GUIDE TO PROJECT EVALUATION

Part 8: Examples
Guide to Project Evaluation Part 8: Examples

Summary
Part 8 of the Guide to Project Evaluation (the Guide) presents worked examples demonstrating appropriate use of project evaluation techniques applied to a selection of infrastructure upgrading projects commonly faced by practitioners. Some of these examples are updated and expanded from the Austroads Benefit Cost Analysis Manual (1996), and are intended to demonstrate the benefit-cost analysis (BCA) methodology and techniques described in Part 2. Each of the nine worked examples (flood mitigation, sealing and realignment, bridge maintenance, ferry upgrade, blackspot evaluation, timing of project, bus priority, town bypass and road widening) is linked to an executable Excel spreadsheet showing all relevant BCA calculations. Different features regarding the BCA application are also explored in each of these worked examples. For instance, the issue of estimating traffic congestion are examined in the ROAD WIDENING example, while the implications of delay in the timing of projects is explained in the TIMING OF PROJECT example. A bicycle infrastructure project evaluation within a broader multi-criteria type approach is also included as developed in another recent Austroads project (Ker, 2004). Finally, a simplified (stand-alone) risk analysis example is included, which complements the more elaborate Risk Explorer application (which requires the proprietary @RISK software) presented in Part 2 of the Guide.

Keywords
Project evaluation, benefit-cost analysis (BCA) application, worked examples demonstrating project evaluation techniques.

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- promoting improved practice by Australasian road agencies
- facilitating collaboration between road agencies to avoid duplication
- promoting harmonisation, consistency and uniformity in road and related operations
- providing expert advice to the Australian Transport Council (ATC) and the Standing Committee on Transport (SCOT).

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- Department of Main Roads Queensland
- Main Roads Western Australia
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- Department of Infrastructure, Energy and Resources Tasmania
- Department of Planning and Infrastructure Northern Territory
- Department of Urban Services Australian Capital Territory
- Australian Department of Transport and Regional Services
- Australian Local Government Association
- Transit New Zealand.

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SUMMARY

Part 8 of the Guide to Project Evaluation (the Guide) presents worked examples demonstrating appropriate use of project evaluation techniques applied to a selection of infrastructure upgrading projects commonly faced by practitioners. Some of these examples are updated and expanded from the Austroads Benefit Cost Analysis Manual (1996), and are intended to demonstrate the BCA methodology and techniques described in Part 2: Project Evaluation Methodology of the Guide. Data for the BCA can be obtained from Part 3: Models and Procedures and from Part 4: Project Evaluation Data. A number of additional examples have also been included - a bus priority scheme and possible changes in the timing of projects. A bicycle infrastructure project evaluation within a broader multi-criteria type approach is also included as developed in another recent Austroads project (Ker, 2004). Finally, a simplified (stand-alone) risk analysis example is included, which complements the more elaborate Risk Explorer application (which requires the proprietary @RISK software) presented in Part 2 of the Guide.

Each of the nine worked examples (flood mitigation, sealing and realignment, bridge maintenance, ferry upgrade, blackspot evaluation, timing of project, bus priority, town bypass and road widening) is linked to an executable Excel spreadsheet showing all relevant BCA calculations. Different features regarding the BCA application are also explored in each of these worked examples. For instance, the issue of estimating traffic congestion is examined in the road widening example, while the implications of delay in the timing of projects are explained in the timing of project example.

Most of the worked examples in the Guide relate to the techniques contained in Part 2. The worked examples demonstrate the use of the methods, techniques and tools associated with the Guide, as well as interpretation of the results. A key task is to examine which tools, techniques and methods contained in the other parts of the Guide could benefit from greater illustration through worked examples in Part 8.

The worked examples relate to the scale of projects that users of the Guide will mostly encounter. Guidance on parameter values and the adoption of conventions required for consistency will also be useful for consultants who are asked to evaluate projects on behalf of transport agencies.

Certain examples in the Guide relate to larger or more complex projects, for instance inter-modal projects (e.g. the Bus Priority case). These issues are likely to arise when a project is large/complex enough to pose methodological issues that go beyond the scope of the Guide (Part 2). They are nevertheless included as they are of interest to the general readership of the Guide. Although they will not necessarily equip the reader with all the analytical tools required for such an analysis, they will assist them to understand analyses done by other project evaluation experts.

Each worked example is presented in a standardised format in most cases replicating the structure of the examples described in Austroads (1996). The data and parameters used in the worked examples are characterised in terms of values applied to specific past project evaluations or simply default (dummy) numbers, and their performance is calculated on the basis of those numbers.

In using the worked examples, practitioners are able to replicate the processes and techniques using values they have derived for their own projects as each worked example is accompanied by an interactive spreadsheet showing how the computations are conducted.

Finally, it should be noted that the spreadsheet models only provide simplified results. For more rigorous analysis more detailed models such as REVS, EVAL4, CBA6, EMME2, HDM4 should be used.
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REFERENCES
1 INTRODUCTION

Part 8 the Guide presents worked examples of project evaluations applied to a selection of infrastructure upgrading projects commonly faced by practitioners. Some of these examples are updated and expanded from the Austroads Benefit Cost Analysis Manual (1996). A number of additional examples have also been included - a bus priority scheme, a bicycle infrastructure project evaluation within a broader multi-criteria type approach, a timing of project (delay) example and a risk analysis example.

These examples are intended to demonstrate the benefit-cost analysis (BCA) methodology and techniques described in Part 2: Project Evaluation Methodology of the Guide. Data for the BCA can be obtained from Part 3: Models and Procedures and from Part 4: Project Evaluation Data. Each worked example is linked to an (executable) Excel spreadsheet showing all relevant BCA calculations.

1.1 Steps in a benefit-cost analysis

The following seven steps are identified in the Austroads Guide to Project Evaluation to provide a practical description of the building blocks for conducting a project benefit-cost evaluation:

**Step 1: Define problems and set objectives** — Obtain a clear picture of what the project purpose is, and what the specific outputs and outcomes are (for more details see Part 1 and Part 2 of the Guide).

**Step 2: Generate options** — Establish a range of viable project options. A base-case must also be defined (for more details see Part 1 and Part 2 of the Guide).

**Step 3: Set the basic parameters** — These will include selecting the evaluation period for the project investment, the start year for project benefits and costs, the price year and discount rate. For the examples contained in Part 8, the nominal discount rate of 7% has been used, and an evaluation period ranging from 20 to 30 years has been set depending on the characteristics of the particular example (for more details see Part 2 of the Guide).

**Step 4: Identify and quantify impacts (costs and benefits) where possible** — For transport projects, benefits are likely to include travel time savings (including reduction in congestion costs), social crash cost reduction, savings in vehicle operating costs and environmental cost reduction (for more details see Part 2 of the Guide).

The practitioner should note that operating costs (i.e. infrastructure maintenance, compliance and traffic management costs) are accounted for by road agencies as costs in the denominator of the benefit-cost ratio (BCR) calculation. This reflects the planning decisions, including ongoing maintenance costs agencies need to consider when undertaking a project. However, an alternative approach to use would be to account for these costs as negative benefits in the nominator of the BCR\(^1\).

**Step 5: Discount costs and benefits** — In this step all identified benefits and costs are properly measured and monetised to produce aggregate estimates for each year over the evaluation period. An appropriate discount rate is then applied to express in present value terms all costs and benefits included in the evaluation (for more detail see Part 2 of the Guide). A calculation engine to perform this step is also included in the corresponding Excel spreadsheet developed for each example. (See executable Excel based spreadsheets provided for each example).

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\(^1\) See Part 2 for more details about using BCA measures such as NPV and BCR for decision making (e.g. project prioritisation).
Step 6: Calculate NPV, BCR, IRR and FYRR — These four output measures (net present value, benefit-cost ratio, internal-rate of return and first-year-rate of return) can be obtained using the Excel spreadsheet calculator. (See executable Excel based spreadsheets provided for each example).

Step 7: Undertake sensitivity tests or risk analysis — Information on project risks can be provided by testing the impact of some changes in assumptions about traffic growth, cost estimates and discount rate used. (for more detail see Part 2 of the Guide).

This seven step broad process is followed in developing the selected examples that are described below.
2 THE EVALUATION TOOL

The evaluation of a number of common types of road project examples was mainly carried out by means of the spreadsheet-based evaluation tool described in this section.

At this stage the tool comes in two versions: one that excludes congestion but includes demand elasticity, and one that includes congestion but excludes demand elasticity. Because congestion is assumed to be insignificant in all but one of the following examples, it is the former version that is explained in this chapter and used to evaluate all examples except one. The latter version is instead described in Section 3.9 dealing with the one example which uses it: ‘Road widening and duplication’.

As both model versions share the same underlying logic and structure, it would be possible to combine them in the future into a single model incorporating the features of both; this possible integration of the two models is beyond the scope of the current project for developing Part 8. Such a combined model might also embody provision for stochastic data inputs and the computation of additional outputs such as noise impact and air emissions.

2.1 Characterising projects

In the typical road related project, the road agency incurs increased expenditures, and in return road users, save on travel time, vehicle operating costs and crashes. There may be significant third-party impacts as well, mainly reduced noise.

The examples of evaluations of some common types of project developed for Part 8 are shown in Table 2.1. Project options are characterised in terms of a set of data inputs specified by the evaluation tool, which then computes incremental NPVs and BCRs for all options.

<table>
<thead>
<tr>
<th>Table 2.1: Principal impacts, by project type</th>
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<tbody>
<tr>
<td>Impact</td>
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<tr>
<td>Flood mitigation</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

Road user impacts:
- Travel time: ● ● ● ● ○ ○ ● ●
- VOCs: ● ● ● ● ○ ○ ● ●
- Safety: ● ○ ● ●

Road agency impacts:
- Capital costs: ● ● ● ● ● ○ ● ● ●
- Operating costs: ● ● ● ● ○ ○ ● ● ○

Third-party impacts:
- Noise: ○ ●

Key: ● = Always or nearly always occurs.
○ = Often occurs.

Note: All projects normally produce savings of all types of road user impact; only the significant ones are shown.
2.2 Data requirements

The evaluation tool requires that all projects be characterised in terms of standard data inputs as shown in Table 2.2.

Although all data inputs must be specified when evaluating a project, only certain ones (indicated on the table) normally differ as between options. For instance, road sealing (example 1) typically increases ‘average speed’, and decreases ‘crash rate’ and ‘VOC rate’; it does not affect anything else, such as ‘trip length’ or ‘traffic composition’. Likewise, a town bypass case (example 4) normally increases ‘road length’ (by sending traffic around, not through, a town), and usually increases ‘average speed’ and decreases ‘crash rate’, as traffic avoids crowded downtown streets. ‘VOC rate’ may also change if the design standard of the road is altered. But not all traffic will take the bypass, and this is reflected in ‘traffic proportion’ affected.

2.2.1 Project-specific data

Discount rate

Impacts for all options are discounted at the rate stipulated by the governing road agency.

Operational life of the project

To enable a fair comparison between project options the practitioner must stipulate the project’s operational life, being the period during which road-user costs are affected by the project. This is done by specifying the first and last years of project operation.

Note that the timing of road-agency costs does not necessarily coincide exactly with the operational life of the project: initial capital cost for instance is usually incurred in the year preceding the first year of operation. In deciding whether or not to include a specific road-agency cost the following test is helpful: costs should only be included if the benefits they give rise to are also included. So if a particular project requires periodic maintenance every ten years, the cost should only be included if the operational life of the project includes the subsequent ten years of road-user savings. To define a shorter operational life would unfairly penalise the project as costs would be counted against it while the subsequent attendant benefits were not.

Traffic

Data inputs relating to traffic never vary between project options. This is not to say that traffic is always the same for all options. If an option relieves congestion it will normally attract traffic from competing routes and, possibly, public transport. Likewise if an option simply makes travel easier it can generate new trips, ones that otherwise would not have been made at all. The volume of traffic generated in this way is calculated automatically within the model from the data provided. These data therefore can more properly be said to describe the underlying demand for trips, not the amount of traffic produced under any given project option.

AADT in year 0 — Traffic flow is expressed in terms of vehicles per day or year and used to compute traffic volume in vehicle-km. It is forecast from a base-year AADT (Annual Average Daily Traffic). AADTs are normally available from historical records, but may need to be updated specifically for the evaluation in question.
Table 2.2: Data required by the model, by project type

<table>
<thead>
<tr>
<th>Data input</th>
<th>Project type</th>
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<tbody>
<tr>
<td></td>
<td>Flood mitigation</td>
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<td>Sealing and realign't</td>
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<td>Bridge maintenance</td>
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<td>Timing of project</td>
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<td>Bus priority</td>
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<td></td>
<td>Town bypass</td>
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<tr>
<td></td>
<td>Widening and duplic'n</td>
</tr>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
</tbody>
</table>

Project-specific data

- Discount rate
- Operational life: Start, End
- Traffic: AADT in year 0, Growth rate, Growth type, Demand elasticity

Option-specific data

- Traffic: Proportion affected, Trip length, Average speed, Composition
- Travel time: Unit cost (pax), Average occupancy, Unit cost (freight)
- Crashes: Risk
- VOc: Unit cost

Road-agency cost data

- Cost
- Timing

Key:
- ● = Usually varies between options.
- ○ = Sometimes varies between options.
- ® = Never varies between options.
- blank = Rarely varies between options.

**Growth rate** — The growth rate is used for forecasting traffic over the planning horizon of the project, normally up to 30 years. Past growth rates can normally be established from historical records. However, it should never be assumed that historical trends may be extrapolated in all cases. Traffic forecasting is potentially complex and outside the scope of this document.
Note that the growth rate stipulated in the model applies to the level of traffic that would pertain in the absence of any change in road-user costs; that is, it assumes that the prices borne by road users are unchanged by the project. Generally this is so if demand is inelastic and traffic uncongested. But if either condition is not satisfied—that is, if there is a significant volume of generated traffic—then traffic will change for reasons unconnected with the ‘growth rate’ parameter. Specifically, traffic may grow if travel on the affected link is getting ‘cheaper’ in terms of travel time and cost, not because there is any underlying growth in demand (though this may be happening as well). Because of its complexity, a full discussion of this issue is presented in Section 3:9: Road widening and duplication.

**Growth type** — Two types of traffic growth can be specified in each example: linear or exponential.

**Demand elasticity** — Projects typically make the affected link more attractive to road users. Demand elasticity is a parameter that determines how much new traffic will be generated in this way: an elasticity of, say, \(-2\) means that a 1% decrease in road-user cost results in a 2% increase in traffic (that is, \(-2 \times -1\% = 2\%\) ). Generated traffic is assumed to produce half as much net benefit per unit of traffic as existing traffic².

Demand elasticities depend crucially on the nature of the project. A project that affects a road for which there are no closely competitive links typically has a low elasticity—its demand is said to be ‘inelastic’. Rural highways are often of this type: if a rural highway is improved, traffic volume is largely unaffected because nearly all the traffic that will ever use it is doing so already. Conversely, traffic demand on urban roads can be highly elastic: in a highly interconnected urban network, improvements on any link immediately attract traffic from competing links, particularly where congestion is widespread.

For these reasons, it is often hard to estimate demand elasticity. For small projects, practitioners may usefully rely on rules of thumb derived from experience of former comparable projects. Large projects, however, generally warrant detailed traffic modelling and are therefore unsuited to the simple evaluation tool demonstrated in Part 8.

**2.2.2 Option-specific data**

The following data inputs are required for the computation of road-user costs. They often vary between project options, reflecting differences in, say, average speeds or crash rates. For consistency, the computation of road-user costs should as far as possible be based on uniform parameters and procedures that are applied equally to all projects and all options.

Road-user unit cost data mostly differ by vehicle type. Currently the model used for each example uses a threefold breakdown for vehicles:

- cars
- light commercial vehicles (LCVs)
- heavy vehicles (HVs).

Road-user costs are calculated and reported separately for each vehicle class. More detailed breakdowns are possible and may be incorporated in future if data are available and they offer significantly greater precision.

² The reasons for this are found in economic theory and assume a linear demand curve.
Traffic

Proportion affected — Project options do not necessarily affect all traffic on the part of the network where the project takes place. For instance, a bypass will normally only attract a certain percentage of the traffic through a town; and a flood mitigation project will only benefit traffic during periods of inundation.

The proportion of traffic affected by an option will normally depend on its particular nature and circumstances. In the case of flood mitigation, for instance, hydrological records may be needed to determine the proportion of the year when roadways of various heights will be inundated.

Trip length — The treatment of road length depends on whether the project affects a significant length of road (such as resurfacing or widening) or the treatment effectively takes place at a point location (such as an intersection). Naturally trip length can vary between project options, for instance where an option provides a more direct route that eliminates detours.

Trip length is expressed in kilometres and is required for the computation of road-user costs. Road-user costs are derived from unit costs that are expressed in terms of dollars per vehicle-km (which naturally requires road length to be specified) or dollars per vehicle-hour (which requires vehicle speed to be specified as well).

A computational issue arises where a project effectively takes place at a point location—say, a bridge or an intersection. In that case the computation of road-user costs must be based on unit costs that are independent of distance; that is, dollars per trip not per kilometre.

Average speed — Different types of vehicle have different average speeds, which respond differently to different types of project. Average speed affects travel time, crash costs, and VOC. It will normally be necessary to record average speeds in advance of each project. If this is not practicable, global parameters may be used.

Composition — Classified AADTs (that is, disaggregated by vehicle type) are often available from historical records, but may need to be updated specifically for the evaluation in question.

Travel time

Unit cost (pax) — Different types of vehicle entail different hourly costs of travel time, mainly because commercial vehicles carry drivers who are remunerated at commercial rates while private cars do not. Global parameters, which are periodically updated, are available for the unit cost of passenger travel time.

Average occupancy — Different types of vehicle have different average occupancies. Average occupancy affects travel time savings. Although average occupancy does not explicitly affect crash costs under the algorithm used in this model, they are calculated from global parameters (below) that already embody assumptions concerning average occupancy. Global parameters, periodically updated, will normally suffice for average occupancy.

Unit cost (freight) — Different types of vehicle entail different hourly costs of freight time, mainly because vehicles carry different quantities of freight. Global parameters, which are periodically updated, are available for the unit cost of freight travel time.

Crashes

Risk — The risk (or rate) of crashing can vary greatly between locations. Normally, crash risk will be established from the crash records kept by the relevant road agency.
**Unit cost** — The unit cost of crashes varies by road type and speed zone. Global parameters, which are periodically updated, are available for the unit cost of crashes.

**VOC**

**Unit cost** — VOCs vary by vehicle type and speed, and road type. Normally, VOCs are calculated using econometric models with empirically estimated parameters. Global VOC parameters, which are periodically updated, are available for the computation of VOC.

**Road agency costs**

Road agency costs normally vary between project options reflecting differences in engineering works and/or traffic management procedures, and will typically be worked up on a consistent basis by the road agency in charge of the project. The evaluation tool recognises three classes of road-agency cost:

- capital expenditure, which occurs once only at the outset and typically precedes the commencement of operations by a year
- routine maintenance, which is incurred annually and normally does not vary from year to year
- periodic maintenance, which is incurred at periods greater than yearly, and may vary through time.

The timing of each class of cost is stipulated by the practitioner over the life of the project.

More detailed breakdowns of road agency cost are possible and may be incorporated in future if data are available and they offer significantly greater precision. Regardless of how road agency costs are classified, it is important to distinguish capital expenditure from other costs. When the road agency’s capital budget is constrained, projects must be prioritised by the ratio of net benefits to capital expenditure—a definition of BCR in which capital expenditure constitutes the denominator of the ratio (see Part 2).

**Results**

**Net Present Value (NPV)** — The model computes the incremental NPV for all project options as compared to the base-case option.

**Benefit-Cost Ratio (BCR)** — The model computes incremental BCR for the project options as compared to the base-case option. For this purpose, BCR is defined as the sum of all non-capital costs and benefits, divided by capital expenditure. This is the appropriate definition to use for prioritising projects when the road agency’s capital budget is constrained.

Internal rate of return (IRR) and first-year rate of return (FYRR) results are also calculated and shown.

**Using the evaluation tool**

The evaluation tool takes the form of a spreadsheet. Up to four project options may be evaluated, one of which must be the base-case option against which the others are compared. Data are entered in the cells with red digits. Results are presented in the form of four charts: incremental NPV, BCR, IRR and FYRR.

Copies of the evaluation tool spreadsheet containing the appropriate data are provided for all but one of the examples that follow. The exception is in Section 3.9: Road widening and duplication. Because congestion is significant in this example, a different evaluation tool is required. The logic of this tool is explained in the example, and a copy is provided.
3 EXAMPLES

3.1 Flood mitigation

3.1.1 Project description and options

A rural road suffers from periodic inundation. This imposes costs on road users, who are forced to divert or abandon their trips, and on the road agency, which incurs pavement repair costs.

The agency may mitigate the impact of periodic inundation by building a bridge or raising the road level. If this is not feasible, because the inundation is too widespread, it may limit access until the saturated pavement dries out. This saves on maintenance but inconveniences/costs road users.

There is a trade-off between road-user and road-agency costs. The more the road agency spends on capital works and post-flood repairs, the less road-users are inconvenienced, and vice versa. At one extreme, the agency may opt to spend nothing on capital works, and to close the road for long periods after each flood in order to avoid pavement damage. At the other extreme, it may opt to build bridges and causeways wherever needed, and so eliminate all possibility of road closure.

Between these two extremes, compromise is possible. The road agency should select the option that optimises the trade-off between road-user and road-agency costs — that is, the option that maximises net benefit.

The current example considers three project options besides the base-case:

**Option 0: Base-case:** The road continues to be closed periodically and users are forced to make long detours.

**Option 1: Low-level causeway:** A low-level causeway is constructed. It is cheaper to build and maintain than options 2 and 3, but still subject to occasional flooding.

**Option 2: Medium-level causeway:** A higher causeway is constructed. More costly to build and maintain than option 1 but cheaper than option 3, it copes with all but the worst floods.

**Option 3: High-level bridge:** A high-level bridge is constructed. The most costly option, it is never closed due to flooding.

3.1.2 Data inputs

Data inputs are shown in the attached spreadsheet (Example-1 Flood Mitigation.xls). The following data inputs differ as between options, and are therefore those that can be said to characterise the various options that make up this project.

**Proportion of traffic affected:** The higher the roadway, the less time it is closed on average during the year. Currently it is estimated to be closed for 4% of the time. Hydrological studies show that this will fall to 3% for the low-level causeway (option 1), 1% for the medium-level causeway (option 2), and zero for the high-level causeway (option 3).

**Capital costs:** The higher the roadway, the more costly it will be to construct. No capital costs are incurred for the base-case (option 0); $1 million for the low-level causeway (option 1), $1.6 million for the medium-level causeway (option 2), and $6.5 million for the high-level causeway (option 3).

**Routine maintenance:** Routine maintenance currently runs at $20,000 per year for the base-case (option 0). This is because the existing roadway sustains extensive damage every year. Routine maintenance will be $3,000 per year for the low-level causeway (option 1), $3,000 per year for the medium-level causeway (option 2), and $12,500 for the high-level causeway (option 3).
**Periodic maintenance:** There is currently no periodic maintenance under the base-case (option 0). Periodic maintenance will be $20,000 every 10 years for the low-level causeway (option 1), $50,000 for the medium-level causeway (option 2), and $400,000 for the high-level causeway (option 3).

### 3.1.3 Results

**NPV** — The best option is clearly option 2 (Figure 3.1). NPV for this option is $2.5 million as compared with $0.6 million for option 1 and -$1.2 million for option 3.

![Graph showing incremental NPV by option](image)

**Figure 3.1: Flood mitigation, incremental NPV, by option**

**BCR** — The best option is again clearly option 2 (Figure 3.2). BCR is 2.6 as compared with 1.7 for the option 1 and 0.8 for option 3.

![Graph showing incremental BCR by option](image)

**Figure 3.2: Flood mitigation, BCR by option**
3.2 Sealing and realignment

3.2.1 Project description and options

The proposal in this example is to seal and possibly realign 10 km of currently unsealed, winding rural road. Capital and operating costs are borne by the road agency. In return, road users experience lower VOC, shorter travel times, and fewer crashes (though in the latter case the reduction is small, as sealed roads encourage faster driving). This comes about both because sealed roads in general are kinder to vehicles, and because, in this case, the road is in some cases shorter.

It is worth noting that sealing is rarely desirable if traffic is light and the terrain and weather are conducive. In such cases unsealed roads can often be maintained easily and cheaply with relatively unskilled labour, and the benefits to road users are necessarily small since there are so few of them. Normally, sealed roads cost more to maintain that unsealed ones. But if weather and/or terrain is harsh, the reverse holds: erosion and rutting make routine maintenance so costly that sealing becomes attractive even at low traffic volumes.

Besides the base-case, three project options were examined:

**Option 0: Base-case:** The road continues to be maintained as an unsealed road.

**Option 1: Sealing only:** The road is sealed but not realigned.

**Option 2: Sealing and realignment:** The road is sealed and realigned, reducing its length by one kilometre.

**Option 3: Sealing and realignment:** The road is sealed and realigned, reducing its length by two kilometres.

3.2.2 Data inputs

Data inputs are shown in the attached spreadsheet (Example-2 Sealing and Realignment.xls). The following data inputs differ as between options, and are therefore those that can be said to characterise the various options that make up this project.

**Traffic: Trip length:** Under option 1, no realignment is carried out. Under options 2 and 3, the length of the segment is reduced from 10 km to 9 and 8 km respectively.

**Traffic: Average speed:** Sealing raises the average speed from currently observed levels (56 to 72 km/h depending on the class of vehicle) to an estimated 100 km/h for cars, and 95 km/h for other traffic. This affects VOC (see below), travel time and crash risk.

**Crashes: Risk:** Sealing reduces the risk of crashing from an estimated 0.28 crashes per million veh-km to an estimated 0.24 crashes per million veh-km.

**VOC: Unit cost:** Sealing reduces unit VOC significantly, especially for heavy vehicles.

**Capital costs:** Capital costs vary from $400,000 to $1 million, depending on the amount of realignment required.

**Routine maintenance:** Routine maintenance currently runs at $15,000 per year. Under the project options, this varies between $10,000 per year and $20,000 per year, depending on the amount of realignment needed. In this case, the shorter the road, the lower the routine maintenance cost.
**Periodic maintenance:** In its unsealed state, the road requires periodic maintenance every three years at a cost of $30,000. When sealed, periodic maintenance is needed every ten years at a cost of between $50,000 per year and $100,000 per year, depending on the amount of realignment needed. In this case, the shorter the road, the lower the periodic maintenance cost.

The example excludes the adverse impact of dust and sediment. Runoff from an unsealed pavement contains about a hundred times more sediment than runoff from a sealed road (Riley et al. 1999) and up to 40 times above accepted limits to maintain healthy waterways. Sealing largely stops dust and sediment discharge. Damage to livestock and crops is also mitigated by sealing. Dust is also a nuisance in residential areas, and can cause health problems. By reducing visibility, it is a safety hazard.

### 3.2.3 Results

**NPV** — The best option is option 3 (Figure 3.3). NPV is about $0.78 million as compared with $0.40 million for option 1 and $0.49 million for option 2.

**Figure 3.3: Sealing and realignment, incremental NPV, by option**

**BCR** — The best option is again option 3 (Figure 3.4). BCR is 1.80 as compared with 1.75 for option 1 and 1.58 for option 2\(^3\).

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\(^3\) IRR and FYRR results are also presented for completeness in the attached spreadsheet. However, it should be noted that IRR must never be used for choosing between mutually exclusive options, such as these. Interestingly, option 1 has the highest IRR, 15% p.a., although option 3, with a lower IRR, has a higher NPV and a higher BCR, and is therefore to be preferred.
3.3 Bridge maintenance

3.3.1 Project description and options

A bridge is in a state of disrepair. It has undergone temporary repairs over recent years to minimise immediate public risk within a restricted budget. Now a site inspection and risk assessment have revealed that it is no longer fit to carry vehicles over 30 tonnes. An immediate load restriction has been placed on it.

Besides the base-case, three project options were examined:

**Option 0: Base-case:** A 30-tonne load limit is placed on the bridge, and vehicles over that weight are required to detour.

**Option 1: Rehabilitation:** The bridge is rehabilitated so as to lift the load restriction.

**Option 2: Replacement on same site:** The bridge is replaced on the same site.

**Option 3: Replacement on different site:** The bridge is replaced at a different site so as to reduce the trip distance.

3.3.2 Some key issues

**Accident reduction**

Possible accident causes include:

- bridge width less than adjoining pavement width
- poor vertical or horizontal alignment on bridge approaches
- poor signing, lighting or visibility.

Significant safety benefits can accrue through bridge upgrading. For high accident risk sites, historic crash rates and estimated percent reduction in crash risk gives the expected number of crashes saved due to upgrading. Benefits are then calculated by multiplying the number of crashes saved by the standard costs of each crash type.
For projects not specifically targeting crash reduction or where no crashes have occurred in the past, expected crash savings due to upgrading may still be estimated.

**Maintenance**

Bridge replacement may reduce costly ongoing maintenance of bridges in poor condition. The whole of life costs of construction and maintenance for both base and project cases should be considered. Replacement bridge options, with low maintenance designs, may also provide benefits to traffic, since high maintenance bridges may need bridge closures or significant traffic management, when future maintenance is carried out, leading to delays and extra user costs.

**Detour reduction**

A bridge that is structurally deficient usually requires large capital expenditure for replacement. In the extreme case, the bridge may be closed for safety reasons, and users are forced to resort to other routes. This situation is very similar to one of flood impedance, except that once the bridge becomes unsafe, the road is closed until it is repaired, which could be indefinitely.

Heavier vehicles may need to resort to longer routes to deviate around height or weight restricted bridges. Significant vehicle operating and time benefits may occur from upgrading bridges along routes that can carry larger vehicles.

**Link evaluation**

A link evaluation approach should be considered where several bridges are restricting the achievement of a desired service standard on the link. As each bridge is successively upgraded, benefits of improved alignment, running surface and safety will accrue to cars and lighter vehicles. However, the full benefits of the improved service standard along the link will not accrue until the last bridge, which restricts movements of heavy/wider vehicles, is upgraded.

Without a total link evaluation approach, benefits of individual, isolated bridge improvements could be overstated. In these circumstances, link evaluation is desirable on both planning and economic grounds.

**Tools**

By taking a simple approach, a computer program can estimate user cost savings from bridge width improvements, assuming the length of the bridge represents a segment of road. However, the model will not be able to accurately simulate constricting effects on vehicle speeds where the bridge width is less than the pavement width, or where there are poor horizontal alignments on bridge approaches. However, general changes in width and alignment can be simulated, and safety benefits can be calculated if sufficient data is available.

Bridge management systems may provide capital and maintenance agency costs for various scenarios.

### 3.3.3 Data inputs

Data inputs for this example are shown in the attached spreadsheet (Example-3 Bridge Maintenance.xls). The following data inputs differ as between options, and are therefore those that can be said to characterise the various options that make up this project.

**Traffic: Trip length.** Under option 0, heavy vehicles are required to detour; trip length is 20 km. Under options 2 and 3, no detour is required; trip length is 10 km. Under option 4, the bridge is relocated to a more convenient site; trip length is shortened to 5 km.
**Capital costs.** At $1 million, option 1 is the cheapest, but entails most maintenance. At $1.5 million, option 2 is more costly, but because the bridge is completely replaced, maintenance is low. Option three at $2 million is structurally similar to option 2, hence maintenance is low, but the new site, though more convenient for road users, requires more costly earthworks.

**Routine maintenance.** Routine maintenance currently runs at $10,000 per year. Under option 1, this rises to $25,000 per year as more must be spent to keep the bridge in good order. Under options 2 and 3, maintenance is very low since the bridge is completely replaced.

### 3.3.4 Results

**NPV** — The best option is option 3 (Figure 3.5). NPV is $471,000 as compared with $366,000 for option 1 and $188,000 million for option 2. In other words, now that the old bridge needs extensive work, it is better to spend more to get (1) a new structure that requires little maintenance and (2) a bridge in a better location that greatly reduces road-user costs.

![Figure 3.5: Bridge maintenance, incremental NPV, by option](image)

**BCR** — Although the preferred option is option 3, option 1 has a higher BCR (Figure 3.6): 1.30 as compared with 1.25 for option 3. There is no contradiction in this. BCR is used for ranking independent projects; individual options pertaining to a given project are not independent, rather they are mutually exclusive. The implication is this: option 3 is the best option, and it is this option that should be ranked against other, unrelated projects.
3.4 Ferry upgrading

3.4.1 Project description and options

A local transport authority funds and operates a free ferry service across a river. The authority is increasingly concerned about the operating costs of the ferry and is investigating the option of replacing the ferry service with a bridge.

Besides the base-case, two project options were examined:

**Option 0**: Base-case: Continue the existing ferry service.

**Option 1**: Bridge: Replace the ferry service with a bridge.

**Option 2**: New ferry: Operate a new and faster ferry service.

3.4.2 Data inputs

Data inputs are shown in the attached spreadsheet (Example-4 Ferry Upgrade.xls). The following data inputs differ as between options, and are therefore those that can be said to characterise the various options that make up this project.

**Traffic: Average speed**: Option 0 (the existing ferry) produces an average speed of 8 km/h over the length of the affected link, allowing for time spent waiting for the ferry. Option 2 (the new ferry) produces an average speed of 12 km/h, also allowing for waiting time, mainly because waiting time is reduced. However, with option 3 (the bridge) the average speed increases to an estimated 100 km/h for cars, and 95 km/h for other traffic.

**Crashes: Risk**: With both ferry options, there is naturally zero crash risk. With a bridge, however, the crash risk rises to the level normal for the class of road.

**VOC: Unit cost**: With both ferry options, there is naturally zero unit cost of VOC. With a bridge, however, the unit cost of VOC rises to the level normal for the class of road.
**Capital costs:** Option 0 entails no capital cost. Options 1 entails a capital cost of $11.6 million for bridge construction spread equally over years 1 and 2. Option 2 entails a capital cost of $3 million in year 2 for the acquisition of a new ferry plus associated dock works, less receipt on disposal of the old ferry.

**Routine maintenance:** Option 0 entails routine maintenance (in this case running costs) of $750,000 per annum. Option 1 entails a mere $10,000 per annum for bridge maintenance, while option 2 entails running cost of $400,000 per annum.

### 3.4.3 Results

**NPV** — The NPV of option 1 is $6.6 million as compared with $6.7 for option 2 (Figure 3.7). In this case, therefore, neither option is significantly superior; one would either seek more information to firm up the cost estimates, or, more likely, favour the bridge on grounds of reliability, as the ferry is likely to be out of service on occasion, the cost of which is omitted from the analysis.

![Figure 3.7: Ferry upgrading, incremental NPV by option](image)

**BCR**—Option 1 has a BCR of 3.49 (Figure 3.8). The BCR for option 2 is undefined as both the road agency and road users experience benefits. It should be noted that if BCR is defined differently, such that only capital costs are included in the denominator, then option 2 would have a BCR; the pros and cons of the alternative definitions of BCR are discussed in Part 2 of the Guide.
3.5 Blackspot treatment

3.5.1 Project description and options

Having identified a blackspot (a point on the network where an inordinate number of crashes have occurred), the road agency has devised two treatments aimed at eliminating the problem by improving safety. The less costly treatment consists of minor engineering works to improve signage, lane delineation and sight-lines, and is expected to reduce crash risk somewhat, but at the cost of some increase in trip time. The more costly treatment consists of major engineering works to realign the roadway and redesign an intersection, and is expected to reduce crash risk to the level normal for that class of road and to reduce trip time.

Besides the base-case, two project options were examined:

Option 0: Base-case: Do nothing.
Option 1: Minor re-engineering: Improve signage, lane markings and sight-lines.
Option 2: Major re-engineering: Realign the roadway and redesign the intersection.

3.5.2 Data inputs

Data inputs are shown in the attached spreadsheet (Example-5 Blackspot Evaluation.xls). The following data inputs differ as between options, and are therefore those that can be said to characterise the various options that make up this project.

Traffic: Average speed: Traffic currently averages 80 km/h for cars and 70 km/h for other vehicles. Under option 1, this will fall to an estimated 70 km/h for cars and 63 km/h for other vehicles. Under option 2, it will rise to an estimated 85 km/h for cars and 74 km/h for other vehicles.
Crashes: Risk: Crash risk is currently about three times the level expected for the class of road in question. Under option 1, it is estimated to drop to double the normal rate; and under option 2, it will drop to the normal rate.

Accidents are best predicted from recent history on the site, and from the history of similar intersections for the various improvement options.

VOC: Unit cost: VOC varies as a function of average speed. Various models simulate vehicle behaviour at intersections: stops, fuel use and idling time. Some models estimate these for different vehicle classes.

Capital costs: Option 0 entails no capital cost. Options 1 and 2 entail capital costs of $175,000 and $400,000 respectively.

Routine maintenance: Option 0 entails routine maintenance of $10,000 per annum. Under options 2 this is unchanged, but rises to $13,000 for option 2.

3.5.3 Results

Ideally, each leg of the intersection should be evaluated separately. In this way, poorly performing elements of the design can be eliminated. Practically, and particularly for major intersections, this might rarely be achieved because of the synergies in intersection design, and the difficulties of attributing capital costs and benefits to individual legs.

NPV — The NPV of option 1 is $40,000 as compared with $146,000 for option 2 (Figure 3.9). Option 2 is significantly superior.

![Figure 3.9: Blackspot treatment, incremental NPV by option](image)

BCR — The BCR of option 1 is 1.23 as compared with 1.30 for option 2 (Figure 3.10). Option 2 is significantly superior.
3.6 Timing of project (Delay)

3.6.1 Project description and options

When undertaking a project, the road agency nearly always faces the question of when to commence. This example examines the consequences of various degrees of delay for a project in which 1.2 km of road is to be shortened to 800 m.

Besides the base-case, three project options were examined:

**Option 0:** Base-case: Do nothing.

**Option 1:** Early start: Capital works in year 0; operation commencing in year 1.

**Option 2:** Medium start: Capital works in year 3; operation commencing in year 4.

**Option 3:** Late start: Capital works in year 6; operation commencing in year 7.

3.6.2 Data inputs

Data inputs are shown in the attached spreadsheet (Example-6 Project Delay.xls). The following data inputs differ as between options, and are therefore those that can be said to characterise the various options that make up this project.

**Traffic:** Trip length: Under option 0 the trip length is 1.2 km. Under all other options, this is shortened to 800 m. This means that all road-user costs decline pro-rata.

**Capital costs:** Under option 0 there is no capital cost. Under options 1 to 3, there is a capital cost of $1 million in years 0, 3 and 6 respectively.

**Routine maintenance:** Under option 0 routine maintenance costs $12,000 per annum. Under options 1 to 3, this declines pro-rata to $8,000 per annum.
3.6.3 Results

NPV — The NPV of option 1 is $953,000 as compared with $782,000 for option 2 and $626,000 for option 3 (Figure 3.11). Clearly, it is better to commence the project immediately.

![Figure 3.11: Timing of project (delay), incremental NPV by option](image)

BCR — The BCR of option 1 is 2.00 as compared with 2.01 for option 2 and 1.98 for option 3 (Figure 3.12). In other words, there would be little to choose between them if they were independent projects (of course, they are not, which is why NPV is the valid choice criterion).

![Figure 3.12: Timing of project (delay), BCR by option](image)
3.7 Bus priority

3.7.1 Project description and options

A bus priority scheme is proposed for a town centre. Buses are to be given priority at controlled intersections, and a system of bus-lanes introduced. The scheme will reduce travel times for bus passengers, which will boost ridership. It will also slightly reduce operating costs for bus operators. At the same time, it will increase travel times and vehicle operating costs for car occupants and operators of freight vehicles.

Project options. Two project cases were considered that differ in the number of bus lanes and the degree of priority granted to buses at intersections. Other combinations were considered and rejected at the design stage.

The current example considers two project options besides the base-case:

Option 0: Base-case: To continue with existing controls in the form of vehicle bans and restrictions.

Option 1: Smaller scheme: 1.5 km of lanes and 13 prioritised intersections.

Option 2: Larger scheme: 3.6 km of lanes and 22 prioritised intersections.

3.7.2 Data inputs

Data inputs are shown in the attached spreadsheet (Example-7 Bus Priority.xls). The following data inputs differ as between options, and are therefore those that can be said to characterise the various options that make up this project.

Traffic: Trip length: Under all options, trip length is taken to be 5 km, which represents the entire area affected by the scheme. It is the same for all options so that all may be compared on an equal basis; and it exceeds the maximum length of lanes installed as the scheme’s impact extends beyond the roads that have bus lanes installed.

Traffic: Average speed: Under option 0 the average speed of all traffic is 15 km/h over the affected part of the network. Under options 1 and 2, this drops to 12 km/h and 10 km/h respectively for all traffic other than buses; conversely, average bus speeds increase.

Capital costs: Under option 0 there is no capital cost. Under options 1 and 2, there is a capital cost of $10 million and $20 million respectively.

Although demand elasticity does not (nor can it) differ between options, it is mentioned here because the current example is the only one in which demand elasticity is nonzero. A nonzero demand elasticity is used to calculate the change in the quantity of traffic when road-user cost changes.

Although any of the other examples could have had a nonzero demand elasticity, for simplicity it was set at zero (that is, demand was taken to be inelastic). In the current example, however, demand elasticity is set at -1.3 as bus priority schemes typically cause a substantial reduction in private road traffic, much of which switches to buses. Indeed, it is this ‘mode shift’ that produces most of the benefits of bus priority schemes.
3.7.3 Results

The following results relate to the impact on private mode (that is, all vehicles other than buses). Hence the results reported here give only part of the story; benefits to bus travellers are not reported here as they would require a separate analysis for which the evaluation tool is not suited. If the bus priority scheme is to be beneficial, the increased benefits to bus travellers must at the very least exceed those lost by private mode road users.

NPV — The NPV of option 1 is $84 million as compared with $147 million for option 2 (Figure 3.13).

\[
\begin{array}{c|c|c|c}
\text{Incremental NPV ($000)} & \text{Option 1} & \text{Option 2} \\
\hline
\text{Road agency costs} & -10,000 & -20,000 \\
\text{RUC: Existing traffic} & -83,617 & -83,631 \\
\text{RUC: Generated traffic} & 9,886 & 39,542 \\
\text{Total} & -73,731 & -44,089 \\
\end{array}
\]

Figure 3.13: Bus priority, incremental NPV by option

BCR — BCR are not reported for this example as they are only meaningful when benefits to bus travellers are included.

3.8 Town bypass

Currently a major rural highway passes through a country town. The proposal is to construct a bypass to take through traffic around the town. The main benefit will be a reduction in travel time and crashes.

3.8.1 Factors for consideration

The objectives of bypasses are to improve linkages by meeting national highway objectives, improve existing road and traffic conditions, and improve amenity and safety. Proposals for highway bypasses often generate diverse reactions in the towns to be bypassed. Some residents welcome perceived increases in safety and amenity, while road service businesses such as petrol stations fear they will lose their customers.
Bypassing a town can cause major economic and other social impacts. Evaluation of impacts on the local community is normally undertaken as part of an environmental impact assessment in order to satisfy planning requirements. A criticism of such assessments is that they do not adequately capture the potential or likely economic impacts on the town before the proposed bypass, and there is lack of a requirement for follow-up, or post completion evaluation after completion (Parolin, 1996).

Ideally, a before study would develop a base-line socio-economic profile of the community to understand the various components of the local economy and the broader regional setting in which the town is situated. Then the impact of highway-generated trade to the local community can be estimated from surveys of expenditure made by through motorists stopping in the town and travellers staying in the town (Parolin, 1996). This assessment, together with the environmental impact assessment and community consultation would inform the decision-making process.

An after study is recommended to measure the actual impacts of the bypass and mitigate any adverse social, economic or environmental effects. Timing of the after study is important. In the short-term, bypasses are likely to result in adjustments in traffic flow patterns and business operations. Longer term impacts such as increased pedestrian, shopping or tourist activity in the town centre due to improved environmental amenity may take longer to eventuate (Parolin, 1996).

Safety
Motorists on long journeys may become frustrated by driving through numerous towns. Local traffic tends to proceed slowly while through traffic tends towards higher speeds and greater anxiety. The interaction between local and through traffic may cause safety problems.

Reducing the traffic in towns by diverting through traffic may significantly reduce certain types of accidents. If safety is a major consideration, then a separate study may be warranted, particularly where detailed accident history is available.

Loss of business
The town to be bypassed may attract business from its through traffic, some of which would be lost with the bypass in place.

This loss may be offset by an equal increase in business in other areas. There will be no net benefit to the economy. This may however raise issues of distributional effects which are discussed in Part 6 of the Guide.

In the case where the bypass is likely to have wider impacts on the regional economy (e.g. implications for productivity of major industries in the region or employment) there may be scope to consider general equilibrium analysis techniques as discussed in Part 5.

Noise effects
Reduced traffic in towns may increase overall amenity by reduced noise and pollution. Part 4 of the Guide provides information and unit values for externalities such as noise and pollution reduction.

Generated traffic
Providing bypasses to small towns (between one major attraction and another) may create significant user cost savings to tourist and recreational travel and therefore generate extra trips. This is a valid inclusion but one which requires a wider link/network evaluation.
Whole of life costs

Providing a bypass to a town results in greater future maintenance due to the increased road capacity (land use) provision. These costs should be taken into account in the bypass (project) case. However, by providing a bypass, upgrading of existing roads within the town may be postponed. Inclusion of these costs in the base case will reduce the change in costs of the project-case options.

3.8.2 Project description

A simple example of a small town has been selected to illustrate issues to consider when building a bypass. The number of vehicles in both the base and project cases is equal. In the base case, all vehicles drive through the town area which is speed restricted at 60 km/h, with an average speed of 50 km/h. In the project case, motorists who do not wish to enter the town area can bypass it.

Identify options

The current example considers one project option besides the base-case:

Option 0: Base-case: No bypass is built.

Option 1: Project-case: A bypass is built.

This example is exceptional in that it analyses not one stream of traffic but two: the traffic that uses the bypass, and the traffic that continues to pass through the town. Purely for convenience, these two traffic streams were evaluated in the model under the headings:

Option A: Bypass case — Through traffic only. Traffic that continues to pass through the town.

Option B: Bypass case — Bypass traffic only. Traffic that uses the bypass.

Naturally, since option A and B are in reality only part-options, they are not displayed. Instead, only option 1 is displayed, being the sum of the impacts associated with part-options A and B.

An assumption is required to determine the split between the two routes in the project-case. User surveys aid in the formulation of realistic assumptions. Figure 3.14 and Table 3.1 illustrate relevant inputs and assumptions for the example. It is estimated that 2000 veh/day will use the new bypass and benefit from speed improvements and shorter trip length. To simplify the example it is assumed that no additional traffic is generated on the bypass.
3.8.3 Data inputs

Data inputs are shown in the attached spreadsheet (Example-8 Town Bypass.xls). The following data inputs differ as between options, and are therefore those that can be said to characterise the various options that make up this project.

**Speed:** Bypass traffic has an average speed of 100 km/h for cars and 95 km/h for commercial vehicles. All other traffic has an average speed of 50 km/h. VOC will naturally vary according to the speed and design standard of the road.

**Traffic composition:** The composition of the traffic stream differs according to the option and whether or not the traffic is bypass traffic or through traffic (see attached spreadsheet). The bypass will disproportionately attract cars and heavy vehicles, most of which are long-haul; while LCVs will largely remain on the existing route as they tend to be short-haul.

**Crash risk:** Bypass traffic will experience 0.24 crashes per million vehicle-km; all other traffic, 0.44 crashes per million vehicle-km.
Trip distance: The bypass is slightly longer than the through route: 5.5 km as compared to 5.0 km.

Capital and maintenance cost: The capital cost of the bypass is $10 million spread over years 0 and 1. Maintenance costs also vary (see Example-8 Town Bypass.xls).

3.8.4 Results

NPV — The NPV of option 1 is $10.7 million (Figure 3.15).

![Figure 3.15: Town bypass, incremental NPV by option](image)

BCR — The BCR of option 1 is 2.2 (Figure 3.16).

![Figure 3.16: Town bypass, BCR by option](image)
3.9 Road widening and duplication

Road widening or duplication are conventional solutions used by authorities to relieve congestion effects. Due to increasing demand for land in urban areas, these solutions are no longer viable in many instances and authorities are considering alternative travel demand options. Where road widening or duplication is an available option in urban areas, congestion effects are usually complex and must be considered at the network level. For these situations specialist traffic modelling programs are recommended.

The example presented here is the duplication of a two-lane undivided road in an outer urban locale where it is assumed that network congestion issues can be safely ignored. The objective of this example is to demonstrate the effect on user costs when a road reaches congestion a level and traffic growth is also assumed to continue after that time.

3.9.1 Factors for consideration

Reduced user costs

Traditional models can be used to estimate reduced vehicle operating costs, delays and accident costs from road widening and duplication. Firstly, the free flow speed needs to be estimated. The free flow speed refers to the steady-state speed of travel given constraints imposed by vehicle characteristics, road geometry (or general terrain), surface condition (or road roughness) and standard of the road (model road state) in a congestion free environment.

Widening or duplication of a road usually increases the model road state, which then increases the speed of vehicle travel from base to project cases. Operating speed is then calculated from the free speed using congestion algorithms.

Volume capacity ratio (VCR) is a major input to the operating speed. Capacity, which is an input to VCR, is affected by model road state, vehicle type and general terrain. In essence, increasing running surface width or duplication improves both free speed and capacity, and therefore markedly alters vehicle speed characteristics (Figure 3.17).

![Figure 3.17: Relationship between speed and vehicle capacity ratio](image-url)
In many cases of widening, the road pavement is also improved, resulting in reduced roughness in the project-case. This is especially so for duplications, as the new carriageway carries approximately 50% of the traffic on a new smooth road. The existing carriageway may also be subject to pavement improvement works over the project life. These improvements in base case roughness should be included in the evaluation.

**Accident benefits**

Accident benefits are traditionally calculated using an ‘Inferred Accident Rate’ method that allows estimation of accident benefits for a project not specifically targeted towards accident reduction and where little or no accident history exists.

Average accident rates have been calculated for the different classes of model road state. When width is improved and therefore model road state, average accident rates change and benefits or dis-benefits can be easily calculated using average crash costs. Major benefits accrue with duplication, because of the reduced interaction with on-coming traffic and avoidance of overtaking. These benefits are processed by the model via changes in model road state. Alternatively, if reduction in actual accident rates from remedial treatments can be estimated, these estimates should be used.

**Capacity**

One factor which has major influence over user costs is capacity. Considerable changes in traffic behaviour occur once a road is near or at capacity. In particular, traffic growth may be suppressed by high levels of congestion. Figure 3.18 illustrates this concept.

In the project case, capacity is increased enabling traffic volume to grow once again. Note that traffic growth in peak and non-peak periods may be different, traffic volumes are different at particular points in time, and therefore growth is suppressed at different points in time. A complication may exist where peak load spreading occurs. As growth of traffic in peak periods ceases, demand spills into the non-peak periods, increasing the growth of traffic in non-peak periods.
When the road is at full capacity, extra vehicles either divert to another route or do not make the journey at all. For diverted traffic, all roads should be included in the analysis and estimates or realistic assumptions made about the level and timing of diversion.

If new traffic grows in the project case due to improved capacity, the AADT difference between the project and base cases is considered to be generated traffic. Benefit equates to the area under the demand curve bounded by user costs (UC) in base and project cases. The ‘rule of half’ is derived from the triangular area, so that benefits to generated traffic (B - A) equals: half x (UC base - UC project) x amount of generated traffic (B - A).

The above arguments are not just restricted to high volume roads. Traditional models can break down where capacities of unsealed roads are low and traffic volumes exceed these capacities. The same rules apply to these situations and generated traffic can amount to significant benefits.

**Agency costs**

Whole of life costs should be considered for both base and project cases. Widening or duplication may increase future maintenance costs due to increased pavement area.
**Tools**

Most modern models for estimating user costs incorporate width as an input. These include NIMPAC and International Study of Highway Development and Management (ISOHDM) based models (Toole & Martin, 2002). Both these model categories however may need to be linked to spreadsheets so that generated traffic and link benefits can be taken into account.

### 3.9.2 Project description and options

It is proposed to widen and duplicate a congested two-lane undivided road, replacing it with a four-lane divided road of urban arterial standard.

The main benefit will be in road users’ time. Because the road is currently congested, the project will raise traffic speeds, both now and, since traffic is forecast to grow, in future. (In the current case road users will not benefit through reduced VOCs, as although they spend less time on the road, they also go faster, and the two effects largely cancel out). Road users will also benefit from a lower crash rate, as divided roads are demonstrably safer than undivided.

Commonly, when congestion is relieved on one link in the network, traffic is drawn from nearby congested links as road users seek out the least congested route. Because this can greatly complicate the evaluation, the road in the current example is assumed to be located in the outer suburbs of a major city, where the network is sufficiently sparse that the impact of wider network congestion can be safely ignored.

The current example considers three project options besides the base-case:

- **Option 0: Base-case:** The road remains unchanged as a two-lane undivided road.
- **Option 1: Widening and duplicating:** The road is widened to four lanes and duplicated, but retains its current alignment.
- **Option 2: Widening, duplicating and realignment:** The road is widened to four lanes and duplicated on a shorter alignment than option 1 but at a higher capital cost.
- **Option 3: Widening, duplicating and realignment:** The road is widened to four lanes and duplicated on a shorter alignment than option 2 but at a higher capital cost.

### 3.9.3 Data inputs

Data inputs are shown in the attached spreadsheet (Example-9 Road Widening.xls). The following data inputs differ as between options, and are therefore those that can be said to characterise the various options that make up this project.

- **Crash risk:** All project options equally reduce the risk of crashing from 0.21 crashes per million vehicle-km to 0.13.
- **Unit cost of crashes:** All project options equally reduce the average social cost per crash from $297,300 to $268,200.
- **Road capacity:** All project options equally raise road capacity from 2,500 veh/h to 8,000.
- **Trip distance:** Project 1 leaves the trip distance unchanged at 10.0 km; project 2 reduces it to 9.5 km, and project 3 to 9.3 km.
- **Capital cost:** Under option 1, the capital cost is $20 million spread over years 0 and 1; under option 2 it is $27 million; and under option 3, $35 million.
3.9.4 Results

NPV — The best option is option 2 (Figure 3.19). NPV is $15.9 million as compared with $8.7 million for option 1 and $13.7 million for option 3.

![Figure 3.19: Road widening and duplication, incremental NPV by option](image)

BCR — The best option is again option 2 (Figure 3.20). BCR is 1.61 as compared with 1.45 for option 1 and 1.40 for option 3.

![Figure 3.20: Road widening and duplication, BCR by option](image)
FYRR — is presented for completeness (Figure 3.21), though it should be noted that these measures should not be used for choosing between mutually exclusive options, such as these.

![First-year rate of return by option](image)

Figure 3.21: First-year rate of return by option

### 3.10 Bicycle network evaluation

This example is a direct adaptation from a Perth bicycle network evaluation project (Ker 2004).

Cycling is an environmentally-friendly mode of transport for a number of trips for which it can be a good substitute for car use. Cycling generates no significant negative externalities, especially when bicycle infrastructure that minimises conflict with motor vehicles is available.

A cycling benefits assessment framework that was developed by the Perth project (Ker 2004) to evaluate the effects of cycling substituting for car travel is summarised below. The methodology used describes the following steps:

- estimate benefits for each cycle-km generated (i.e. new) and diverted (from other routes) as shown in Table 3.2

---

4 The program that is the subject of evaluation in this example consists of the following components of the Perth bicycle network to be funded over 5 years:

- principal shared paths - $37.35 million
- PTS train station precinct projects - $1.6 million
- local bicycle routes - $15 million (including $7.5 million local government)
- cycling Infrastructure Grants - $15 million (including $5 million local government)
- regional recreational paths - $8 million (including $4 million local government).

5 There are, however, issues beyond the effective scope of benefit-cost analysis, especially given the incomplete nature of most bicycle networks, and these are being looked at in another project ARRB is currently doing for the Australian Bicycle Council titled: ‘Parameters to effectively prioritise bicycle infrastructure proposals’. Information on this project can be found at [http://www.abc.dotars.gov.au/projects/prioritise_bicycle_infrastructure.aspx](http://www.abc.dotars.gov.au/projects/prioritise_bicycle_infrastructure.aspx).
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- estimate usage of new facility and convert to cycle-km, taking care to relate to existing trend (e.g. if cycle use is generally increasing, then some part of the facility usage would have been expected even without the facility) and distinguishing between new trips and diverted trips
- estimate capital and maintenance costs of the new facility
- discount values to base year to calculate net worth of project.

Table 3.2 shows the values used to calculate the benefit per kilometre of car travel transferred to bicycle.

As shown in Table 3.2, the direct financial benefits to the user (i.e. the person who previously travelled by car) are equivalent to 19.7 cents per kilometre. These are based only on the savings in variable running costs for a car. Some households might decide that they are then able to do without a second car, in which case there would be additional fixed cost savings (vehicle registration, depreciation, interest on capital), but no account has been taken of this possibility, as in these circumstances it would be likely that other changes in travel behaviour would be made and a simple benefit-cost evaluation would be of limited use. This benefit is only offset to a small extent (3.6 cents/km) by the cost of owning and operating a bicycle (Table 3.2).

The socio-economic benefits are calculated to be substantially higher than the individual’s financial benefits, and are greater in the peak than the off-peak traffic period. Within this overall value, there is only one negative (other than the cost of owning and operating a bicycle) and that is the increase in cyclist road trauma, but this is more than offset by the health and fitness benefits6.

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6 For discussion of key aspects of the derivation and application of these values, see Ker (2004).
Table 3.2: Benefit values per kilometre reduction in car travel (2004 prices)

<table>
<thead>
<tr>
<th>Item of benefit</th>
<th>Value (cents/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peak</td>
</tr>
<tr>
<td><strong>Financial benefit to individual</strong></td>
<td></td>
</tr>
<tr>
<td>Private vehicle operating costs</td>
<td>19.7</td>
</tr>
<tr>
<td>Cycle user cost (increase)</td>
<td>(3.6)</td>
</tr>
<tr>
<td><strong>Socio-economic benefits</strong></td>
<td></td>
</tr>
<tr>
<td>Private vehicle operating costs (net of tax)</td>
<td>12.9</td>
</tr>
<tr>
<td>Cycling user cost</td>
<td>(3.3)</td>
</tr>
<tr>
<td>Road trauma (increased cycling)</td>
<td>(14.6)</td>
</tr>
<tr>
<td>Road trauma (cycling diverted to PSPs)</td>
<td>14.6</td>
</tr>
<tr>
<td>Road trauma (reduced car use)</td>
<td>5.2</td>
</tr>
<tr>
<td>Road traffic congestion</td>
<td>15.8</td>
</tr>
<tr>
<td>Air pollution costs to community</td>
<td>3.6</td>
</tr>
<tr>
<td>Greenhouse gas emissions</td>
<td>1.2</td>
</tr>
<tr>
<td>Improved health and fitness due to exercise</td>
<td>17.2 – 34.4</td>
</tr>
<tr>
<td>Traffic noise</td>
<td>3.6</td>
</tr>
<tr>
<td>Water pollution</td>
<td>2.4</td>
</tr>
<tr>
<td>Social impacts</td>
<td>Not quantified</td>
</tr>
<tr>
<td>TOTAL per new cycle trip-km</td>
<td>61.2</td>
</tr>
<tr>
<td>TOTAL per existing cycle trip diverted to PSP</td>
<td>14.6</td>
</tr>
</tbody>
</table>

(a) Based on current traffic conditions. All studies indicate that traffic volume will increase relative to road capacity and, hence congestion, vehicle operating costs, exhaust emissions and associated impacts will increase. In the case of exhaust emissions and greenhouse gas emissions, technological improvements (e.g. use of cleaner fuels) may offset this to some extent.

### 3.10.1 Impact of cycle use

Counts of cyclist numbers across Perth have been undertaken annually since 1998. Counts at all sites showed an 84% (13% per year) increase between 1999 and 2004. This demonstrates the effectiveness of the Perth Bicycle Network, along with other initiatives, in increasing cycle use in key areas. Screenline counts in the East Perth/Highgate area indicate that the opening of the Principal Shared Paths (PSP) along the railway between Maylands and East Perth resulted in substantial increases in cycle trips from 2002 to 2004. The net trip generation of the PSP has been around 600 trips per weekday (3000 per week), with around 100 trips per day (500 per week) gaining the benefit of a substantially safer cycling environment by transferring from other routes to the PSP. The net trip generation of the PSP has been around 207,000 per year, with around 35,000 gaining the benefit of a substantially safer cycling environment by transferring from other routes to the PSP.

### 3.10.2 Benefit-cost evaluation

A conventional benefit-cost analysis framework was then applied to the PSP component of Stage 3 of the Perth Bicycle Network (Table 3.3). For evaluation purposes, it was assumed that:

- Each km of PSP constructed will generate and attract cycle trips at the same rate as the Maylands-East Perth PSP (which was 2.9 km).
Trip lengths will be substantially longer than the average cycle trip length of 2.25 km, as this figure includes a high proportion of purely local trips not served by PSPs. It was assumed that the average cycle trip length is 6.1 km, in line with the average length of cycle trips generated by TravelSmart Individualised Marketing in Perth.

The results of this conventional project evaluation demonstrate a net present value (NPV) of $75.6 million and a benefit-cost ratio of 3.3 for this project. These results have been obtained using a discount rate of 7% per annum over a 25 year project horizon, with no residual value assumed for the PSPs. The evaluation includes appropriate allowance for the maintenance costs of the PSPs under the WA Main Roads term network maintenance contracts.

Other factors affecting level of benefits

In addition to the level of cycle usage as identified above, the following factors will affect the actual benefits achieved by the PSP program:

- **Level of path usage by pedestrians.** Whilst walking trips are generally substantially shorter than cycle trips, the PSPs will attract walking activity. They are adjacent to rail lines and train stations, thus serving walk access to public transport, and also serve a number of activity centres (schools, shops, employment) along the way. These benefits will be additional to those estimated above.

- **Concentrated promotion of new PSPs.** Previous PSPs have not been given strong marketing in the area they serve. The proposed Stage 3 PSPs will be given concentrated marketing to potential users in the area. This will increase the levels of use beyond those observed for previous PSPs and, hence, those used as the basis of this evaluation.

- **The extent to which cycle trips replace trips other than car driver.** The evaluation has been based on all new cycle trips being converted from car driver trips (i.e. each cycle trip means one less car on the road). In practice, there may be some substitution from other modes, although this is least likely for walk (as walk trips are short) and public transport (as the main ‘competition’ is with rail (for which trips are longer than average, so more likely to be beyond typical cycling distance – in 1986 (the most recent travel survey data available for Perth) only 14% of train trips were less than 5 km and 30% less than 10 km).

- That leaves car passenger trips, a proportion of which (including driving children to and from school and other activities) are undertaken solely for the benefit of the passenger and involve two car trips (there and back) for each passenger trip. For those previous car passenger trips where the driver still has to travel, this evaluation will overstate the benefits of the substitute cycle trip, as the car will still be on the road for the same amount of time. However, for those where the driver no longer has to travel, the evaluation will understated the benefits by a factor of two, as two car trips are removed for each cycle trip.

- Given that car occupancy rates in Perth are low (around 1.2, on average) and around 40% of car passenger trips are for education (mainly school) purposes, the net impact of substitution for car passenger, rather than car driver trips is likely to be small.

Overall, it is likely that the factors indicating that the evaluation will underestimate benefits, including the pre-existing declining trend in cycle usage, will outweigh any factors leading to overestimation.
3.10.3 An overview of this bicycle example

The Principal Shared Path (PSP) component of the proposed Stage 3 of the Perth Bicycle Network has been demonstrated to generate user and community benefits in excess of the costs of building the facilities. A benefit-cost evaluation, using conventional transport project assessment methodology has calculated a project NPV of $75.6 million and a BCR of 3.3.

This is likely to be a conservative value as it takes no account of the additional usage likely to be generated by the extension of an incomplete network of facilities, including some key ‘missing links’, that will greatly enhance the range of destinations it serves.

Other components of the investment proposal are for much lower cost facilities, including local bicycle routes and other local, rather than regional, bicycle facilities. The general increase in cyclist numbers at sites surveyed since 1998-99, especially those on local bicycle routes, is sufficient to justify the investment, given the substantially lower cost of these facilities.

Regional recreation paths, in particular, will also generate substantial levels of recreational walking activity, which has been acknowledged to be highly beneficial in relation to health outcomes.

Public sector proposals are increasingly required to be assessed against the triple bottom line (TBL) criteria of economic, environmental and social impacts. The Perth Bicycle Network proposal demonstrates a positive outcome on:

- financial/economic outcomes, primarily through savings in car operating costs and congestion costs
- the environmental bottom line, through reductions in air pollution, water pollution and greenhouse gas emissions
- the social bottom line, through improvements in health and fitness that more than offset any net increase in road trauma.
### Table 3.3: Benefit-cost evaluation of PSP in stage 3 of the Perth bicycle network

| Year | Weekday daily trips per km of PSP (a) | Length of PSP constructed (km) | Total trips/day (b) (start year following construction) | Total trips/year (b) (start year following construction) | Benefits per trip (2004 prices) | Total User Benefits | Net Benefits | Costs (PSPs) | Present Value | Actual | Present Value | Actual | Present Value | Actual | Present Value | Actual | Present Value | Actual |
|------|--------------------------------------|------------------------------|------------------------------------------------------|------------------------------------------------------|--------------------------------|---------------------|-------------|-------------|-------------|----------|-------------|----------|-------------|----------|-------------|----------|
| 2005 | 207 34                               | 3.8                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2006 | 207 34                               | 7.3                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2007 | 207 34                               | 12.7                         | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2008 | 207 34                               | 10.3                         | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2009 | 207 34                               | 6.3                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2010 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2011 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2012 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2013 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2014 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2015 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2016 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2017 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2018 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2019 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2020 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2021 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2022 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2023 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2024 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2025 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2026 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2027 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2028 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2029 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |
| 2030 | 207 34                               | 207                          | New Diverted                                        | Diverted                                             | $0                              | $0                  | $0          | $0          | $0          | $0       | $0          | $0       | $0          | $0       |

**Present Value (25 Years)**: $113,260,230  $5,143,195  $108,475,000  $32,616,523

(a) Based on 600 additional and 100 diverted trips per weekday for the Maylands-East Perth PSP (2.9km)  (See Appendix A)
(b) Includes population-induced growth @ 1.5% per year.

**Assumptions:**
- Natural growth (population) 1.50% per year
- Average trip length for PSP 6.1 km (based on length of new cycle trips generated by TravelSmart)
- Benefit:Cost Ratio 3.3
- Net Present Value $75,862,090

**Peak Off-Peak**
- Benefits per new trip-km $0.61  $0.45
- Benefits per diverted trip-km $0.15  $0.15
- Trips 67% 33%
- PSP maintenance cost 2% of capital per year after 5 years
3.11 Risk analysis example

Part 2 of the Guide provides a framework for risk analysis (as an option) in project evaluation. There are uncertainties in all stages of the project development cycle including uncertainty in the costs involved in selecting, designing and constructing transport infrastructure projects. These uncertainties represent project risks that may result in outcomes different from those intended. It is suggested as good practice in project evaluation to consider project uncertainty through the use of risk analysis techniques.

Risk analysis enables an estimate of the distribution (or the range of uncertainty) in the values of key project evaluation measures such as BCR and NPV. These distributions assist the practitioner in determining if the level of risk is acceptable or if risk reduction or risk management measures are required.

Risk Explorer - a risk analysis tool - developed by ARRB for the Austroads Guide to Project Evaluation has been included in Part 2 of the Guide to help the practitioner to perform risk analysis as required. The Part 2 version of the Risk Explorer provides a complete analysis package using an illustrative Excel based model and the use of third-party software from Palisade called @Risk. For those practitioners who do not have access (or wish not to use) the commercial software @Risk, a simpler version of the Risk Explorer tutorial, called 'Risk Analysis Example', has been produced and is included in Part 8. A user-designed (separate Excel file): ‘Stand-alone Risk Evaluation Spreadsheet’ (developed by Tony Boyd and his team at VicRoads) is supplied with it as the calculation engine to perform the required simulations.

The application of a **triangular distribution** is the only option of analysis within this stand-alone calculation engine. In addition, the risk analysis data generated using the Risk Analysis Example tutorial would have to be manually inserted into the Stand-alone Risk Evaluation Spreadsheet.

The brief ‘how-to-use’ manual, which is provided with Part 2 as a separate pdf file, is also copied in Part 8 for convenience and completeness.

3.12 A Multi-criteria analysis (MCA) example

As described in Part 2 of the Guide, multi-criteria analysis (MCA)—neither an alternative to BCA, nor an extension of it—is best regarded as an adjunct to BCA. Specifically, it is a means of coping with a partial BCA—one that fails to monetise some of the impacts. Sometimes the unmonetisable impacts may be safely ignored; but if not, decision-makers may have to trade-off the incommensurable monetary and non-monetary impacts. The main criticism of MCA is levelled against the arbitrary and subjective weights that are often attached to the non-monetary objectives. However, a ‘weak’ MCA (see Part 2 of the Guide) provides a valuable conceptual framework to enable decision-makers to marshal the known facts, and to reduce the role of subjective judgment to a minimum.

A simple table (scorecard) example of a ‘weak’ MCA used in the UK to evaluate road projects is presented below for illustrative purposes (Table 3.4, see Department of the Environment, Transport and the Regions, 1998).
Table 3.4: Appraisal summary table approach, UK example

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>SUB-CRITERIA</th>
<th>QUALITATIVE IMPACTS</th>
<th>QUANTITATIVE MEASURE</th>
<th>ASSESSMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVIRONMENTAL IMPACT</td>
<td>Noise</td>
<td>Benefits from removal of traffic from Coulsdon town centre.</td>
<td>No. properties experiencing (w/s): - Increase in noise 48 - Decrease in noise 179</td>
<td>net 131 properties win with scheme</td>
</tr>
<tr>
<td></td>
<td>CO₂ tonnes added</td>
<td>Air quality improves as traffic removed from Coulsdon town centre.</td>
<td>No. properties experiencing: - improved air quality 129 - worse air quality 3</td>
<td>-130PM₁₀ -772 NO₂</td>
</tr>
<tr>
<td></td>
<td>Landscape</td>
<td>Line of route is in urban setting and closely parallels the existing railway line.</td>
<td>-</td>
<td>Neutral</td>
</tr>
<tr>
<td></td>
<td>Biodiversity</td>
<td>Adversely affects important chalk grassland habitat forming part of site of local conservation importance.</td>
<td>-</td>
<td>Moderate +ve</td>
</tr>
<tr>
<td></td>
<td>Heritage</td>
<td>Slight impact on one listed building and archaeological area of potential, but mitigation agreed.</td>
<td>-</td>
<td>Neutral</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>There are particular concerns with this scheme regarding the impact of contaminated land on the underlying aquifer, which is used for public water supply. Further investigations will be required to determine whether or not an acceptable solution can be identified.</td>
<td>-</td>
<td>Large +ve</td>
</tr>
<tr>
<td>SAFETY</td>
<td>-</td>
<td>Accident rates in Coulsdon town centre are currently above national average.</td>
<td>Accidents Deaths Serious Slight peak 760 8 184 590</td>
<td>PVB £8.1m 36% of PVC</td>
</tr>
<tr>
<td>ECONOMY</td>
<td>Journey times &amp; VOCs</td>
<td>Town centre flows fall to 20% of pre-opening levels, but total traffic (on both old/new routes) would increase by over 20%.</td>
<td>N/A  N/A</td>
<td>PVB £164m 690% of PVC</td>
</tr>
<tr>
<td></td>
<td>Cost</td>
<td>-</td>
<td>-</td>
<td>PVC £22.4m</td>
</tr>
<tr>
<td></td>
<td>Reliability</td>
<td>Currently highly congested and forecast to get worse.</td>
<td>Route stress Before: 130% After: 48%</td>
<td>Moderate Mod rel to PVC</td>
</tr>
<tr>
<td></td>
<td>Regeneration</td>
<td>Serves regeneration priority area?</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td>ACCESSIBILITY</td>
<td>Public transport</td>
<td>Increased reliability of public transport journey times in Coulsdon town centre.</td>
<td>-</td>
<td>Moderate +ve</td>
</tr>
<tr>
<td></td>
<td>Severance</td>
<td>Over 7,000 people experience substantial relief from community severance</td>
<td>-</td>
<td>Large +ve</td>
</tr>
<tr>
<td></td>
<td>Pedestrians and others</td>
<td>Facilities for pedestrians would be improved in Town centre.</td>
<td>-</td>
<td>Large +ve</td>
</tr>
<tr>
<td>INTEGRATION</td>
<td>-</td>
<td>Croydon UDP supports use of strategic network by longer distance traffic and improving conditions for cyclists and pedestrians</td>
<td>-</td>
<td>+ve</td>
</tr>
<tr>
<td>COBA</td>
<td></td>
<td></td>
<td>PVB £160m   PVC £22. NPV £140m  BCR 7.2</td>
<td></td>
</tr>
</tbody>
</table>
REFERENCES


Ker, IR 2004, *Perth Bicycle Network, Stage 3: evaluation*, ARRB Transport Research for Bikewest, Department for Planning and Infrastructure, Perth, WA.

