negative impacts identified.

Table 1: Dis-benefits for consideration in road transport cost-benefit analysis

Typically included	Occasionally included	Rarely included
Changes in driver behaviour	Congestion issues associated with place	Environmental impacts of construction materials
Increases in maintenance costs	Local road impacts	Impacts of the project on other modes
Crowding of public transport	Amenity impacts	Disruption to local economies
	Delays during construction	Biodiversity loss

These are explored in more detail below.

3.2. Changes in driver behaviour

Not all road users or public transport users benefit from infrastructure projects. There are cases where new infrastructure benefits a majority of road users, but some users have their trip times increased which leads to a dis-benefit.

These considerations are included in most typical transport CBAs.

3.3. Increases in ongoing costs

Many infrastructure projects lead to an increase in maintenance costs. For road infrastructure, the surface area of the road often increases which leads to a corresponding increase in maintenance requirements. For public transport, the increase in the number of services offered leads to increased operational costs.

These considerations are included in most typical transport CBAs.

3.4. Crowding of public transport

Where projects shift private vehicle users towards public transport, or lead to induced demand for public transport, there may be increases in the number of people on each service. This is often counterbalanced by the introduction of new services which helps reduce the number of people on each service.

Where there is an increase in patronage, crowding may increase which dis-benefits existing public transport users as they may be required to stand where they otherwise could have sat. This is particularly important for public transport users since COVID-19 as people are less likely to want to sit next to other passengers and are less likely to use crowded services.

These considerations are included in most typical public transport CBAs.

3.5. Congestion issues associated with place

When considering place, or adjacent considerations such as active travel, there are often negative consequences for the private vehicle-based road network. This occurs where road space is redirected from private vehicles towards active travel, public transport or improving elements of place.

These considerations are often included in typical transport CBAs. There are occasions when these issues have been excluded from considerations as the associated benefits are viewed as equal and opposite to the congestion. This is expected to change as the methods for quantifying and monetising place continue to evolve.

3.6. Local road impacts

The development of infrastructure projects has the potential to impact the wider network in a variety of ways, but the focus of the business case is typically only on the project being delivered. This leads to local road infrastructure requirements being ignored, or additional congestion being added to the local road network. Either way, the benefits of the project being analysed are overstated.

These impacts are considered where the traffic model covers a sufficient geographical area. However, there are projects where the traffic model coverage is dictated by the project design rather than the requirements of the economic assessment.

3.7. Amenity impacts

Large scale infrastructure projects have the potential to negatively impact amenity. This may be through changes in the availability of space, changes to view, or from the look of the infrastructure itself. Amenity is becoming an increasingly important consideration in infrastructure design, particularly as focus shifts towards active travel, public transport and place.

In an effort to reduce capital spend of projects, costs associated with improving the amenity impact of the project are often excluded. This makes sense in the context of CBAs as the benefits associated with improving or maintaining amenity are not captured, so the cost allocation provided for amenity does not deliver ‘value for money’. Similarly, degrading amenity does not attract a monetised negative benefit, so is not penalised in project design. This has the potential to lead to sub-optimal outcomes with respect to amenity as project designs which focus on amenity are undervalued.

3.8. Delays during construction

During construction, vehicles are often delayed while the works occur, particularly where night works are not feasible. Even where works are able to be focused outside of the peak, there are often speed reductions for the life of the project. Some projects make allowances in the capital costs for traffic management, and this is used as justification for the exclusion of the consideration of impacts during construction, but it understates the overall impact. The exclusion of these impacts has the potential to impact the viability or comparative merit of a project.

Without consideration of delays during construction, it is difficult to accurately compare online versus offline options. The primary benefit of offline options is that travellers are not delayed during construction, so without this consideration the lower cost (online) option is almost universally preferred.

Similarly, staged solutions are always viewed more favourably in CBA frameworks as staging extends the construction period, lowering the present value of the construction. However, the staging also extends the period in which road users experience delay, which is typically not fully quantified.

These impacts are rarely included in typical transport CBAs. This has the potential to lead to sub-optimal decision making, in both identifying the preferred option and when making the ultimate investment decision. In some cases, it would be expected that projects which previously achieved a Benefit Cost Ratio (BCR) greater than one (or a Net Present Value (NPV) greater than 0) would return less favourable values where the delays during construction are incorporated.

3.9. Environmental impacts of construction materials

An emerging consideration in infrastructure is environmental accounting. Environmental accounts are a way to measure and track environmental impacts through time, between locations and between owners. Importantly, environment accounts track whether a particular value has increased or decreased, or reduced or expanded in extent, over a certain time period. Environmental accounts use physical measures (such as area, volume, or weight), derived or composite measures (such as an index) or, where appropriate, monetary measures (Bureau of Meteorology, 2013). The extension of monetary valuation techniques to environmental accounting subjects is an active area of experimentation and trials, consequently, their inclusion in CBAs may not be recommended, however, there are certain elements of environmental accounting which are relevant.

Infrastructure projects require resources to be delivered. This includes rock, gravel, sand, cement and concrete, amongst other construction materials. Concrete alone is responsible for 8 percent of global CO_2 emissions (Lehne & Preston, 2018). Even low-carbon alternatives remain relatively high in their carbon intensity.

The use of these materials means that the delivery of infrastructure projects has negative environmental impacts. Without their construction, it would be expected that these materials would not be required. A direct example of this may be seen in water infrastructure where cement is often made using materials onsite. In this case, it is clear that without the project these materials would not have been made and therefore the emissions would not have occurred. In the case of roads it may be less clear whether the materials are incremental.

These impacts are rarely included in typical transport CBAs. Their inclusion is becoming more important, however, as the effects of global warming continue to worsen. Innovative technologies and materials are increasingly becoming available, but the existing CBA approaches do not provide guidance on how they may be included. This means that project teams are not provided with an incentive to consider their inclusion when they come at a higher cost.

CO_2 emissions associated with construction are often included in major infrastructure assessments, but their link to the economic analysis is typically overlooked. Broader environmental impacts and damages are more challenging to include as their quantitative assessments are less common.

3.10. Impacts to other modes

In many cases, transport projects are viewed in isolation. Some assessments take a wider network view of the project impacts, but these typically only consider the impacts to the mode in focus. This has the potential to skew decision making processes as there is not sufficient consideration for other modes and the interaction between modes.

Using road projects as the example, typical assessments review the movement of road trips in the base case and project case. Where the base case network is unable to accommodate all vehicle movements, various approaches to incorporating latent demand or vehicles unable to enter the network may be used. These include assigning the average trip time to vehicles waiting to enter, or 'completing' their trip by assigning the difference in partial completed trip time and average trip time.

While these types of approaches are appropriate when assessing a project in isolation, there may be unintended negative consequences for the network as a whole. Continuing the example, the implicit assumption for vehicles unable to enter the network in the base case is that they complete their trip in a time outside the modelled period. However, this is not always practical, particularly when reviewing peak periods where people travel to school or work. These trips require completion in a relatively tight timeframe, even with the move towards more flexible work arrangements. In reality, some of these trips would need to switch to other modes, such as rail, to have their trip completed within an appropriate time. As such, the project case is removing vehicles from rail in favour of completing their trip via road.

From a network standpoint, a shift towards rail may be more optimal. Without consideration of the switch between modes, the potential changes in how a network is used is not captured, and therefore not considered when making an investment decision.

3.11. Disruption to local economies

Infrastructure projects have the potential to disrupt local economies during construction and once the project is delivered. During construction, access to businesses may be negatively impacted where it becomes more difficult to access premises. This may be due to a reduction in roadside parking, lengthy delays to accessing the business or other means. Businesses may also be negatively impacted where amenity degrades, particularly for hospitality or other experience-based businesses. These impacts are of particular importance in high-density urban areas.

Once the project is delivered, there may be additional disruptions to the local economy. At the extreme, a bypass of a town has the potential to ruin the local economy. On a smaller scale,

transport infrastructure which impacts access to shopping areas would have negative impacts to the regional economy. A common argument is that potential shoppers will simply shop elsewhere, thereby not impacting the overall economy. This is true for necessities such as groceries, but it is not the case for all items.

This consideration also does not consider the impact to businesses. While there are equal and offsetting impacts between the impacted business and the alternative business, there are impacts outside of the sale itself which impact businesses. Where the disruption is sufficiently large, businesses may need to close, or jobs may be lost which has negative impacts to the economy. Negative impacts to regional economies are particularly damaging. Relatively small negative impacts to businesses in smaller economies can far outweigh the offsetting positive impact to the competing business.

The quantification and monetisation of these impacts is challenging, particularly when considered in addition to the amenity impacts discussed earlier.

3.12. Biodiversity loss

Biodiversity is becoming an increasingly important consideration when assessing potential transport infrastructure projects. There are a range of established methodologies to value biodiversity and the associated contribution to urban cooling, carbon sequestration and air pollution. Business cases often include biodiversity offsets in the cost estimates. However, this only offsets listed threatened species, with the disbenefit of broader biodiversity loss rarely included.

While there are existing methods for capturing the impacts to biodiversity, their inclusion in transport business cases is relatively rare. Major projects which are near notable areas, such as wetlands or national parks, make explicit considerations for biodiversity in the business case, but the link to the economic analysis is not always made. For smaller projects, biodiversity impacts are less likely to be quantified in detail sufficient for inclusion in a CBA.

4. Why bother?

4.1. Improved decision making

Road CBAs follow a relatively standardised process in which travel time impacts dominate benefits. Projects which save the most people the most time typically are prioritised highly. This leads to large-scale infrastructure projects being desirable.

These types of projects have unintended negative consequences which are often overlooked. These include a shift towards private vehicles, the introduction of negative externalities particularly with respect to emissions, increases in congestion during the long construction periods and the degrading of place and amenity.

If these negative impacts are included more explicitly in the CBA, it may be found that more, smaller projects would generate improved outcomes for the community. Even where the preferred options remains, decision makers are more informed as to the negative outcomes which may result from the project. This provides an upper bound estimate of the mitigation processes which may be included in the project design to reduce the negative outcomes. While individually these dis-benefits may not have a material impact on the headline results or the associated decisions, the cumulative effects may be significant. This is particularly true where there are cumulative impacts unique to a project option. For example, a project option which

has a long construction period may have negative impacts for vehicle movements during construction, negative amenity impacts, significant negative environmental impacts and disruption to the local economy. Individually, their impacts may not impact decision making but in combination there may be changes in priority.

4.2. Non-infrastructure options

Many of the Business Case frameworks in Australia and New Zealand require investigations into the viability of non-infrastructure options in solving the proposed problem. It is rare that these options proceed as one of the short-listed options as they often fail to meet the required objectives.

One of the strengths of non-infrastructure options is that they avoid the negatives of delivering infrastructure. That is, they typically avoid delays during construction (as there is no construction), they do not generate carbon through the requirement of construction materials (as there are no construction materials) and they do not negatively impact amenity (as nothing is disturbed). The failure to capture these impacts in CBA means that these options always perform poorly, and are often overlooked as viable alternatives. The consideration of dis-benefits would promote outside-the-box thinking regarding options which do not require significant construction stages.

4.3. Focus on environmental impacts

Consideration of environmental impacts principally lie at the core of most public sector Business Cases. However, this is rarely reflected in the headline CBA results. Most road transport assessments are comparing a base case with high private vehicle use to a project case with slightly higher private vehicle use. This results in very minor changes in emissions and negative externalities when applying the existing guidelines.

The findings of the environmental analyses within public sector Business Cases do not tend to be quantified or monetised in the CBA framework. Rather, notional capital costs are applied, or risk allocations included which typically do not have a material impact on the headline results.

Constructing infrastructure has the potential to lead to negative environmental outcomes. The use of machinery over a lengthy period generates carbon emissions, which is not captured in traditional CBAs. Similarly, the potential degradation of environmental landscapes associated with infrastructure delivery is not considered. More importantly, the use of construction materials has a substantial impact on carbon emissions. For example, the use of cement generates more than 9 million tonnes of carbon emissions each year in Australia. Should this be considered in traditional CBAs, opportunities arise for project teams, designers and engineers to find innovative solutions, even if that leads to an increase in capital expenditure.

Improved consideration of these dis-benefits would increase the focus on identifying and incorporating project elements which have positive impacts on the environment. As an example, the inclusion of innovative technologies which draw on recycled components would likely not reflect positively in a CBA framework as it involves the avoidance of a negative (environmental harm, carbon emissions, etc.) which is not captured in typical CBAs. Without the inclusion of these types of environmental impacts as dis-benefits in CBAs, there is less urgency for project teams to consider the environmental consequences of the project and it is challenging for innovative, environmental-focus solutions or elements to gain support.

4.4. Case Study

To show the potential impact of considering some of these dis-benefits, a case study has been developed. While this case study was developed specifically to illustrate the points being made in this paper, it provides a worked example of how decision making may be skewed when negatives are not considered.

Consider two hypothetical road projects which both cost $90m. One is delivered in a single year, while the other is staged which allows for delivery over 3 years. In both cases, average annual daily traffic (AADT) is 10,000 with 2% growth over a 30 year evaluation period. Each project delivers the same travel time saving of 1 minute in Year 1 which increases by 20 seconds each year as congestion worsens in the base case. During construction, there are delays of 5 minutes per vehicle.

A summary of these projects is presented in the table below.

Table 2: Case Study Inputs

	Option 1 (Single Year Delivery)	Option 2 (Staged 3 Year Delivery)
Cost	$90m	$90m
Construction Period	2022 (1 year)	2022 to 2024 (3 years)
AADT	10,000	10,000
Traffic Growth Factor	2%	2%
Annualisation Factor	251	251
Time Saving	1 minute in 2023, increasing by 20 seconds per year	1 minute in 2023, increasing by 20 seconds per year, noting that the benefit is only accrued from 2025
Delay During Construction	5 minutes	5 minutes
Evaluation Period	30 years	30 years
Discount Rate	7%	7%

When delays during construction are not considered, Option 2 is preferred, as shown in the table below. While the projects deliver similar benefits, the discounted capital costs are lower for Option 2 as the capital spend is spread over multiple years. When a decision maker reviews these findings, Option 2 is likely to be selected as the headline results are better. However, this fails to consider the negative impacts associated with longer construction windows. When the delays of construction are incorporated, the headline results fall for both options, which has the potential to change a decision makers overall investment decision. In this case, the preference between options changes with Option 1 delivering a higher BCR and NPV.

Table 3: Case Study Outputs

	Option 1 (Single Year Delivery)	Option 2 (Staged 3 Year Delivery)
Delays During Construction **Not Considered**		
BCR	1.53	**1.69**
NPV	$47.5m	**$58.5m**
Delays During Construction **Considered**		
BCR	**1.45**	1.44
NPV	**$40.1m**	$37.4m

5. Problems with including dis-benefits

5.1. No incentive for project teams

Project teams may only have a handful of projects each year which apply for funding. They hope for all of their projects to be funded as that has the biggest benefit for their community. As such, it is not always in the best interest for a project proponent to consider the negatives when they are competing for investment funding. Proponents are incentivised to make their project as attractive as possible when applying for funding. Most assessments will qualitatively assess negatives, but there is no incentive to convert these to monetary values.

5.2. Additional CBA inputs are required

To accurately estimate these dis-benefits, additional inputs from other advisors are required. Some of these are relatively simple and low cost, while others require more effort and are likely to be costly. Where additional traffic model outputs are required, there is the potential for Business Case costs to increase. However, where this becomes business as usual for the Business Case process, efficiencies would arise, which may reduce this cost increase. The table below presents a summary of the data inputs required to incorporate dis-benefits in CBAs.

Table 4: Required inputs

Impact	Input Required	Impact on Time / Cost
Changes in driver behaviour	No additional inputs *(Considered in existing traffic modelling)*	*N/A*
Increases in maintenance costs	No additional inputs *(Included in existing cost estimates)*	*N/A*
Crowding of public transport	No additional inputs *(Considered in existing modelling where public transport services are impacted)*	*N/A*
Congestion issues associated with place	One additional traffic model run may be required.	Medium
Local road impacts	Wider geographical coverage of the traffic model may be required	Medium to High
Amenity impacts	Additional assessments may be required, such as assessments of place (e.g., PERS), or assessments of the reduction in active travel use.	High
Delays during construction	One additional traffic model run may be required.	Medium
Environmental impacts of construction materials	Summary table from cost estimate report	Low
Impacts of the project on other modes	A multi-model transport model would be required	Medium to High
Disruption to local economies	Engagement with local business owners	High
Biodiversity loss	Sustainability or environmental assessments	Medium

While there are some additional time investments to increase the number of impacts included, there is scope to include additional impacts at low cost. Assessing delays during construction, delays associated with place and the environmental impacts of construction materials would help with option prioritisation while involving relatively low time impacts. If these inclusions became common practice, there is the potential that there would be limited residual impact on time.

6. Conclusion and Recommendations

The exclusion of dis-benefits has the potential to influence decision making for transport infrastructure projects. Without appropriate consideration of disbenefits, projects which incur costs associated with minimising negative impacts will never be preferred. This encourages projects to exclude these costs as the associated benefit is not realised.

Not only does the exclusion of dis-benefits mean that options are not prioritised appropriately, but it also means that negative outcomes are perpetuated through project design. For example, projects which do not consider the environmental damages associated with construction materials will continue to be favoured which perpetuates environmental harm. Projects which do not consider delays during construction may result in unnecessarily increasing the congestion that they are designed to mitigate. Options which do not consider place or amenity appropriately will continue the push towards purely functional urban form with potentially negative social and environmental consequences. Only when these negatives are consistently accounted for in the project analysis will this cycle be broken.

To encourage the incorporation of dis-benefits or negative impacts in standard CBAs, a consolidated list of impacts for quantification and monetisation should be considered. This

would help make the consideration of dis-benefits commonplace, rather than a project specific consideration. The list may be refined to apply varying levels of detail or complexity depending on project size and scope, as applies to the typical benefits list.

A streamlined approach to assessing dis-benefits may be achieved by considering sub-projects within the overall project which address the negatives explicitly. For example, incorporating trees into the design of a road project to help offset the negative emissions from construction, or building an animal overpass to minimise animal deaths. This would be particularly helpful in the short-term, as the inclusion of additional negatives in economic assessments would lower the headline results.

Specific guidance is required, or existing guidelines should be amended, to demonstrate to project owners the importance of these considerations. First movers who decide to consider dis-benefits are penalised when submitting for competitive funding as the headline statistics from their analysis will be lower. Specific guidance provides a reference for project teams to justify the inclusion of dis-benefits, even where it may be detrimental to the project's funding success. It also provides a basis for economists to request additional data from the project team, particularly where this requires additional work from other members of the business case team such as engineering, traffic modelling or cost estimators.

Initially, these dis-benefits may be considered 'below-the-line' to not unfairly impact projects that adopt these approaches early. This approach is often used where there is insufficient detail to accurately measure benefits, and could be adapted for use with dis-benefits.

For this to be actioned in practice, jurisdictions would need to include these impacts in their project specifications. Without requiring negatives to be included, there is little incentive for project owners to incorporate these impacts as it disadvantages their project. Given the complexities of including dis-benefits discussed throughout the paper, it is recommended that these considerations are initially focused on large scale infrastructure projects, such as those seeking federal level funds.

It is expected that more rigour around the quantification and monetisation of dis-benefits would lead to improved decision making. Decision makers would be supported to make a more informed choice when selecting a preferred option and ultimately when making the investment decision. This will also support other business case processes such as the consideration of non-infrastructure solutions.

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