Chapter 3 Evaluation of road projects

3.1 Overview

Introduction

This chapter describes the specific procedures to be used for economic efficiency evaluation of road projects submitted to Land Transport NZ for funding.

In this chapter

This chapter contains the following topics:

3.2 Stages of analysis

Introduction

At every stage of the economic evaluation of road projects, the analysis is carried out for the do minimum and any other options as outlined in the table below with references to the relevant section. A similar table is provide in chapter 5 that refers to the specific procedures and worksheets. The final stages of the economic evaluation involve a check on the quality and completeness of the evaluation.

Stages

Stage	Description	Section
1	Where appropriate, complete a project feasibility report (PFR).	chapter 5
2	Describe the do minimum, alternatives and options and consider packages.	2.8, 2.13, 2.14, 3.3 and 3.9
3	Assemble road and traffic data.	3.4
4	Undertake transport model checks as required.	2.15
5	Calculate travel times for the do minimum and options.	3.4
6	Quantify and calculate the appropriate monetised benefits and disbenefits for the do minimum and options, including: • travel time cost savings • vehicle operating cost savings • accident cost savings • seal extension comfort and productivity benefits • driver frustration reduction benefits • risk reduction benefits • vehicle emission reduction benefits • disbenefits during construction • other external benefits.	3.5
7	Describe and quantify where possible any significant non-monetised external impacts.	3.5
8	Describe and quantify any national strategic factors relevant to the project and if possible determine the monetary value(s).	3.5
9	Estimate the appropriate project costs, including: • investigation and design • property • construction, including preconstruction and supervision • maintenance, renewal and operating • risk management • mitigation of external impacts.	3.6

3.2 Stages of analysis, continued

Stages, continued

Stage	Description	Section
10	Summarise the benefits and costs of the do minimum and project options, including their: • type • timing • estimated value • year in which estimate was made • growth rate over project evaluation period.	2.6, 2.7, 3.7, chapters 4 and 5
11	Where appropriate, describe and evaluate the benefits and costs of mitigation measures.	2.13 and 3.6
12	Discount the benefits, disbenefits and costs for the do minimum and project options over the period of analysis and sum them to obtain the present value (PV) of net national economic benefits and costs. Apply update factors as necessary.	2.6, 2.7 and 3.7
13	Calculate the national benefit cost ratio, BCR_N and if appropriate, the government benefit cost ratio, BCR_G.	2.9
14	Where there is more than one mutually exclusive option, use incremental analysis to select the preferred option.	2.10
15	Calculate the first year rate of return for the preferred project option.	2.11
16	When the full procedures for project evaluation are used, conduct a sensitivity analysis on the uncertain elements of the preferred project option.	2.12 and 3.8
17	Where the project costs are greater than $4 million or there are other unpredictable events that may affect the project, undertake a risk analysis.	2.12 and 3.8
18	When the full procedures for project evaluation are used, complete the project evaluation checklist to verify completeness of information, accuracy of calculations and validity of assumptions.	Chapter 5
19	Complete the project evaluation summary, including the project details, location, do minimum, alternatives and options, timing, PV of costs for the do minimum, PV of net costs and net benefits for the preferred option, BCR and FYRR.	Chapter 4 or 5

3.3 The do minimum

Introduction

Generally, the do minimum for road projects shall only include work that is absolutely essential to preserve a minimum level of service. However, in some cases, as described below, the do minimum may need to be specified differently.

It is important that the do minimum is fully described in the evaluation.

Low volume roads

For some projects on low volume roads, the existing level of maintenance expenditure may not be the do minimum. In such cases, particularly where the existing level of maintenance expenditure is high, the maintenance expenditure shall be justified as an option along with other improvement options, and the do minimum shall only be the work necessary to keep the road open.

Bridges serving little traffic

Similarly, if a bridge serves little traffic and is expensive to replace, a replacement option should not automatically be taken as the do minimum, particularly if alternative routes are available to traffic presently using the bridge. In this case the do minimum may be to not replace the existing bridge and to have no bridge. If it is unacceptable to have no bridge at all, then another possible do minimum could be rehabilitating the existing bridge.

Pavement rehabilitation

The do minimum generally should not include pavement rehabilitation to an improved standard. The only exception is when the present value of the cost of the project and its future maintenance is less than the present value of continued maintenance of the existing situation.

For example, on steep unsealed roads, which need frequent grading, to remove corrugations the continued maintenance of the unsealed road can be more costly than sealing the road. In such a situation it is possible that sealing the road may be the do minimum, so long as it is the lowest-cost option available (eg, there is not a realignment option available that is even cheaper).

3.4 Road and traffic data

Road sections, intersections and time periods

For purposes of economic evaluation, a road project needs to be divided into sections with similar geometric and traffic flow characteristics and with similar costs of construction and maintenance. In some cases it may be necessary to separately consider individual traffic movements at intersections. In other cases, vehicle operating costs may differ by direction of travel, for example on continuous sections of grade, and in these cases it will be necessary to consider each direction as a separate section.

For the do minimum and for each project option, the road should be divided into:

- road sections over which the terrain, road width, road roughness, speed limit and traffic volume are essentially constant, and/or
- intersections.

For minor projects and for pre-selection studies, all time periods can be considered together. For significant capital projects, it will be necessary to consider traffic variation with time of day and weekday versus weekend and holiday periods. The year or day must be divided into appropriate time periods (refer to appendix A2.4).

Data for road sections

For each road section and intersection, the following data is collected as required:

- route data including length, average gradient and roughness
- traffic data for each time period
- accident data.

3.4 Road and traffic data, continued

Project location and layout

Information provided must include:

- a location/route map
- a map showing linked projects and/or strategic routes
- a layout plan of the project.

As is appropriate to the particular project, the layout plan shall show:

- section end points by name, physical features, including the start and end points of the project
- intersections approaches and traffic movements
- identifying numbers for each road section, intersection approach and traffic movement
- road section lengths, average gradient and surface type
- speeds, if road sections are determined by speed changes
- locations of traffic survey points
- traffic volumes of intersection movements.

If accident savings are claimed for the project a separate diagram showing accident sites in collision diagram format shall be attached to the report.

3.4 Road and traffic data, continued

Traffic data (appendix A2 and appendix A11)

Traffic data required for road projects includes:

- traffic composition
- vehicle occupancy and travel purpose
- traffic volumes
- travel times and speeds.

Appendix A2 provides default values for traffic composition, vehicle occupancy and travel purpose. Guidance is given on estimating traffic volumes and traffic growth, and measuring travel times and speeds. Where the traffic growth is likely to vary from the normal traffic growth, future traffic volumes shall be predicted by taking account of:

- normal traffic growth
- diverted traffic
- intermittent traffic
- suppressed traffic
- induced or generated traffic (appendix A11).

For projects with congested conditions it may be necessary to consider growth suppression or variable matrix techniques (see appendix A11).

Irrespective of their capital cost, the effect of projects on traffic flows in the surrounding network should also be assessed. For example, a traffic management scheme having a small capital cost may have significant effects on traffic flows.

Estimation of travel time (appendix A3)

Appendix A3 sets out procedures for determining travel times for various road and intersection types.

Accident data requirements

Accident records kept in Land Transport NZ's crash analysis system shall be used for determining the historic accident numbers at the site and typical accident rates. Other accident records, such as those kept by the ambulance or fire service, may be considered if crash analysis system records are incomplete.

If accident savings are claimed for the project, a separate diagram showing accident sites in collision diagram format shall be attached to the report.

3.5 Benefits of road projects

Introduction

Typical benefits for a road project are the reduction in road-user costs and the reduction in external impacts compared with the do minimum. Road user benefits considered include:

- travel time cost savings (including those gained from reduced traffic congestion and improved trip reliability)
- vehicle operating cost (VOC) savings
- accident cost savings
- comfort and productivity benefits from sealing an unsealed road
- driver frustration reduction benefits from passing options
- benefits from reducing or eliminating the risks of damage.
- carbon dioxide reduction benefits
- other external benefits
- national strategic factors.

Travel time cost savings (appendix A4)

Travel time savings are a function of travel times and traffic volumes and vary by travel purpose and mode, vehicle occupancy, traffic composition and congestion.

Appendix A4 provides unit values for vehicle occupant, vehicle and freight time costs, along with values for travel in congested conditions and procedures for estimating the costs of improved trip reliability. Unit travel time values are given for standard traffic compositions on urban arterial, urban other, rural strategic and rural other roads by time period.

New trips generated or induced as a result of travel time savings for existing traffic (see appendix A11) shall be assessed at half the benefits from travel time saving per vehicle for existing traffic.

Reduced traffic congestion (appendix A4)

Road users value improvements in traffic congestion over and above the benefits gained from travel time saving. The benefits from reduced traffic congestion apply to both work and non-work travel time, and are calculated using the procedures in appendix A4.

The change in congestion calculated using the procedures in appendix A4, may also help demonstrate how a particular project contributes to the wider objectives considered under Land Transport NZ’s funding allocation process.

3.5 Benefits of road projects, continued

Improved trip reliability (appendix A4)

Journey times tend to vary throughout the day, particularly between peak and off-peak periods, and between weekdays and weekends. This type of variation is well known to regular drivers and is taken into account in calculating the travel time values (including congestion values).

Trip reliability is a different type of variability, which is much less predictable to the driver. (For example, drivers that make a particular journey at the same time every day, and some days it takes as little as 20 minutes, and on other days as much as 40 minutes.) Hence, when drivers plan their trips, they have to consider not just the expected travel time but also its variability. Where a project improves trip reliability, the benefits apply to both work and non-work trips, and can be calculated using the procedures in appendix A4.

The change in trip reliability calculated using appendix A4 may also help demonstrate how a particular project contributes to the wider objectives considered under Land Transport NZ's funding allocation process.

In addition to the normal day-to-day variation in travel times, there can be occasional large delays resulting from major incidents (eg, crashes or breakdowns). Assessing this type of variability is best handled separately from normal day-to-day variability and is outside the scope of the procedures contained in appendix A4.

Vehicle operating cost savings (appendix A5)

Vehicle operating cost (VOC) savings for road sections are functions of the length of the section, traffic volume and composition on the section, and vary by road roughness condition, gradient and vehicle speed. Unit values for VOC are given in appendix A5. The values are made up of the following components:

- basic running costs of the vehicle, such as fuel, and repairs and maintenance
- additional running costs due to the road surface
- additional running costs due to any significant speed fluctuations from the cruise speed
- additional running costs due to traffic congestion
- additional fuel costs due to being stopped, such as queuing at traffic signals.

3.5 Benefits of road projects, continued

Accident cost savings (appendix A6)

Accident cost savings are a function of predicted numbers of accidents and unit accident costs. Unit accident costs vary by accident type and severity, and vehicle speed, while predicted accident numbers need to take account of the road environment, under-reporting and the exposure to the risk of having an accident.

Based on historical data of accidents at the site and other information (including typical accident rates), the following methods can be used for estimating future accident numbers and costs:

- accident-by-accident analysis, when there are limited modifications to an existing site and a high number of accidents (ie, five or more injury accidents at the site, or three or more injury accidents per kilometre)
- accident rate analysis, when a new facility is being provided or an existing site is being modified to such an extent that the historic accident record can no longer be used as the basis for prediction
- weighted accident procedure, when there are limited numbers of accidents and information is used from both of the above procedures, drawing on both site history and predictive model information.

Formulae for determining typical accident rates are given in Appendix A6. Unit values of accident costs are provided in appendix A6 for each accident type by movement category, speed limit, severity and vehicle involvement.

Driver frustration reduction benefits (appendix A7)

Vehicle passing options may be provided through the construction of dedicated passing lanes, climbing lanes, slow vehicle bays, and improved alignments.

Providing passing options releases vehicles from platoons of slower moving vehicles, allowing them to travel along the road at their desired speed until they are once again constrained by platoons. Typically, the evaluation of passing options has been undertaken by micro-simulation programmes, which use various vehicle performance models together with terrain data to establish, in detail, the speeds of vehicles at each location along the road. These assessments can be excessively complex, particularly given the general magnitude of such projects.

An alternative method is based on multiple simulations and the Unified Passing Model described in appendix A7. This method can be used to:

- identify the most appropriate strategy for providing improved vehicle passing options over a route, and
- assessing the benefits of individual vehicle passing options within those strategies.

3.5 Benefits of road projects, continued

Other external benefits (appendix A8)

Where an indicative monetary value has been established in appendix A8, the external impact should be quantified, and the total benefit calculated using worksheet A8.1.

Benefits and disbenefits that do not have monetary values shall be described and, where appropriate, quantified in their natural units. This information is taken into account in the funding allocation process.

Seal extension benefits (appendix A8)

Road user comfort benefits and productivity gains from sealing an unsealed road should also be taken into account. Appendix A8 provides information on productivity gains. A value of 10 cents per vehicle per kilometre can be used for road user comfort, which takes account of the other benefits associated with avoiding unsealed roads.

Risk reduction benefits (appendix A13)

Where there is a quantifiable risk of disruption to traffic, damage to vehicles, the roadway or structures, or injuries to road users from natural or human-made events, and the project reduces or eliminates the impacts compared with the *do minimum*, then the benefits of the reduced or eliminated impacts must be included in the project evaluation.

The benefits of risk reduction shall be included for each year of the analysis period over which they occur, both in the *do minimum* and the project options. These benefits shall be included either as expected values or as a probability distribution, depending on the size and nature of the project as discussed in section 3.8.

Vehicle emission impacts (appendix A9)

Benefits to the environment and public health result from the reduction of vehicle emissions. Appendix A9 provides procedures for the estimation of vehicle emissions. Carbon dioxide has been given a standard value of $40 per tonne and therefore any reduction in carbon dioxide emissions is included in the calculation of the BCR. The reduction of particulate emissions has also been assigned a monetary value and is included in the calculation of the BCR.

National strategic factors (appendix A10)

Land Transport NZ recognises the following as national strategic factors for road projects:

- providing for security of access on busy inter-regional routes
- providing for investment option values – including building-in extra capacity or flexibility today to enable easier future expansion.

The criteria for assessing national strategic factors and the valuation of the above factors are discussed in more detail in appendix A10.

3.6 Costs of road projects

Introduction

For road projects, costs are those incurred by approved organisations and comprise:

- planning, investigation and design fees
- costs of property required for the project
- construction costs, including preconstruction and supervision
- maintenance and renewal costs, including repair and reinstatement
- operating costs
- risk management costs
- external impact mitigation costs
- provisional costs
- contingencies.

Planning, investigation and design costs

The costs of engineering investigation and design, and the costs of environmental and planning procedures, shall be included unless they have already been incurred, in which case they are sunk costs (and are not included in the evaluation).

Capital, maintenance and operating costs

Project capital costs comprise property acquisition and construction costs, including preconstruction and supervision costs.

Costs for the maintenance and renewal of an asset shall be included as part of the project costs where these occur in the analysis period.

Depreciation of capital assets is fully accounted for by the inclusion of maintenance and renewal costs so that no separate allowance shall be made for depreciation. To do otherwise would be double counting.

Operational costs (ie, those routine or periodic costs not associated with the maintenance or renewal of an asset) shall be included as part of the project costs where these occur in the analysis period.

3.6 Costs of road projects, continued

Property costs

Where land has to be acquired for road development, its resource cost shall be assumed to equate to its market value for project evaluation purposes. Similarly, land available for sale due to obsolescence of an existing road shall be included as a cost saving.

Where land required for a project is already owned by the road controlling authority, its market value at the base date shall be included in the analysis. Land shall not be treated as a 'sunk cost', as the option of alternative use nearly always exists.

Market value shall be assessed on the basis that the land is available indefinitely for other use. Small isolated or irregularly shaped lots of land are often difficult to develop. If amalgamation with adjacent property is impracticable, the resource cost of the land is its amenity value only. If amalgamation is possible, the market value of the main property, with and without the addition of the small lot, shall be assessed. The difference is the resource value of the lot, which in some cases may be considerably more than the achievable sale price.

Risk management costs

Where there is a quantifiable risk of disruption to traffic, damage to vehicles, the roadway or structures, or injuries to road users from natural or human-made events, and the project reduces or eliminates the impacts compared with the *do minimum*, then the appropriate risk-management costs must be included in the project evaluation.

The costs of mitigation, repair and reinstatement shall be included for each year of the analysis period over which they occur, both in the *do minimum* and the project options. These costs and benefits shall be included either as expected values or as a probability distribution, depending on the size and nature of the project as discussed in section 3.8.

External impact mitigation costs

Where a design feature to avoid, remedy or mitigate adverse external impacts is included in a project and the feature significantly increases the project cost, it shall be treated in the following way. If the feature is:

(a) required by the consenting authority in order to conform with the Resource Management Act or other legislation, then the cost of the feature shall be treated as an integral part of the project cost;

(b) not required by the consenting authority in order to conform with the Resource Management Act or other legislation, then the feature shall be described and evaluated in terms of benefits and costs, and the results reported in worksheet A8.2.

Where several features are to be included or there are several ways of mitigating an adverse impact, they should be evaluated separately in worksheet A8.2.

The cost of the preferred mitigation feature should be included in the project cost calculations.

3.6 Costs of road projects, continued

Provisional costs

Provisional costs shall be included for those costs that are expected to be incurred, but are not quantified at the time of preparing the estimate. For example, it may be known that street lighting is required but detailed costing for the lighting is yet to be undertaken.

Contingencies

Contingency allowances shall be included in the project costs to allow for possible cost increases and the uncertainty of cost estimates. These allowances shall be based on the phase of development of the project and the level of accuracy of the estimate and that phase. The following table of default contingency allowances provides guidance.

This information is to be used when the analyst does not have better information based on road controlling authority experience:

Phase	Earthworks component	Other works
Project feasibility report	30%	20%
Scheme assessment	25%	15%
Design and contract estimate	20%	10%
Contract	10%	5%

Loans and interest payments

Capital costs shall be included in the analysis as lump sums in the year in which the work is carried out, irrespective of any arrangements to finance the project by way of loans. Interest payments on loans shall be excluded from the analysis.

Residual value

The residual value of the investment at the end of 25 years has a very small effect on the evaluation when discounted at 10 percent and shall generally be omitted. Where two options have widely differing service lives, this shall be noted in the project summary sheet.

3.7 Period of analysis

Period of analysis

The analysis period for road projects shall start at time zero and finish 25 years (unless otherwise agreed with Land Transport NZ) from the year in which significant benefit or cost commences. Where several options are being evaluated, the analysis period for all options shall be determined by the option with the earliest benefit or cost. The start of construction/implementation shall be the earliest feasible date, irrespective of expectations of funding.

3.8 Uncertainty and risk for road projects

Introduction

See section 2.12 for discussion and application of sensitivity analysis and risk analysis.

Cost benefit analysis of road projects will involve making assumptions and estimates, which may involve uncertainty or be subjective in nature. The input value of significant factors must be subject to sensitivity testing (and a risk analysis if appropriate) for the effect on the economic efficiency of the project.

Significant inputs

Inputs to road projects that should be considered for testing include:

- maintenance costs, particularly where there are significant savings
- traffic volumes, particularly model results, growth rates, and the assessment of diverted and induced traffic
- travel speeds
- road roughness
- accident reductions.

For each significant input the following shall be listed:

- the assumptions and estimates on which the evaluation has been based
- an upper and lower bound of the range of the estimate, and the resultant BCR at the upper and lower bound of each estimate.

Risk analysis

Risk analysis must be undertaken for all road projects with any of the following characteristics:

- the principal objective of the project is reduction or elimination of an unpredictable event (eg, a landslip or accident)
- there is a significant element of uncertainty
- the capital value of the project exceeds $4 million.

Appendix A13 outlines the procedures for risk analysis of road projects and gives examples. These risk analysis procedures are not intended for projects subject to minor risks, such as occasional small slips from adjacent hills onto the road, etc.

3.9 Roading packages

Evaluation of roading packages

Where a package of projects includes a series of proposals that form a strategic long-term plan for a road corridor or area network, the following procedure should be used to determine the most cost-effective package of projects:

(a) Develop options comprising alternative combinations, staging and sequences of components

(b) Calculate the optimal start date for each component using a target FYRR as the criteria. The target FYRR is based on the target incremental BCR divided by 11 and expressed as a percentage (ie, if the target incremental BCR is 3.0 the target FYRR will be 27 percent, etc). The procedures to use for determining the year when each project in each option is likely to qualify for funding are as follows:

(i) starting with the first project in the sequence of projects in each option, calculate the PV of the benefits in each year and the PV of the project costs, and on this basis determine the timing of this project which will yield a FYRR above the target FYRR

(ii) include the first project in the do minimum and repeat (i) above to determine the timing of the second project, which will yield a FYRR above the target FYRR for this next project

(iii) repeat this process for each project in order.

(c) Calculate the benefits for each year and option, based on the year when each project will qualify for funding under (b) above.

(d) Calculate the PV of the benefits and costs of the projects in each strategy option.

(e) Calculate the incremental BCR of each option in accordance with the procedures set out in section 2.10.

(f) Select the package with the highest NPV which has an incremental BCR equal to or greater than the target incremental BCR.

Evaluating packages of projects will generally be undertaken over the full life of the projects. Accordingly, it may sometimes be necessary to extend the evaluation period to capture the benefits of all the projects during their expected useful lives.

It should be noted that options may consist of varying numbers of projects. Some options may consist of just one project, in which case the year when this project is likely to qualify for funding should be determined as the basis for comparing this option with other options.

3.9 Roading packages, continued

Sequenced components

When considering packages of road projects that are to be sequenced over time, the FYRR should be used to confirm the appropriate start time of each individual component of the package.

Evaluation of packages comprising road and TDM projects

The method of evaluation for packages comprising road and TDM projects (such as passenger transport or travel behaviour change strategies) is described in chapter 3 of volume 2.

3.10 References

1. Beca Carter Hollings and Ferner Ltd and Sinclair Knight Merz, *Trip reliability procedure,* report for Transfund New Zealand, 2002.
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