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Australian Transport Assessment and Planning Guidelines

O6 Alternative Options to Large Capital Investments

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Alternative Options to Large Capital Investments

At a glance

- This guidance considers the assessment of alternative options to large capital investments in transport (referred to simply as 'alternative options' in this guidance), with a focus on using cost–benefit analysis (CBA) to appraise them
- Alternative options as used here refer specifically to alternatives to large high cost investment options
- Alternative options make better use of existing infrastructure and avoid the need for large-scale capital expenditures. They include:
  - Non-capital investment options (regulatory reform, land use reform, governance reform, better asset use reform, service reform, operations and strategy reform) on both the demand side and supply side
  - Low cost, small scale, capital investment options, often aimed at making better use of existing large scale infrastructure
- The guidance lists a wide range of examples of alternative options
- Use of alternative options may be justified on several grounds:
  - The scale of the problem may not be large enough to justify a large scale and costly investment
  - Limits on government budgets. Addressing a transport problem with an alternative option reduces the demand for scarce government funds, which can then be used to address other problems. They also allow governments flexibility when faced with managing revenue downturn shocks
  - By providing some short-term relief to a pressing transport problem, an alternative option can save costs by allowing investment in large-scale infrastructure to be deferred. Risk and uncertainty might be reduced too if the decision to invest in large-scale infrastructure is delayed until better information becomes available about, for example, demand and decisions about other initiatives. This is an example of the real options approach addressed in O8 of the ATAP Guidelines (forthcoming)
  - The consideration of alternative options as a broader set of options than just build options helps project teams maintain their focus on the underlying problem being addressed; the related economic, social, environmental and project outcomes and objectives sought; and system-wide effects
  - While less visible than large scale capital projects, alternative projects are widely used across transport (as direct substitutes or complements to capital projects). For example, road safety strategies clearly combine both capital investment and alternative options as a complementary a suite of solutions to the problem
- Compared with large infrastructure, the appraisal of alternative options will involve a number of features: smaller capital cost; shorter option lives; greater difficulty in sourcing suitable data and modelling; some adaptations to accommodate specific option types; less risk and uncertainty.
- If an alternative option does not involve up-front investment, the appraisal simplifies to a comparison of annual benefit and annual cost
- The guidance discusses a series of case studies to illustrate the rules of CBA application to alternative options. The case studies are: road pricing; operation of clearways; road safety campaigns; public transport stop/station and vehicle upgrades; travel behaviour change initiatives; intelligent transport systems (ITS)
- Cross-reference is also made to two ATAP worked examples: a public transport route extension and active travel paths

1. Introduction

This part of the Guidelines provides guidance on the assessment of alternative options to large capital investments in transport (referred to simply as 'alternative options' in this guidance), where alternative options as used here refers specifically to alternatives to large high cost capital investment options. The importance of such options in the infrastructure sector was highlighted by the Productivity Commission (2014), noting that they can provide less costly solutions and reduce the need for new investment.

Its primary purpose is to:

- Illustrate the range of alternative options in transport
- Highlight how cost-benefit analysis (CBA) can be used in the assessment of alternative options.

Note that transport regulatory initiatives are not discussed here in detail. They are addressed in a complementary part of the Guidelines, Part O7.

This guidance is closely related to the following ATAP guidance:

- Part F3 Options Generation and Assessment
- Part T2 Cost–Benefit Analysis. This guidance complements T2.

Users should therefore read this guidance alongside T2 and F3.

Structure of this guidance

Chapter 2 explains the context for this guidance. It discusses: the requirement in best practice to identify a wide range of options for solving transport problems; what is meant here by alternative options; the rationale for considering these options; and examples of alternative options.

Chapter 3 discusses the application of CBA to alternative options. It briefly restates the ATAP assessment model and then discusses key aspects of the application of CBA to transport alternative options.

Chapter 4 considers a range of case studies of alternative options, using examples that are less established or well known. It also includes brief summaries of relevant examples contained in the ATAP worked examples category of the ATAP website (public transport and active travel).

2. Context and Outline

2.1 Options for solving transport problems

Having identified a priority problem in the transport system (IA 2018, B1, D1; ATAP Part F2), options need to be found and assessed for solving the problem. This involves a number of steps (IA 2018, B2; ATAP Part F3 Options Generation and Assessment):

- Generating a broad range of options for addressing the identified problem (see Chapter 2 of ATAP F3)
- Assessing each option (see section 3.1 below)
- Leading to a preferred option (or package of options) being recommended.

Types of options that may be available (IA 2018 B2, ATAP F3) include:

- Non-capital investment options:
  - Regulatory reform
  - Land use reform
  - Governance reform
  - Better asset use reform
  - Service reform
- Capital investment options

Options can be further categorised as (IA 2018, B2.3):

- Demand side options
- Supply side options

As mentioned in Chapter 1, regulatory initiatives are considered separately in ATAP Part O7.

2.2 What are alternative options?

This guidance focuses on 'alternative' options, which include:

- Non-capital investment options
- Low-cost[1], smaller-scale capital investment options, often aimed at making better use of existing large-scale infrastructure.

Alternative options may involve both capital costs and operating costs in developed solutions.

[1] Across Australian jurisdictions low-cost is interpreted as falling in the range $3 million to $10 million.

More specifically, alternative options include:

- Minor initiatives that provide or enhance ancillary infrastructure assets, such as traffic signals, transport signage or amenity improvements at public transport stations/stops
- Intelligent transport system (ITS) initiatives that enhance the capacity of existing infrastructure (although some of these initiatives can entail large investment expenditure, for example for ramp enhancement in managed motorway initiatives)
- Travel demand management including
  - Pricing
  - Travel behaviour change
  - Land–use policy
- Augmentation or upgrading of existing vehicle fleets
- Other relatively low–cost upgrades to fixed infrastructure such as intersection layout improvements and/or signalling of intersections or additions to pedestrian/cycle paths
- Operational improvements to the existing system, e.g. timetable optimisation, maintenance optimisation, optimising traffic flows through improved use of signalling
- Better coordination within the system
- Better information about transport services and operating conditions

Pedestrian crossing supervisors near schools are an example of an alternative option to the problem of child pedestrian safety. Another example is passenger information systems which reduce user timetable uncertainty and waiting time for services.

We are using the term ‘alternative’ here to provide a contrast with large high-cost capital investment options. Historically, high-cost investment options have dominated the planning and assessment of transport systems. By publishing a guideline specifically on alternative options, the Guidelines aim to encourage a balanced approach to transport planning and assessment.

A final point to note is that the design of infrastructure is also critical to performance, e.g. good seating design (latitudinal vs longitudinal) in public transport vehicle design; and designing to allow for future expansion.

2.3 The rational for alternative options

There are several strands to the rationale for considering alternative options:

- Not all transport problems require large upfront investment. Sometimes small–scale capital works or on-going operational resources can overcome a problem or achieve an improvement in service provision at lower cost and with less risk and uncertainty compared to a large upfront investment.
- The scale of the problem may not be large enough to justify a large-scale and costly investment.
- Major transport infrastructure is typified by large and lumpy capital investments due to scale economies. Alternative options might offer small and intermediate-size alternatives that prove more economic than the large-scale investment

- Limits on government budgets. Addressing a transport problem with an alternative option reduces the demand for scarce government funds, which can then be used to address other problems. They also allow governments flexibility when faced with managing revenue downturn shocks
- By providing some short-term relief to a pressing transport problem, an alternative option can save costs by allowing investment in large-scale infrastructure to be deferred. Risk and uncertainty might be reduced too if the decision to invest in large-scale infrastructure is delayed until better information becomes available about, for example, demand and decisions about other initiatives. This is an example of the real options approach addressed in O8 of the ATAP Guidelines (forthcoming)
- The consideration of alternative options as a broader set of options than just 'build options' helps project teams maintain their focus on: the underlying problem being addressed; the related economic, social, environmental and project outcomes and objectives sought; and system–wide effects.
- While less visible than large scale capital projects, alternative options are widely used across transport (as direct substitutes or complements to capital projects). For example, road safety strategies clearly combine both capital investment and alternative options as a complementary suite of solutions to the problem
- Note also that sometimes alternative options are packaged up with large capital investment options as part of an overall package of responses to the problem.

Despite their potential role for solving or managing transport problems, observed practice suggests that alternative options are frequently overlooked in preference to large infrastructure projects. In addition, they are also less frequently considered in planning and assessment processes and related business cases. There are likely to be a number of reasons for this,2 including that alternative options:

- May not align with a stated government policy position. For example, road pricing options may be excluded because of a government policy position of not supporting road pricing
- May not address a stated long term project objective, for example, to expand capacity.[3]

For best practice, it is suggested that:

- Alternative options be identified and at least mentioned in the business case as part of the long list of potential options
- When a feasible alternative option is not considered in an assessment, or taken forward as a legitimate option alongside larger scoped options, clear reasons be provided.

[2] See Productivity Commission (2014) chapter 2 for an extended discussion of the infrastructure sector.
[3] Note, however, that capacity expansion is often a response to the underlying problem of congestion, for which alternative options may be suitable solutions. See ATAP Part F3, section 2.2 for further discussion.

2.4 Examples of alternative options for congestion

It is beyond the scope of this guidance to provide a listing of all alternative options. Instead, this section illustrates the range of alternative options for dealing with the important problem of urban congestion. BITRE (2015) estimated that the avoidable social costs of congestion (where the benefits to road users of some travel in congested conditions are less than the costs imposed on other road users and the wider community) for the eight Australian capital cities was around $16 billion in 2015, and that this is expected to increase significantly in future years, especially under a business-as-usual future.

In ATAP Part F3, Figure 3 sets out parallel infrastructure and alternative option paths for addressing urban congestion, illustrated with a few examples of alternative options. A very wide range of alternative options have been considered for congestion management around the world. In that context, Table 1 from COAG (2006) provides an expanded range of alternative options directed specifically at congestion management.

Table 1: Typology of congestion management initiatives considered internationally

Policy area	Example initiative
A. ROAD SUPPLY MANAGEMENT	
A1. Road Space Re-allocation	Public transport/ High Occupancy Vehicle (HOV) priority
	Truck priority
A2. Road Capacity Enhancement	Ramp metering
	Speed control
	En-route information
	Incident management systems
B. ROAD DEMAND MANAGEMENT – NON-PRICE MEASURES	
B1. Travel Demand Modification	Staggered/flexible work or school hours
B2. Travel Planning	Household-based travel planning (TravelSmart) etc
	Workplace/school travel plans
	Ride-sharing
B3. Travel Substitution	Telework centres
	e-work programs
B4. Administrative Measures	Trip reduction ordinances
	Transport Management Associations
C. ROAD DEMAND MANAGEMENT – PRICE MEASURES	
C1. Road Use Charging	Comprehensive charging schemes (area/cordon/link-based)
	Congestion pricing - select route charging (toll roads, HOT lanes)
C2. Parking Pricing/ Supply Policies	Public parking price/supply policies
	Private non-residential parking price/supply policies

Policy area	Example initiative
	Private non-residential parking price/supply policies
C3. Other Pricing Measures	Car purchase/ownership fees and duties
	Pricing re commuting costs:
	- cars (ownership/use/parking)
	- alternative modes
D. ALTERNATIVE PASSENGER TRANSPORT	
D1. PT System/Service Enhancements	Major service expansions
	Service level enhancements
	Service integration
	Service quality enhancements
	Information and marketing
	Fares/ticketing policy including subsidies and pricing
D2. Walking/Cycling	Provision of infrastructure, marketing
E. FREIGHT MANAGEMENT	
E1. Road Freight Management	Access regulation (routes/areas/times)
	Vehicle capacities and standards
F. URBAN LAND USE PLANNING	
F1 Urban Land use/ Planning Policies	Development densities
	Transit-oriented development
	Facility location policies

Source: Adapted from COAG (2006)

Over the last couple of decades, focus has also been given to travel behaviour change (TBhC) initiatives as another approach to managing travel demand. TBhC is specifically addressed in ATAP Part M5. Examples of TBhC initiatives are shown in Table 2.

Table 2: Examples of Travel behaviour change initiatives

Policy area or objective	Example initiative
B. ROAD DEMAND MANAGEMENT – NON-PRICE MEASURES	
Community - or household-based initiatives to support efficient travel decisions	Personalised trip analysis and advice (travel blending, trip chaining, forward planning)
	Pre-trip information about options and conditions for specific trips
	'Living neighbourhoods'
	Ride share matching service

Policy area or objective	Example initiative
	Education, information and training
Community - or household-based initiatives to encourage reductions in the use of cars	Marketing of PT / walking / cycling
	Improve image of PT and other environmentally friendly modes
	Advertising and education on travel choices, impacts and costs
	Counter fear of personal insecurity using other environmentally friendly modes
	Marketing of travel choices (such as personalised marketing)
	Education, information and training
	Car clubs / car sharing
School travel	Education and training (such as TravelSmart, cycle training, street crossing behaviour)
	Travel plans
	Establish non-motorised alternatives (walking school buses, cycle trains)
Workplace trip reduction	Workplace parking management / provision
	Company van pools / ride share
	Voluntary trip reduction
	Flexible work hours
	Guaranteed ride home programs
	Workplace car sharing
Substitutes for travel (may be done through workplaces or at a community level)	Tele-working
	Tele-conferencing
	Tele-shopping / home shopping
	E-commerce
Financial inducements to potential users of alternative modes	Discounts for walking shoes or cycling gear
	Free cycle maintenance
	Discounted public transport tickets
	Free ticket to try public transport.

Source: Adapted from ATAP M5

3. Application of cost-benefit analysis

This chapter discusses the application of CBA to alternative options. Section 3.1 briefly restates the ATAP assessment model. The subsequent sections then discuss key aspects of the application of CBA to alternative options.

As with large infrastructure upfront capital investments, alternative options entail the use of scarce resources, albeit on a smaller scale and not always upfront. Cost-benefit analysis (CBA) is therefore important in their assessment. CBA should be used to assess all options, irrespective of their size or nature.

CBA should be used whenever it is feasible to do so. In very rare cases, a cost-effectiveness analysis (CEA) might be applied (IA 2018). CEA would be used only where the benefits of the range of options are deemed identical and the analysis is seeking to identify the least cost solution to achieve the stated benefits (IA 2018, section D2.5).

As stated above, CBA should be applied to options, initiatives and expenditures of all sizes and natures. Traditionally, however, CBA has been more widely applied to large capital projects. Funding approval and assurance processes can also differ between large and small projects and between capital and operating expenditures creating the potential for alternative options not to be front of mind in investment decision making.

3.1 The ATAP assessment model

The ATAP assessment model outlined in Section 3.3 in ATAP Part F3 provides the basis for assessing all initiatives, including alternative options. The model consists of:

- Clarification of relevant jurisdictional goals, transport system objectives and targets – It is important to be clear from early in an assessment about which of these relate to the alternative options
- Consideration of strategic merit / alignment – The degree of strategic alignment of the alternative options should be assessed
- Use of CBA (see ATAP Part T2) and the Appraisal Summary Table (AST). The AST provides the mechanism for presenting all the appraisal results — monetised and non-monetised — in a single location
- The ATAP appraisal methodology recognises that all benefits and costs—monetised and non-monetised—are relevant to the appraisal of initiatives. It facilitates this through use of the AST, in which monetised and non-monetised benefits and costs are presented side-by-side – see Part F3 Chapter 3.
- Bringing together all aspects of the assessment into a Business Case (see ATAP Part F4).

Within this context, the remainder of this chapter is on the application of CBA to alternative options. It is in line with ATAP T2, which provides guidance on how to undertake CBA of transport initiatives.

3.2 Relationship to appraisal of large capital investments

As mentioned above, in principle there is no difference between a CBA for a large scale capital investment option and a CBA for an alternative option. The broad principles and methodology outlined in ATAP T2 apply equally to both. In each case, the CBA is endeavouring to estimate the effects of a proposed change in resource use and the associated costs and benefits.

The differences between these two applications of CBA lie in the nature of the changes being appraised:

- The typical CBA of large transport infrastructure assesses costs of large, relatively long–lived assets, with large capital investment costs
- In contrast, in the appraisal of alternative options, investment costs will be smaller
- Both infrastructure and alternative appraisals will involve ongoing recurrent operating and maintenance costs
- In practice, for alternative initiatives, some costs and benefits might not be as readily estimated as more conventional infrastructure options. The case studies presented in Chapter 4 (4.2 on road pricing; 4.3 on road safety; and 4.6 on travel behaviour change) are particularly illustrative of this point. In addition, some adaptations may be required to accommodate specific characteristics of some option types.

3.3 Appraisal period

On many occasions, alternative options will have relatively short lives. This could be for several reasons:

- The equipment or technology may have a short asset life
- The intent of the initiative might be experimental
- The intent of the initiative may be to achieve some short–term one–off change in behaviour.

If options to solve a problem include both short-duration alternative options as well as infrastructure options with longer asset lives, the appraisal period should equal that with the longest asset life. ATAP Part T2 section 2.4 provides two methods for dealing with this situation:

- The alternative option is repeated during the appraisal period
- Alternatively, each option’s NPV is converted to an annuity over the appraisal period.

Probabilistic analysis will be needed to estimate expected values of NPVs if the options being compared involve different risks. Shorter-lived and alternative options preserve the option of not renewing or discontinuing the solution and deferring investment in more expensive longer-lived infrastructure. This is discussed further below in section 3.6.

These considerations are not relevant if an alternative solution is one initiative in a candidate list being prioritised for funding from a fixed program budget. They are only relevant if mutually exclusive options to address the same problem have differing project lives.

Road safety information and advertising campaigns are examples of alternative options with short appraisal periods. Improving cleanliness at public transport stations/stops is another.

3.4 Up-front investment

Some alternative options will require no or only minimal upfront expenditure. Those that do require investment expenditure can often be appraised using the mode-specific ATAP guidance. If no upfront investment is required, you will only be able to calculate the benefit–cost ratio (BCR) using the BCR1 formula in the ATAP Part T2 (see section 10.4) in which operating costs are included in the denominator of the BCR formula. The net present value (NPV) can be calculated irrespective of whether the initiative has upfront investment costs, as per the NPV formula in T2 (section 11.3).

Signing of clearways is an example of an alternative option that would not require large upfront investment.

3.5 Scale of initiatives

Deciding on a suitable methodology for appraising an alternative option will be determined more by the nature of the initiative than by its size. For example, for appraising public transport vehicle and fleet initiatives, processes outlined in ATAP Part M1 can be employed whether a small number of vehicles are being upgraded or whole fleets are being upgraded. Similarly, appraisal of a small section of road widening and of the widening of a whole corridor would use the same methodology as set out in ATAP Part M2.

The types of initiatives that call for almost customised methodologies are those that are not very frequently implemented or those where the link between the initiative and its impacts in terms of system use (passengers, passenger km etc) or system outputs (service frequency, seat km, vehicle km) are less direct. Initiatives that aim to change user behaviour or to influence the volume of demand are examples of the latter.

3.6 Related options

The alternative option cannot be appraised in isolation where it affects the costs and benefits of related infrastructure. ATAP Part F3 Appendix A discusses inter-relationships between initiatives under the headings of independence, complementarity and substitutability. Where there is a range of alternative options that address the same problem, for example, the options listed in Table 1 and 2 above for congestion, combinations of options may be proposed. Where there is significant complementarity or substitutability between alternative options, each combination should be assessed as if they were a single option, including each option by itself, to find the combination with the greatest net present value.

An example of relatedness between an alternative and a conventional option is where the alternative option provides some short-term relief to a pressing transport problem such as alleviating congestion in the face of growing demand, which enables investment in large-scale infrastructure to be deferred. In such a situation, the do-minimum base case could be compared with the option of proceeding with the large capital project implemented as soon as practical, and the alternative option of implementing the alternative solution as soon as practical combined with delaying the large capital project by some years. The second option is disadvantaged by the additional costs of the alternative solution but is advantaged by the saving in the present value of capital costs from deferring the large project.

Where there is uncertainty about the benefits from the large capital project and a probabilistic analysis is undertaken, this is a case of the real options approach documented in O8 of the ATAP Guidelines (forthcoming). Benefits from the large capital project might be risky due to uncertain growth in demand or uncertainty about whether other large capital projects or land use changes proceed. Deferring the large capital project could change the probabilities of various scenarios by allowing time for future uncertainties to be resolved.

4. Case Studies

4.1 Introduction

Eight non–infrastructure case studies are described in this chapter. The rationale for inclusion of each case study is described in Table 3.

Table 3: Case study summary

Policy Area	Appraisal case study	Rationale for inclusion of case study	Covered in other ATAP guidance	Upfront costs	Ongoing recurrent costs
Road demand management	Road pricing	Example of a demand management initiative; Infrequently appraised.	No	Yes	Yes
Road supply management/ freight management	Operation of clearways	Does not require infrastructure investment.	No	No	Yes
Road demand management – non-price measures	Road safety campaigns	Does not require infrastructure investment but has other upfront costs (campaign design and production). Aims to change driver behaviour by changing attitudes to risk.	No	No	Yes
Alternative passenger transport	Bus/train stop facility upgrades	Relatively small investment cost.	See M1 Supporting technical report	Yes	Yes
Road demand management	Travel behaviour change (TBhC)	Does not require infrastructure investment but has other upfront costs (campaign design and production). Seeks to change behaviour by educating users in assessing individual travel alternatives. Infrequently appraised.	See M5	Yes	Sometimes
Alternative passenger transport	Public transport route extension	Relatively low cost infrastructure-based.	See M1 and W1.1	Yes	Yes
Alternative transport	Active travel path	Relatively low cost infrastructure-based.	See M4 and W4	Yes	Yes
Road supply management	Intelligent Transport Systems (ITS)	Relatively low cost. Incorporates infrastructure elements (e.g. electronic signs and gantries) and non-infrastructure elements (software).	No	Yes	Yes

4.2 Stockholm road pricing trial

A cordon-based road pricing system was trialled in Stockholm in 2006, the objective being the reduction in motor vehicle congestion in central Stockholm.4 The trial was supported by infrastructure comprising cameras and transponders to identify vehicles crossing the tolled cordon.5

The objectives of the trial were (Transek AB 2006):

- To reduce the number of vehicles passing in or out of the congestion-charge zone during the morning and afternoon-evening peak periods by 10%
- To improve the flow of traffic on the busiest streets and roads in Stockholm
- To reduce emissions of carbon dioxide, nitric oxide and other particles into the air in the inner city
- To improve the urban environment as perceived by Stockholm residents.

There were three elements in the trial (Transek AB 2006):

- The congestion charging system including minor upgrades of road infrastructure (primarily in new or improved signalling)
- Provision of additional bus and rail public transport services including additional park-and-ride spaces
- Production and distribution of information about the trial and its evaluation.

Inputs used to estimate user benefits included traffic/transport modelling, public transport boarding counts and travel time surveys.

Table 4 summarises the appraisal of the initiative. The principal benefit categories were:

- Travel time savings for car and public transport users
- Reliability benefits for car users
- Improvements in road safety
- Emissions and health benefits
- Increased public transport revenues.

The principal cost categories[6] reported were:

- Increase in public transport operating costs
- Operation of the congestion charging system.

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[4] The discussion of the Stockholm road pricing trial is based on Eliasson (2008a).
[5] In an apparently political decision to facilitate the implementation of the trial, additional public transport services were provided. That additional public transport capacity does not appear to have been influential in the outcomes of the trial.
[6] Road charging systems would typically also involve upfront capital investment costs, such as transponders, cameras, gantries, etc.

Table 4 reports the benefits of the Stockholm road pricing trial (assuming it extended beyond a trial and into permanent operation). Note that the reporting of the investment costs of the trial is unclear. Major investment costs were not included in the reported comparison of benefits and costs (including cost to governments). However, Transek AB (2006) suggests that they were approximately SEK 2 billion including the costs of decommissioning tolling infrastructure at the conclusion of the trial and evaluating the results of the trial.

Table 4: Costs and Benefits of the Stockholm Road Pricing Trial (SEK millions pa)

Costs and Benefits	Congestion charge	Expansion of bus services	Total
Benefits			
Shorter travel times	523	157	680
More predictable travel times	78	0	78
Change in mode of travel	-13	24	11
Congestion tax paid	-763	0	-763
Total effect: road-users	*-175*	*181*	*6*
Reduced climate gas emissions	64	0	64
Health and other environmental benefits	22	0	22
Improved traffic safety	125	0	125
Total effect: other factors	*211*	*0*	*211*
Congestion tax revenues	763	0	763
Public transport revenues	184	0	184
Fuel tax revenues	-53	0	-53
Wear and tear on infrastructure	1	0	1
Maintaining public transport standards (Note 1)	-64	990	-64
Total public sector income and expenses excl. operating and investment costs	*831*	*0*	*831*
Total surplus of benefits over costs excl. operating and investment costs (Note 2)	*867*	*181*	*1,048*
Costs			
Operating costs	-220	-341	-561
Distortion and opportunity cost	118	-181	-62
Cost benefit surplus excluding investment costs	***765***	***-341***	***424***

Source: Transek AB (2006) Tables 1 and 3

SEK: Swedish krona
Note 1: The cost for maintaining the same average standard of comfort on public transport despite increased passenger numbers. Calculated using the average cost-correlation model developed by Banverket (the authority responsible for rail traffic in Sweden), implemented in the sumKalk computational program.
Note 2: Not including distortion and opportunity costs (so called tax factors)

User benefits were estimated via a combination of traffic counts, traffic/transport modelling and travel time user surveys. Two key points from this analysis were that:

- Tolled off work trips largely diverted to public transport
- Tolled off discretionary trips ‘disappeared’ – trips were either not made after tolling or there was increased trip chaining.[7]

The Stockholm trial and the associated CBA illustrate how CBA can be applied to initiatives targeting behavioural change (see section 4.6 below for further discussion on travel behaviour change initiatives). It should not be taken to imply that all initiatives aimed at changing travel behaviour will necessarily produce a net benefit. They can be poorly designed and have excessive implementation costs. Eliasson 2008b) notes[8] ‘Even if it is well established that perfect congestion pricing will yield a social surplus, it is neither evident that it will be enough to cover investment and operating costs, nor that a real congestion pricing system, with all its practical and political limitations, will be socially beneficial.’

4.3 Operation of clearways

TfNSW (2018, section 8.3.8) provides a process and a model for the economic appraisal of clearway proposals. The model is able to accommodate:

- Changing clearway periods, e.g. peak hours only to 12-hour or 24-hour clearway
- Changing clearway direction, e.g. from eastbound to westbound or from one direction only to both directions
- Changing clearway operation from weekday only to full week including weekends.

The key inputs to the TfNSW model include:

- Average hourly traffic volumes disaggregated according to light vehicles, heavy vehicles and buses for weekdays and weekends
- Current clearway status including hours and days of operation (base case)
- Proposed clearway status including hours and days of operation
- Length of proposed additional clearways
- Road capacity
- Number of lanes
- Investment and operating costs
- Numbers of crashes per year.

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[7] ‘Tolled off’ trips are those that were no longer made by private motor vehicle after the application of tolls. ‘Disappearing’ trips are those that were no longer made, whether by private motor vehicle or public transport or were subsumed in longer ‘chained’ trips after the application of tolls.

[8] For example, Durakovic & Swahn’s (2014) analysis suggests that the roll out of a congestion scheme in Gotenburg made the community worse off by –73.8 million SEK due to small changes in toll charges, and showed further the BCR for the project was highly sensitive to changes in the value and volume of travel time savings and the substitution of travel from private vehicles to public transport. Several studies of the London Congestion Scheme suggested that the initiative decreased the overall welfare of the community, with Prud’homme and Bocarejo (2005) finding that ‘the proceeds of the charge are about two-and-a-half times as large as this economic gain .. and … the economic costs associated with the system are larger than the economic gains it generates …. The economic benefits represent less than 60% of the economic costs.’, suggesting a NPV of –€73 million per year.

Operation of the model requires estimation of average speeds in the affected section, with and without clearways, using an Austroads speed-flow relationship.

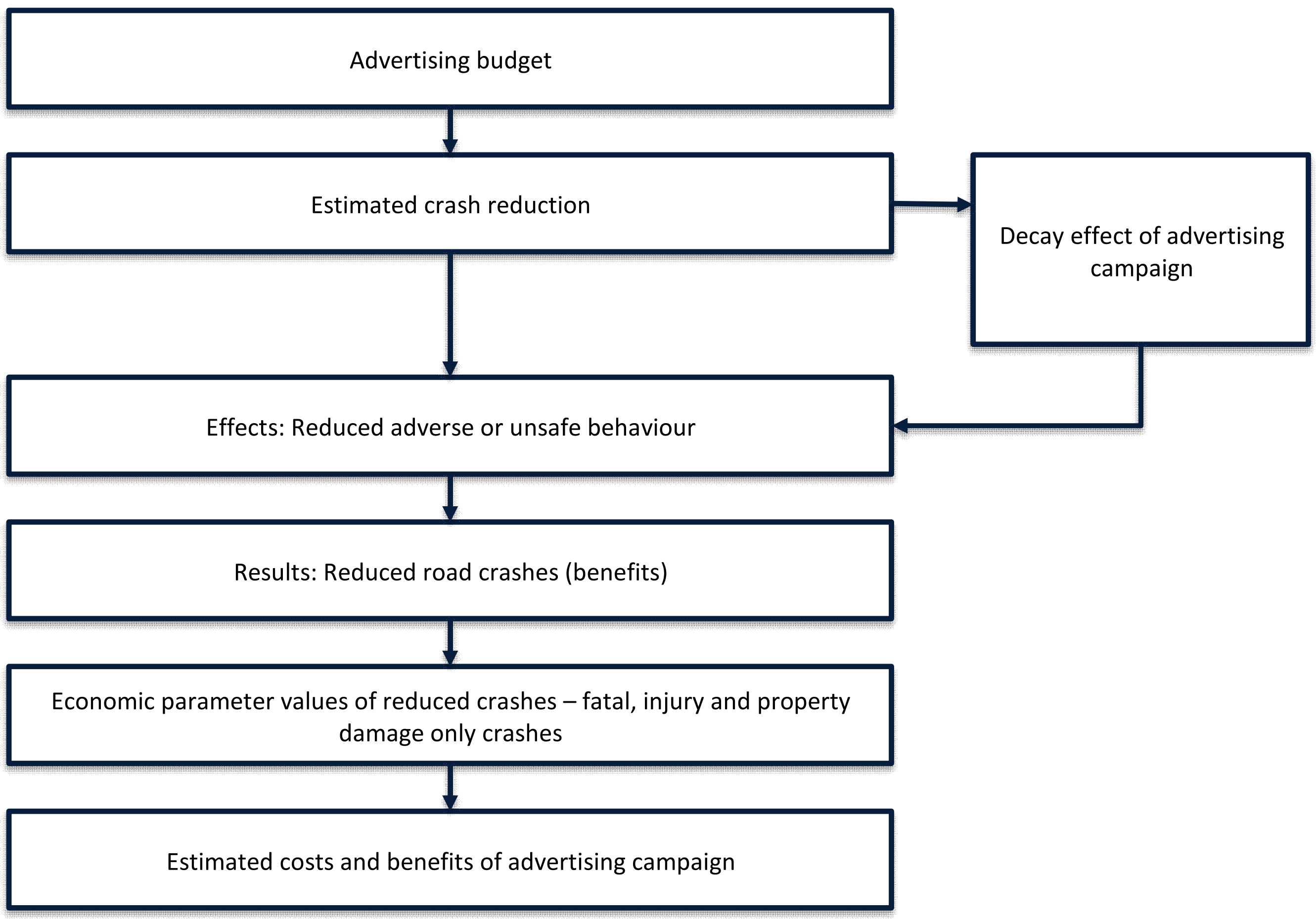
The model estimates the following benefits: travel time savings, reduced vehicle operating costs (using the Austroads urban stop-start model – provided in ATAP Part PV2), reduced environmental and crash reduction.

4.4 Road safety campaigns

TfNSW (2018, section 8.3.9) describes a methodology for the economic appraisal of road safety advertising campaigns. The specific example provided is a campaign to reduce mobile phone use while driving on the road.

The TfNSW methodology illustrates the integration into a core CBA of research about the effectiveness of road safety advertising campaigns and agency knowledge about influences on crash reduction. The methodology also illustrates how economic appraisals can be applied to short-lived initiatives: each marketing campaign loses its effectiveness after a year or two (TfNSW (2016) notes that advertising campaigns tend to lose their effectiveness after three years).

Figure 1: Methodology – CBA of advertising campaign



Source: TfNSW (2016)

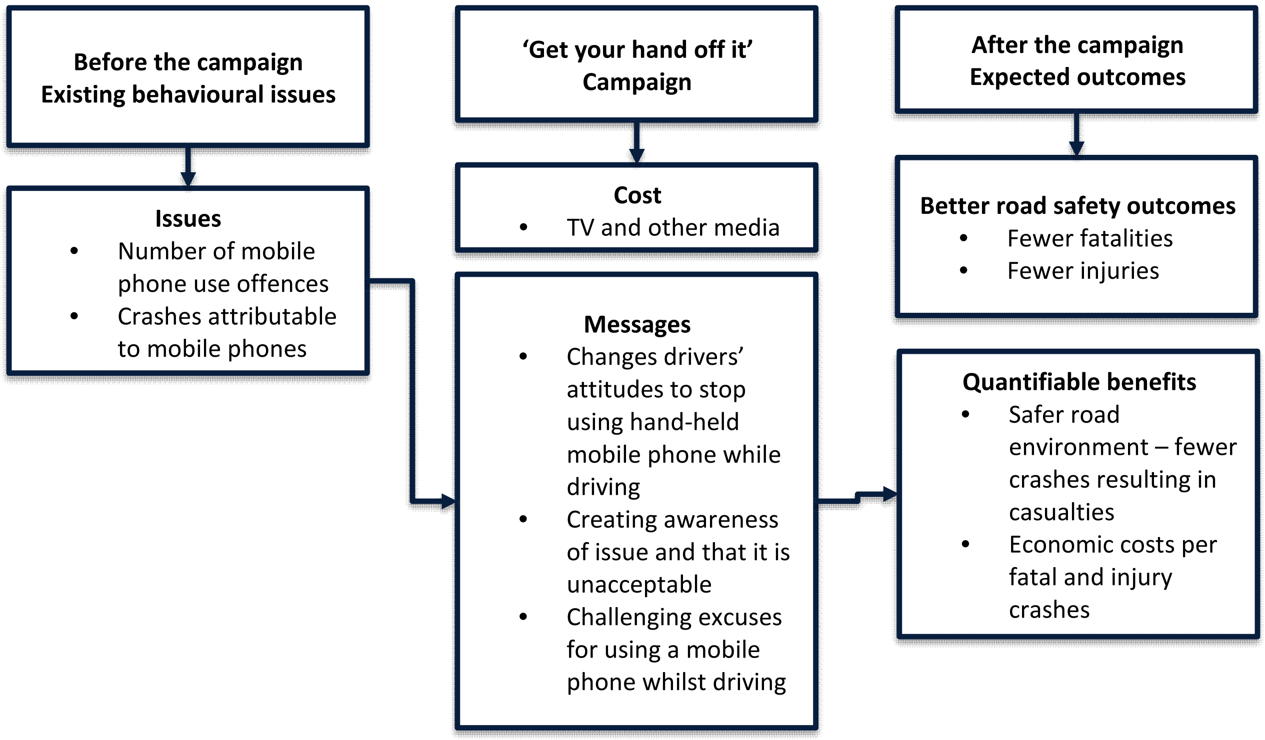
In this initiative, the investment cost comprises the cost of producing the advertising material and the costs of running it in the selected media. Because individual advertising campaigns can quickly lose their effectiveness, the appraisal period is three years.

The steps in the analysis are:

Step 1 – Develop the analytical framework

The approach to the CBA taken by TfNSW is shown in Figure 2. The analysis is conceptually similar to using crash reduction factors to estimate the crash effects of an infrastructure-based road safety initiative in which the base case crash record (left hand side of Figure 2) is modified by the crash reduction effect (middle of the diagram) to produce the project case crash record on the right hand side of the diagram. The difference in approach relative to an infrastructure-based initiative is that the crash reduction factor may be subject to 'decay' when there is a break in the campaign (see step 4) below.

Figure 2: Analytical structure – road safety campaign



Source: TfNSW (2016)

Step 2 – Collect data

Base case crash data will include those crashes attributable to mobile phone use.

Step 3 - Identify the Base Case, Base Year, Appraisal Period and Option Case

These details are outlined in the TfNSW example.

Step 4 - Estimate crash reduction factor attributable to advertising

The TfNSW case study identified four ways to estimate the crash reduction factor:

- Fully controlled before and after analysis: involves comparing crash incidence between two periods. The only difference between the periods in terms of crash causation is that an advertising campaign was run in one period targeting a particular crash risk

- Partially controlled before and after analysis: used when other influencing factors in crash incidence might also be present. The TfNSW methodology used in-house experience and professional judgement to isolate the effectiveness of advertising campaigns from other crash causes (see Table 5).
- According to the Table during periods when speed-related public education campaigns are delivered, those campaigns account for 15% of speed-related crash reduction. By comparison, during the life of driver fatigue campaigns those campaigns are judged to account for 40% of fatigue crash reductions.

Table 5: Contribution of key factors in selected road safety campaigns

	Speeding campaign	Drink driving campaign	Fatigue campaign
Engineering	35%	10%	60%
Enforcement	50%	60%	0%
Education	15%	30%	40%
Total	**100%**	**100%**	**100%**

Source: TfNSW (2016)

- Diminishing return model: This method draws on research conducted by Monash University Accident Research Centre (MUARC 1993) in the early 1990s that identified the optimum level of advertising expenditure after which campaign effectiveness diminishes. MUARC found the optimum expenditure to be $457,000 per month in 2014$ values at which the average crash reduction per month would be 7.5% per month.
- Total audience points model: TfNSW recommends that this method developed by MUARC only be used when no other causative information is available. It relates advertising campaign expenditure to crash reduction using the concept of Total Audience Rating Points (TARPS). In this model a TARP is worth $827 in 2013$ values, so that a campaign costing $1 million would generate 1209 TARPS. The relationship is as follows:

$$Casualty\ crashes\ with\ advertising\ campaign = Existing\ casualty\ crashes\ x\ TARPs\hat{}-0.0077$$

Step 5 - Estimate safety benefits from advertising campaign

Once the crash reduction is estimated using one of the methods in Step 4, crash benefits are estimated by multiplying the estimated crash reduction according to crash severity by the unit crash costs contained in PV2.

Once the advertising campaign is finished, benefits will continue but will decline month by month. TfNSW (2016) uses a constant decay rate, from MUARC research. This is the equivalent of 87% of a campaign’s awareness in one week being retained in the following week and the 87% of the awareness retained in that week being retained in the following week and so on.

Step 6 - Calculate NPV, BCR and conduct sensitivity tests

Benefits calculated in Step 5 are then combined with costs in a standard cost–benefit discounted cash flow analysis and NPV and BCR calculated. Unit crash costs in ATAP PV2 would be used to convert estimated crash reduction to crash benefits.

Suitable sensitivity tests could include the crash reduction factor (however it is measured) and the post-campaign decay rate.

4.5 Public transport stop/station and vehicle upgrades

The ATAP M1 technical appendix contains a set of parameter values that can be used to estimate the benefits of initiatives to improve user comfort and amenity at public transport stations/stops. A similar set of values is provided there for public transport vehicle-related improvements but the approach outlined here for station/stop can also be used for vehicle-related improvements.

The parameter values shown in Table 6 are drawn from M1 and represent the effect of station/stop improvements in terms of equivalent savings in in-vehicle time minutes per boarding. In other words, users value a specified improvement in attribute x at station stop type y as being the equivalent of reducing their in-vehicle time per boarding by z minutes. The parameter values in Table 6 relate to an improvement in the rating of a set of station/stop attributes from 40% (‘fair’ condition) to 80% (‘good’ condition). M1 also contains a methodology for calculating the in-vehicle time (IVT) minutes saved for any given improvement (say from 50% to 80%) but the values for 40% to 80% improvements are used in the example here.

Table 6: Value of improving stop attribute readings from 40% to 80%

Attribute	Value mins/boardings		
	Bus Stop	Tram/LRT stop	Rail station
Platform weather protection	1.18	1.14	0.79
Platform seating	1.00	0.97	0.77
Timetable information & announcements	1.01	0.99	0.67
Station lighting	0.57	0.56	0.53
Cleanliness & graffiti	0.89	0.86	0.90
Ease of ticket purchase	na	0.30	0.58
Platform surface	na	na	0.68
Ease of getting to & from the platform	na	na	0.59
Toilet availability & cleanliness	na	na	0.16
Availability & helpfulness of staff	na	na	0.23
Retail	na	na	0.18
Car parking	na	na	0.27
Ease of transferring to & from bus	na	na	0.11
Sum of individual attributes	4.65	4.82	5.70
Modelled package	3.79	3.88	5.19
Change in all attributes	3.81	3.90	5.21

Source: ATAP M1 Technical Report

Table 7 illustrates how the numbers in Table 6 can be used for the appraisal of improvement proposals. It considers the following three initiatives:

- Platform seating – Bus stop (benefit of 1 minute saved per boarding)
- Station lighting – Tram/LRT (benefit of 0.56 minutes saved per boarding)
- Cleanliness and graffiti removal – Tram/LRT (0.86 minutes saved per boarding).

IVT minutes saving per boarding for each initiative are extracted from in Table 6. Annual benefits are estimated using daily boardings for the weekday peaks, weekday off peaks and weekends because different expansion factors apply to each of these time periods. Peak and off-peak travel time values for bus are taken from ATAP M1. Off-peak values are used for weekend travel. Expansion factors used are 250 for converting weekday peak and off-peak benefits to annual weekday benefits and 115 for converting weekend day benefits to annual weekend benefits. Patronage is estimated to be growing at 1.5% per year. Each of the upgrades is assumed to have a 10–year operating life.

BCRs and NPVs are calculated and options compared. Two of the proposed improvements have investment as well as maintenance costs. The cleanliness and graffiti initiative does not have investment cost but will require an increase in cleaners' hours and materials; accordingly the appropriate BCR measure is BCR1.

This analysis could also be undertaken for a full list of candidate station improvements.

Table 7: Estimating benefits of improving selected attributes

	Attribute		
	Platform seating	Station lighting	Cleanliness and graffiti removal
Benefit per boarding (IVT minutes saved)	1.00	0.56	0.86
Peak boardings/weekday	600	600	600
Off peak boardings/weekday	400	400	400
Weekend boardings per day	250	250	250
IVT $/hr Peak (Note)	$12.00	$12.00	$12.00
IVT $/hr Off peak (Note)	$10.10	$10.10	$10.10
Peak benefit per weekday	$120.00	$67.20	$103.20
Off peak benefit per weekday	$67.33	$37.71	$57.91
Benefit per weekend day	$42.08	$24.04	$36.19
Expansion factor weekdays	250	250	250
Expansion factor weekend days	115	115	115
Initiative life (years)	10	10	10
Annual peak benefits	$30,000	$16,800	$25,800
Annual off peak benefits	$16,833	$9,427	$14,477
Annual weekend benefits	$4,840	$2,764	$4,162
Annual benefits total	$51,673	$28,991	$44,439
PV benefits	$360,033	$201,619	$309,629
Investment cost	$50,000	$100,000	0
Maintenance costs/year	$3,000	$5,000	$20,000
PV investment costs	$46,729	$93,458	$0
PV maintenance costs	$19,692	$32,820	$131,282
NPV	$293,612	$75,340	$178,347
BCR1	5.4	1.6	2.4
BCR2	7.3	1.8	na

Note: See ATAP M1 Table 15

4.6 Travel behaviour change (TBhC) initiatives

TBhC is a sub-set of broader demand management measures that aim to achieve better use out of existing infrastructure. However, whereas the focus of demand management has typically been on changing mode, route, time of day or trip frequency using measures such as pricing for roads, public transport and parking, TBhC aims to change how people perceive the full range of transport options available to them including public transport and active travel. The intention of TBhC initiatives is that with better information about the attributes of all modes, more people will be encouraged to switch some of their trips from private motorised travel to public transport or active travel.

M5 provides a simplified methodology (including a worked example) for estimating the benefits of TBhC initiatives. The methodology is illustrated here.

Default diversion rates

The first step is to decide on diversion rates. Diversion rates are critical to estimation of TBhC initiatives, even if the methodology set out in M5 is not used. Diversion rates show the percentages of trips diverted from current modes to other modes among the subject population that has been exposed to a TBhC initiative. For ease of calculation, the diversion rates are expressed in percentage point terms, so that the positive and negative diversion rates sum to zero. In effect, diversion rates measure the demand effects of TBhC initiatives. Table 8 presents default diversion rates for analysts to use.

Table 8: Default diversion rates for TBhC initiatives

	Car as driver	Car as passenger	PT	Cycling	Walking
Low	-1.0%	-0.2%	0.5%	0.3%	0.4%
Standard	-3.1%	-0.5%	1.4%	0.9%	1.3%

Source: ATAP M5

Default values for estimating perceived user benefits

Once the number of mode changing trips has been estimated by applying diversion rates, the second element of the M5 methodology is to estimate unit perceived user benefits ($ per trip) associated with mode switching in response to a TBhC initiative. A set of default values are presented in M5, along with the basis of these parameter values, which is unique to appraisal of TBhC initiatives, as illustrated in Table 9. Note that Table 9 values incorporate rule-of-a-half adjustments for perceived user benefits of mode change.

Table 9: Default mode changer perceived net benefit values ($/trip)

Mode change	Size of mode change (percentage points)	Benefit ($/trip)
Car driver/passenger switch to public transport		
	1	$0.35
	2	$0.70
	4	$1.40

Mode change	Size of mode change (percentage points)	Benefit ($/trip)
Car driver/passenger switch to cycle/walk		
	1	$0.25
	2	$0.50
	4	$1.00

Source: ATAP M5

Default values for resource correction and externality benefits

The next step is to calculate any resource corrections and externality benefits that apply. M5 contains default values for estimating these. Table 10 summarises these. The estimate of the number of mode changing trips (calculated above) and the default average trip lengths (see Table 11 Default average trip lengths for TBhC) can then be used to estimate this class of benefit.

Table 10: Default resource corrections and other benefit unit values (cents/km or cents/trip)

	Peak		Off-peak	
	Large city (1)	Other city (2)	Large city	Other city
Car driver per km				
VOC resource cost correction	0.0	0.0	0.0	0.0
Congestion externality X 0.5 (Note 3)	42.5	11.5	11.5	0.0
Accident cost externalities	8.7	8.7	8.7	8.7
Environmental externalities	6.2	6.2	6.2	6.2
Total per km	57.4	26.4	26.4	14.9
per trip				
Parking resource cost correction				
- trips to/from CBD	200.0	100.0	50.0	25.0
- trips to/from other destinations	50.0	25.0	0.0	0.0
Car passenger (Note 4)				
per km				
VOC resource cost correction	0.0	0.0	0.0	0.0
Congesting externality x 0.5 (Note 3)	21.3	5.8	5.8	0.0
Accident cost externalities	4.4	4.4	4.4	4.4
Environmental externalities	3.1	3.1	3.1	3.1
Total per km	28.7	13.2	13.2	7.5
per trip				

	Peak		Off-peak	
	Large city (1)	Other city (2)	Large city	Other city
Parking resource cost correction	0.0	0.0	0.0	0.0
Public transport passenger				
per km				
Accident cost externalities	0.0	0.0	0.0	0.0
Environmental externalities	0.0	0.0	0.0	0.0
Total per km	0.0	0.0	0.0	0.0
per trip				
Fare resource cost correction	-300.0	-225.0	-300.0	-225.0
Cycling				
per km				
Accident externality	0.0	0.0	0.0	0.0
Health effects	-73.0	-73.0	-73.0	-73.0
Total per km	-73.0	-73.0	-73.0	-73.0
Walking				
per km				
Accident externality	0.0	0.0	0.0	0.0
Health effects	-145.0	-145.0	-145.0	-145.0
Total per km	-145.0	-145.0	-145.0	-145.0

Source: ATAP M5

These values are costs (resource cost corrections and externalities) per kilometre or per trip. They become benefits if a trip is avoided, or costs if a trip is added. A negative value indicates that the effect is a benefit of a new trip on that mode; for example, health effects are benefits of cycling and walking trips.

Notes:
(1) Large city = population > 1 million
(2) Other city = population < 1 million
(3) Net congestion externality is 0.5 x congestion externality to account for induced traffic effect, which acts in opposite direction
(4) Car passenger per km values are 50% of car driver values (rather than zero) to account for a proportion of trips being made specifically for the passenger.

Table 11: Default average trip lengths for TBhC initiatives

	Peak	Peak	Off peak	Peak	Peak	Off peak
	To/from CBD	Other destination	All destinations	To/from CBD	Other destination	All destinations
Commuting						
car driver	14.0	12.5	11.0	12.0	12.0	7.5
car passenger	13.0	11.5	10.0	11.0	11.0	7.5
public transport	18.0	17.0	15.0	13.0	13.0	9.0
cycle	7.0	7.0	5.0	5.0	5.0	4.5
walk	2.0	2.0	2.0	2.0	2.0	2.0
Other trips						
car driver	10.0	10.0	8.0	10.0	10.0	7.5
car passenger	9.0	9.0	7.5	9.0	9.0	7.5
public transport	12.0	12.0	11.0	10.0	10.0	8.5
cycle	5.0	5.0	4.5	5.0	5.0	4.5
walk	2.0	2.0	2.0	2.0	2.0	2.0
Primary school						
car driver						
car passenger		4.0	4.0		4.0	4.0
public transport		11.5	11.5		10.0	10.0
cycle		2.0	2.0		2.0	2.0
walk		1.0	1.0		1.0	1.0
Secondary school						
car driver		7.5	7.5		7.5	7.5
car passenger		7.5	7.5		7.5	7.5
public transport		11.5	11.5		11.5	11.5
cycle		3.0	3.0		3.0	3.0
walk		1.5	1.5		1.5	1.5
Tertiary institution						
car driver		12.5	12.5		10.0	10.0
car passenger		11.0	11.0		10.0	10.0
public transport		17.0	17.0		12.0	12.0
cycle		4.0	4.0		4.0	4.0
walk		1.5	1.5		1.5	1.5

Source: ATAP M5

4.6.1 TBhC methodology

Economic analysis of TBhC initiatives involves the following steps (ATAP M5):

1. Define the type and scope of the TBhC initiative or package that is to be analysed (such as workplace travel plan, school travel plan, household and community based initiatives)
2. Separate out any 'hard' measures (such as cycling/walking infrastructure or public transport improvements) for separate analysis using relevant guidelines (see Section 1.3)
3. Identify the target population (such as all employees at a workplace/total population of an area to be covered by a TBhC initiatives)
4. Determine the costs of the proposal, including costs of any intended follow-up refresher program or ongoing support
5. Determine the expected level of diversion (the changes in mode shares) – Table 8 above
6. Determine the number of diverted trips per day of each trip type – multiply target population (from step 3) by diversion rate percentages (from step 5) and average daily trips per person
7. Determine average trip lengths and any other trip changes by different modes – Table 11 above
8. Obtain unit costs for each trip type. Use TBhC-specific unit values described earlier (or other standard values, provided that all perceived costs are excluded) – Tables 9 and 10 above
9. Determine average costs per trip for each trip type - combine average trip lengths (from step 7) with unit costs (from step 8) for each trip type
10. Determine total costs of each trip type – multiply number of diverted trips (from step 6) by costs per trip (from step 9) for each trip type, separately for the former and new modes
11. Determine the total perceived net benefits of mode changers
12. Determine total benefits per day – sum of trip costs avoided (from step 10) less trip costs of new trips (from step 10) plus mode changer perceived net benefits (from step 11)
13. Calculate the annual TBhC benefits – multiply benefits per day (from step 12) by an appropriate annualisation factor
14. Discount the costs and benefits over the period of analysis (a default analysis period of three years from completion of the initiative is suggested, unless it includes follow-up or ongoing expenditure)
15. Calculate benefit cost ratio and net present value
16. Conduct sensitivity tests if required.

4.6.2 Estimation of benefits

M5 outlines a conventional theoretical framework for CBA of transport projects involving users changing between modes (of which TBhC projects are a subset) and assesses the benefits as the sum of the following:

- (A) Benefits of the project to existing users of the 'to' mode[9] (estimated as changes in private generalised cost for that mode, usually including cost, time and comfort aspects)
- (B) Perceived benefits to new users of the 'to' mode, including mode changers (generally valued at half the unit benefits to existing users of the 'to' mode)
- (C) Benefits from avoidance of unperceived costs[10] associated with the 'from' mode (the previous behaviour of mode changers), comprising:
  - (i) resource cost corrections for mode changers themselves, including monetary (such as car maintenance and other non-fuel variable vehicle operating costs and car parking costs) and non-monetary (such as accident trauma)
  - (ii) other resource cost impacts (externalities) on other transport system users or of the transport system (such as decongestion and reductions in private car-related environmental and accident externalities)
- (D) Unperceived costs associated with the new users of the 'to' mode, comprising:
  - (i) resource cost corrections for mode changers themselves, including monetary (such as public transport fare payments that are perceived as a cost but in fact are a transfer rather than a resource cost[11]) and non-monetary (such as health benefits of cycling and walking, which may be under-perceived)
  - (ii) other resource cost impacts (externalities) on other transport system users or of the transport system (such as environmental, accident and health externalities - to the extent that the costs of poorer health were being incurred by society rather than the behaviour changer).

4.7 Public transport route extension

The public transport worked example W1.1 Simple Bus Route Improvement has a project case comprising sections of bus lane supported by traffic signal priority. This worked example builds on well-known principles in M1 for appraisal of PT initiatives.

Table 12 Monetised benefits and cots – simple bus route improvement

	Monetised	Non-monetised
Benefits		
Existing users:		
- Travel time savings for bus passengers	✓	
- Improved reliability of bus services	✓	
Generated travel on the bus service	✓	

[9] The 'to' mode is generally the mode that is being improved by the transport project. In the examples given here the 'to' mode is public transport and/or cycling and walking while the 'from' mode is the private car. These would be reversed in the case of a highway improvement.

[10] Unperceived costs comprise all variances between perceived costs and resource costs and include privately incurred resource costs that are not perceived (e.g. most non-fuel private vehicle operating costs), private costs that are perceived but are not actually resource costs (e.g. fares, tolls and fuel taxes), and externalities to third parties (e.g. environment and accident-related externalities).

[11] Any increase in operating costs for the 'to' mode (in this case public transport) are accounted for in full in the costs side of the CBA, yet the fare payments (which are a transfer reflecting this same cost) are included in the perceived net benefit of new users of the 'to' mode (as a disbenefit). A resource cost correction equal to the fare is required to avoid double counting of costs.

	Monetised	Non-monetised
Disruption during construction (disbenefit)	✓	
Decongestion benefits	✓	
Increased car travel times at signal priority location		✓
Environmental benefits	✓	
Residual value	✓	
Costs		
Fixed infrastructure costs (capital, operating, maintenance)	✓	
Bus service provision costs (capital, operating, maintenance)	✓	

Source: ATAP W1.1

4.8 Active travel crossing

ATAP worked example 4.1 illustrates the appraisal of a signalised at-grade crossing or grade-separated crossing for walkers and cyclists which builds on the principles in W4. The methodology embraces techniques and issues common to a wide range of infrastructure-based transport initiatives.

Table 13 Monetised benefits and costs pedestrian/cycle signalised crossing overpass

	Monetised	Non-monetised
Benefits		
Travel time savings (disbenefit)	✓	
Crash cost savings	✓	
Residual value	✓	
Costs		
Construction costs	✓	
Maintenance costs	✓	

Source: ATAP W4

ATAP worked example 4.2 considers a missing cycleway link, and takes the assessment further by including the health benefits and road decongestion benefits.

4.9 Intelligent Transport Systems (ITS)

The ATAP Glossary (Part A2) defines ITS as the:

> **Integrated application of modern computer and communications technology to improve transport safety, use of infrastructure, transport systems and the environment.**

ITS initiatives use technology to improve the effectiveness and efficiency of existing infrastructure. Examples of ITS applications are set out in Table 14. In most of these examples the benefits of ITS initiative comprise:

- User travel time and vehicle operating costs resulting from improved link or network capacity
- Reduction in crash costs (see Table 15).

Table 14 Purpose and functionality of selected ITS technologies

Technology	Description
Signal coordination	Such as SCATS, improve network efficiency by coordinating signals in response to real world traffic conditions.
High occupancy vehicle prioritisation	Extends SCATS to provide priority to buses and other high occupancy vehicles.
Ramp metering	Facilitates higher speeds and throughput on freeways by using signals on entrances to control access. The signals operate with varying degrees of sophistication, from fixed timing to a coordinated response to congestion along the length of the freeway.
Variable speed limits	Improve safety and efficiency by varying speed limits in response to congestion levels on freeways.
Variable message boards	Improve efficiency by providing drivers with real-time congestion, weather and incident information.
Hard shoulder running	Reduces travel times and increases capacity by allowing vehicles access to shoulders when the freeway is congested. The decision to open the shoulder is based on loop data and camera information and communicated to road users through electronic signs.
Emergency vehicle prioritisation	Is a refinement of traffic management systems that enable emergency vehicles right of way through traffic lights.

Source: BITRE (2017)

Table 15 Summary of costs and benefits of selected ITS technologies

Technology	Costs	Benefits	BCRs
Signal coordination	Capital: $100 000-$130 000 per intersection On-going: $20 000-$30 000 pa	Reduced travel time 0 to 20 per cent across multiple studies	17 in California 62 in Texas 57 in Pennsylvania
HOV prioritisation	Capital: $13 000-$21 000 per intersection On-going: $3 000-$5 000 pa	21 per cent decrease in bus travel time in Sydney	na
Ramp metering	Capital: $130 000-$180 000 Ongoing: $26 000-$38 000 pa	Reduced travel time	13.8 in Australia 15 in Minnesota
Variable speed limits	Capital: $140 000-$240 000 per km Ongoing: $30 000-$50 000 pa	10 and 30 per cent reduction in crashes. Small increases in throughput	4.7 to 11.4 in New Zealand
Variable message boards	Capital: $250 000-$440 000 per km Ongoing: $50 000-$90 000 pa	Up to 2.8 per cent reduction in accidents and potential decrease in travel time	1.1 to 1.9 for VMBs providing weather information in Finland
Hard shoulder running	Capital: $180 000-$240 000 per km Ongoing: $40 000-$60 000 pa	57 per cent reduction in crashes on the M42 in UK	na

na - not available

Sources: Queensland Department of Transport and Main Roads (2016b); United States Department of Transportation (2017) cited in BITRE (2017)

4.9.1 Approaches to appraisal

Appraisal of most of the initiatives described in Table 15 would need to be supported by suitable traffic modelling to provide inputs of changes in vehicle hours and vehicle kilometres of travel. While large scale initiatives might not have large investment costs, they could influence large parts of networks. Where that was the case, suitable modelling outputs would be required for application of the rule-of-a-half for diverted and generated traffic. Appraisals would use the following broad methodology.

Table 16 Broad brush methodology for appraising ITS initiatives

Cost or benefit type	Data source	Comment
Investment cost	Initiative costing reports	Note that some electronic equipment and supporting software might have a relatively short life.
Maintenance costs	Initiative costing reports or by literature search	
Savings in travel time costs	Traffic model outputs. Value of travel time parameters in PV2	Improvements in link/network capacity will be reflected in increased speeds. Not relevant to emergency vehicle prioritisation.
Savings in vehicle operating costs	Traffic model outputs. Base case and project case VOCs estimated using VOC algorithms in PV2	Improvements in link/network capacity will be reflected in increased speeds. Not relevant to emergency vehicle prioritisation.
Crash benefits	Crash reduction factors from other initiatives in Australia and overseas applied to the crash record for the affected network	
Environmental benefits	Changes in vehicle km of travel and parameter values in PV2	Not relevant to emergency vehicle prioritisation.

Source: ATAP M5

4.9.2 Estimation of benefits and costs

Estimation of benefits follows the principles for urban transport initiatives contained in M1. In broad terms the steps are:

- Estimate changes in vehicle hours of travel using an appropriate traffic/transport model and use the unit travel time values in PV2 to estimate travel time benefits for each modelled year
- Estimate changes in network vehicle kilometres of travel and speed from the traffic/transport model and use an appropriate VOC algorithm to estimate changes in vehicle operating costs for each modelled year
- Use the literature or agency experience to identify appropriate crash reduction factors (if relevant) to be applied to the crash record for the link or network. Use the unit crash costs from PV2 to estimate crash benefits
- Estimate total benefits for each modelled year and use linear interpolation (see M2) to estimate benefits in each year of the project life
- Enter investment costs and changes in maintenance costs into the appraisal
- Calculate results (NPV, BCR1, BCR2, FYRR) as per T2 and conduct sensitivity tests.

If the initiative is expected to have significant network effects, user benefits including benefits of trip diversion and/or generation might need to be estimated within the traffic/transport model.

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