

# Active travel economic appraisal tool: Rapid cost-benefit analysis for active travel and micromobility

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## Abstract

Social cost-benefit analysis (CBA) is the primary tool for evaluating transport projects and interventions in Australia. However, the small scale of most active transport projects can be an impediment to the procurement of bespoke CBA and economic analysis because evaluation budgets tend to scale with project size. To help fill this gap we have developed a web-based Active Travel Economic Appraisal Tool. The tool allows for rapid, low-cost CBA by implementing analysis of a simple, stylised active transport project with methods and default parameter values from the Australian Transport Assessment and Planning guidelines on Active Transport.

## 1. Introduction

Social cost-benefit analysis (CBA) is a central tool in the evaluation of transport infrastructure and the primary means by which active travel interventions are evaluated in Australia.

- The Infrastructure Australia (IA) Assessment Framework requires CBA of the preferred option as part of all business cases (stage 3) and CBA is one of the techniques available for the required analysis of alternate options (stage 2 and 3).
- The Australian Transport Assessment and Planning (ATAP) guidelines similarly recommend CBA of the preferred option within the final business case, as well as rapid CBA of a filtered shortlist of options within the options assessment stage.
- CBA also features prominently in the options evaluation and final business case stages of project approval processes of state and territory transport and infrastructure bodies.

However, the small scale of many active transport projects can be an impediment to the procurement of bespoke CBA and economic analysis. Because evaluation budgets tend to scale with project size, the limited pool of resources available for development of cycle lanes, bikeways and other cycling and pedestrian projects are often focussed on other tasks. In some cases this can mean that economic analysis simply doesn't take place. In others, it is performed late in the project development cycle, limiting the role the analysis plays in problem definition, or options generation and selection.

One approach to overcoming this challenge is to reduce the cost, effort and expertise required to perform economic analysis for active transport projects. To this end, the Queensland Department of Transport and Main Roads engaged CDM Research in 2015 to develop an economic appraisal tool for active travel projects. That tool was made publicly available in 2019 and featured an easy-to-use, web-based interface and implemented the ATAP guidelines for a template active transport project. It was used for project evaluation and planning as well as post-implementation evaluation for many active transport projects in Queensland.

As practice and guidance has evolved in this area, we have developed a tool following on from this previous work by CDM. It is a web-based CBA tool for active transport projects which has modest data input requirements, conforms to IA and ATAP guidance on CBAs, does not require the engagement of a specialist CBA practitioner, and provides reasonable and defensible estimates of major cost and benefit streams.

The tool can assist users at all stages of the project life cycle, from early-stage project planning to assist in estimating the likely scale of benefits that might occur, to a CBA required to support the detailed business case, as well as post-implementation review.

The subsequent sections of this paper describe: the application of the ATAP guidelines for CBA for active travel; an overview of the tool, its user interface and its implementation in Python; the stylised project and users adopted for analysis by the tool; how the analyst inputs demand; CBA calculations and inputs; the tool's results presentation; our conclusions and next steps with for the tool and active transport evaluation.

## **2. ATAP guidance for active transport CBA**

The ATAP guidelines provide a comprehensive framework for planning, assessing, and developing transport systems and related initiatives. The guidelines are best practice for transport planning, including for performing CBAs, in Australia and are endorsed by all Australian jurisdictions through the Transport and Infrastructure Council (ATAP 2022a, p.1).

The guidelines recommend CBA at several different stages of project development. Depending on the project scale and governance, this can include at the options generation and assessment, business case development, prioritisation of initiatives, and post-completion evaluation stages. Relevantly to active transport projects, the guidelines include a step-by step guide to CBA (ATAP 2022b) mode-specific guidance for active travel (ATAP 2022b, hereafter: M4) and guidance for the modes active transport users may have switched from (ATAP 2021 *M1 Public Transport* and ATAP 2022c *M2 Road Transport*).

The ATAP guidelines for Active Travel have recently been updated. This tool is designed to implement these guidelines directly within the context of the stylised user and project description adopted (see section 4).

## **3. Tool overview and implementation**

The tool is implemented in Python 3. The user interface is implemented using the Streamlit package in Python. Streamlit is a Python package that generates web apps directly from simple python code. It was designed to simplify the creation of basic functional front-ends for data science applications and avoid the need for dedicated web development. Python was chosen for its popularity with data scientists and transport modellers as well as the relative readability of its code. Python and Streamlit together makes inspecting, altering and extending the tool relatively accessible for users with modest coding ability.

The tool can be hosted locally on a user's machine by simply running an executable, hosted within an intranet, or hosted on the internet through a web hosting service or the Streamlit community cloud. At present, the Queensland Department of Transport and Main Roads version of the tool is hosted in the Streamlit community cloud at <https://era-tpb-at-cba-tool-interface-t64vcd.streamlit.app/> from a public GitHub repo <https://github.com/ERA-TPB/AT-CBA-tool>.

The tool itself is accessed by analysts as a page within a web browser. The page includes inputs for numbers, text, drop-down boxes and tables, for each of the project details, assumptions or parameters required for the CBA calculations.

Each input takes a value by default. Where that input is for a characteristic of the project, its value was selected to represent a generic “blank” project. This allows the tool to fully function without any analyst input, demonstrating directly how the tool works and allowing it to be explored by a new user easily. Where that input is for a parameter value which a user may adopt for any given project, this figure is derived from the relevant part of the ATAP guidelines. The source for each default is given in the appendix. Throughout the rest of this article, where a figure is described as being input by the analyst, this includes by adopting these default figures.

Each input also contains a *help* button which opens a sidebar in the interface which gives a simple description of what the input describes and how it is used. It also refers the analyst to the appropriate part of the ATAP guidelines for additional information.

The tool first calculates the per-trip benefits for each category using the analyst's inputs. This allows the analyst to immediately see the impact of their input assumptions on the per-trip benefits. The tool then applies the analyst's inputs on demand to aggregate costs and benefits across the projects users and over the assessment period. See figure 1 below for an overview of the tool's calculations.

The next section of the tool calculates and displays headline CBA results along with a table and chart which can be customised by the user to break down the results by mode, year, cost and benefit stream and by diversion source (see results section below).

#### **4. Stylised project and user descriptions**

The key trade-off in the tool’s design is between ease of use and realism of analysis. The more choice given to analysts in how they describe the project and specify inputs, the closer the analysis will be to representing the project, but the more expertise the user will require and the more data they will need to collect. The goal of the tool is to be usable by policymakers without training in cost-benefit analysis or economics and produce results that are realistic enough to add value to the project planning, selection and assessment process, so adding detail comes at a considerable premium in ease of use.

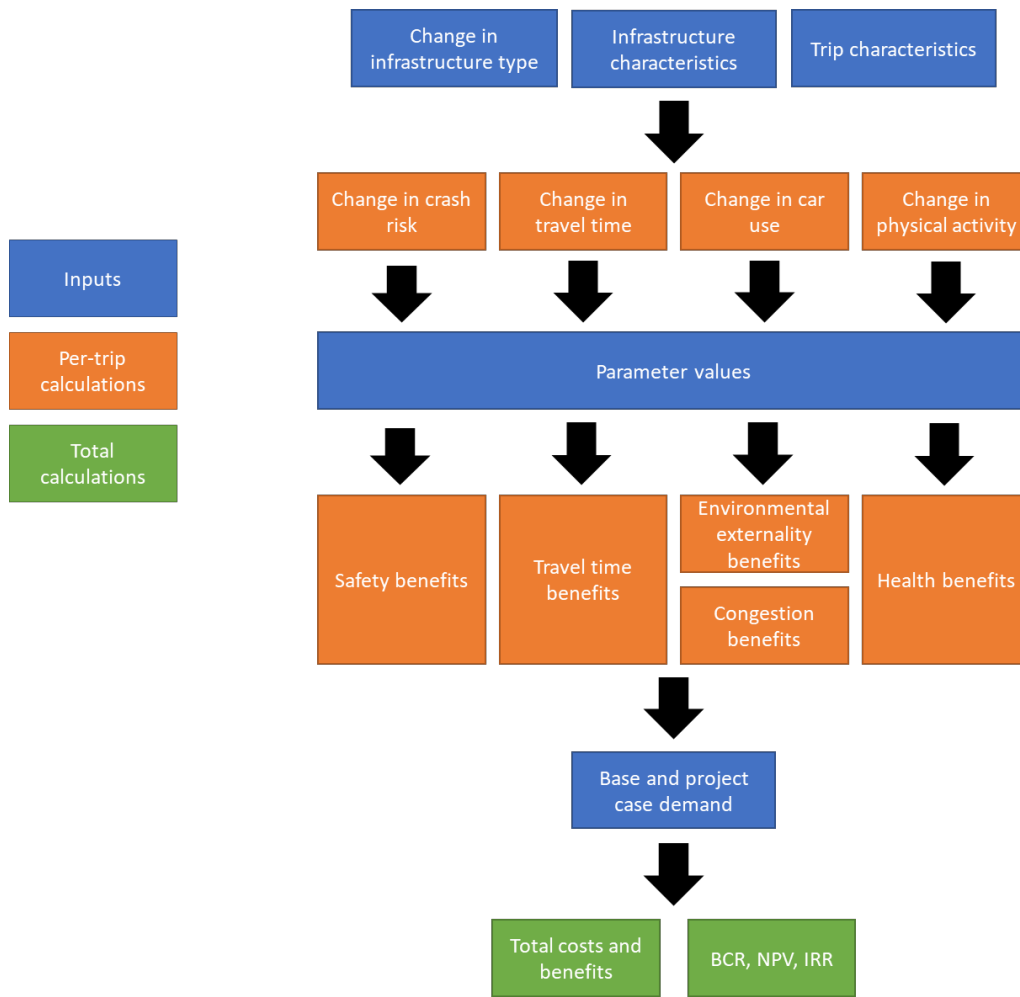
To conform to these constraints, the tool adopts:

- a stylised description of a generic active transport project
- a single representative user for each mode (pedestrian, bicycle, e-bike, e-mobility) with the average characteristics of expected users of the project (e.g. trip length, travel speed, value of travel time)

The generic project description adopted is an upgrade of an existing link within the transport network accessible via walking, cycling and micromobility. Given the comprehensiveness of the road network in urban areas in Australia and most of the developed world, many active transport projects are effectively upgrades to links already available to riders and pedestrians.

The effects of this upgrade flow through two broad channels: changes in the “infrastructure type”, and changes in the distance covered by users of the infrastructure. The tool broadly categorises infrastructure into four types based on the characteristics of the infrastructure and how different users interact (see table 1).

**Figure 1: Model overview**



**Table 1: Infrastructure types**

Infrastructure type	Bicycles	Micromobility	Pedestrians
On road (no provision)	Standard roads shared with motor vehicles	Traditional sidewalk	Traditional sidewalk
Bicycle lane	Bicycle lane on a road separated from motor vehicles	Bicycle lane on a road separated from motor vehicles	Traditional sidewalk
Shared path	Shared bicycle and pedestrian path	Shared bicycle and pedestrian path	Shared bicycle and pedestrian path
Separated path	Dedicated, separated path or veloway.	Dedicated, separated path or veloway.	Dedicated, separated path

The infrastructure types in the tool reflect the level of detail on speed and safety within the ATAP M4 guidance on safety (p.22) and travel speed (p.24). The tool’s help text describes how this guidance has been adopted and advises the analyst to ensure the infrastructure they are evaluating matches the safety and speed characteristics described there.

The tool adopts a representative user of the infrastructure for each mode (pedestrian, bicycle, e-bike, e-mobility) assuming uniformity in the trip characteristics among all users of the

infrastructure on that mode. This allows for a fairly simple set of demand assumptions, but somewhat limits the ability for the tool to analyse larger projects with significantly non-uniform demand (see below).

Reducing differences in infrastructure characteristics to four types of infrastructure and trip characteristics to four modes reduces the complexity of inputs. The following inputs are therefore uniform, only varying across the listed dimension:

- Inputs and parameters that vary by mode:
  - Trip distance
  - Per-km health benefits associated with reduced inactivity
  - Diversion rates for new users (from other routes, from other modes and newly generated trips)
  
- Inputs and parameters that vary by mode and by infrastructure type:
  - Crash risk and costs
  - Average travel speed
  - Crash costs

This means that benefits flow directly from analyst's inputs about how the infrastructure has changed between types and the input assumptions about the characteristics of those types. For example, for a project to build a dedicated cycle way where the existing route is on a standard road, the per trip safety benefits will be calculated as the difference between the crash risk on the *On road (no provision)* infrastructure type and the *Separated path* type for the representative trip (for each mode).

In addition to costs and benefits that flow from changes to the basic infrastructure types or the distance covered, the tool also allows the inputting of discrete intersection treatments. These allow for the manual inputting of additional per-user safety and travel time changes associated with changes to intersections.

This simple version of project and user specification will fit some real-world projects better than others. The assumption of a single representative user is the most obvious limitation in the tool's approach to representing of reality. Where a project upgrades a discrete link of modest length in the active transport network where all users will use the entire length of the link, the representative user is likely to be a decent fit. This is especially true for paths (and bridges) which intersect the rest of the network only at the ends of the link. Where a project upgrades a longer link with many entry and exit points, the representative user will be a worse fit. This is especially true for longer, more integrated parts of the active transport network; the tool is unlikely to be fit for purpose for long sections of well-connected veloway which have many different users using different parts of the infrastructure.<sup>1</sup>

## 5. Demand

To calculate the total benefits from a project, a transport CBA requires an assumption for the level of traffic on the infrastructure in the base case (in the absence of the project), the level of traffic in the project case and, where there is an increase, the source of those additional trips

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<sup>1</sup> An enterprising analyst could use the tool to estimate the NPV of benefits for such a project by splitting demand into multiple representative user types, treating them as separate projects then adding them up themselves. Future development of the tool will include investigation of a simple way to provide this functionality.

(i.e. were they active trips made by a different route, trips made on a different mode or new trips induced by the project?).

The tool takes base case demand as an input. The analyst must specify the number of users on each mode in the project’s opening year.<sup>2</sup> For subsequent years they can either input annual rates of growth over the assessment period or manually input users for each year for each mode.

The tool provides options for inputting project case demand. The analyst may:

- Elect for the tool to calculate the number of users in the project case based on an assumed generalised cost elasticity of demand (this calculation is based on the changes in perceived costs described in the cost-benefit analysis calculation section below)
- Input an uplift percentage (a simple proportional difference between the number of users in the base and project cases)
- Manually input the number of users in the project case for each year and mode.

The analyst must also specify diversion rates for each mode (though, as mentioned above there is a default value taken from ATAP M4). These rates are used to apportion new trips to their diversion source: whether the trip was completed by active travel but on a different route (reassigned), by car, by public transport or whether the trip was not taken at all in the base case.

The increase in project case demand is also subject to a ramp-up period which may be set by the analyst in the tool (ATAP recommends a linear 3-year ramp up period) (ATAP M4, p. 52.) Additional traffic will be reduced from the figures derived from the previous assumptions during the ramp up period proportionally to the number of years through that period. For example, for a 3-year ramp up, additional traffic will be reduced by  $\frac{2}{3}$  in the first year and  $\frac{1}{3}$  in the second year, taking 3 years to reach the otherwise assumed value.

Finally, the analyst chooses an appropriate expansion factor for the demand they have specified. This defaults to 52 reflecting the simple use of whole-of-week counts but can be altered to reflect the way demand has been input.

These demand inputs are combined to create a total annual traffic figure in the base case and project case for each year. This traffic figure is broken down by mode (pedestrian, bicycle, e-bike and e-scooter) and for the project case, how the trip was taken in the base case (whether it was an existing trip on the infrastructure being upgraded, a trip on the same mode but diverted onto the project, a public transport trip, a car trip or a new trip induced by the infrastructure). See Table 2 below.

**Table 2: Example annual demand**

Mode in project case	Trip source				
	Existing trip on this mode		Diverted trip from other mode		New trip
	Existing trip	Reassigned	From car	From transit	
Pedestrian	600	12	24	78	6
Bicycle	2000	40	80	260	20
e-Bicycle	500	10	20	65	5
e-scooter	200	4	8	26	2

<sup>2</sup> In practice, this will usually be based on the number of trips measured on the existing infrastructure with an allowance for expected growth between when the observation was made and the proposed opening year.

## 6. Cost benefit analysis calculations

The tool implements the recently updated *M4 Active Travel* guidance (specifically sections 5 and 6 which cover cost-benefit analysis methodology and benefits estimation) which outlines the methodology for undertaking an economic appraisal of an active travel initiative. This guidance is available on the ATAP website <https://www.atap.gov.au/mode-specific-guidance/active-travel/index>.

The tool follows the ATAP CBA methodology within the context of active travel interventions – it is a comparison of the base case and project case over an appraisal period. Costs and benefits are calculated from the incremental change(s) between the base and project case.

### 6.1 Travel time

Travel time calculations are a direct implementation of *M4 Active Travel*, section 6.8.1. ‘Step 1: Estimate the time saving per trip between the Base Case and the Project Case’ (ATAP 2023, p. 23).

Time saving per trip is a function of speed and distance. Within the tool the analyst inputs

- average travel speed for each combination of mode and infrastructure type
- the distance of each infrastructure type in the base and project case
- additional per trip travel time saving from intersection treatments.

For transport-purpose trips on mode  $m$  the change in travel time per trip is equal to

$$\Delta \text{Travel time}_m = \left( \sum_i^N \frac{\text{Distance}_{i,m,PC}}{\text{Speed}_{i,m,PC}} - \sum_i^N \frac{\text{Distance}_{i,m,BC}}{\text{Speed}_{i,m,BC}} \right) + \text{per trip time savings from intersection treatments}_m$$

where

- $i$  is the infrastructure type
- $PC$  is the project case
- $BC$  is the base case

This allows changes in per-trip travel time costs to arise in the tool’s analysis from three different sources:

- A change in travel distance over the link (e.g. where a cycle path cuts across a city block)
- A change in travel speeds resulting from a change in infrastructure type (e.g. where an off-road cycle path increases travel speed by reducing traffic interaction)
- A change in time spent at intersections input manually as an intersection treatment.

ATAP M4 Section 6.8.1 Continues:

Step 2: Calculate per trip cost reduction by multiplying per trip time saving (step 1) by unit value of travel time savings.

Step 3: [apply expansion factors]

Step 4: ... the benefit per trip for new trips is a half the benefit per trip of existing trips. (ATAP M4, p. 23)

*ATAP M4* provides three values of travel time: employer’s business, other transport purposes and non-transport purposes (which is zero) (*ATAP M4*, p. 24). The practitioner is required to enter each of these. Each purpose is also allocated a proportion of total demand by the analyst to which the applicable value of time is applied.<sup>3</sup>

For trips on mode  $m$  with purpose  $p$  the travel time cost saving for a trip is

$$\text{Travel time benefit}_{m,p} = -\Delta \text{Travel time}_m \times \text{value of travel time}_p$$

## 6.2 Safety

There are two separate safety calculations within the tool. The first is a direct implementation of *ATAP M4*, section 6.7.1

Step 1: Calculate Base Case crash cost per trip by multiplying unit crash cost per km (Table 2) by estimated Base Case distance travelled on the facility. (*ATAP M4*, p. 20)

*ATAP M4* (p. 21) provides a per-km crash cost for cyclists and pedestrians and recommends the use of the cyclist figure for e-bikes and e-scooters.<sup>4</sup>

Section 6.7.1 continues:

Step 2: Select a suitable crash cost reduction factor that will apply for the improvement option from Table 3.

Step 3: Calculate per trip cost reduction by combining steps 1 and 2. This represents the unit crash cost reduction benefit (\$ per trip) for existing active travel trips. (*ATAP M4* p. 20)

Within the tool, the analyst is required to provide:

- the base per-km unit crash cost for each active mode
- a risk reduction rate for each infrastructure type for each mode relative to *on-road (no provision)* infrastructure
- the distance of each infrastructure type in the base and project case

So, the safety benefit for an existing trip on mode  $m$  is

$$\text{Safety benefit}_m = \sum_i^N \text{Distance}_{i,m,BC} \times \text{Crash cost}_m \times \text{Risk}_{m,i} - \sum_i^N \text{Distance}_{i,m,PC} \times \text{Crash cost}_m \times \text{Risk}_{m,i}$$

where:

$i$  is the infrastructure type

$PC$  is the project case

$BC$  is the base case

The second calculation of safety costs is from the separate infrastructure treatments inputs. This calculation closely follows the safety calculations in *Worked Examples: W4 Active Travel*, Part 8 (*ATAP 2018*, p. 12). The example focusses on a discrete intersection project where the safety

<sup>3</sup> In most cases, employer’s business trips on active travel are likely to be rare and limited to couriers and delivery drivers who operate on bicycles and other micromobility modes. The tool adopts a 0% default for the proportion of such trips.

<sup>4</sup> The guidance notes that this is merely in the absence of more systematic evidence for these newer modes. The tool advises analysts to consider incorporating newer evidence if it is available.



benefit is based on reducing fatalities and serious injuries from an observed rate. The formula applied to fatal and serious injury crash types there is:

$$Safety\ benefit = \left( \sum_{Type}^N Annual\ crashes_{Type} \times Crash\ cost_{Type} \right) \times Crash\ reduction$$

This approach is followed directly in the tool. The analyst is required to provide:

- Expected 10-year fatalities at the site to be treated in the base case
- Expected 10-year serious injuries at the site to be treated in the base case
- Average willingness to pay value of avoiding a fatality
- Average willingness to pay value of avoiding a serious injury
- The percentage reduction in crashes resulting from the treatment

The formula above is used to calculate the total base safety benefit. This benefit is divided by the total number of trips in the base case in the opening year to get a per trip benefit.

### 6.3 Health system benefits

The calculation of health system benefits in the tool is a simple application of *M4 Active Travel*, section 6.10.3:

Step 1: Estimate average trip length of switching active travel trips. For trips that switch, also estimate average distance walked (e.g. walking to and from the bus stop for a public transport trip, or walking from the car park to the trip destination for a car trip).

Step 2: Convert distance estimates in step 1 to \$ values by multiplying by relevant unit health system benefit in Table 6. (ATAP M4, p. 30)

Section 6.10.1 also states, ‘For existing active travel trips, it is expected that most active travel improvements would not change the trip length, with no change in health benefits.’ (ATAP M4, p. 27). This is adopted as an alterable default by the tool.

Within the tool, the analyst is required to input an average trip length for each mode (pedestrian, bicycle, e-bike, e-mobility).<sup>5</sup> The analyst also provides a per-km health system benefit for each mode.

For new trips (that is, those taken by car or public transit in the base case, or those not taken at all in the base case) per trip benefits for a trip on mode *m* are calculated as:

$$Health\ system\ benefits = Trip\ Distance_m \times Health\ system\ benefit\ per\ km_m$$

For trips where travel was on an active mode in the base case (existing trips and reassigned trips) the benefit is zero.

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<sup>5</sup> The total trip length is adopted by ATAP M4 as the measure of additional exercise from new trips.

## 6.4 Private health benefits

*M4 Active Travel*, section 6.10.1 states:

The base assumption in M4 is that private health costs are perceived, and so are accounted for in the rule-of-a-half calculation of benefits for new trips. (ATAP M4 p. 27)

In practical terms, the assumption that private health benefits are perceived implies that they do not require explicit calculation. For existing users, there is no change in their level of exercise; they cycled/walked in both the base case and the project case. For new users, (mode switchers or genuinely new trips) changes in perceived costs are inferred from those experienced by existing users using the rule of a half. Because there are no health benefits for existing users, they do not require explicit calculation for new users either.<sup>6</sup>

*M4 Active Travel*, section 6.10.1 continues:

We recognise, however, that there continues to be uncertainty about degrees of perception. As a result, we recommend that users undertake a sensitivity test with private health benefits being unperceived, requiring a resource cost correction. (ATAP M4 p. 27)

As recommended above, the calculation of private health benefits as an unperceived benefit are included in the tool as a sensitivity. Section 6.10.2 provides the steps to do this:

Step 3: Estimate average trip length of switching active travel trips. For trips that switch, also estimate average distance walked (e.g. walking to and from the bus stop for a public transport trip, or walking from the car park to the trip destination for a car trip).

Step 4: Convert distance estimates in step 3 to \$ values by multiplying by relevant unit private health benefit in Table 6. (ATAP M4 p. 29)

Similarly to health system benefits, the analyst is required to input an average trip length a per-km private health benefit for each mode. Also similarly, the average trip length is adopted as the increase in walking or cycling distance.

For new trips (that is, those taken by car or public transit in the base case, or those not taken at all in the base case) per trip benefits for a trip on mode  $m$  are calculated as:

$$\text{Private health benefits}_m = \text{Trip Distance}_m \times \text{Avoided costs per km}_m$$

## 6.5 Decongestion benefits

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<sup>6</sup> This is consistent with the calculation of travel time and safety benefits above. For example, for a trip switching from car to bicycle, travel time benefits are not calculated by comparing the travel time in a car in the base case to the travel time on a bike in the project case. The travel time benefits for existing users are simply multiplied by a half. Technically, perceived benefits for new trips are not calculated in categories at all; The rule of a half infers the total change in perceived costs for new users from the total change in perceived costs for existing users. While it is convenient to describe the calculation of perceived benefits as being ‘half of existing users’ (as ATAP M4 does), this is the method for calculating the total change in willingness to pay for these users, not the change in travel time, safety or health for them. A new user may experience decreases or increases in each perceived cost (as well as other, unobserved categories) and it is the sum of these changes the rule of a half is capturing. This is also why the tool’s results section reports total benefits to new users separate from the benefit categories reported for existing users. See *ATAP (2018) W4.2 Worked Example: W4 Active Travel 4.2 Missing cycleway segment* for a numerical explanation of application of the rule-of-a-half to an active transport project.

*M4 Active Travel*, section 6.12 adopts the approach of *M1 Public Transport*, section 4.8 which provides for a simple per-km benefit for reductions in car trips caused by a project (in M1 this is caused by public transport projects) (ATAP M4 36, p. 37; ATAP 2021, p. 37).

Within the tool the analyst is required to input an average trip length for each mode (pedestrian, bicycle, e-bike, e-mobility). For simplicity this is adopted as the length of the car trip that is avoided. The analyst also provides a single, all-day per-km value of decongestion. While the default adopted from *M1 Public Transport* is a generic value, the tool advises analysts it may be appropriate to adopt a higher value for infrastructure which replaces car trips in significantly congested corridors.

Thus, for a trip on mode  $m$  which replaces a car trip in the base case, the benefit is calculated as:

$$\text{Decongestion benefit}_m = \text{Trip Distance}_m \times \text{Decongestion benefit per km}$$

## 6.6 Environmental benefits

*M4 Active Travel*, section 6.13 adopts the approach of *T2 Cost Benefit Analysis*, chapter 8 which provides per-km benefits for reductions in air pollution, greenhouse gas emissions and noise caused by a reduction in car trips (ATAP M4, p. 37; ATAP 2022b, p. 47).

Within the tool the analyst is required to input an average trip length for each mode (pedestrian, bicycle, e-bike, e-mobility). Similarly to decongestion benefits this is adopted as the length of the car trip that is avoided. The analyst also provides a single per-km value of environmental benefits.

Thus, for a trip on mode  $m$  which replace a car trip in the base case, the benefit is calculated as:

$$\text{Environmental benefit}_m = \text{Trip Distance}_m \times \text{Environmental benefit per km}$$

## 6.7 Applying trip numbers and the rule of a half

In the next calculation step, the tool multiplies per-trip benefit flows to the relevant project-case trip numbers from the demand section. At this stage, the rule of a half is also applied where relevant. *M4 Active Travel*, section 6.2 explains:

The following assumptions about user cost perception are adopted here in M4:

- Perceived user costs consist of: time, safety, private health costs, some money vehicle operating costs (fuel, parking costs) and modal preferences — across all modes.
- Unperceived user costs consist of: all other private costs: some money vehicle operating costs (vehicle servicing and maintenance, vehicle depreciation). Bike maintenance and repair costs may expected to be unperceived (consistent with vehicle costs) and are expected to be small.

So in terms of active travel user cost, all private cost components are assumed to be perceived, including private health costs. By definition, external costs are also unperceived. This includes road congestion, environmental impacts and health system costs. Reductions in external costs are benefits. (ATAP M4, p. 13)

As *T2 Cost Benefit Analysis* section 6 explains and is applied in the formulas part of *M4 Active Travel*, section 6.3, the total perceived user benefit for new and diverted traffic is calculated as half the total perceived user benefit for existing traffic, while unperceived and external costs

are calculated simply as the change in those costs from the base case (ATAP 2022b, p. 32; ATAP 2023, p. 14).

Within the tool, the ATAP definitions of which benefit stream applies to what sort of traffic and the above section on the rule of a half are applied through the following table.

**Table 3: Aggregation table**

Benefit	Diversion source				
	Existing	Reassigned	Car	Public Transit	Induced
Travel time <sup>^</sup>	1	½	½	½	½
Safety	1	½	½	½	½
Health System	0	0	1	1	1
Private Health	0	0	0 (1*)	0 (1*)	0 (1*)
Decongestion	0	0	1	0	0
Environmental	0	0	1	0	0

\*Private health benefits are included as a sensitivity (see health benefits section above and results below)

<sup>^</sup> Travel time benefits are only applied to transport purpose trips (see travel time section above)

This table is applied as follows. For the total of benefit flow  $b$  on mode  $m$  from diversion source  $d$  in year  $t$  are equal to

$$Benefit_{b,m,d,t} = Traffic_{m,d,t,PC} \times Trip\ Benefit_{b,m} \times Table_{b,d}$$

where:

$Traffic$  is the traffic from the demand calculations

$Trip\ Benefit$  is the calculated per trip benefit (for each benefit type and mode)

$Table$  is the figure (1, ½, 0) from the table above

$PC$  is the project case (for demand)

This results in an undiscounted benefit for each combination of benefit type, mode, diversion source and year.

## 6.8 Capital and operating costs

Real capital costs are input by the analyst for each year in the assessment period. This can be input as a simple total to be shared across an input number of years or can be provided in a table for each year.

Real operating costs are also input by the analyst for each year in the assessment period. This can be input simply as a figure for the starting year with an annual cost escalation factor or can be provided in a table for each year.

The help text for this section also contains a reference to *M4 Active Travel*, Table 15 which contains indicative unit costs for different infrastructure interventions which are useful in the absence of project specific data (ATAP M4, p. 55).

## 6.9 Discounting and aggregation

*T2 Cost Benefit Analysis*, Step 10 provides that costs and benefits are discounted to their net present value (NPV) in the calculations of both the project NPV and BCR (ATAP 2022b, p. 53). While formulas in the guidance sum benefits and costs in a given year then discount this aggregate, this is equivalent to discounting each cost and benefit item first then aggregating them and taking relevant ratios (for BCR calculations). For example, the ATAP formulation

$$NPV = \sum_{t=0}^n \frac{B_t - OC_t - IC_t}{(1+r)^t}$$

implies

$$NPV = \sum_{t=0}^n \frac{B_t}{(1+r)^t} - \frac{OC_t}{(1+r)^t} - \frac{IC_{t,t}}{(1+r)^t}$$

In the tool, the analyst specifies a discount rate, base year and assessment period. The tool takes the undiscounted benefits and costs and calculates their present value. For the total discounted benefit flow  $b$  on mode  $m$  from diversion source  $d$  in year  $t$ :

$$PV(Benefit)_{b,m,d,t} = \frac{Benefit_{b,m,d,t}}{(1+r)^{t-base\ year}}$$

with a similar formula for both investment and operating costs:

$$PV(Cost)_t = \frac{Cost_t}{(1+r)^{t-base\ year}}$$

where:

$r$  is the discount rate

$base\ year$  is the base year for discounting

With disaggregated benefits and costs in present value terms, the tool calculates headline CBA outputs as follows (consistent with *T2 Cost Benefit Analysis* (ATAP M4, p. 54):

$$NPV = \sum_{b,m,d,t}^n PV(Benefit)_{b,m,d,t} - \sum_t^n PV(IC)_t - \sum_t^n PV(OC)_t$$

$$BCR1 = \frac{\sum_{b,m,d,t}^n PV(Benefit)_{b,m,d,t}}{\sum_t^n PV(IC)_t + \sum_t^n PV(OC)_t}$$

$$BCR2 = \frac{\sum_{b,m,d,t}^n PV(Benefit)_{b,m,d,t} - \sum_t^n PV(OC)_t}{\sum_t^n PV(IC)_t}$$

The tool also uses the *irr* (internal rate of return) feature in the python package *numpy* to calculate the internal rate of return using the un-discounted benefit and cost flows by year.

## 7. Results presentation and sensitivity tests

The tool presents the headline CBA results in a separate section. A summary results display shows net present value, benefit cost ratios (BCR1 and BCR2), internal rate of return, and list of the present value of cost and benefit streams summing to the net present value. The tool also presents the user with a customisable table or bar chart with benefit flows that can be grouped and aggregated by mode, diversion source year and benefit flow.

These tables and charts can be downloaded in a range of common formats which can be imported into common word processing, spreadsheet, presentation, and data processing software.

The tool also implements and presents headlines results for several standard sensitivity tests. Each sensitivity test performs the CBA calculations listed above with a change to one of the inputs, the magnitude of which is input by the analyst. The inputs that are altered in a sensitivity test are those included from *Worked Examples: W4 Active Travel*: Discount rate, investment cost operating cost total discounted benefits trip length, car diversion rate, newly generated trips, transport-purpose trips, and private health benefits as unperceived. (ATAP 2018, p. 11).

In each case, the tool checks to ensure the input sensitivity test does not result in nonsensical inputs (e.g. a base transport trip purpose of 80% and a sensitivity test of +30 percentage points is limited to 100% and warns the analyst). The tool also allows a download of a PDF report listing the values of every input used by the tool, the standard results listed above and a range of tables and charts from the full set of combinations possible.

## 8. Conclusion and next steps

The Active Travel Economic Appraisal Tool is intended as an easy-to-use CBA tool for active transport projects which conforms to the ATAP guidance on CBAs. It allows for rapid CBA of a range of projects by reducing the complexity of inputs through adopting a simple, stylised project representation with a small set of representative users and implementing CBA calculations based on the methodology and default parameters from the ATAP guidance.

The tool is designed to be especially useful in situations where economic analysis would otherwise not be performed due to time, cost and expertise barriers. It is hoped that it will improve project design, selection and analysis in such cases by helping project teams explore the sources of costs and benefits of solving particular transport problems and the scale of benefits and costs for the options considered in solving them. While the tool it is not intended to replace bespoke, expert analysis where this is already performed, it is hoped it will broaden the application of CBA to the analysis of active transport problems and projects.

We will continue to update the tool to reflect changes in best practice. The tool's ability to quickly test how sensitive each cost and benefit stream is to changes in parameter values and input assumptions for different project types may also assist in identifying areas where research might materially impact on CBA cost and benefit streams. ATAP (2023, p. 61) provides a comprehensive list of research needs.

We are also intending to undertake research within two main areas to assist in improving the tool over time – demand estimation and benefits valuation.

With respect to demand estimation, improvements suggested in *M4 Active Travel* include the development of more consistent methods for monitoring and collecting data from the change in travel that occurs following the implementation of an active travel project, ensuring that data collection is adequate to enable estimation of disaggregated demand elasticities for generalised cost and its components, estimation of disaggregated demand elasticities for active travel, further estimation of diversion rates, improved and standardised methods for estimating network and link level active travel volumes, active monitoring of the uptake of new micromobility modes and network effects.

With respect to benefits estimation, many of the tools default parameter values would likely benefit from additional research. The most obvious area is around micromobility where the literature is still emerging. Key questions include the level of health benefits associated with e-

bikes, as well as crash rates and the degree to which they might change with different infrastructure treatments and interventions.

More broadly, the literature on health benefits continues to improve and may require translation into the parameters within *M4 Active Travel*. There may also be additional benefit streams that could be monetised around social equity, accessibility and amenity.

## References

Australian Transport Assessment and Planning Guidelines 2018, *Worked Examples: W4 Active Travel*, Transport and Infrastructure Council: Australia.

Australian Transport Assessment and Planning Guidelines 2021, *M1 Public Transport*, Transport and Infrastructure Council: Australia.

Australian Transport Assessment and Planning Guidelines 2022a, *A1 Overview*, Transport and Infrastructure Council: Australia.

Australian Transport Assessment and Planning Guidelines 2022b, *T2 Cost Benefit Analysis*, Transport and Infrastructure Council: Australia.

Australian Transport Assessment and Planning Guidelines 2023, *M4 Active Travel*, Transport and Infrastructure Council: Australia.

## Appendix: source of default parameter values

Parameter	Source of default value
Discount rate	ATAP T2 Cost Benefit Analysis: 10.1
Costs of fatality and serious injury*	ATAP 4.2.2 PV2 Road transport Table 14
Diversion rates	ATAP M4 Active Travel 7.5 table 11
Demand ramp-up period	ATAP M4 Active Travel 7.8.1
Average trip length	ATAP M4 Active Travel Background 2.5 Table 2
Transport share of trips	ATAP M4 Active Travel Background 2.4
Relative risk of infrastructure types	ATAP M4 Active Travel 6.7.3 Table 3: Risk reduction for partial separation for Bicycle lane and high separation is for shared and separated path (see section 4 above)
Average travel speed by mode and infrastructure type	ATAP M4 Active Travel 6.8.2 Table 4 (also commentary on e-bike speeds in that section). E-scooter speeds reflect Queensland regulation.
Value of travel time	ATAP M4 Active Travel 6.8.2 Table 5
Private and health system costs of inactivity	ATAP M4 Active Travel 6.10.4 Table 6
Cost of congestion	ATAP M4 Active Travel 6.4 Table 1
Crash costs	ATAP M4 Active Travel 6.7.3 Table 2
Car decongestion and environmental benefit	ATAP M4 Active Travel 6.4 Table 1

\* Figure was indexed into 2021\$ to match ATAP M4 using Average Weekly Ordinary Time Earnings from ABS Average Weekly Earning