INFRASTRUCTURE AND TRANSPORT MINISTERS

M4 Active travel
DRAFT FOR PUBLIC CONSULTATION

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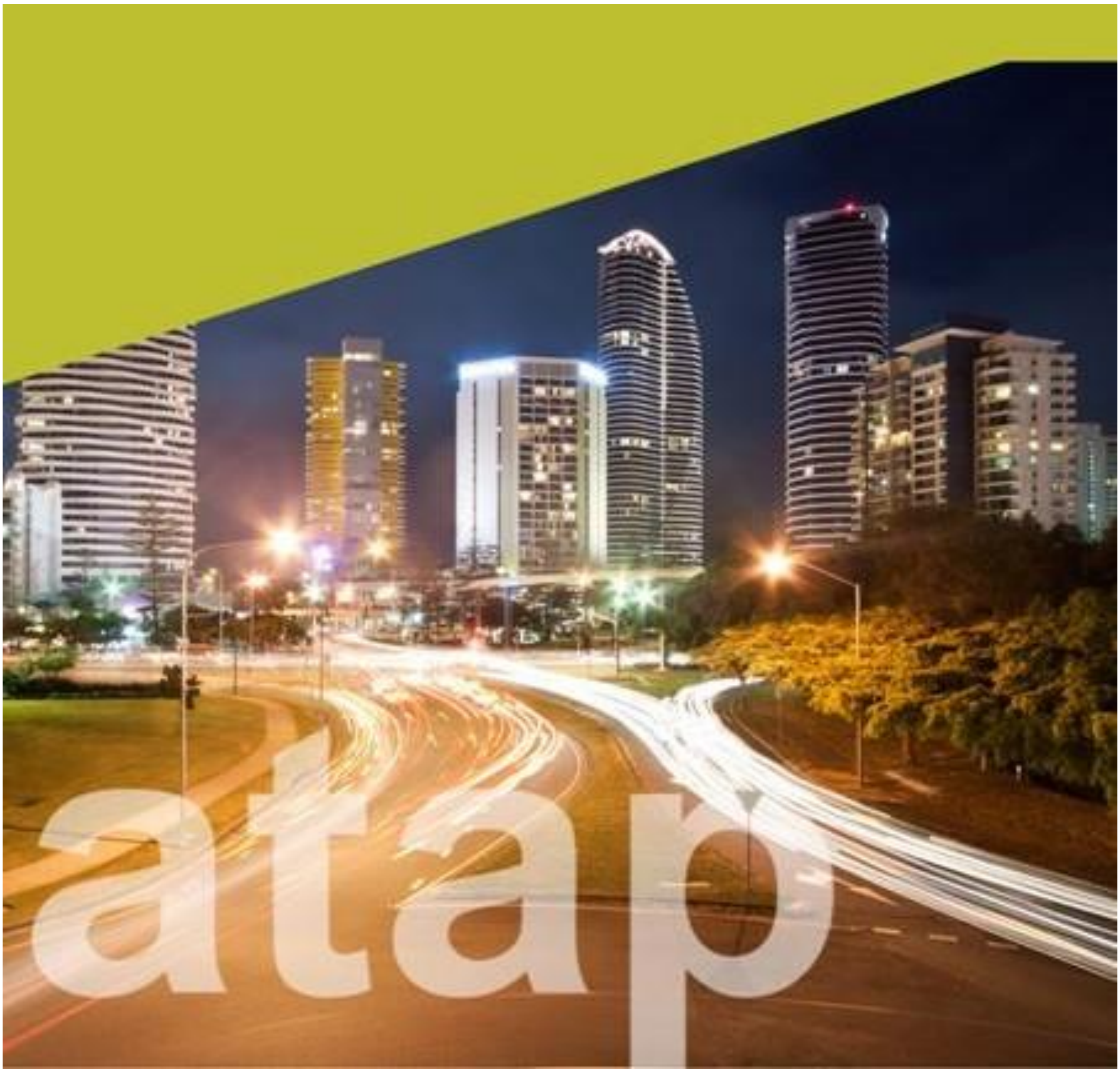

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1. Introduction

This document (ATAP Part M4) provides specialist Mode Specific Guidance on active travel. It complements other parts of the ATAP Guidelines, applying the generic ATAP principles, framework and methodologies to active travel. The material will assist practitioners in the planning of active travel and assessment of active travel initiatives. M4 is complemented by a supporting Background Report in the ATAP Technical Support Library. In cross-referencing between the reports, the Background Report is referred to as M4-BR.

1.1 Active travel

The defining characteristic of active travel is that it is 'human powered mobility'. In this guidance, we interpret active travel as comprising primarily walking and cycling[1], but can also include use of e-bikes, skateboards, roller skates, roller blades and non-electric scooters.

E-scooters and e-skateboards are not 'human-powered', so do not fit with the above definition of active travel. However, they are also considered here because they share some of the facilities provided for active travel, and hence experience associated benefits.

The term micro-mobility is increasingly used to refer to all of these modes of transport.

The key features of active travel compared to other travel modes (car, public transport) are:

- Greater physical muscular effort is involved, with associated health benefits
- It can be used by age groups too young or old to drive
- The 'vehicles' involved are relatively small, light and slower, and thus have a set of design constraints and advantages. They are also relatively inexpensive and space-efficient
- It is generally more common for short and medium distance trips than for longer trips, such as those beyond 7km
- It has no direct emissions
- People undertaking active travel are more vulnerable in crashes and hence greater road trauma
- Shifts to active travel from other modes, particularly car use, reduces road congestion and emissions.

Active travel trips may be:

- Self-contained — such as a trip from home to the shops and back, or
- Form part of a multi-modal trip, e.g. walking from home to the bus stop, or from the bus stop to the office.

All trip purposes are relevant in this guidance, except competition (i.e. racing or endurance). A key distinction is made between transport and non-transport trip purposes:

- Non-transport trips: Recreational and exercise
- Transport: All other trip purposes — journey to work or education, trips for shopping and other personal business, and business trips on employer's business.

[1] Cycle, bike and bicycle are used interchangeably throughout this document.

The active travel network encompasses a range of components:

- Roads that legally allow active travel — much active travel takes place in a road corridor
- On-road paths and facilities enabling active travel along and across roads, or adjacent off-road paths and facilities within the road reserve
- Off-road routes and facilities over other public land such as parks, rivers and coastal paths, at transport interchanges and car parks
- Private land including access points to buildings and parking areas and routes through private developments.

From a planning perspective, an active travel network should ideally incorporate good quality infrastructure that is well maintained, safe, accessible, connected, illuminated, signed and integrated. Where possible, the infrastructure should provide direct routes to trip destinations and public transport facilities, and where appropriate have end of trip facilities such as bike parking, showers, change rooms and lockers.

The suitability of a given road for active travel is influenced by the road's designation in the road hierarchy. Some elements of active travel infrastructure are complementary to the road network (such as footpaths along the edge of the carriageway) while other elements (such as cycle lanes) compete for road space. The design and construction of new roads and road upgrades should consider all road users at the earliest possible point in the planning process.

1.2 Links to other parts of the Guidelines

This guidance is one of several areas of Mode Specific Guidance provided in the ATAP Guidelines. As with all ATAP mode specific guidance, M4 is built on, and applies, the generic principles and methodologies underpinning the Guidelines. The most closely related Parts of the Guidelines are:

- F0.2 Integrated transport and land use planning
- F2 Problem identification and assessment
- F3 Options generation and assessment
- T2 Cost–benefit analysis (CBA)
- PV2 Road parameter values
- PV5 Environmental parameter values
- Worked examples: 2 active travel examples W4.1 and W4.2

While M4 can be used on a standalone basis, familiarity with these complementary parts is advised.

1.3 Structure of this guidance

- Chapter 2 provides a brief summary of the ATAP assessment approach, and the nature of active travel impacts, as context for the remaining chapters
- Chapter 3 describes the identification and assessment of active travel problems and opportunities
- Chapter 4 discusses options generation
- Chapter 5 provides a brief summary of the ATAP CBA methodology (a key part of the ATAP appraisal process) and its interpretation for the appraisal of active travel initiatives

- Chapter 6 covers the estimation of benefits for active travel initiatives, including a summary of parameter values and detailed guidance on calculating benefits
- Chapter 7 discusses active travel demand estimation
- Chapter 8 briefly discusses infrastructure costs
- Chapter 9 discusses performance measurement and monitoring
- Chapter 10 discusses parameter value indexation
- Chapter 11 discusses outstanding research needs.

The chapters are complemented by the following appendices:

- A: Glossary
- B: An overview of active travel intervention options
- C: An indicative rapid appraisal of active travel options
- D: A summary of the CBA results formulas

2. The ATAP assessment approach

This chapter provides a brief overview of the ATAP assessment approach as context for the guidance in the rest of M4. It provides the basis for assessing active travel problems, opportunities and options.

Planning is a precursor to the identification and assessment of improvement options. Options should ideally be generated from integrated land use and transport planning processes at the strategic (ATAP Part F0.2) and local (Austroads 2020a) levels that include consideration of active travel alongside all other transport modes.

The ATAP assessment model is presented in Section 3.3 of ATAP Part F3. It consists of:

- Clarification of relevant jurisdictional goals, transport system objectives and targets (see ATAP Part F1). It is important to be clear early in an assessment about which of these are relevant in the given assessment
- Clarification of policy choices that have already been made (as part of the context for the assessment (see ATAP Part F0.1)
- Consideration of the degree of strategic merit / alignment of the problem, opportunity or option being assessed with goals, transport system objectives, targets, policies and strategies
- Generation of a wide range of options for addressing the problem or opportunity being assessed. Note that Infrastructure Australia (2021) recommends that at least two Project Cases in addition to the base case are presented in business cases submitted to them for evaluation.
- Assessing options using cost–benefit analysis (CBA) (see ATAP Part T2), complemented by an Appraisal Summary Table (AST) (see ATAP Part F3). The AST is a mechanism for presenting all appraisal results — monetised and non-monetised — side-by-side in a single location. This approach recognises that all benefits and costs — monetised and non-monetised — are relevant to an appraisal
- The AST also includes quantitative and qualitative impact descriptions — these are necessary inputs to calculating monetised and non-monetised benefits, costs and impacts. Presentation of these inputs will be of assistance to the decision-maker. Non-monetised impacts that are non-quantifiable can only be described in qualitative terms
- The assessment of all options should include an assessment of risk and uncertainty, in order to ensure that the recommended option is robust (see ATAP Part T2 Chapter 11, and ATAP Part T7)
- Bringing together all aspects of the assessment into a Business Case (see ATAP Part F4).

3. Problem and opportunity identification and assessment

Step 2 of the ATAP Framework requires the identification and assessment of problems and opportunities, in this case related to active travel. Broad guidance on problem identification and assessment can be found in ATAP Part F2. This chapter applies that guidance to active travel.

3.1 Types of problems and opportunities

Problems and opportunities in relation to active travel can take various forms.

Problems

- Trips are unsheltered and therefore affected by the weather
- Lack of active travel infrastructure or appropriate facilities
- Poor access and or connectivity: between paths, to relevant land uses, across the network, and with public transport interchanges
- Physical safety concerns with inappropriate infrastructure for the speed and volume of traffic, or poor quality facilities not navigable by wheelchairs, prams or the elderly —– these inadequacies may be the result of poorly designed and maintained infrastructure (such as trip hazards, lack of ramps, inadequate path widths or excessive poles)
- Lack of security as people may feel unsafe without CCTV, lighting or 'passive surveillance' from activity of nearby building or facilities along the path
- Inadequate ancillary infrastructure (such as drinking fountains, shade planting, seating, wayfinding/signage, bicycle parking and end of trip facilities)
- Poor knowledge and awareness of the facilities available and associated benefits (such as better health and travel time savings).

Opportunities

- Through shifting trips from motorised travel to active travel:
  - Reducing population health problems caused by sedentary (inactive) lifestyles and air pollution
  - Reducing greenhouse gas emissions and the associated climate impacts
  - Reducing road traffic congestion external costs
- Improving transport accessibility
- Reducing travel time and reducing vehicle operating costs (for road users through decreased congestion, and for those who shift from car to active travel), especially in inner-urban areas
- Reducing transport inequity, by providing accessibility to those too young or old to drive, or for people who otherwise to not have access to a motor vehicle or do not live close to public transport (e.g. see Buehler and Pucher, 2021).

3.2 Understanding the problem or opportunity and its strategic context

The ATAP Guidelines require that a problem or opportunity be well understood before possible solutions are considered. This requires an understanding of:

- The strategic alignment of addressing the problem or opportunity with prevailing jurisdictional goals, transport system objectives, targets, policies and strategies (see ATAP Parts F1 and F0.1)
- The nature of the problem or opportunity (see ATAP Part F2)
- How the problem or opportunity relates to the rest of the network, given the inter-relationships between system elements.

The problem or opportunity must be clearly defined, preferably in consultation with stakeholders. For example, in relation to active travel:

- For a safety problem: Research the nature of crashes contributing to the problem and understand the causal factors and level of risk
- For a problem of an inadequate network that is limiting access: Understand the existing network structure, and how that aligns with overall active travel demand patterns and needs.

Examining issues at the strategic level, will often bring a broader perspective, including the influence of:

- Current and planned land use
- The current and planned network and hierarchy of active travel routes and infrastructure
- The role of other modes, particularly roads and public transport, and current and planned routes and services, and policy settings. Ideally there should be a recognised hierarchy of roles and functions for all elements of the transport system, and for adjacent places (see ATAP F0.2).

3.3 Assessment of problems and opportunities

The assessment of problems and opportunities involves identification, quantification, and where feasible monetisation, of the identified problems and opportunities. Where neither of these are feasible, describing the problem or opportunity in qualitative terms will be required.

ATAP F2 provides further detail on problem assessment. With respect to costing the problems/opportunities identified, users should use the unit cost figures provided in Chapter 6 below for the various cost components (health, safety, travel time, etc).

4. Options generation

Having identified and assessed a relevant problem or opportunity, Step 3 of the ATAP Framework requires the generation and assessment of a range of options for addressing the problem or opportunity. As indicated in Chapter 2, a wide range of options for addressing a problem or opportunity should be generated and assessed. ATAP guidance on options generation can be found in the following ATAP Parts:

- F3 Options generation and assessment
- O6 Alternative options to large capital investment
- O7 Regulatory initiatives.

Within that context, this chapter discusses the generation of active travel options.

4.1 Options generation

It is important to think broadly and creatively in generating options for addressing an identified problem or opportunity. It is critical that options are clearly specified, and that the relationships between options and improvements elsewhere in the transport network be well understood. The relationship can involve independence, complementarity or substitutability (see ATAP F3 appendix A for further discussion).

Active travel option categories include (with build and non-build aspects):

- Active travel zones and shared zones
- Pathways within the road corridor
- Pathways separate to the road corridor
- Path upgrades or retrofitting
- Ancillary infrastructure: lighting, seating, shade
- Crossings
- Roundabout and intersection treatments
- Bike parking, and other end-of-trip facilities
- Lower road speed limits and other traffic calming techniques
- Filtered permeability, which typically involves placing physical barriers at some intersections to minimise motor vehicle volume by diverting away from streets in which pedestrian and cycle traffic is prioritised
- Complete Street design, in which streets are designed to offer safe and attractive mobility across different modes of transport, and usually includes public realm improvements to enhance the quality of place. Complete Streets offer improved levels of service for people walking, cycling, and public transport
- Pop up bike lanes
- Soft options, such as travel behaviour change programs, financial incentives for e-bikes, and parking cash-out schemes.

Appendix B presents and discusses various options in these categories. Appendix C provides an indicative high level assessment of the relative merits of each of the option types — which can be used early in the assessment process to narrow down the list of options. Users will also find useful the pedestrian facility selection tool developed by Austroads (2020b). It can assist practitioners to identify potential pedestrian crossing treatments.

4.2 Use of network design principles

Where a jurisdiction has a policy objective of attaining mode shift to active travel, its achievement will be enhanced by having an effective active travel network. A network allows a greater number of potential end-to-end trips to be accommodated. In contrast, a network with ‘missing links’, or a segmented network, creates significant challenges for active travel, and limits the size of potential mode shifts.

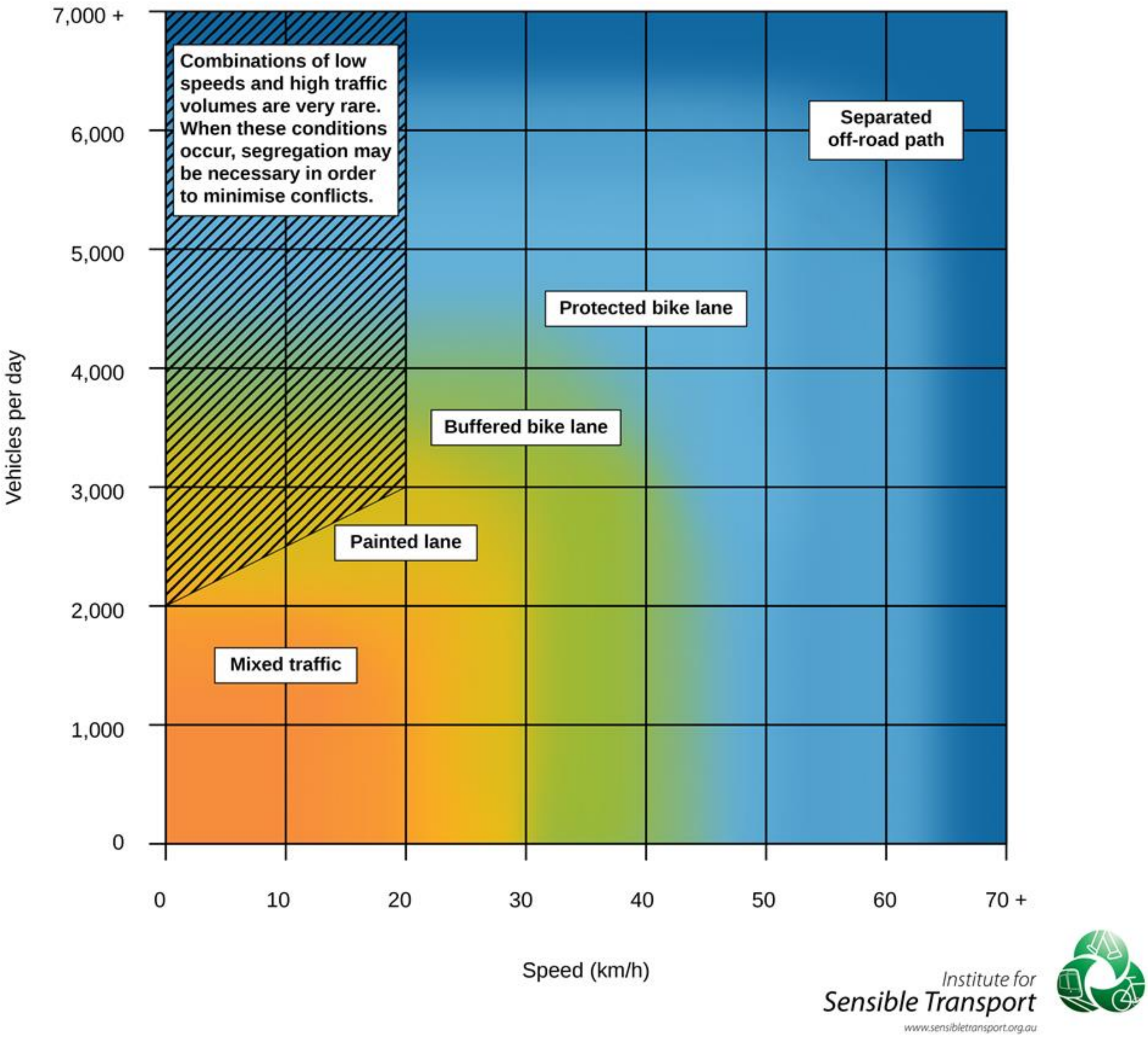
Noting this, options generation can be aided by using active travel network design principles. This ensures that the options generated will work effectively in unison with the other elements of the network. The Dutch network design principles (CROW 2017) identifies five network design principles for bicycle planning: cohesion, directness, safety, comfort, and attractiveness.

Figure 1 provides a conceptual illustration of appropriate bike infrastructure typology, based on motor vehicle speed and volume. It shows that as vehicle volumes and speeds increase, greater levels of separation are required.

While these types of graphs have been produced elsewhere (Department of Infrastructure and Transport, 2013, Austroads 2020a), Figure 1 provides some advancements based on empirical research on user preferences and recent work by the City of Melbourne (City of Melbourne, 2019). A further advancement is the inclusion of protected bike lanes, which had not been included in past uses of this concept (in Australia).

Research conducted in Sydney has demonstrated an increased utility when low-stress facilities (comprising bike paths physically or spatially separated from traffic, and low-speed streets) are offered and that commuters are less willing to divert from their shortest path, compared to riders cycling for other purposes (Standen, 2018). This has important implications for the design of bike routes that are intended to serve a commuter function, and is consistent with Dutch network design principles.

Figure 1 Bike infrastructure type based on vehicle volume and speed (conceptual)



Source: Created by the Institute for Sensible Transport via an adaptation from Austroads (2009)

5. Cost-benefit analysis methodology

Cost–benefit analysis (CBA) is central to the ATAP appraisal system (as explained in Part F3). The general features of a transport CBA are set out in Part T2 of the Guidelines. This chapter summarises the most important features in CBA as a backdrop for the discussion in the rest of M4.

- A CBA is a comparison of the Base Case and the Project Cases over the appraisal period where the:
  - Base Case is the situation over the appraisal period *without* the improvement option being assessed
  - Project Case is the situation over the appraisal period *with* the improvement option being assessed
- The Guidelines recommend that the Base Case be defined as the 'Do-Minimum' option. For further discussion on defining the Base Case, see ATAP Part T2, Section 1.6.
- The benefits, costs and results in a CBA are calculated from incremental changes between the Base Case and Project Case
- Where an asset reaches the end of its economic life before the end of the appraisal period, the asset is re-invested at the end of its life
- When assets have part of their economic life left at the end of the appraisal period, a suitable residual value should be included at the end of the appraisal period (see T2, Section 3.3)
- The primary results from a CBA are the net present value (NPV) and the benefit–cost ratio (BCR) — measures of net benefit. An improvement option is considered economically viable when NPV > 0 and BCR > 1. When trying to identify the economically best option by comparing options of varying scale within an initiative, incremental BCR (IBCR) is required. Formulas are presented here in Appendix D.
- The following distinctions are drawn between several categories of travel:
  - Existing: Trips in the Base Case that continue in the Project Case
  - Induced: The sum of diverted and generated trips:
    - Diverted: Trips that switch mode, route, time of day, origin or destination due to an initiative
    - Generated: Altogether new trips that are only made because an initiative is implemented.

CBA measures net benefits as changes in national economic welfare. Net benefit is the sum of gains and losses to the various parties affected by an improvement option, namely (Infrastructure Australia, 2021):

- Change in consumer surplus (CS) — user benefits
- Change in producer surplus (PS) — net benefits to service providers and government
- Change in third party (externality) effects
- Plus any resource cost corrections for unperceived user costs.

In T2, Chapters 6 to 9 discuss benefit measurement in detail, and Table 2 provides estimation formulas. The principles and methodology in T2 Chapters 6 to 9 are applied here. The appendix of active travel worked example 4.2 provides an extended discussion and derivation of the methodology in an active travel context with a particular focus on the rule-of-a-half.

6. Estimation of benefits

This chapter sets out the basis for estimating the benefits of active travel improvements and how they can be calculated. Default parameter values are also provided for practitioners to use, which provides a basis for consistent comparisons of project proposals across the nation. Where location specific parameter values are available and used, a comparison with default values is encouraged.

6.1 User generalised costs

The generalised cost (GC) of travel is a central concept in transport demand and benefit estimation. The GC of a trip:

- Is the combined perceived money and non-money private / personal costs the user faces
- As perceived by the user.

GC is the sum of various cost components:

GC = TC + SC + HPC + MC + OC

where:

TC = time cost = T x VTT

SC = safety (or crash) cost = TL x s

HPC = health private cost to the user (morbidity and mortality impacts) = TL x hpc

MC = money cost (vehicle operating costs, fares, tolls, parking charges, etc)

OC = other costs — this category is used here to represent the relative cost of personal likes and dislikes about travelling by one transport mode vs another, e.g. “I just don’t like travelling on buses” or “I refuse to cycle when it’s raining”; termed the ‘mode specific constant’ in M1 Public Transport. For active travel, it will pick up factors discussed in section 7.1 and the barriers referred to in M4-BR section 3.5.

where

T = travel time

VTT = value of travel time

TL = trip length

s = crash cost per kilometre (km) travelled

hpc = private health cost per kilometre travelled

The following components are expressed in $ per trip units:

VTT, MC, s, hpc, OC.

6.2 Perceived vs unperceived

Whether travellers perceive the costs they face is important in transport assessment in two ways:

- In demand modelling, only perceived costs influence demand

- In the appraisal of initiatives, benefit calculations for changes in user costs vary depending on whether a cost component is perceived or unperceived by the user (see below).

Travel activities involve many costs to users and society, including vehicle ownership and operating costs (for bicycles and motor vehicles), fares (for public transport), tolls and parking fees, travel time, and discomfort. Some of these affect travel decisions more than others. For example, fixed vehicle costs can affect the number and types of vehicles households own, while vehicle operating costs affect how much vehicles are used. Most vehicle costs are fixed; motorists pay about the same depreciation, financing, registration, insurance and residential parking costs regardless of how many kilometres their vehicle is driven each year. Short-term travel decisions, such as how people travel to work or errands, are most affected by “out of pocket” costs, such as fuel, tolls, parking fees and transit fares, plus travel time costs, which vary by comfort.

People’s perception of transport costs can have a powerful impact on travel decisions (Verhoef et al., 2008, Litman, 2012, Vonk Noordegraaf et al., 2014, Litman, 2014, Litman, 2018). This is a critically important area for further research. Behavioural economics is also a rapidly emerging field, and provides important insights into how people perceive costs (Kahneman, 2013, Tversky and Kahneman, 1992). The field spans transport psychology, sociology and transport demand analysis.

Active travel decisions, such as whether to travel by walking or bicycling, are most affected by the relative convenience and comfort of travel by these modes, land use factors that affect travel distances, plus the relative convenience and costs of motorised travel (Fishman, 2019).

There does not appear to be widespread agreement on perception of user cost components. Based on the limited available information, 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.

6.3 Benefits estimation basis and formulas

As summarised in the last chapter, the methodology for estimating the benefits of transport initiatives is presented in ATAP Part T2 chapters 6 to 8 based on standard economic theory and practice. The methodology is applied here for the appraisal of active travel initiatives. The appendix of active travel worked example 4.2 provides an extended supporting discussion.

In brief, benefits consist of:

- User benefits to active travellers
- Any resource cost corrections that are required for unperceived user costs
- External benefits (i.e. external cost reductions) to third parties.

Notation

The notation used is as follows:

- BC refers to Base Case
- PC refers to Project Case
- D is demand
- AC is average generalised cost
- Q is trips
- P is the perceived component of generalised cost
- AT-IMP refers to the improved active travel route
- AT-X refers to other existing active travel routes
- AT-N refers to a totally new active travel facility
- GEN refers to newly generated trips.

Formulas

The formulas to apply are as follows:

User benefits to active travel trips

Existing trips

- Benefit per trip = $(AC_{AT,BC} – AC_{AT,PC})$ (1)
- Total benefit across all existing trips = $(AC_{AT,BC} – AC_{AT,PC}) \times Q_{AT,BC}$ (2)

AC is user generalised cost, and in benefit calculations consists of the safety, travel time and private health components.

New trips

- Benefit per trip = $0.5 * (P_{AT,BC} – P_{AT,PC})$ (i.e. rule-of-a-half, discussed below) (3)
- Total benefit across all new trips = $0.5 * (P_{AT,BC} – P_{AT,PC}) \times (Q_{AT,PC} – Q_{AT,BC})$ (4)

- These formulas are applied to combined perceived user cost components. As discussed above, all active travel private costs components are assumed to be perceived. So $P_{AT} = AC_{AT}$, and no resource corrections are required.

Other benefits

Four additional benefits relate to reduced car travel. Three are from the reduced external costs:

- Decongestion benefit = ΔKM_{CAR} x d (5)
- Environmental benefit = ΔKM_{CAR} x e (6)
- Health system benefit = ΔKM_{AT} x hpc (7)

and the final benefit is a resource correction accounting for the reduction in:

- Unperceived car travel costs benefit = ΔKM_{CAR} x c_u (8)

where

- ΔKM_{CAR} is the reduction in car-kilometres from switching to active travel
- ΔKM_{AT} is the active travel kilometres travelled for trips switching from car to active travel
- d is the unit road decongestion cost of car travel ($ per car-km)
- e is the unit environmental cost of car travel in ($ per car-km)
- hpc is the unit health system benefit of switching from car travel to active travel ($ per active travel person-km)
- c_u is the unit unperceived car operating cost which is avoided by switching from car travel to active travel ($ per car-km).

Explanation

The appendix of active travel worked example 4.2 provides an extended supporting discussion.

Figure 2 shows the demand and cost curves for this case. An example is the introduction of a bike lane on a road already used by cyclists. The number of trips on the route increase from $Q_{AT\text{-}IMP,BC}$ to $Q_{AT\text{-}IMP,PC}$.

Existing active travel trips ($Q_{AT\text{-}IMP,BC}$) on the route benefit by the full reduction in user cost arising from the improvement (formulas (1) and (2) above). This is shown as *area A* in the left hand panel of Figure 2.

For new active travel trips on the improved route (both diverted from other modes and newly generated trips):

- The benefit from the improvement is the area below the demand curve, and above the Project Case perceived generalised cost $P_{AT\text{-}IMP,PC}$ (= $AC_{AT\text{-}IMP,PC}$), for the increased trips ($Q_{AT\text{-}IMP,BC}$ to $Q_{AT\text{-}IMP,PC}$). This is shown in Figure 2 as *area B*.
- The height of the demand curve measures the marginal willingness-to-pay ($MWTP_{AT}$) for each additional trip, so, at any point on the curve, the perceived generalised cost $P_{AT\text{-}IMP,PC}$ measures the user's valuation of the particular trip. The first of the new active travel trips had a $MWTP_{AT}$ marginally below P_{AT} in the Base Case, so their benefit in the Project Case is effectively equal to the full active travel cost reduction from the initiative. The last of the new active travel trips requires the full active travel cost reduction to be enticed to make the trip, so their benefit of the trip is close to zero. If the demand curve is assumed to be linear over the trip increase range ($Q_{AT,BC}$ to $Q_{AT,PC}$), the 'rule-of-a-half' can be applied. That is the benefit per trip for the new active travel trips is, on average, one half the benefit per trip for

existing active travel trips (formula (3) above per trip, and formula (4) for all new trips).

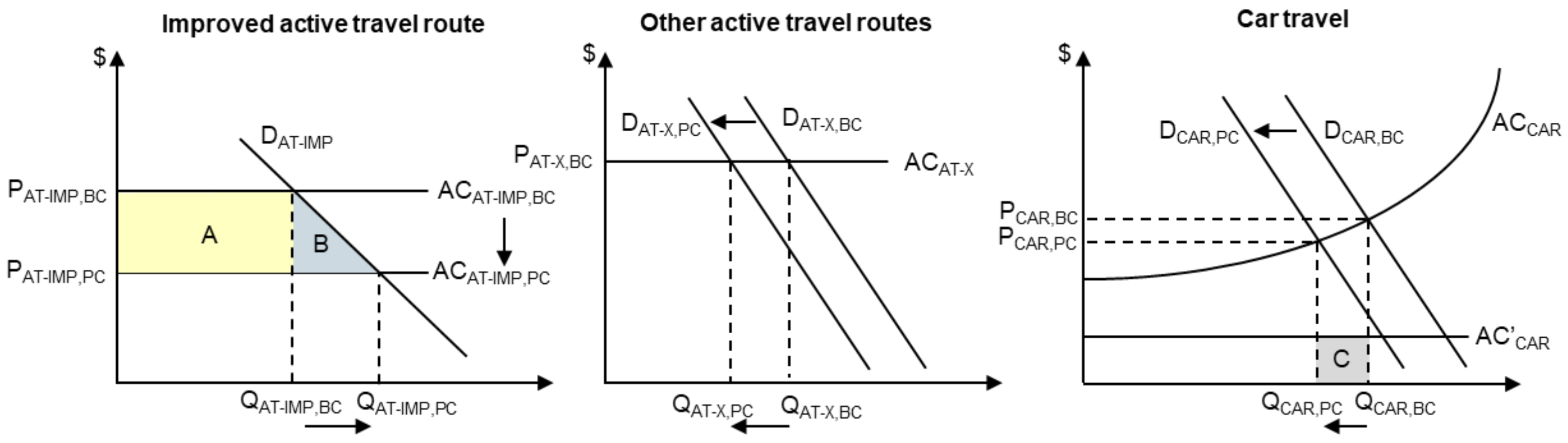
- The rule-of-a-half calculation is a simple calculation using the active travel generalised cost reduction and increase in trips. It Takes into account willingness to pay, and all perceived cost components, for all available modes. It is therefore incorrect to then also add in changes in individual cost components between Base Case and Project Case. This point is discussed in detail in the appendix of active travel worked example 4.2.

Figure 2 shows the sum of the other benefits (decongestion, environment, health system cost, unperceived car operating costs) as *area C* in the right-hand panel (formulas (5) to (8) above). AC'_{CAR} is the sum of the unit costs d + e + hpc + c_u in $/km units (as defined above).

The middle panel shows active travel on other routes. There is some shift from these to the improved active travel route. There are no benefits for the remaining trips on those other routes.

Sections 6.14.1 provides two benefit calculation examples.

Figure 2 Travel demand and cost curves — active travel infrastructure improvement



6.4 Parameter values summary

Section 6.3 provides the methodology for estimating benefits. Table 1 below summarises the parameter values to use in applying the formulas, reflecting the assumptions about perception discussed in section6.2. The discussion in section 6.7 onwards of this chapter provides supporting discussion on these parameter values, with cross-references to M4-BR. More disaggregated values of unit costs are provided in M4-BR, e.g. unit costs for separated vs on-road cycle paths.

Table 1 Summary of unit costs — perceived, unperceived and external (2021 dollars)

	Item	Unit cost	Units	Source
Perceived user costs				
Walking	Safety	1.92	$/vehicle-km	Table 2
	Time:			
	- employer's business	59.84	$/person-hour	Table 5
	- other transport purpose	18.45	$/person-hour	Table 5
	- recreation	0	$/person-hour	Table 5
	Private health	–2.64	$/person-km	Table 6
Cycling	Safety	1.27	$/vehicle-km	Table 2
	Time:			
	- employer's business	59.84	$/person-hour	Table 5
	- other transport purpose	18.45	$/person-hour	Table 5
	- recreation	0	$/person-hour	Table 5
	Private health	–1.32	$/person-km	Table 6
Unperceived user costs				
Car	Oil, tyres, maintenance, depreciation	0.18	$/car-km	M2 table 10
External costs				
Walk	Health system	–1.43	$/person-km	Table 6
Cycling	Health system	–0.71	$/person-km	Table 6
Car	- Decongestion	0.60	$/car-km	M1 table 11
	- Environment	0.04	$/car-km	PV5 table 5-1

Table notes: The safety values are willingness-to-pay values. The health numbers are negative costs, i.e. benefits of increased physical activity. Numbers from M1 and M2 have been indexed to 2021 $s. The unit decongestion figure is an approximate average across the day.

6.5 E-bikes and e-scooters

The types of benefits and costs associated with conventional bikes discussed above will also apply to e-bikes and e-scooters, and the calculation methodologies presented here in M4 can be applied equally to each of these transport modes. There will, however, be some differences in relation to the parameter values to use:

- E-bikes: M4-BR chapter 10 suggests that: Health unit benefits per km are lower than for conventional bikes, and speed is higher
- E-scooters: M4-BR chapter 11 suggests that e-scooters do not have any health benefits, and that they have associated safety concerns.

In the remainder of this chapter, specific recommendations are made where adjustments should be made for e-bikes and e-scooters.

6.6 Annual expansion factors

The annual expansion factor converts daily demand estimates to annual demand, to calculate annual benefits. An appropriate factor should reflect the expected usage of the facility and how demand assumptions have been reached. It is important that the expansion factor and demand assumptions are aligned. The following are recommended:

- If the demand estimate is in units of average weekly trips, the expansion factor is 52
- If the demand estimate is in units of average daily trips, the expansion factor is 365
- If the split of trips by trip purpose is available, separate expansion factors should be used by purpose:
  - Work, school and tertiary education trips: The annual expansion factors should reflect the standard work or education year, that is, Monday to Friday for all weeks except holidays. Typically, there are more holidays in education than work, so the following default values are suggested:
    - Journey to work trips, and trips on employer’s business: 230 (= (52 x 5) – 30)
    - Education trips: 220 (44 x 5)
  - Other transport purpose trips: These are expected to be undertaken evenly across the week, so a factor of 365 is suggested
  - Non-transport (recreational) trips: These are more likely on weekends and public holidays than on workdays, so a lower expansion factor is suitable. A minimum factor, reflecting just weekends and public holidays, would be between 104 (= 52 x 2) to 114 (assuming 10 public holidays).

Undiscounted annual benefit over appraisal period

The initial step in an appraisal is to calculate the annual benefit for the first year of operation of the improvement. For subsequent years in the appraisal period, the annual benefit is increased in line with expected growth. For example, if uniform growth is expected, annual benefit is increased at a stated growth rate. For example, if annual benefit is $100,000 in the first year of operation, and a 1% growth rate is assumed, the first three years of benefits are: $100,000, $101,000. $102,010.

6.7 Safety benefits

Safety benefits arise when there is a reduction in the safety risk faced by active travellers. This section outlines how to calculate safety benefits for an active travel improvement, provides default parameter values for use in calculations and illustrates with a benefit calculation example. Readers are directed to M4-BR chapter 5 for more detailed supporting material on active travel safety.

Safety benefits are a function of two things:

- The reduction in crash risk, and
- The monetised unit value of crash costs.

6.7.1 Crash risk

The primary risk to the safety of active travel users is a crash, most likely from interactions with motorised transport. There are also risks to physical safety posed by inadequate infrastructure such as trip hazards (for example, uneven surface, heaving in concrete footpaths and potholes in roads), lack of ramps, inadequate path widths or excessive or poor placement of power and light poles. Safety issues also arise when pedestrians and cyclists share the same facility.

The crash effects attributable to an active travel infrastructure improvement are as follows:

- Existing active travel trips will experience a crash reduction benefit to the extent that active travel infrastructure aims to separate motorised and non-motorised traffic streams including improving safety at intersections and crossings.
- New active travel trips in the Project Case (trips diverted from other modes, or newly generated trips) are likely to experience an elevation in crash risk because walking and cycling have a much higher crash risk than motorised private transport or public transport. Improved infrastructure may reduce that expected crash cost, but trip conversion will still produce a negative crash benefit that partly offsets other active travel benefits. This offsetting effect is reduced if the length of the motorised trip in the Base Case is longer than the replacement active travel trip in the Project Case.

In the guidance provided below, crash risk is converted into per km unit costs based on average (exposure-based) risk values. Practitioners can use these as default values where site-specific crash data is unavailable. Where reliable site-specific crash data is available for an assessment, it should be the main source of data for crash cost estimation.

Accident prediction models for different road elements — such as mid-blocks, roundabouts and T-intersections — have been developed in New Zealand (NZTA 2018, Turner et al, 2006), and could improve an assessment, but their application may be beyond the time and resource budgets for all but the largest appraisals.

The input of qualified safety specialists may be required to access and interpret crash data, and to choose suitable crash reduction factors (see below).

An issue in the assessment of cycling is whether the s*afety in numbers* effect occurs. That is, the average risk may decrease as cycling level increases (rather than a proportional relationship). The effect is well discussed in the research literature, and has been integrated into some practitioner tools. The effect may reflect various factors: as walking and bicycling increase, drivers probably become more cautious, and pedestrians and bicyclists impose minimal risk to motorists, which increases safety to all road users. M4-BR section 5.6 provides an overview of the literature on this topic. At this point in time, the literature is not certain enough about the existence of a safety in numbers phenomenon to recommend its reporting in core assessment results. If the effect is included in an assessment, it is recommended that it be considered in a sensitivity test, with clear documentation of the assumptions made.

6.7.2 Calculating benefits

This section explains the steps for calculating crash reduction benefits of a given active travel improvement option using the parameter values outlined in section 6.7.3 below. Apply these steps for separately for: walkers and cyclists, and for each benefit year of the appraisal period.

The calculations are illustrated with the following cycling example:

- An improvement is made to an existing cycling facility. The facility is 2 kms long and carries 300 daily trips (on average along its length) in the Base Case. The improvement results in a 70% crash cost reduction. 30 new cycling trips are estimated to result from the improvement. The daily to annual expansion factor is 250.

Existing active travel trips

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.

Example: Base Case crash cost per trip = $1.27 per trip-km x 2 kms = $2.54 per trip

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

Example: Crash cost reduction factor is 70% (illustrative).

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.

Example: Per trip crash cost reduction = $2.54 per trip x 70% = $1.78 per trip = unit crash cost reduction benefit.

Step 4: Multiply per trip benefit (step 3) by number of existing daily trips, and expansion factor, to convert to annual benefit for existing active travel trips.

Example: Annual benefit for existing active travel trips = $1.78 x 300 x 250 = $133,500 per year.

New (generated and diverted) active travel trips

Step 5: As explained in section 6.3, for new active travel trips, the 'rule-of-a-half' is used to calculate the net benefit of reductions in any perceived cost component. That is, the benefit per trip for new trips is a half the benefit per trip of existing trips (from step 3).

Example: Average unit benefit for new trips = 0.5 x $1.78 = $0.89.

Step 6: Multiply average per trip benefit (step 5) by number of new daily active travel trips, and expansion factor, to convert to annual benefit for new active travel trips.

Example: Annual benefit for new trips = $0.89 x 30 x 250 = $6,675 per year.

Intersections

The above steps describe application using crash cost per km. In cases of assessing intersection improvements, a per km unit cost cannot be applied. Instead, figures should be sought from the relevant transport agency on crashes per trip using the intersection, and converted to crash costs using values of statistical life and injuries provided in PV2 chapter 4.

6.7.3 Parameter values

This section provides default parameter values recommended for practitioners to use.

Unit crash costs

Unit crash costs estimated on a per distance basis are shown in Table 2. See M4-BR section 5.7 for a comparison across transport modes and the basis for estimation. The estimates are based on crash exposure risk calculated separately for driver and passengers, and hence should not need to be adjusted for vehicle occupancy.

Two sets of crash costs are shown in Table 2: the more recent inclusive willingness to pay approach; and the older hybrid human capital approach that has been used in Australia for many years and that derives from research carried out by BITRE. The ATAP Guidelines favour the inclusive willingness to pay approach. [2].

Table 2 Crash costs by mode per vehicle km (2021 dollars)

Mode	Crash cost per veh km	
	Inclusive willingness to pay approach	**Hybrid human capital approach**
Cyclist	$1.27	$0.65
Pedestrian	$1.92	$0.89

Source: See M4-BR section 5.7

With respect to e-bikes and e-scooters, we recommend the cyclist unit costs in Table 2 be used in appraisal (see section 10.4 of M4-BR). Where practitioners have reliable evidence of higher unit costs, they can be used instead (with supporting documentation). As the findings of further research are published, this recommendation will be reviewed.

M4-BR section 5.2 indicates the relative level of risk across the range of on-road and off-road facilities. Those numbers can be combined to scale the unit costs in Table 3 to generate unit costs for specific facility types.

Whichever values are used, they should be consistent with the values used elsewhere in the cost–benefit analysis, and consistent across severity levels (e.g. fatal, serious injury, minor injury crashes).

Crash risk reduction

Table 3 shows the order of magnitude of crash risk reductions that can be expected.

Table 3 Crash risk reduction effectiveness of interventions

Intervention	Active travel crash risk reduction
Interventions that partially separate walkers and cyclers from the traffic stream, such as kerb lanes located in the roadway	30 to 40%
Interventions that achieve a high degree of active traveller separation from the traffic stream, such as off road cycle lanes and grade separations, or that enhance protection of active travellers at intersections.	80 to 100%

[2] The value of statistical life incorporated in the willingness to pay estimates in Table 23 derives from recent research into the value road users place on avoiding premature death in a range of trip choice situations (see Austroads (2015) and Volume 2 of NGTSM). Those values might not be readily transferrable to active travellers. The value of statistical life that is included in the health benefit estimates has a broader base, representing the willingness of individuals to pay to avoid a small increase in the risk of premature death.

More specific figures from a range of studies across the range of interventions are reported in M4-BR section 5.3.

For corridor initiatives — that combine a number of infrastructure elements — a larger reduction might be appropriate than for individual initiatives, but there is insufficient research to provide guidance on this point.

Roundabouts generally form a safe intersection for motorists, but result in higher crash rates for cyclists. This is especially the cases when roundabout design prioritises capacity over safety. In particular, multi-lane roundabouts are a concern, with fast moving vehicles interacting with bicycles.

6.7.4 Personal security risks

Active travel can also involve personal security risks from being in potentially insecure environments, e.g. walking through on a path through a park at night. Personal security needs to be considered where facilities are not properly monitored through CCTV or passive surveillance, or where there is poor lighting. This can be dealt with using Crime Prevention through Environmental Design (CPTED), a crime prevention strategy that outlines how physical environments can be designed to lessen the opportunity for crime. These have not been specifically addressed here, but the principles of assessment are the same. The associated risks would need to be quantified, monetised, risk reduction estimated for given security improvement measures and benefits estimated.

6.8 Travel time benefits

Travel time benefits arise when there is a reduction in active travel trip time. This section outlines how to calculate time saving benefits for an active travel improvement, provides default parameter values for use in calculations and illustrates with a benefit calculation example. Readers are directed to M4-BR chapter 6 for more detailed supporting material on active travel time.

Typically in transport, travel time is a disincentive to travel, that is travel time is a user cost. This means that initiatives that save travel time generate benefits. When applied to motorised travel, *travel time savings* are one of the main benefits included in conventional studies (Washington et al., 2011).

Time saving benefits are a function of two things:

- The physical time saved, which is a function of speed, and
- The monetised unit value of time savings.

6.8.1 Calculating benefits

This section explains the steps for calculating travel time reduction benefits of a given active travel improvement option. Apply these steps separately for: walkers and cyclists; each trip purpose; and for each benefit year of the appraisal period.

The calculations are illustrated with the following cycling example:

- An improvement is made to an existing cycling facility. There are 300 daily trips made on the facility in the Base Case. The improvement results in a 5-minute reduction in cycling travel time per active travel trip. 30 new cycling trips are estimated to result from the improvement. The daily to annual expansion factor is 250. Time savings benefits are calculated here just for employer’s business trips.

Existing active travel trips

Step 1: Estimate the time saving per trip between the Base Case and the Project Case.

> Example: Calculation not required in this example, as we are told that the improvement results in a 5-minute travel time saving.

Step 2: Calculate per trip cost reduction by multiplying per trip time saving (step 1) by unit value of travel time savings (from Table 5).

> Example: The time cost reduction per trip = 5/60 hours/trip x $59.84 per hour = $4.99 per trip

Step 3: Multiply per trip benefit (step 2) by number of daily trips, and expansion factor, to convert to annual benefit for existing active travel trips.

> Example: Annual time saving benefit = $4.99 x 300 x 250 = $374,250 per year.

New (generated and diverted) active travel trips

Step 4: As explained in section 6.3, for new active travel trips, the ‘rule-of-a-half’ is used to calculate the net benefit of reductions in any perceived cost component. That is, the benefit per trip for new trips is a half the benefit per trip of existing trips (from step 2).

> Example: Average unit benefit for new trips = 0.5 x $4.99 = $2.50 per trip.

Step 5: Multiply average per trip benefit (step 4) by number of new daily active travel trips, and expansion factor, to convert to annual benefit for new active travel trips.

> Example: Total annual benefit for new trips = $2.50 x 30 x 250 = $18,750 per year.

6.8.2 Parameter values

This section provides default parameter values for practitioners to use.

Speed

Table 4 Active travel speeds

Case	Speed, kms/hr
Walking	6 km/hr
Cycling	
On road (door-to-door)	16 kms/hr
On-road (cruising)	23 kms/hr
Cycleway	25 kms/hr

Source: M4-BR section 6.1.

With respect to e-bikes and e-scooters, it is recommended that practitioners apply realistic markups to the speeds provided in in Table 4 to reflect possible higher speeds:

- For e-bikes, section 6.1 of M4-BR suggests an additional speed of 1 to 3 km/hr

- For e-scooters, limited information is currently available. Where local evidence is available it can be used (with supporting documentation), otherwise the speeds in Table 4 should be.

As the findings of further research are published, this recommendation will be reviewed.

Unit value of travel time

The ATAP Guidelines use two types of values of time:

- *Behavioural values* for use in *demand modelling*: These values are the willingness-to pay (WTP) values observed in surveys, and vary across transport modes
- *Equity values* for use in the *appraisal of initiatives*: The equity value is an average value used consistently across all transport modes in appraisal.

ATAP Part M1 sections 6.2 and 6.3 provide further discussion on the value of time.

For the appraisal of active travel initiatives, the equity values in Table 5 should be used. These values are the same as those used in PV2 Road Parameter Values (Table 12) and PV1 Public Transport, and provides a consistent equity value across modes.

Table 5 Unit values of travel time saving for active travel (2021 dollars)

Trip purpose	Unit value ($/person-hr)
Transport trip purposes: • Employer's business • Other transport purposes	 $59.84 $18.45
Non-transport purposes	0

Source: ATAP PV2 Table 12

Note the trip purpose distinctions in Table 5:

- For non-transport active travel (i.e. recreational or exercise) the value of time is set at zero. Time might be a positive feature of travel and be associated with enjoyment or with the positive outcomes of physical activity. In those circumstances, an infrastructure improvement that allows walkers and cyclists to travel faster — such as a pedestrian/cycle overpass — active travellers might simply do more exercise within the time available. Hence for non-transport active travellers travel time savings are unlikely to generate time-related benefits.
- On the other hand, for transport trips (journey to work or education, trips for shopping and other personal business, and on employer's business), as with motorised travel, travel time is a disincentive to travel. This means that time savings should be recognised as a benefit. Consistent with PV2, time saved on employer's business is valued more highly than other transport trip purposes.

For demand modelling of active travel, no specific behavioural values are recommended here. M4-BR discusses various studies on value of time, however it does not provide clear behavioural values for active travel. As a default, it is recommended that practitioners could use the same values as in Table 5.

Weighting in calculating travel time savings

Weighting by trip segment

In transport assessment, it is recognised that different segments of a trip create a greater travel disincentive than others. This plays a central role in public transport assessment (see M1 Chapter 5 and the M1 Technical Report). As discussed in section 5.2 of M1, the standard approach is to reflect these relative inconvenience effects in terms of the generalised cost of a trip. Each trip time component is weighted to reflect its relative perceived inconvenience cost compared to in-vehicle time (IVT), with the sum of weighted elements referred as the 'generalised time'. Generalised time is then multiplied by the value of in-vehicle time to generate generalised cost.

Of relevance to active travel assessment, M1 shows a weighting of 1.4 for wait time at public transport stops, and 1.5 for walk time at trips ends (access/egress). For consistency it is recommended that these weighting values also be used here, i.e. 1.4 for wait time, and 1.5 for walk time in the assessment of active travel.

Active travel can also involve end of trip time, e.g. parking a bike, or changing clothes. If available, analysts should use case-specific evidence-based weightings, otherwise use of a trip end time weighting of 1.4 the same as waiting time, is recommended.

The respective weights are applied to the time involved and then multiplied by the equity value of time.

> Example 1: Active travel trips along a facility involve waiting to cross a road. A signalised crossing is installed, and on average, the wait time is reduced by 1.2 minutes.
>
> The weighted time saving is 1.68 minutes per trip (1.2 mins x weighting of 1.4). Converting to hours, and multiplying by the value of time savings (Table 5), gives the $ per trip benefit. For example, for 'other transport' trip purposes, the benefit is $0.52 per trip (= 1.68/60 x $18.45). This is the benefit to existing trips. Benefits to new trips are captured through the rule-of-a-half calculation.
>
> Example 2: An improvement of trip end facilities results in being able to more quickly park a bike in a secure facility. A time saving of 2.1 minutes occurs.
>
> The weighted time saving is 2.94 minutes per trip (2.1 mins x weighting of 1.4). Converting to hours, and multiplying by the value of time savings (Table 5), gives the $ per trip benefit. For example, for a journey to work (non-transport) trips, the benefit is $0.52 per trip (= 2.94/60 x $18.45). This is the benefit to existing trips. This is the benefit to existing trips. Benefits to new trips are captured through the rule-of-a-half calculation.

Weighting for different cycling infrastructure

Surveys have been found to reveal a difference in willingness to pay for different active travel facilities, in different conditions and at different times. A method sometimes used is to use assign weights to the value of time to reflect these different willingness to pay values.

For example, riding on a path with a very high levels of service or comfort may result in a different value of time compared to riding in a highly stressful, mixed traffic environment, as it is well established that stressful environments deter cycling (Department of Transport, 2020).

Similarly, Australian and international research shows, as would be expected, that cyclists place a higher value on quiet street environments and off-road paths than they do on busy roads without any cycling infrastructure. Put another way, cyclists experience less disutility in using quiet streets or off-road paths than they do in using busy roads that lack cycling infrastructure. A study by Mulley et al (2013) calculated weights from a stated preference survey of cycling in Sydney imply that:

- 1 km of riding on a busy road with no bicycle lanes is perceived as equivalent to:

- cycling 2.3 kms on a busy road with bicycle lanes or in a quiet street
- cycling 2.9 kms on an off-road path.

Litman (2020) provides an even broader assessment, reporting variations in the value of time across a spectrum of levels of service (A to F) in passenger travel modes, including active travel. For example, active travel time at level of service F has a weight of 2.0 compared to level of service A to C.

More details on the Mulley (2013) and Litman (2020) studies are discussed in M4-BR chapter 6.

In principle, these weights could be used in comparing the perceived costs of cycling on different facility type. A major impediment to their use is the potential over-counting of crash benefits. It is not possible to determine how much the relative preference for off-road paths is influenced by perceptions of safety and how much by other factors such as reduced stress from less interactions with motor vehicles, reduced exposure to road rage or other forms of abuse or the pleasure associated with cycling in a pleasant environment.

Until more research is carried out, it is recommended that value of time weights across infrastructure types not be used in benefit estimation. If they are used, they should be presented in sensitivity tests, noting that there is a risk they may double count other perceived benefits, and presenting a result with safety benefits excluded.

Further research is required. When stated preference surveys are undertaken regarding the relative preference across different facility types, the questions should be structured to specifically target individual characteristics (time, safety or other quality features). Or alternatively, multiple questions should be asked that allow separate valuations of each of the elements (time, safety and other quality features).

6.9 Health aspects of active travel

From the broadest interpretation of health, there are a range of health aspects related to active travel. Sections 6.7 and 6.10 discuss safety (road trauma) and physical activity impacts, both of which are monetised. Air pollution exposure effects are discussed in section 6.15.1 as a non-monetised impact.

M4-BR chapters 5, 7 and 8 provides background discussion on these impacts. M4-BR chapter 9 then discusses the overall combined health effects of these factors, suggesting an overall positive net health effect of greater active travel.

6.10 Physical activity health benefits

Physical activity health benefits arise when there is an increase in the amount of active travel, measured in kms travelled. The benefit applies only for transport purpose trips. It is assumed that for recreational travel the person will simply adjust their route to retain a distance or time goal.

This section outlines how to calculate physical activity health benefits for an active travel improvement, provides default parameter values for use in calculations and illustrates with a benefit calculation example. Readers are directed to M4-BR chapter 7 for more detailed supporting material.

6.10.1 Physical activity

The physical activity associated with active travel results in two types of health-related benefits:

- Reduced morbidity (illness) and mortality (death) costs — people who are active get sick less often and have a longer life expectancy than people who are inactive. These are referred to here as ‘health private costs’ (HPC), and are assumed to be perceived and therefore influence travel choices.

- Reduction in health system costs — active people are less likely to need medical and hospital care, so less health system resources are required. These are referred to here as 'health system costs' (HSC). They are not considered in travel decision-making, and are treated here as an externality.

There are two things to note from the outset:

- It is recommended that physical health benefits only be applied to new active travel trips, and not existing trips. The methodology involves using the per km unit benefits in Table 6, which are estimates of average increased health using population-level statistics on activity levels. Applying this where a project has changed the trip length for existing trips is, at this stage, considered unlikely to reflect the activity levels of existing active travellers, nor the resulting changes in health costs. Ultimately, this question should be subject to further research.
- 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. 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.

6.10.2 Calculating private health benefits

This section explains the steps for calculating physical activity private health benefits to new trips resulting from an active travel improvement. Apply these steps separately for: walkers and cyclists; and for each benefit year of the appraisal period.

The calculations are illustrated with an extension of the example used in section 6.7.2:

- An improvement is made to an existing cycling facility. The facility is 2 kms long and carries 300 daily trips (on average along its length) in the Base Case. The improvement results in a 70% crash cost reduction. 30 new cycling trips are estimated to result from the improvement. Two-thirds of the new trips switch from other modes: 16 trips (80%) come from car, and 4 trips (20%) from public transport. The other 10 new trips are newly generated. Trips are (on average) 3 kms in length, with public transport trips involving (on average) 0.3 kms of walking to the bus stop or train station. The daily to annual expansion factor is 250.

For existing active travel trips

As mentioned above, physical activity health benefits are assumed to be zero for existing users.

For new active travel trips

a) Private health costs are perceived

As explained in section 6.3, for new active travel trips, the 'rule-of-a-half' is used to calculate the net benefit of reductions in combined perceived cost components. That is, the benefit per trip for new trips is a half the total perceived benefit per trip of existing trips. (It is not calculated as the change in cost between active and non-active travel). With private health benefits perceived, they are captured in the rule-of-a-half benefit calculation.

Step 1: Calculate the net reductions in combined perceived cost components per existing trip, and apply the rule-of-a-half for new trips.

> Example: From the example in section 6.7.2, existing trips experience a benefit by \$1.78 per trip. Applying the rule-of-a-half, average unit benefit for new trips = 0.5 x \$1.78 = \$0.89 per new trip.

Step 2: Multiply average per trip benefit (step 1) by number of new daily active travel trips, and expansion factor, to convert to annual benefit for new active travel trips.

Example: Annual benefit for new trips = $0.89 x 30 x 250 = $6,675 per year.

b) Private health benefits are unperceived

As recommended above, a sensitivity test should be done with private health costs assumed to be unperceived rather than perceived. This requires a resource cost correction.

Trips that switch from other modes

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).

Example: Switching from car: Cycling trip length = 3 kms.

Switching from public transport: Cycling trip length = 3 kms. Decrease in walking distance = 0.3 kms.

Step 4: Convert distance estimates in step 3 to $ values by multiplying by relevant unit private health benefit in Table 6.

Example: Switching from car: Unit cycling benefit = 3 x $1.32 = $3.96 per trip.

Switching from public transport: Unit cycling benefit = $3.96 per trip. Unit walking *disbenefit* = 0.3 x $2.64 = $0.79 per trip. Net benefit = $3.96 – $0.79 = $3.17 per trip

Step 5: Multiply per trip benefit (step 4) by number of daily trips, and expansion factor, to convert to annual health system benefit.

Example: Switching from car: Annual private health benefit = $3.96 x 16 x 250 = $15,840 per year

Switching from public transport: Annual private health benefit = $3.17 x 4 x 250 = $3,170 per year.

For newly generated trips

Step 6: Estimate average length in kilometres of newly generated active travel trips.

Example: Trip length for newly generated trips is also 3 kms.

Step 7: Multiply trip length (step 6) by unit private health benefit in Table 6 to yield benefit per trip.

Example: 3 kms x $1.32 = $3.96 per trip.

Step 8: Multiply by daily number of trips, and expansion factor, to convert to annual health system benefit.

Example: $3.96 x 10 x 250 = $9,900 per year.

6.10.3 Calculating health system benefits

This section explains the steps for calculating physical activity health system benefits of a given active travel improvement option. Apply these steps separately for: walkers and cyclists; and for each benefit year of the appraisal period.

As explained above, health system costs are treated here as an externality (and external cost). The benefit is calculated using formula 7 in section 6.3. The steps here provide a process for applying formula 7.

The example calculation uses the same example as for private health benefits above.

Existing trips

As mentioned above, physical activity health benefits are assumed to be zero for existing users.

Trips that switch from other modes

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).

> Example: Switching from car: Cycling trip length = 3 kms.
>
> Switching from public transport: Cycling trip length = 3 kms. Decrease in walking distance = 0.3 kms.

Step 2: Convert distance estimates in step 1 to $ values by multiplying by relevant unit health system benefit in Table 6.

> Example: Switching from car: Unit cycling benefit = 3 x $0.71 = $2.13 per trip.
>
> Switching from public transport: Unit cycling benefit = $2.13 per trip. Unit walking *disbenefit* = 0.3 x $1.42 = $0.43 per trip. Net benefit = $2.13 – $0.43 = $ 1.70 per trip

Step 3: Multiply per trip benefit (step 2) by number of daily trips, and expansion factor, to convert to annual health system benefit.

> Example: Switching from car: Annual health system benefit = $2.13 x 16 x 250 = $8,520 per year
>
> Switching from public transport: Annual health system benefit = $1.70 x 4 x 250 = $1,700 per year.

For newly generated trips

Some people might become active travellers because the improvement removes a perceived barrier or sparks their interest. For whatever reason they become active travellers, the health system benefits are estimated as follows:

Step 4: Estimate average length in kilometres of newly generated active travel trips.

> Example: Trip length for newly generated trips is also 3 kms.

Step 5: Multiply trip length (step 4) by unit health system benefit in Table 6 to yield benefit per trip.

> Example: 3 kms x $0.71 = $2.13 per trip.

Step 6: Multiply by daily number of trips, and expansion factor, to convert to annual health system benefit.

> Example: $2.13 x 10 x 250 = $5,325 per year.

6.10.4 Parameter values

Unit physical activity benefits

The physical inactivity private health and health system benefit per kilometre of walking and cycling is provided in Table 6.

Table 6 Physical inactivity health unit benefit per kilometre travelled (2021 dollars)

	Health private benefit (reduced morbidity and mortality costs)	Health system benefit (reduced health system costs)	Combined
Walking	$2.64	$1.42	$4.06
Cycling	$1.32	$0.71	$2.03

Source: M4-BR chapter 7.

Application recommendations

The unit benefit estimates in Table 6 provide above allow practitioners to include physical health benefits in appraisals. Their use is subject to certain qualifications:

- Where local data is available on the levels of physical activity are available, they should be used instead (via M4-BR Tables 31 and 32) to amend the unit benefits estimates.
- For the benefit to be counted, the trip duration must exceed 10 mins. If benefits involving trips of less than 10 mins are reported, the underlying assumptions and supporting evidence should be provided, and the benefits presented as a sensitivity test.
- If information is available on the per person level of activity, an upper limit should be applied to benefits. The upper limit should be the annual values given in M4-BR Tables 31 and 32 by activity category (or the values in M4-BR Table 28 and Table 29 if activity levels information is not available). Upper limits are adopted in NZ. If any benefits above the annual per person maximum are to be reported, they should be presented as a sensitivity test only.
- If information is available on trip frequency in the catchment, that can be used to moderate the benefits. As discussed earlier, the research suggests that more frequent activity sessions may be more beneficial than only one or two sessions. There is no specific guidance on how to moderate benefits for reduced frequency. A sensitivity test could be undertaken scaling benefits in proportion to, say, 10 trips per week.
- Purely recreational trips of less than moderate intensity are likely to have more limited health benefits, and this should be considered when estimating benefits of an initiative.
- With respect to e-bikes, we recommend that practitioners apply only 70% of the unit costs per km given in Table 6, reflecting the expected lower physical effort (per km) required for e-bikes compared to conventional bikes (see section 10.5 of M4-BR). As the findings of further research are published, this recommendation will be reviewed.
- For e-scooters, no health benefits should be assigned to their use (see M4-BR chapter 11).
- For trip that diverts from active travel, the loss of health benefits that would otherwise have occurred in the Base Case should be counted as a disbenefit for both e-bikes and e-scooters.

6.11 Amenity benefits of walking

A newly monetised category of benefit is the amenity benefit of walking, brought about by an improvement of the walking environment, and is discussed in this section Transport for NSW (TfNSW 2022).[3]

Two approaches are recommended for assessing amenity benefits of walking environment:

- Using the Walking Environment Quality Rating, or
- Using the Walking Environment Attribute Valuation.

For a specific project, only one approach should be used, dependent on information available.

6.11.1 Estimating amenity benefits using the Walk Environment Quality Rating Approach

The amenity benefit of walk infrastructure can be estimated using a walk environment rating approach by following the 6-step procedure in the worked example below.

Step 1: Decide the base case walk environment rating on 0-100 scale where 0 representing poor and 100 representing the best. It is suggested that the rating should be undertaken by 3-5 urban designers and planners independent to the project team to reduce the subjectivity. The rating should be based on the following attributes of the route:

- Route view- streetscape & landscape
- Green and peaceful
- Lively and interesting
- Healthy
- Pedestrian friendly
- Weather protection
- Feeling of personal security - Day
- Personal security - Night

Step 2: Repeat Step 1 and decide the project case walk environment rating.

Step 3: Calculate the weighted average ratings in the base case and the project case using Table 7 as a template.

Table 7 Worked example of assessment of a proposal for walking environment / Pedestrian project

Waking Route Attribute	Base Case Attribute Rating	Project Case Attribute Rating	Changes in Rating from the Base Case	Attribute weighting
Route view- streetscape & landscape	50%	80%	30%	24%
Green and peaceful of route	60%	70%	10%	9%

[3] The methodology, parameter values and discussion have been developed and published by TfNSW 2022. Permission has been provided to reproduce it here.

Lively and interesting	60%	70%	10%	8%
Healthy	50%	75%	25%	15%
Pedestrians friendly route	50%	70%	20%	15%
Weather Protection	30%	60%	30%	5%
Feeling personal security - Day	50%	70%	20%	19%
Personal security - Night	30%	60%	30%	5%
Overall rating (weighted average)	**53%**	**77%**	**24%**	**-**

Step 4: Find the Equivalent Walk Time Factor (EWTF) either from equation 11 or from Figure 3 for the weighted average ratings in the Base Case and Project Case.

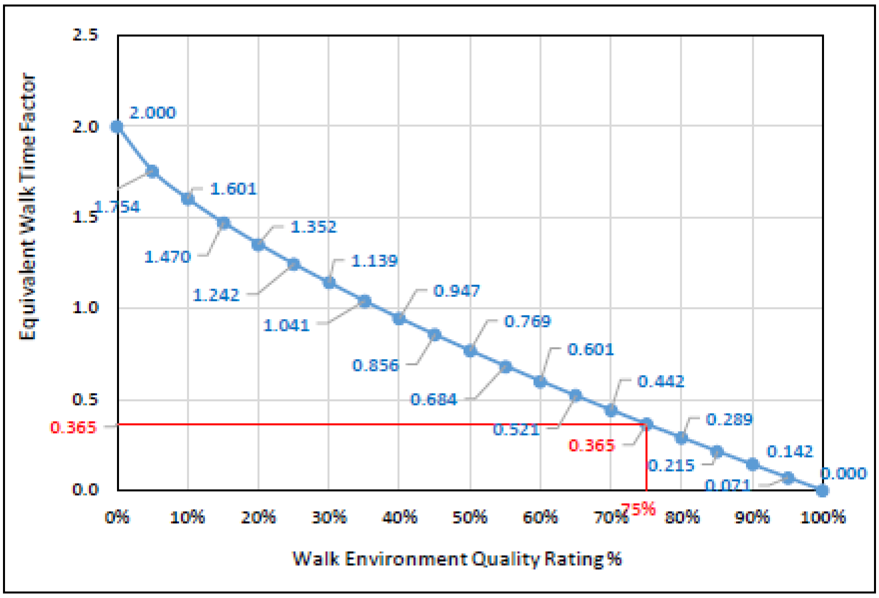
$$EWTF = 2 – (2 \times WQ^{0.7}) \qquad (11)$$

where:

• EWTF = Equivalent Walk Time Factor

• WQ = walk environmental quality rating (expressed as a proportion).

Figure 3 Equivalent Walk Time Factor with Walk Environmental Quality Rating



Source: Douglas (2022)

The example is a base case rating of 53%, and project case rating of 77%, a 24% change. From either equation 11 or Figure 3:

- For the base case rating of 53%, the base case EWTF is 0.72
- For the project case option rating is 77%, the project case EWTF is 0.33.

Step 5: Determine the patronage, walk time and evaluation parameter values such as value of walk time. Estimate induced patronage if any.

- In the example, pedestrian patronage is 1 million trips per annum

- The induced walking trips are estimated using the elasticity of demand with respect to walking environment rating. The recommended elasticity is 0.78 (Douglas, Jones and Whatley 2022).

  The induced patronage

  = 1,000,000 trips x 0.78 x 24% = 187,200 trips per annum.

- The average walk time on the project section is 30 minutes.
- Value of walk time is $28.5 per hour (1.5 times private travel time, based on standard practice of valuing walk time at 50% higher than in-vehicle time).

Step 6: Estimate the amenity benefit of walk environment from the base case to the project case.

Amenity benefit for existing trips

= Patronage x Walk Time x (Base Case EWTF – Project EWTF) x Value of walk time

= 1,000,000 trips x 0.5 hours x (0.72 – 0.33) x $28.5

= $5,557,500 per annum.

Amenity benefit for induced walking trips (using rule-of-a-half)

= Induced patronage x Walk Time x (Base Case EWTF – Project EWTF) x Value of walk time / 2

= 187,200 trips x 0.5 hours x (0.72 – 0.33) x $28.5 / 2

= $520,182 per annum.

The total amenity benefits for existing and induced walking trips are ($5,557,500 + $520,182) = $6,077,682 per annum.

6.11.2 Estimating amenity benefit from Walk Environment Quality Rating Approach

The amenity benefit of walking infrastructure can also be estimated using the attribute valuation approach. It should be noted that the amenity benefit can be estimated from either the Walk Environment Rating Approach or from Walk Environment Attribute Valuation Approach. The two approaches are measuring the same benefit which is not additive. For a specific project, only one approach should be used dependent on information available.

Table 8 presents 12 walk environment attributes (Column 2). Each attribute has a base setting that alternative settings are compared with. The attribute levels (Column 3) are defined by the relativity between the base and alternative settings. Value of walk environment (cents per walk minute) was estimated in Douglas (2022) for a range (Column 4), mean (Column 5) and confidence level (Column 6). The mean value of walk environment is converted to dollar per walk hour (Column 7) for economic appraisal application.

Some illustrative Interpretations of Table 8 are provided below for a few attributes:

- Attribute 3 – Pedestrian Crowding. Compared to “a reasonable pedestrian number”, alternative scenarios, “Crowded”, “No Pedestrians” and “Cycle/Scooters on Pavement”, generate negative values. The scenario “Few Pedestrians” generates a positive value. This can be interpreted that, pedestrians like a walking environment of a few other walkers, but dislike crowding (including due to COVID-19 risks) and dislike situations with no other pedestrian at all for personal security concerns.

Table 8 Value of Walk Environmental Attributes Cents per Minute

Walk Environment Attribute		Attribute Levels	Value of Walk Attribute (Original study)			Economic Parameter Value ($/hour)
			Range (cents per minute)	Mean (cents per minute)	Confidence Level	
1	Walk Setting **versus suburb**	Suburb = Base	-4.5 to +1.5		High	
		City	-3 to +2	-0.8	Med	-$0.48
		Park	0.5 to 3.5	1.7	Med	$1.02
2	Road Traffic **versus Moderate**	Busy Traffic	-4.5 to -2	-3	High	-$1.80
		Light Traffic	0 to 1.5	0.8	Low	$0.48
		Pedestrianized	0 to 3	1.7	Med	$1.02
3	Pedestrian Crowding **versus a reasonable number**	Crowded	-6 to -3	-4.5	High	-$2.70
		Few Pedestrians	0 to 2	0.8	Low	$0.48
		No Pedestrians	-2.5 to 0	-1.3	Low	-$0.78
		Cycle/Scooters on Pavement	-4.5 to -2	-3.2	Med	-$1.92
4	Road Crossing **versus Wait at Junction**	Overpass	0 to 3	1.2	Med	$0.72
		Underpass	-1.5 to +1.5	0.6	Low	$0.36
		Pedestrian Crossing	0 to 2	0.8	Low	$0.48
5	Wide **vs standard**, continuous **vs kerb at crossings,** uneven **vs smooth**	Wide	0.5 to 3.5	2.1	Med	$1.26
		No Kerb	0 to 1.3	0.4	Low	$0.24
		Uneven	-5.5 to -2.5	-3.4	Med	-$2.04
6	Trees **versus No Trees** & Grass Strip **vs no Grass Strip**	Lots of Trees	1.5 to 5.5	3.3	High	$1.98
		Some Trees	0.5 to 3	1.7	Med	$1.02
		Grass Strip	0 to 1	0.4	Low	$0.24
7	Litter / Graffiti **versus Tidy / Graffiti free**	Litter	-3.5 to -0.5	-1.3	Med	-$0.78
		Graffiti	-3 to 0.5	-1.7	Med	-$1.02
8	Seats & Clear Signing versus No Seats & Unclear Signing	Seats	0.5 to 2.5	1.7	Med	$1.02
		Clear Signing	0.5 to 3.5	1.7	Med	$1.02
9	Art / Security Cameras **versus no provision**	Art	-0.5 to 3	0.8	Low	$0.48
		Sec Cameras	-0.5 to 2	0.8	Low	$0.48
10	Night-time **versus Daytime taking account brightness of lighting**	Park - Bright Lighting	-8.5 to -4	-6	High	-$3.60
		Sub/City - Bright Lighting	-3 to -0.5	-1.7	High	-$1.02
		Sub/City - Dim Lighting	-4.5 to -2	-3	High	-$1.80
11	Pavement Quality	Decorative paving **versus asphalt**	-1 to +3.5	1.7	Low	$1.02
12	Provision of Footpath	Basic footpath **versus none**	12 to 44	27	Low	$16.20

Source: (1) Douglas (2022), (2) Douglas, Jones and Whatley (2022).

- Attribute 4 – Road Crossing. Compared to “wait at junction/intersection (base setting), three alternative settings, “Overpass”, “Underpass” and “Pedestrian Crossing”, will all generate positive values thus economic benefit. The “Overpass” is the most favourite road crossing from pedestrian perspective.
- • Attribute 9 – Night-time. Compared to daytime, all night-time settings generate negative values (likely due to security concerns). “Bright Lighting” is better than “Dim Lighting” in suburb and city. In a park, pedestrians attach a high negative value even with “Bright Lighting”.

The following 6-step procedure illustrates how economic benefit can be estimated from one or more attribute changes from a base case to a project case in an economic appraisal.

Step 1: Define a walk environment using the attributes listed in Table 8.

Step 2: For each attribute, decide the appropriate attribute level at the base case and the project case.

- In this worked example, the travel demand is 1 million trips per annum. Each pedestrian needs 5 minutes to cross a busy road.
- Base case: Pedestrian level crossing. Each pedestrian needs 5 minutes to cross a busy road.
- Project case: Overpass. Each pedestrian needs 5 minutes to cross the road via a pedestrian overpass.

Step 3: Look for the equivalent economic value for the attribute level. From section 4 of Table 8:

- In the base case, the parameter value is $0.48 per hour/ pedestrian.
- In the project case, the parameter value is $0.72 per hour/ pedestrian.

Step 4: Estimate economic benefit from the base case to the project case.

Amenity benefit for existing trips

= Patronage x Walk Time x (Project Case Parameter Value – Base Case Parameter Value) x Value of walk time

= 1,000,000 trips x (5/60) hours x ($0.72 – 0.48) x $28.5

= $570,000 per annum.

Step 5: If the project case changes other attributes, repeat steps 1-5 to estimate amenity benefit for changes of each attribute.

Step 6: Sum amenity benefits for all attributes.

6.12 Road decongestion

When car drivers shift to active travel in the Project Case, other motorists who continue to use the road network face less traffic congestion, and thus gain a benefit. The estimation of this benefit is discussed in section 4.8 of ATAP Part M1. The same methodology applies here. Default road decongestion benefit rates set out in section 4.8.3 of M1. A default all day average value for use in benefit estimation of active travel initiatives is provided in Table 1 above.

6.13 Environmental benefits

When car drivers shift to active travel in the Project Case, there is a reduction in road travel, resulting in environmental benefits from reductions in air pollution, greenhouse gas emissions and noise.

These should be estimated in the conventional manner set out in Chapter 8 of ATAP Part T2. Default unit environmental costs are set out in ATAP Part PV5, with a default overall environmental unit cost for use in benefit estimation of active travel initiatives provided in Table 1 above.

6.14 Example benefit calculations — improvement to existing infrastructure

Sections 6.3 to 6.13 above have set out the basis for benefit estimation and example calculations for individual benefit categories. In this section, the examples illustrate the calculation of benefits across the full spectrum of benefits. The input values used are those reported here in M4. Where M4 provides a range, an illustrative value in the range is used. The trip, and trip change numbers, are also purely illustrative. Practitioners should select input values that best reflect their specific application. All the dollar values are in 2021 dollars.

6.14.1 Example 1: On-road bike lane

A 2 kilometre segment of arterial road used by cyclists has no treatments to accommodate cycling, so there is a considerable safety risk. A well designed bike lane is proposed that will reduce the crash risk for cyclists by 70%.

The road carries 100 cycle trips per day, with an average cycle trip length of 3 kilometres. The improvement is expected to attract 10 new cycling trips per day (of similar trip length), all of which switch from car travel, resulting in 10 fewer car trips per day, and three fewer daily car-km per switching trip. The conversion factor from daily to annual benefits is 250.

The benefits resulting from the project are:

- Safety benefits for existing cycling trips (area A in Figure 2)
- Benefits for new cycling trips based on the rule of-a-half (area B in Figure 2). New cycle trips result after the person weighs up the full generalised cost and willingness to pay to make the trip by car and cycling. Those that switch must make a net gain (by definition).
- Benefits in the form of reduction in various costs resulting from the shift of the 10 trips from car to cycling: unperceived car operating cost, health system cost, environmental cost and road congestion cost.

Using the unit values summarised in Table 1, the annual benefits are calculated in Table 9.

For trips that switch from car to cycle:

- There is an average benefit of $0.89 per trip from applying the rule-of-a-half, which converts to an annual benefit of $2,225/year across all new active travel trips. This annual benefit estimate is used in the CBA.
- The people who switch from car to cycle experience a combination of gains and losses, that together add up to the $0.89 average benefit per trip. They gain a private health benefit, and gain in terms of savings in perceived vehicle operating costs. On the other hand, they lose in terms of additional time spent travelling (door to door), likely reduced safety per kilometre travelled, and for some a loss of preference for car travel. The $0.89 per trip average benefit is the net gain across all these gains and losses. The individual components gained and lost by people switching from car to active travel cannot be added to the $0.89 figure because they are already captured in this net gain estimate.

Table 9 Annual benefit calculations — bike lane example

Item	Calculation	Benefit
Existing cycling trips		
• crash cost per trip	$1.27 x 2 kms (average trip distance)	$2.54/trip
• crash cost reduction per trip	$2.54 x 70% (% reduction in crash risk)	$1.78/trip
• annual benefit all trips	$1.78 x 100 existing cycling trips/day x 250 days/year	$44,500/year
New cycling trips		
• benefit per trip	$1.78 crash cost reduction per trip x 0.5 (rule-of-a-half)	$0.89/trip
• annual benefit all trips	$0.89 x 10 new cycling trips/day x 250 days/year	$2,225/year
Unperceived vehicle operating costs		
• benefit per trip	$0.18 x 3 kms	$0.54/trip
• annual benefit	$0.54 x 10 car trips x 250 days/year	$1,350 /year
Health system costs		
• benefit per trip	$0.71 x 3 kms	$2.13/trip
• annual benefit	$2.13 x 10 more cycling trips x 250 days/year	$5,325/year
Environment		
• benefit per trip	$0.04 x 3 kms	$0.12/trip
• annual benefit	$0.12 x 10 car trips x 250 days/year	$300/year
Decongestion		
• benefit per trip	$0.60 x 3 kms	$1.80/trip
• annual benefit	1.80 x 10 car trips x 250 days/year	$4,500/year
Combined benefits		$58,200/year

6.15 Other considerations

6.15.1 Air pollution health impact

Active travellers within a road corridor will be exposed to the air pollution generated by motorised road vehicles, resulting in a health cost to them. M4-BR chapter 8 discuss the research on this impact and compares it with the other health effects of active travel.

In an assessment of an active travel proposal, this effect needs to be recognised as a cost to people that shift from car use to active travel as a result of the project. As explained in section 6.3, application of the rule-of-a-half determines the net gain from switching, including accounting for this cost.

If a separate reporting of the size of this health cost component is required, there are two issues:

- M4-BR Chapter 8 does not provide a sufficiently clear estimate of the size of this health cost ~~scale~~ at this point in time
- Section 6.13 above reports the air pollution costs of car use, which become air pollution reduction benefits of the switching from car use to active travel that arises from an active travel project. There is therefore potential for double-counting if these benefits are reported again here.

Overall, if this impact is to be recognised in an appraisal, it is recommended that it be noted as a potential non-monetised impact, with a caveat noting that it could be double-counting the pollution benefits in the environmental benefits estimation.

6.15.2 Productivity impacts of active travel

At this point in time, based on the literature reviewed, insufficient evidence is available to justify including in a CBA improved productivity as a benefit of increased active travel.

Some have suggested that there are productivity benefits from active travel arising from the increase in healthy life years. However, the productivity impacts of active travel are rarely explored within the literature (Möller et al., 2020).

If future research provides evidence for such a relationship, the benefits could then be included in cost benefit analysis of active travel (Möller et al., 2019) — although any inclusion of productivity benefits would need to ensure there is no double counting of other benefits associated with increases in healthy life.

6.15.3 Reduced absenteeism

At this point in time, based on the literature reviewed, insufficient evidence is available to justify including in a CBA reduced absenteeism as a benefit of increased active travel.

Absenteeism does not seem to be included in the various tools that exist to assess the impacts of active travel. The overwhelming majority of the literature reviewed for the development of this guidance did not assign a value to reduced absenteeism associated with active travel. One exception was Hendriksen et al., 2010, that found some evidence that cyclists experience slightly fewer sick days, For instance, they found that Dutch cyclists have around one less sick day per year than non-cyclists, and the significance of this remained even when controlling for the health status of both groups. The results of this study also found a dose response relationship, in that those that reported more cycling had fewer sick days than those that cycle shorter distances.

6.15.4 Liveability, accessibility and social inclusion

See ATAP Part O3 for further discussion on assessing urban amenity and liveability.

At this stage, these effects should be recognised as non-monetised benefits of active travel improvements.

Liveability is a general term for local economic, social and environmental quality, including factors such as affordability, economic opportunity, safety, opportunities for recreation and fitness, community cohesion (positive interactions among neighbours), quiet, air quality and beauty. Active transportation planning can help achieve these liveability goals by providing affordable, sociable, fun, healthy and environmentally responsible travel, and by improving the public realm (Appleyard et al., 2014).

It has been asserted that cities that have more comprehensively embraced active travel are more attractive and desirable (van Wee, 2021). Although it may be difficult to monetise these factors individually, there is little doubt that many people place a high value on protecting and enhancing their community's liveability (Harper, 2018), and will pay significant premiums to live in more walkable and rideable neighbourhoods (Boarnet et al., 2017). Recent Australian work has found that enhancements to a city's bicycle infrastructure can have substantial welfare benefits with regard to increased accessibility and transport choice (Standen, 2018). It is argued that the ability of high quality bicycle infrastructure to attract users, which in many cases may result in longer travel times for the user, suggests some welfare benefit (Standen, 2018).

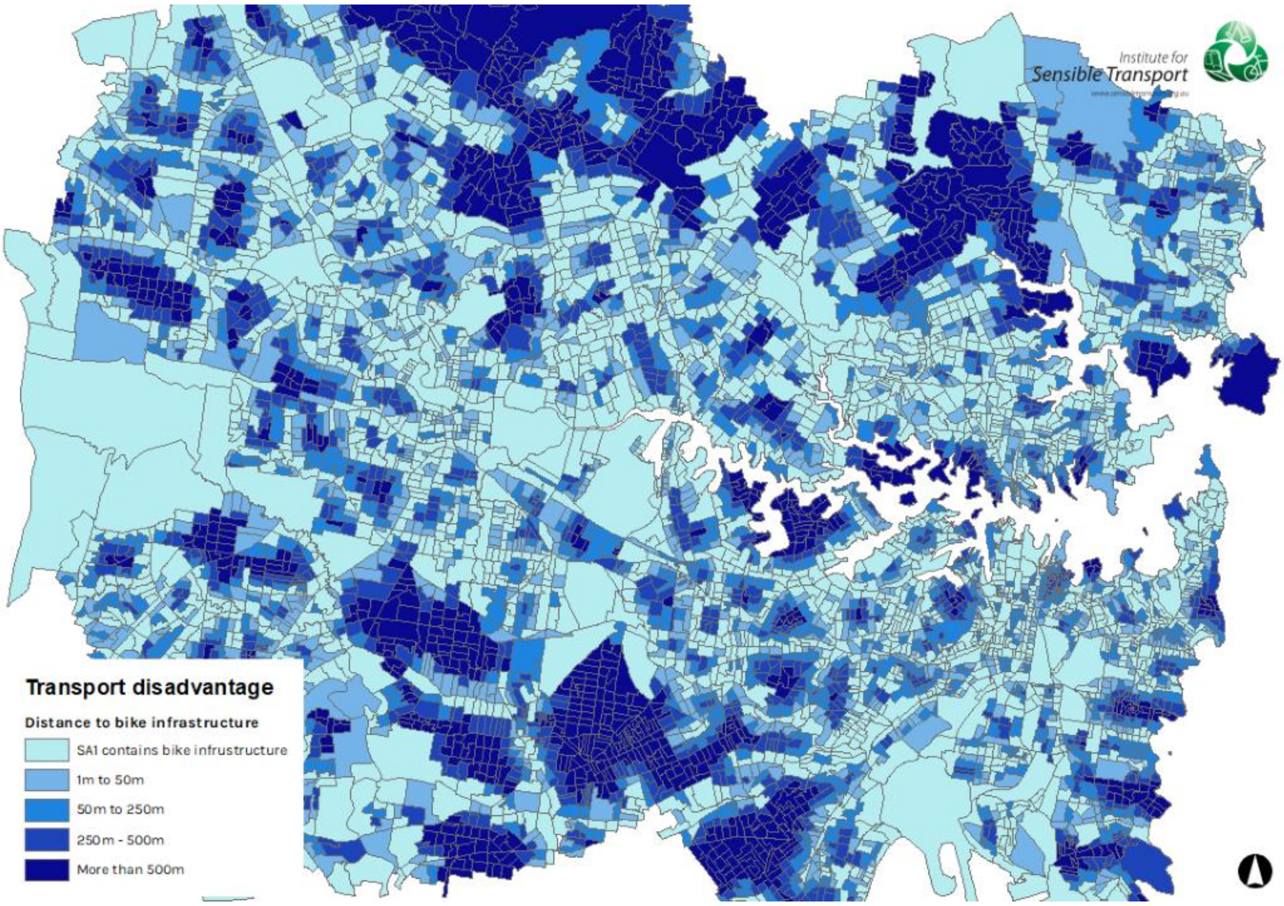
6.15.5 Transport disadvantage

Reduction in transport disadvantage as a result of an active travel initiative should be considered as part of the distributional impact assessment (see ATAP Part T5).

Improvements to active travel opportunities are capable of improving accessibility and reducing transport disadvantage (Buehler and Pucher, 2021). Walking is the lowest cost mode of transport, and with few operational costs and modest capital costs, bicycling is considerably more affordable than motor vehicle transport. For these reasons, enhancing the walking and cycling environment provides higher levels of transport equity, enabling lower cost access to jobs, services and other destinations.

When planning future cycling networks, some Australian agencies have begun to integrate GIS tools to prioritise the development of infrastructure to specifically address areas of transport disadvantage. Public Transport Accessibility Level (PTAL) maps use geospatial tools to calculate distance from public transport stops, often weighted by service frequency, the ability to access other parts of the transport network, and everyday services. Just as public transport departments use PTALs, it is possible to create maps highlighting areas without bicycle infrastructure (see Figure 4 as an example). Combining both the conventional PTAL, and the map shown in Figure 4 helps to create a picture of where both public transport *and* bicycle infrastructure is lacking, in order to prioritise infrastructure in areas that address locations of transport disadvantage. In effect, it provides a more robust understanding of areas with high levels of forced car dependence — that is, areas where motor vehicle use is the only viable option to meet daily transport needs.

Figure 4 Transport Disadvantage (cycling), Sydney



Source: Davies et al (2020)

6.16 CBA application tool

The Queensland Government have an Active Travel CBA Tool. The tool has recently been updated to retain consistency with this ATAP guidance (M4). For further details and access to the tool click here.

7. Demand estimation

This chapter is concerned with estimating active travel demand. It considers principles, data sources and methods, discussing their use in estimating the demand impact of active travel initiatives (projects, plans and policies). M4-BR provides supporting background information (travel patterns in chapter 2, factors influencing active travel in chapter 3, and demand estimation in chapter 4).

An important observation is that this area of active travel assessment is significantly under-developed, with significant scope for further research. As a result, the guidance provided here is quite high level. Further research would allow more definitive guidance to be developed. It also means that sensitivity testing of assumptions is important with all active travel demand estimation.

A range of approaches are discussed here: simpler approaches including elasticities and diversion rates (sections 7.3 to 7.5); the use of models (section 7.6); complementary approaches (section 7.9). The choice of approach will depend on various factors: scale of initiative; availability of existing models and data; budget and time available; and level of accuracy required.

With respect to scale of initiative, the following considerations will assist practitioners:

- Small scale initiatives unconnected from the rest of the active travel network are unlikely to increase active travel trips. For instance, a pedestrian refuge might make existing walking more comfortable, but is unlikely to generate new walking trips. In these cases what is required is information about existing active travel trips.
- In contrast, a small-scale initiative that overcomes a weakness in the overall network is likely to generate new trips. One of the simpler methods (section 7.3), and/or the use of the elasticity and diversion rates (sections 7.4 and 7.5) would be suitable.
- For medium scale initiatives with some impact on demand, one of the simpler methods, elasticity and diversion rates are all suitable.
- As the size of the initiative increases, the use of a demand model could be considered worthwhile (section 7.6). For example, for a sizeable extension to a cycle network, construction of a missing link, or construction of an off-road shared path. Use of a model will allow any network consequences, including influences on demand for other transport modes, to be recognised.
- For a major infrastructure initiative, more complex modelling approaches may be required, such as a fully specified four-step network-based model (section 7.6.2). For example, a bridge over a river connecting with large residential or working populations.

The choice of approach will typically require advice and judgement from an experienced analyst. Advice of professional demand modellers should be sought in deciding when, and how, more complex modelling should be used.

In network and area planning, at the initial strategic stages of planning, the simpler methods and aggregate level elasticities will be useful. As the planning process progresses to more detailed stages, demand models with network representation would facilitate better assessment.

Impact of COVID

The occurrence of the COVID-19 pandemic since early 2020 has had various impacts on travel patterns. On the evidence available to date, a primary observation has been that substantially more people worked from home during the pandemic, with some of that effect continuing. For active travel, recent research has shown that:

- In Melbourne, compared to 2019 numbers, pedestrian trips dropped by up to 90% at the worst parts of lockdowns, with trips numbers still well down in April 2021 (Hermann et al. 2021)
- Cycling increased for recreation and exercise, but decreased for commuting. In Melbourne, bicycle counts leading into the city were significantly dampened during lockdowns, they remain around 40% below pre-COVID levels, but have fallen less near upgraded infrastructure (Delbosc et al. 2022).

A clearer picture of the full impact of the pandemic will be understood as further research is published.

E-bikes and e-scooters

No specific guidance is provided here on demand estimation for e-bikes and e-scooters. Both are expected increase their share of the urban travel market as they open up new trip opportunities. Numerous studies have found that e-bike riding patterns are different to those riding conventional bikes, including that they appear to replace motor vehicle travel to a greater extent than conventional bikes. As further research is undertaken, the guidance here can be expanded to address e-bikes and e-scooters.

7.1 Influencing factors

There is a wide and varied set of factors that influence, or drive, the amount and nature of active travel. A range of personal characteristics, such as demographics and attitudes influence travel behaviour choices directly, and indirectly through residential location decisions which in turn influence whether people choose active modes. Some factors are barriers that hinder the uptake of active travel, while others are facilitators that encourage its uptake.

Table 10 below offers a spectrum of factors that can influence active travel. It identifies whether they are able to be significantly influenced by transport agencies or wider government policies. It also provides planners and analysts a tool to check the scope and adequacy of coverage of their models and studies are realistic.

The table lists demographics as a factor that can be influenced by transport agencies and wider government. policies. It could be the case that major active transport initiatives could draw people to live in nearby areas. Younger populations, who favour active travel more, would be more likely to choose residential locations with better access to active-travel infrastructures (Caulfield et al. 2017). Monitoring and research is required to see whether major active travel initiatives result in such an effect. The proposed green bridges initiatives in Brisbane is potentially one such initiative.

Of particular importance is the *relative utility* offered by the active travel network, compared to other travel options. All other factors being equal, if a city has high levels of traffic congestion and limited, expensive parking, the demand for cycling will be stronger than a city in which there are few constraints on motorised travel (Fishman, 2016, Fishman, 2019).

M4-BR chapter 3 provides further discussion on influencing factors.

Table 10 Factors influencing active travel demand

Factors influencing active travel	Influenced by transport agencies	Influence by wider government policies
Demographics (age, physical ability, income)	✓	✓
Active mode type, including variations such as cargo bike, e-bikes etc, as well as bike, scooter share services	✓	
Community attitudes and preferences	✕	
Climate (short term)	✕	✕

Geography and topography	✗	✗
Development density and mix, and projections for future growth	✗	✓
Car ownership	✓	✓
Relative ease and cost of travel by different modes. Car travel competes with active modes, while public transport tends to complement it. Included within this category are: road and parking supply, regulations and pricing; severity of traffic congestion	✓	✓
Active travel conditions (safety, protection from weather)	✓	✓
Active travel infrastructure and facilities (such as footpaths, bikes lanes and shared paths)	✓	✓
Surrounding network conditions (motor vehicle volumes and speeds)	✓	✓
Universal design (whether the facilities accommodate people with disabilities and other special needs)	✓	✓
Targeted active transport education and encouragement campaigns	✓	✓
Transport demand management programs, such as TravelSmart programs and marketing campaigns	✓	✓
Wayfinding signage offering time and distance estimates to key destinations	✓	✗

Note: ✓ denotes can influence, ✗ denotes cannot influence.

7.2 Active travel data

The quality of demand estimates is critical to effective transport assessment and planning. Despite its importance, demand estimation remains a difficult area in active travel assessment and planning. Active travel levels and patterns are less well known than motorised travel. So understanding the assumptions that underpin demand estimates are critical and should always be clearly stated and documented.

The primary sources of active travel demand data are: the ABS Census which measures the journey to work every 5 years at a national level; and travel surveys and traffic counts in each jurisdiction. M4-BR section 2.1 and 2.10 provide further discussion on active travel datasets in Australia.

7.3 Simpler estimation approaches

This section draws on UK Government guidance on active travel (UK Department for Transport (DfT), 2020).

Comparison studies

This method is the least complex and least costly. It involves, predicting active travel demand changes resulting from an intervention through comparisons with the responses to similar interventions in similar settings (population, land use and socio-economic). The difficulty is that there are potentially many differences between the two cases. Notwithstanding this, the comparison may be a useful guide.

Responses to similar completed interventions should ideally be investigated using rigorous before and after studies. The data can also be assessed to identify variables that contribute to the different levels of usage between areas, time or facility.

Sketch planning method

This method predicts active travel demand changes based on simple rules-of-thumb calculations (UK DfT, 2020) involving trip lengths, mode share and other aspects of active travel behaviour. Sketch planning relies generally on existing data or easily collected data (such as population or census data, traffic counts, pedestrian counts, cyclist counts, zoning or land use data, trip length or crash data). For aspects where data is not available, assumptions have to be made. These can be informed by aggregate behaviour studies (see below), or less formal data from other locations, noting concerns about transferability of results.

Aggregate behaviour studies

This approach relates active travel in an area to its local population, land use and other characteristics, usually through regression analysis research. The model equations can be used to predict demand in other areas. Some data used for these studies is obtainable from census or geographical data sets (such as car ownership, income, average age, gender and journey to work data). This approach may be useful for a large network study, but otherwise may not be cost effective. Also, data such as bicycle ownership is not readily available at the local or zonal level. Geographical information systems (GIS) may be used to obtain data on the topographical profile of an area, network or city, which may be a useful characteristic for cycling demand.

The bike use propensity index discussed in M4-BR section 4.4 included aggregate behaviour as an element in a wider cycling network model.

7.4 Demand elasticities

Demand elasticities are a standard tool for assessing demand changes in transport economics and assessment. The elasticity of demand, with respect to a given variable is the percentage change in quantity demanded resulting from a 1% change in the variable (ATAP T1).

In transport demand estimation, demand is measured in trips, and the variables for which elasticity estimates are generated are typically price, income, and various measures of quality (e.g. time). In the case of active travel especially, the quality attribute might be changes to the level of *comfort*. For instance, an elasticity of 0.5 for bike use with regard to levels of comfort/protection would mean that each 1% increase in comfort results in a 0.5% increase in cycle travel.

Note that an elasticity estimates the size of increase in trips, whereas a diversion rate (discussed in section 7.5) indicates their source (diverted and newly generated). They should be used in combination.

Aggregate level elasticities

M4-BR section 4.1 summarises the findings of an extensive review of the North American literature on active travel elasticities for a range of different measures of active travel infrastructure quantity or quality. For example, for trips to work by bike, it showed a demand elasticity of around 0.35 for increases in the percentage of streets with bike lanes. It also reported elasticities for walking between 0.09 and 0.27.

The elasticities reported in the literature relate to fairly *aggregated* measures of infrastructure level, e.g. proportion of bike lanes or footpaths in the road network or in an area. Such coarse measures will be helpful in a network planning context, but too coarse for the assessment of many active travel initiatives, especially smaller ones.

With other modes, demand elasticities have been estimated for generalised user cost and its components (money prices, travel time and various other aspects of trip quality). These provide an important mechanism for estimating the impact on demand of the various types of transport initiatives. Unfortunately, no evidence has been found in the literature of such *disaggregated* demand elasticity values for active travel.

In the absence of such disaggregated estimates, practitioners will need to continue to use the simpler estimation approaches discussed in section 7.3.

Generalised cost elasticity

A complementary approach that practitioners can also consider using is to develop indicative active travel change estimates using a generalised cost elasticity. Section 2.2.2 of ATAP Part M1 reports generalised cost elasticities for public transport.

If this approach is applied, it is recommended that a range of generalised cost elasticity values be used as sensitivity testing in the appraisal of an initiative. Using the estimates from M1 as indicative, it is suggested that practitioners estimate active travel demand changes using generalised cost elasticity values of – 0.5, – 1.0 and –1.5.

Section 6.1 discussed generalised cost, and its components and estimation for active travel. To estimate the size of the increase in active travel trips due to an initiative using a generalised cost elasticity use the following steps:

- Estimate the generalised cost per trip in the Base Case and the Project Case
- Express the cost reduction as a percentage of the Base Case generalised cost
- Multiply by the generalised cost elasticity to generate the percentage increase in active travel trips
- Multiply the percentage increase in trips by the number of Base Case trips to estimate the increase in active travel trips.

Example

Assume there are 500 active travel trips per day in the Base Case, with a generalised cost calculated at $3.00 per trip. An active travel improvement results in the generalised cost to change by – $0.30, i.e. – 10%. This results in:

- For elasticity of –0.5: increase in trips = 5% (i.e. – 10% x – 0.5); i.e. 25 trip increase (i.e. 100 x 5%)
- For elasticity of –1.0: increase in trips = 10% (i.e. – 10% x – 1.0); i.e. 50 trip increase (i.e. 100 x 10%)
- For elasticity of –1.5: increase in trips = 15% (i.e. – 10% x – 1.5); i.e. 75 trip increase (i.e. 100 x 15%)

A related approach was used in active travel worked example 4.2 where the generalised cost elasticity was estimated for an assumed per cent demand increase.

Caveats

A few caveats should be noted about using elasticities:

- They are most reliable when used to assess changes of similar scale to the case where the estimate is derived
- Demand is influenced by a wide range of factors other than those represented in a given elasticity. As such, an elasticity estimate must be viewed in combination with other factors when undertaking holistic active travel planning
- Elasticities may change over time as broader changes in tastes and preferences occur, so estimates should be reviewed as general population trends evolve over time.

Note that different steps are required for application of diversion rates (section 7.5), or models (section 7.6).

7.5 Diversion rates

Once the overall scale of active travel response is estimated (sections 7.3 and 7.4 above), diversion rates can be used to indicate the sources of additional travel:

- Newly generated trips that would not otherwise have been made, or
- Trips that have diverted from other modes or routes.[4]

This enables quantification of the changed travel patterns: trips, trip-kilometres, trip-hours by mode for use in appraisal of improvements. A Queensland Government (SKM PwC, 2011) investigation found demand changes resulting from a new walking or cycling initiative came from a mix of the following four groups:

1. Reassignment: existing walking or cycling trips that changed their path to take in the new route
2. Induced: a trip generated by the project, from someone that would not have otherwise travelled
3. Car mode substitution: An active travel trip that replaced a car trip
4. Public transport mode substitution: An active travel trip that replaced a public transport journey.

Queensland examples

Table 11 reports diversion rates based on intercept surveys in Brisbane (SKM PwC, 2011) conducted at four locations, primarily bridges in which active transport infrastructure was present. Reassignment from other active travel routes was the biggest sources of trips after the active travel improvements, particularly in inner city areas. A similar result was observed in the UK (Goodman et al, 2013).

Table 11 Trip diversion rates from Brisbane intercept surveys

Trips from	Diverting to			
	Cycling		Walking	
	Inner city	Other areas	Inner city	Other areas
Car	10%	15%	5%	10%
Public transport	20%	0%	15%	0%
Reassign	65%	55%	70%	50%
Generated	5%	30%	10%	40%

Source: SKM PWC (2011) p.33

Table 12 provides an indication of potential diversion rates from surveys of Queensland active travel projects (CDM Research, 2016). Respondents were asked what mode they would have taken if the project did not exist/had not been undertaken.

Table 12 Diversion rates — transport purpose journeys (QLD example)

	Cycling	Walking
Car mode substitution (would have driven)	~15%	9%
Reassigned	60%	37%
Induced	7% or less	7% or less

[4] Metz (2020) notes that shifts to active travel may mostly come from public transport rather than car, referring to experience in Copenhagen and reflecting on the UK context.

NB: Numbers do not add up to 100 due to the exclusion of public transport.

Source: CDM Research 2016

The authors of the above study note that high levels of variation in public transport diversion can be expected based on the quality of the public transport in the specific location.

The results in Table 12 are for transport purpose journeys. For recreational journeys:

- ~66 – 75% of path users would have used another route, had the path not been built (reassigned)
- Almost all the remaining users would have not travelled (induced)
- Very few shift from other modes.

It is important to recognise that the study results varied considerably between projects investigated, and this should be taken into account when determining diversion rates for new projects. The statistical uncertainty of the above estimates led CDM Research (2016) to suggest the above rates should be customised based on the individual characteristics of each site. This includes such factors as residential and population density, the level of car ownership and use, trip patterns, access to public transport and various trip attractors (such as public transport hubs, shopping centres and recreational areas), and the quality of other active travel route options. The authors of the CDM Research report stress that the figures presented above should not be viewed as definitive, but rather a guide. Given the paucity of data on this topic in Australia, it is defensible to use the above figures as a starting point. The individual site diversion rates can be found in CDM Research (2016). Future research in this area, particularly relating results to the range of influencing factors listed above, would be worthwhile.

Application example

The worked example in section 7.4 is continued here: 500 active travel trips in the Base Case; a 10% reduction in generalised cost due to an improvement. For illustration here, we assume a generalised cost elasticity of – 1, which results in a 10% increase in trips, that is 50 trips. For simplicity, we assume the improvement is to a middle suburb walking facility.

Step 1: Adopt the ‘other areas’ walking diversion rates from Table 11.

Step 2: Using the diversion rates from step 1, estimate the number of trips from the various sources, as shown below:

Trips from	Trips diverting to walking
Car	10% x 50 trips = 5 trips
Public transport	0%, 0 trips
Reassign	50% x 50 trips = 25 trips
Induced	40% x 50 trips = 20 trips

Step 3: For trips diverted from car travel, apply a suitable car occupancy rate to infer the reduced number of vehicle trips. To illustrate, if an occupancy rate of 1.3 is used, the number of vehicle trips diverted is 5 / 1.3 = 3.8 (round up to 4).

Other examples

Diversion rates can also be applied to the introduction of new *policies* not just infrastructure improvements. For example, diversion rates for travel behaviour change initiatives are reported in ATAP Part M5, Chapter 3, and in NZ guidance (NZTA 2020, see Table 5).

7.6 Modelling

For many active travel initiatives, the above approaches will provide a cost-effective basis for estimating active travel demand. Where more complex network effects are likely, it may be cost effective to develop a model, or use an existing model.

7.6.1 Discrete choice models

Discrete choice models are widely used in travel demand estimation. They predict an individual's trip decisions as a function of any number of variables. They do this by estimating the probability of selecting each of the choice options. Discrete choice models can be used to estimate the total number of people who change their behaviour in response to an intervention. Parameters from these models can also be used to estimate the elasticity of demand (see section 7.4).

Discrete choice models are often sed to model mode choice. Transport mode choice can be dependent on a vast array of variables. These include trip distance, trip time, level of safety (actual or perceived), level of infrastructure provided, embedded travel habits, and cultural bias towards modes of transport.

Discrete choice models can be calibrated using stated preference survey data or revealed preference data. As such, they can be a cost-effective way of estimating active travel demand for new facilities in areas with little or no relevant data (although cost effectiveness will depend on the scale of the active travel initiative).

Examples of discrete choice model applied to cycling can be found in: UK DfT (2020, section 2.3) and Mulley et al (2013).

7.6.2 Traditional four-step network demand models

The four-step travel demand model has been the standard model to investigate urban travel for many decades. It models land use conditions, transport network characteristics and relevant travel behaviour variables to predict current and future travel patterns. The four steps are: trip generation by trip purpose; trip distribution between origins and destinations; mode choice; and trip assignment to a network. Part T1 of the Guidelines provides guidance on four-step models.

Some Australian cities have active travel as one of the travel modes in their four-step model. In the standard application of the model, the zone system is of a size suited to modelling motorised travel. At this level of modelling, the model generates indicative macro level active travel demand estimates as follows:

- An active travel trip matrix, showing trip numbers between each origin-destination pair, including intrazonal trips within each zone
- Active travel mode share.

Active travel trip assignment is generally not undertaken for a standard modelling application of a four-step model, as the zones are too coarse to provide any accuracy. In practice, active travel is generally dealt with by simplifying assumptions:

- About what happens intrazonal (and a lot of active mode trips occur here)
- As a function of distance to the surrounding zones only (e.g. as-the-crow-flies centroid to centroid).

As a result, most active travel interventions cannot be introduced and cost-skimmed as for mechanized modes, and their impacts must be proxied. If trip assignment is required, a complementary sub-model would be required with increased spatial detail, with a significantly finer zone sub-system and finer network representation. This would be required to model the majority of active travel trip lengths which are much shorter (e.g. 0.4 to 1.2 kilometres for walking and 3 – 7km for cycling). Active travel models need to have greater detail to account for the various paths and routes available.

There are a range of other challenges in modelling cycling using a four-step model:

- The factors behind a decision to cycle, and the route used, are complex. This includes consideration of path quality, actual and perceived safety, time competitiveness against other modes of transport, trip distance, and cultural factors.
- While theoretically every road is able to be used be a bicycle user, the quantity and speed of traffic has negative impacts on the desire to use a given route, meaning cycling may not occur or cyclist may take a longer and slower route to increase safety, but decrease attractiveness.
- Trip assignment for cycling therefore requires consideration of the quality of the network, rather than just the shortest path across the network. Research by SGS Economics (commissioned by the City of Melbourne) found that cyclists are willing to travel up to 30% further for a given trip if that route takes in safer infrastructure (SGS Economics and Planning, 2015). Stated or revealed preference surveys can be used to determine the relative attractiveness of different cycling infrastructure. Trips can be then assigned to the network based on weighted scores for the proposed bike network. This can be used to model changes to daily ridership over different links, including new riders that have shifted from other modes and those who change route to use the higher-quality infrastructure.
- By contrast, road users can be understood to generally favour faster, more direct routes, as do public transport users. Road and public transport users are also more concerned with overall trip time rather than trip distance, whereas most cycling journeys are 5km or less. This places significant restrictions on the number of trips across an urban area of which the bike is likely to be a valid mode choice.

Any four-step modelling must directly address these issues to produce defendable results.

7.7 Forecasting

For planning and assessment, demand needs to be forecast into the future. Two approaches are available:

- Direct growth rate projections: This is the simpler approach, and involves directly applying an assumed growth rate(s) into the future from a base year. The growth rates would be based on observations and forecasts for key influencing factors, such as population growth and economic growth. Growth rates could vary across transport mode, time period, and trip purpose. Data and information should be sought to guide these choices.
- Indirect modelled projections: This involves using a model to estimate future travel levels and patterns. In this approach, future growth rates of the model's various explanatory variables are estimated. This approach has the advantage of better representation of key inter-relationships, such as network effects.

Whichever approach is used:

- The underlying growth assumptions (e.g. demographics, the economy) need to be the same in both the Base Case and Project Case of an appraisal. Any differences in growth between the two cases are then due to the effect of the proposed initiative in the Project Case.
- The quality of the forecasts are dependent on the quality of the inputs. So if limited data is available, as is usually the case with active travel, sensitivity testing of projections is critical to test the robustness of assessment results to variation in inputs.

7.8 Other considerations

7.8.1 Demand ramp-up

A linear ramp-up over 3 years is recommended.

Initiatives will usually take time for adoption levels to reach their plateau point (Kahlmeier et al., 2017). It is therefore appropriate to apply a ramping up period. This period will vary from project to project, often in ways that are difficult to anticipate. Limited evidence has been found on this, although the WHO HEAT tool uses a 5 year ramp-up period, with a 20% increase in each of the 5 years (Kahlmeier et al., 2017). This is considered higher than the ramp-up typically assumed in Australian transport initiative assessments.

7.8.2 Retention rate

What is the retention rate for new active travel trips? How confident can we be that forecast levels of new active travel generated by improved infrastructure will be retained? Goodman et al (2013, p.1) noted the lack of research into this question. Their before and after study of three new active travel infrastructure initiatives in the UK noted very high retention levels two years after initiative opening. However, they did note that the new initiatives 'may have primarily attracted existing walkers and cyclists'. A similar outcome was evident in the results of intercept surveys in Brisbane reported in SKM PwC (2011).

It is important to check if any assumptions made about retention rates have been built into future year demand forecasts. All assumptions should be well documented.

Until better data becomes available on retention rates, it is recommended that sensitivity testing be carried out to simulate the effects of different retention rates, particularly if there is little usage history in the relevant initiative catchment.

7.8.3 The use of GIS

Geographical Information Systems (GIS) are information management tools with graphical display capabilities that can be used in many ways to analyse potential demand. GIS can also be used to enhance active travel demand forecasting and initiative assessment.

An example of this approach was developed in a University of Queensland study (Hutchinson 2000) of cyclists travelling to the campus. An multiple criteria analysis was undertaken using survey data to determine the important factors in cycle route choice. Data on factors such as directness, quality and topography of the route were used in a GIS map of the area from which predictions of cyclists' preferred routes could be made.

GIS is used in two applications here: activity / agent based models (see above); and the 'bike use propensity index' (see below).

7.9 Other tools for active travel network planning

Several other demand assessment tools are available for use in active travel network planning. These can be used to complement conventional demand models, or when such models are not available.

Origin-destination mapping

The mapping of trips on an origin-destination basis has long been an important tool for understanding travel for a given area. Origin-destination data for active travel trips comes from household travel surveys and the ABS Census for Journey to Work. (See M4-BR section 4.2 for further discussion).

Identifying latent demand — the bike use propensity index

An important aspect of planning for an active travel network is an understanding of latent demand.

High quality bicycle infrastructure in built up areas can be expensive and government budgets are limited. It is therefore important, when planning a future cycling network, to determine spatial variation in the latent demand for cycling. The Bike Use Propensity Index is a tool that can assist in this task by generating a heat map of latent demand for cycling. These maps provide a clear illustration of the spatial variation in propensity to cycle.

Using this information, the Propensity Index can help guide areas for future policies, plans and investment in cycling by identifying the areas where the greatest uptake in cycling is likely to occur. Actions focusing on high propensity areas are likely to include infrastructure projects, but should also consider behaviour change initiatives and other support programs to encourage greater cycling uptake. Note, however, that the tool does not identify the extent to which uptake will occur.

Use of the tool should still be complemented with assessments of barriers, which may not be fully picked up by the tool.

(See M4-BR section 4.4 for further discussion on the tool and its application.)

Time competitiveness analysis of mode choice

Davies et al, (2019) investigated the role of time competitiveness between cycling and public transport in explaining mode share. The work found that when public transport is faster it depresses the mode share for cycling, and when bicycle travel is faster the bike mode share is amplified. This finding has the potential to influence the way bicycle network planning is undertaken, to identify corridors where bicycles are most competitive against other modes of transport (particularly car travel) to provide the most mode shift towards bicycle use. (M4-BR section 4.5 provides further discussion.)

Elevation mapping

Another tool for planning is the elevation difference in routes. For commuting active travel, routes with steep hills might want to be avoided (Fraser and Lock, 2016).

Note that this is less of an issue with e-bikes, which essentially ‘flatten’ hills that would otherwise deter cycling. E-bikes sales are rising substantially, as is their use in cities and towns (see M4-BR chapter 10).

Relative attractiveness

The NZ *Monetised benefits and costs manual* (NZTA 2020) provides a *relative attractiveness* table for different types of bicycle infrastructure, and this has been reproduced in Table 13. The table does not contain *protected bike lanes*, which, as shown earlier, provides higher levels of attractiveness than painted bike lanes. The difference between a street with parking and no parking would also appear to conflict with the earlier reported literature on people’s preference for different types of infrastructure (i.e. there is likely to be a bigger difference in relative attractiveness than the 0.1 difference shown in Table 13).

Table 13 NZ cycle infrastructure relative attractiveness

Type of cycle facility	Relative attractiveness
On-street with parking, no marked cycle lane	1.0
On-street with parking, marked cycle lane	1.8
On-street without parking, marked cycle lane	1.9
Off-street cycle path	2.0

Source: Barnes et al (2005), reported in NZTA (2020)

8. Infrastructure costs

The cost of active travel infrastructure will vary depending on its type, location, scale, quality and construction industry conditions. ATAP Part O1 provides guidance on cost estimation.

A range of indicative unit cost estimates are provided below for various active travel initiatives. These indicative unit costs are suitable for use in strategic planning, strategic assessment and rapid appraisal.

Table 14 Indicative unit costs of active travel infrastructure

Item	Unit cost
Foot and cycle bridge over four-lane road with stairs	$1.8 million
Foot and cycle bridge over four-lane road with ramps	$5 million
Pedestrian refuge island (depending on style and extent)	$5,800 to $35,000
On-road cycle lane markings	$2,900 per km, plus $120 per bicycle symbol
Off-road shared pedestrian and cycle path: • components – Concrete pathway, plus – Associated works and line marking	$1.8 to $3.5 million per km[1] $150 per square metre $760 per lineal metre

Source: ATAP M4 2016 values indexed to 2021 dollars using ABS 2022.

1. DIT (2012, p.65).

9. Performance monitoring

9.1 Why monitor?

Performance monitoring is a process for testing whether an initiative is achieving, or has achieved, its objectives. Performance monitoring results could be used to:

- Identify features of initiatives that have been successful in achieving objectives and those which could be improved for future active travel initiatives
- Identify the need for on-going improvements to recently delivered infrastructure
- Improve the design and delivery of future active travel initiatives
- Communicate insights to stakeholders.

Effective performance monitoring includes:

- Obtaining data that can be used to validate assumptions and improve the accuracy of demand estimation models
- Identifying missing gaps and addressing those gaps.

Resources available for monitoring tasks — including design of the monitoring program, data collection and reporting — will always be constrained. Monitoring is therefore likely to be confined to high cost initiatives, initiatives that are expected to have a significant impact on a specific policy objective (such as reducing crash risk at a blackspot) or initiatives that are intended to test new design philosophies or concepts.

9.2 Measures of success

Data collection to determine the level of success or changes attributable to an active travel infrastructure upgrade or new facility would include the following:

- Facility usage (such as trips/day, trips/hour) disaggregated by:
  - New trips (that is, previous latent demand)
  - Mode shift (from private vehicle or public transport to active travel)
  - Mode shift (from private vehicle to supporting public transport trips)
  - Route shift (re-routing existing active travel trips onto more attractive routes) (Bucher and Froyen 2019).
- Changes in participation:
  - Participation rates (weekly, monthly, other as suitable to the context, e.g., regional locations may require longer time frames to capture tourism related activity)
  - Per mode (walk, run/jog, push bike, electric bike, push scooter, electric scooter, mobility device)
  - Demographic characteristics (age, gender, attitude (e.g. confident, cautious))
- Changes in travel times
- Safety improvements (that is, fewer crashes)
- Personal security (that is, lower incidence of crime)
- Active travel user satisfaction (that is, percentage of users happy with the facility)

- Condition of the facilities provided (that is, level of feedback from active travel users)
- Health benefits (as measured by an increase in the number of active travel trips in an area or a network) may be difficult to discern at the level of individual initiatives.

9.3 Data collection

The appropriate monitoring methods should be considered at an early stage of the planning process. Suitable approaches are dependent upon the objective being monitored and could include:

- Pedestrian and cyclists count surveys (observation or video surveys)
- Intercept, resident or interest group surveys, including face to face interviews on site or self-administered mail-back or email-back questionnaires
- Origin-destination surveys (such as Bluetooth, GPS, Strava Metro or other app-based source, and survey questions that request journey start and end points)
- Facility condition surveys
- Piezoelectric bike counters installed on cycle paths
- Other active transport counting technologies, such as beam counters, thermal imaging, wireless / bluetooth sensors, stereo vision counters
- Smartcard data, if available at the level of de-identified users' meshblock residential address location and trip boarding/alighting or bike cage use if that's also linked to the smartcard.
- Bike counts installed in cycle lanes.

When considering what monitoring approaches to utilise, the proponent should consider how the data from each source will be analysed and interpreted, and how it can be triangulated with other data sources to enhance the understanding of change in movement flow and active transport use due to the new infrastructure facilities provided.

Planning of the monitoring approaches should also account for:

- Location of the infrastructure being monitored and whether known externalities may influence the interpretations
- Scale and distribution of the infrastructure solutions being monitored – e.g., if an area-wide initiative is being undertaken then monitoring should account for ingress and egress from the area and use of a cordon or a selection of representative monitoring sites could be considered
- Duplication of counts, i.e. the same people being counted at multiple monitoring sites along a route.

Another potential data source could be public transport smartcard records (Agarwal et al. 2020). Public transport smart records have residential address and boarding/alighting stops GEO locations that are within walking distances. By examining the distance from residential address to these stops and fare differences, it may be possible to observe the extent to which public transport users substitute walking to public transport to get a cheaper fare, hence allowing the estimation of cross elasticity between these two modes.

9.4 Timing of performance monitoring

Performance monitoring should be undertaken before and after an intervention is implemented. The same method, location and time period should be replicated where possible for the ‘before’ and ‘after initiative' monitoring.

Care needs to be taken when monitoring the performance of a new facility or delivery of a new policy as there will always be a 'ramp up' period before up-take reaches expected demand. A ramp-up period should always be incorporated in demand forecasts to reflect the time for the initiative to affect user trip making behaviour. For relatively small initiatives, it would be sensible to commence monitoring processes once expected demand volumes have reached the expected level or after sufficient time has elapsed for users to adjust to the new infrastructure. For larger initiatives, the ramp-up period could be quite long, in which case periodic monitoring initiatives would be appropriate. The length of time between opening and commencement of monitoring will be initiative-specific. For example, a small facility (such as a pedestrian refuge island) might be surveyed one month after opening, whereas it would be better to wait a year to assess the performance of a new pedestrian bridge.

The time of day, day of the week and time of year at which surveys are taken should be the same for the before and after monitoring, with care being taken to avoid special event days (unless of course the subject upgrade is intended to service special events). These survey design parameters will be determined by each initiative’s key origins, destinations and surrounding land uses. For example:

- A commuter shared pedestrian and cycle path would likely be surveyed during the morning and evening commuter peak periods
- A monitoring program for an active travel initiative near a school would need to take account of the school’s daily start and finish times and term start and end dates
- A recreational pathway through a park would probably be used more during the weekend.

Having comparable weather conditions in the ‘before’ and ‘after’ monitoring is essential as weather has significant effects on travel. The longer the survey period the more reliable the data, but this will be influenced by the time and budget available for performance monitoring.

Depending on the project objectives and the data collection methods being utilised, it could also be useful to undertake phased monitoring of a large-scale or multi-stage project, whereby monitoring of a completed section of a route or a bridge is undertaken in the first 3-6 months post construction, and then again in the 3-6 months post the opening of the new section with consideration given to the time of year and seasonality to maintain as close an alignment as possible.

Design of the monitoring program will be influenced by each initiative’s key origins, destinations and surrounding land uses. Ultimately, however, the design should be based on project objectives and the measurement tools available. For example:

- If the project objectives include increasing active travel across the week, and the facility happens to be connecting to a school, then 6am to 6pm video surveys on 2 weekdays and 1 weekend day could be used to determine if increases in activity are observed among school families or if the infrastructure is also having the effect of increasing active travel at other days and times.
- If the project objectives include increasing active travel for commuting purposes, and the facility happens to be a high-quality shared path that connects to a CBD, then:
  - Fixed piezoelectric bike counters or other longitudinal counter technology could be utilised to look for trends over the first 3-6 months and 12+ months post opening and determine if the infrastructure is impacting increases in commute-hour travel or also impacting active travel at other times of day or on weekends, which could indicate that it is also serving a recreational purpose
  - To triangulate with the quantitative data sources, user surveys could be undertaken to better understand and report on the trip purpose, travel times and participation rates of new and returning users.

10. Research needs

The following gaps have been identified as requiring further research:

- The degree to which the components of private generalised cost of active travel (travel time, safety, private health) are perceived by the user.
- Separate valuation of each of the various quality aspects of active travel, rather than having a number of them aggregated in a single value of time valuation.
- Amenity benefits of cycling
- A major improvement in active travel demand estimation. This includes:
  - More consistent methods for monitoring and collecting data from the change in travel that occurs following the implementation of an active travel project. Few projects include sufficiently detailed before and after counts of pedestrians and cyclists to be confident of the change in travel behaviour. Improvements in this area, including the implementation of mandatory evaluation requirements for all projects over a certain value would provide a stronger evidence base regarding the change in active travel caused by enhanced conditions for active travel.
  - Ensuring that data collection is adequate to enable estimation of disaggregated demand elasticities for generalised cost and its components (time, safety, private health)
  - 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 the new micromobility modes (e-bikes, e-scooters, etc).
- Discussion of the many roles that active travel plays in an efficient and equitable transport system, including basic mobility for non-drivers, reducing chauffeuring burdens on drivers, access to public transport and parked cars (and therefore a way to increase public transport ridership and reduce parking problems), public fitness and health, and recreation.
- Methods for monetising the barrier effect.
- Exploration of factors that may be increasing the value of active travel, including an ageing population, increasing health and environmental concerns, and pandemic response: reducing contagion risk of travel, increasing physical activity as a response to the growth in sedentary lifestyles.
- Analysis of the value that people place on walkability and bikeability, reflected in surveys, hedonic pricing studies, and the increases in active travel that occurs when conditions are improved.
- Explore how active travel can help achieve social equity goals including improved mobility for disadvantaged people, increased affordability, and reduced external costs (congestion, crash risk and pollution exposure) imposed on vulnerable populations such as children, seniors, and economically disadvantaged.
- Analysis of how improved walkability affects per capita vehicle ownership and use, and resulting transport costs.
- Better analysis of how active travel can reduce parking problems and costs.
- GIS based tools that are able to appraise the costs and benefits of active travel investment across metropolitan regions. Single project appraisal can miss some of the important network benefits where the whole is greater than the sum of its parts.
- Clarification of whether, for existing trips, changes in active travel distances travelled (that may result from network improvements) results in a net change in physical activity, and health

Appendix A Glossary

A.1 Physical activity definitions

Vigorous intensity physical activity is defined as activity undertaken for fitness, recreation or sport that caused a large increase in the respondent's heart rate or breathing.

Moderate intensity physical activity is more moderate and not already reported as vigorous physical activity.

The level of activity reported is based on the following Sufficient Physical Activity measure:

Inactive	No walking, moderate or vigorous intensity physical activity
Insufficiently active	Some activity* but not enough to reach the levels required for 'sufficiently active'
Sufficiently active (for health)	150 minutes of moderate/vigorous physical activity* from five or more sessions

**Vigorous physical activity time is multiplied by two.*

Source: ABS 2013

Appendix B Active Travel Interventions and Options

A list of infrastructure options and interventions available to support active travel is presented below. The majority of these options are associated with the road network where road crossing facilities and interactions at intersections are of significant importance

B.1 Roads and streets

- Pedestrian streets are pedestrian only areas created by restricting traffic access or closing street to traffic e.g. Brisbane's Queen Street mall shown in the following figure.

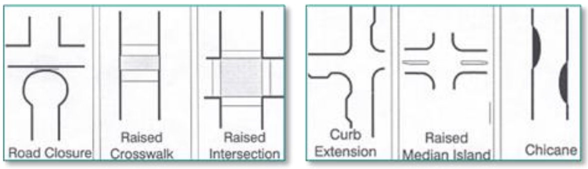
Figure 5 Pedestrian street

- Shared zone is a street that has been designed to give priority to pedestrians by significantly reducing the dominance of the motorised transport through the road environment and speed reduction, e.g. Duporth Avenue, Maroochydore shown in the following figure.

Figure 6 Shared zone

- Traffic calming measures are interventions that impact motorised transport, aiming to improve the active transport network. These include:
  - Road closure
  - Half closure
  - Build outs
  - Gateway or entry treatment
  - Chicanes
  - Raised intersections
  - Speed humps.

Figure 7 Traffic control devices



B.2 Bicycle boulevard

- A bicycle boulevard is a street that is designed to reduce the speed and volume of motor vehicle traffic. This is often done through restricting through vehicles, lowering speed limits, and tactile road surfaces. Popular in Portland, Oregon and the Netherlands (where they are known as Fietsstraat, or bike street). Motor vehicles are permitted, but as ‘guests’. Perth has begun to install this bike infrastructure.

Figure 8 Bicycle boulevard

https://engage.bayswater.wa.gov.au/bayswater-bike-boulevard1

B.3 Pathways within the road corridor

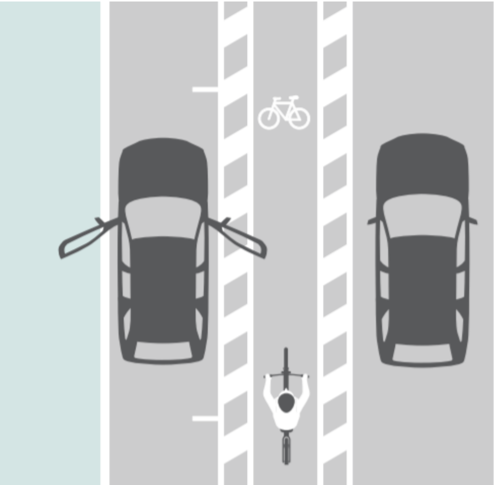
- Footpaths running adjacent to the road/carriageway
- Sealed road shoulders (mainly relevant to rural roads): could be within the travel lane, or to the left of the travel lane. Could be provided specifically for bike riding, or for emergency stopping for vehicles
- Wide kerb-side lanes, which are widened traffic lanes adjacent to the kerb giving more space for cyclists
- Shared bus or parking lanes with cyclists
- Peak period cycle lanes
- Exclusive on-road cycle lanes can take the form of painted lanes, green surface treatment, road markings, white line marking and bicycle symbol or bicycle awareness zones (BAZ) with bicycle symbols in the traffic lane
- Often, but not always, placed between parking bays and travel lanes. This has been the standard on road bike infrastructure used since the 1980s/90s, although this has begun to be replaced with greater levels of separation in areas with high usage and/or high crash risk
- Buffered painted lanes: This is a painted bike lane, with the addition of a 'buffer zone'. This zone could be between the parking bay and bike lane, between the bike lane and car travel lane, or both. Usually at least 0.6m is provided in a buffer, though it could be more.

Figure 9 Road shoulder

Figure 10 On-road cycle lane facilities

Figure 11 Painted lanes

Figure 12 Buffered painted lanes



- Protected bike lanes: This is a dedicated bike lane, protected from parking bays and the main carriageway. They are placed adjacent to the footpath. Protection can be through physical barriers or vertical separation.

Figure 13 Protected bike lanes

https://www.bicyclenetwork.com.au/newsroom/2019/08/13/its-not-just-about-bikes/

- Protected, bi-directional cycle lanes: This is the same as a protected bike lane but provides two-way travel for cycling on one side of the road. Bi-directional lanes often use less space than uni-directional protected bike lanes but have higher crash risk, as drivers from side streets are less likely to look both ways when making left hand turns.

Figure 14 Bi-directional bike lane

https://www.governmentarchitect.nsw.gov.au/resources/case-studies/2017/11/bourke-street-cycleway

B.4 Pop-up bike lanes

- Fast build, or pop-up, bike lanes have increased as a popular method for installing new bike infrastructure. This is done through the use of cheaper, light-weight materials that can be installed without re-sheeting the road surface or drainage works. This allows for trialling the effects the bike lane has and can be adjusted or removed depending on the results of the trial. The City of Melbourne estimate that pop-up bike lanes can be 50% cheaper than a heavier solution (City of Melbourne, 2019), although figures from the City of Sydney suggest a kilometre of protected pop up bike lane can be delivered for as little as $800,000 per kilometre, which is around a tenth of what protected infrastructure can cost in inner Sydney. COVID-19 has been a catalyst for the installation of pop up bike lanes, as a response to rising cycling demand, and to act as alternative to public transport to reduce infection. Figure 15 shows a pop-up cycleway that was installed as part of an initiative by Transport for NSW and the City of Sydney.

Figure 15 Pop-up Cycleway - Sydney

Source: TfNSW / Sydney Cycleways

B.5 Pathways separate to the road corridor

- Exclusive pedestrian path
- Shared pedestrian and bicycle path
- Segregated pedestrian and cycle path
- Exclusive cycle path.

Figure 16 Shared pedestrian/cycle path and segregated pedestrian/cycle path

Shared ped/cycle

- Cycle Path
- Pedestrian Path

Source: http://www.thestickybidon.com/a-view-from-the-shared-cycle-path/

B.6 Sharrows

- Bike symbols installed on the road surface. The road space is intended to be shared between people on bikes and in motor vehicles
- Typically require low speed and volume, however there are cases in which they have been used in environments that are unsuitable (i.e. roads with speed limits in excess of 40km/h and high vehicle volumes).

Figure 17 Sharrows

B.7 Path upgrades or retrofitting

- Widening of an existing path
- Resurfacing of an existing path
- Ramps to improve the movement along an active travel route for cyclists and pedestrians
- Steps to improve pedestrian movements along a pathway.

B.8 Ancillary infrastructure

- Lighting along pedestrian and cyclist routes will improve safety, security and the likelihood of the facility being used particular at night time
- Seating provided at appropriate locations will improve the amenity of a facility, particularly for walkers
- Water points, such as water fountains sited at appropriate locations along an active travel route
- Landscaping, such as shade planting along an active travel path or at rest areas
- Handrails and guiderails at appropriate locations to assist users of active travel facilities
- Security cameras, such as CCTV surveillance to improve personal security
- Emergency help points to improve personal security

Figure 18 Improve amenity of footpaths

- Wayfinding signage to inform people of the location and distance to the land uses in the area
- Lifts or escalators at grade separated crossing will promote use of the crossing facility
- Non-slip surface treatments for pedestrian will improve safety of the path.

Figure 19 Wayfinding signage and guardrail

B.9 Crossings

- Dropped kerb e.g. pram ramps, is where part of the path along the kerb is lowered to the same level of the adjacent carriageway to allow easier use
- Blended kerb crossings is where the path and road are at the same level, these usually are formed in shared zones or by raised pedestrian crossing platforms

Figure 20 Blended crossing across side street

- Refuge island treatments (such as medians) will enhance safety for active travellers crossing at that point
- Pedestrian platforms (such as raised crossings) remove the level difference making crossing easier for pedestrians
- Zebra crossing is marked with longitudinal road markings with traffic required to give way to pedestrians
- Mid-block pedestrian signals are traffic signals not at an intersection that stop traffic to allow crossing
- Grade separated crossing, such as overpass or bridge, underpass or tunnel that separates active travel users from motorised transport, improving safety, connectivity and promoting active travel

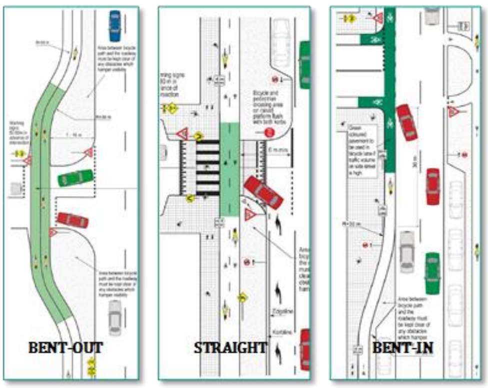
Figure 21 Active travel bridge crossing over a river

- School patrol crossing usually involves a parent/guardian who controls the traffic to allow children to cross without conflict; sometimes they incorporate markers and swing signs
- Gate controlled crossing are usually found at railway crossing points to enhance safety.

B.10 Cycle path crossing treatments of side roads at priority intersections

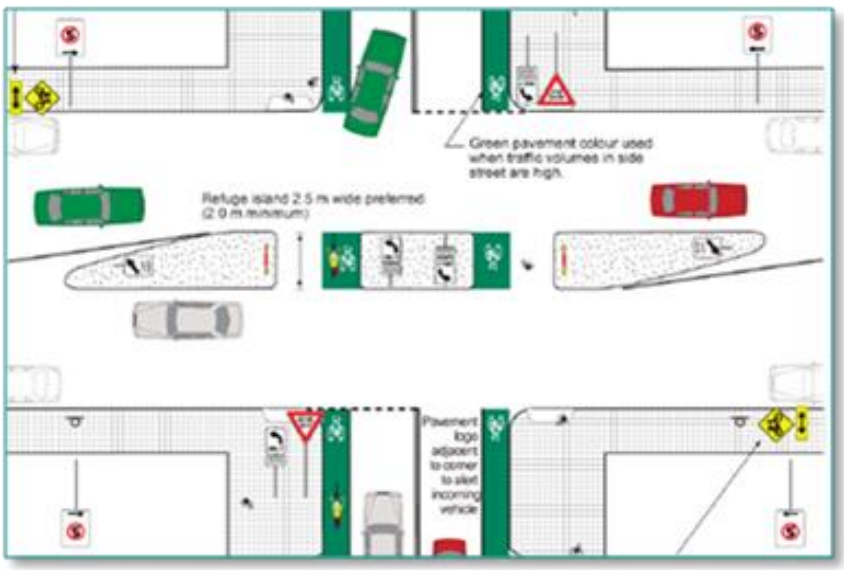
- Bent-out treatment where off-road cycle path bends away from the road if there is sufficient space in the road reserve, with priority given to cyclists over the traffic on the side road
- Straight crossing treatment allows the straight movements across the side road
- Bent-in treatment provides for a one-way off-road cycle lane transitions into an on-road cycle lane thereby enabling cyclists to have priority over the side street

Figure 22 Cycle path crossing side road



- Refuge treatment within an intersection to accommodate cycle crossing while restricting vehicles to left turn movements only

Figure 23 Refuge treatment within an intersection



B.11 Further crossing treatments at roundabouts

- On-road cycle facilities within the traffic lane can take the form of the cycle lane facilities listed above (such as BAZ, green colour and line marking) with a significant concern being the speed of traffic approaching the roundabout

Figure 24 Mixed cycle lanes with traffic at roundabout

- Physically separated cycle lanes at grade minimise bicycle and vehicle interaction on the roadway, with cyclists crossing the arms of the roundabout similar to pedestrians.

Figure 25 Separated cycle lanes at grade at roundabout

B.12 Further crossing treatments at signalised intersections

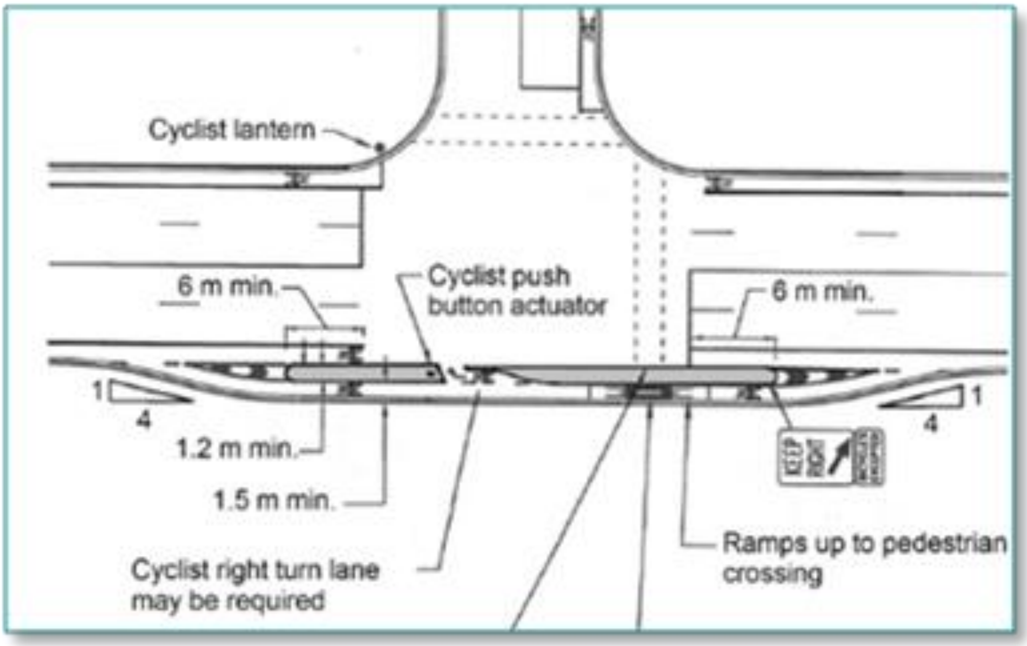
- Single stage signalised pedestrian crossing

- Head-start or expanded storage areas (advanced cycle stop lines) are used at signalised intersections to facilitate stacking of cyclists, allowing them to stop and wait ahead of the vehicular traffic improving safety
- Hook turn storage boxes are used as an alternative to right turn movements from the centre of the road where cyclists go straight through and wait at the corner the intersection and make the right turn manoeuvre when it is safe to do so or with through movement on the other arm

Figure 26 Expanded storage and hook turn at signalised intersection

- Left-turn treatments for cyclists are often required as part of channelised left turn treatment or left turn slip lanes for the vehicular traffic, which can involve cyclists sharing the left turn lane vehicles or a free-flow or bypass treatment
- Bypass of T-intersection for the through movement opposite discontinuing arm will limit delay to cyclists and be incorporated as a separated lane - as shown in the following figure - or provide for cyclists on the adjacent path
- Bicycle loop detectors with sensitive detection arrangements often provided at separate bicycle lane
- Push button bicycle signalised crossing usually provided where cyclists share the intersection with vehicles as detection is not always possible due to their small electromagnetic footprint.

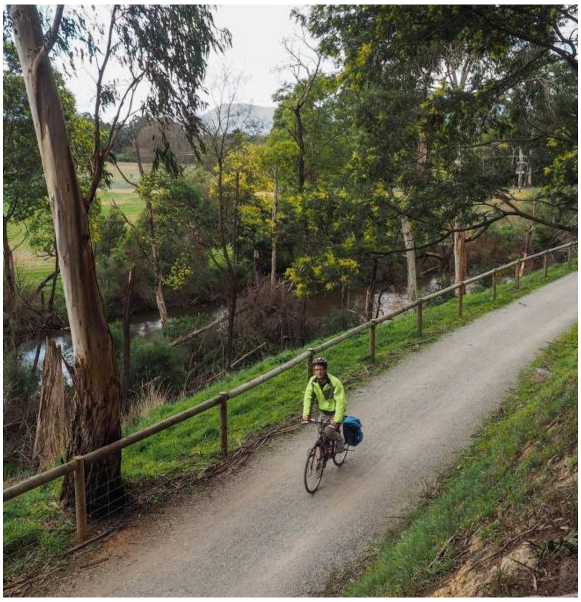
Figure 27 Bypass of T-intersection



B.13 Off-road trails

- Similar to a shared use path, however, is typically found in regional areas and uses unsealed surface material. Horse riding may also be permitted on an off-road trail.

Figure 28 Off-road trail



https://macedonrangescycling.org.au/lilydale-warburton-rail-trail-ride/

B.14 Other strategies

- Pedestrian signals co-ordination can be useful in a city centre area with significant commuter movements to improve pedestrian travel time along the route
- Count-down timers at signalised crossings promote safety for pedestrians and give them greater knowledge of the waiting and crossing times
- Scramble crossings involve an all red signal phase for vehicles to allow pedestrian crossings in all directions at the intersection.

B.15 End-of-trip facilities

- Showers sometimes be provided at all end-of-trip locations for cyclists
- Changing rooms sometimes made available for cyclists
- Lockers to store clothing and bike equipment sometimes provided.

B.16 Bike parking

- Bike stands or racks allow cyclists to lock their bike frame and wheels as required
- Shared gated parking areas (such as lockable enclosure/shelter with bike stands or racks enclosed)
- Individual secure bike parking lockers are the most secure bike parking facility available.

Figure 29 Bike racks at public transport interchange

Figure 30 Bike enclosure and locker

Appendix C Rapid assessment of interventions

The table below provides illustrates a rapid assessment across the range of possible initiatives. The ratings are indicative and illustrative. Practitioners should review these ratings on a case-by-case basis as they apply to specific jurisdictional and geographical settings.

	Interventions / Options	Health	Physical Safety	Personal Security	Pedestrian Amenity	Cycle Amenity	Encourag-ing Mode Shift	Capacity	Travel Time Saving	Installation Cost	Maintenance Cost
Roads and streets											
	Pedestrian Street (e.g. mall)	✓	✓✓✓		✓✓✓		✓	✓	✓	Low-High (see Note 1)	Low-High (See Note 1)
	Shared zone (e.g. Duporth Avenue)	✓	✓✓		✓✓	✓✓		✓	✓	Medium-High (see Note 1)	Medium-High (See Note 1)
Traffic calming measures											
	Road closure (See Note 2)		✓✓		✓	✓	✓			Low-Medium	Low
	Half closure (See Note 2)		✓		✓	✓	✓			Low-Medium	Low
	Build-outs (e.g. kerb extensions)		✓		✓					Low	Low
	Gateway treatment		✓ (See Note 3)							Low	Low
	Chicanes		✓		✓					Low	Low
	Raised intersections		✓							Low	Low

	Interventions / Options	Health	Physical Safety	Personal Security	Pedestrian Amenity	Cycle Amenity	Encouraging Mode Shift	Capacity	Travel Time Saving	Installation Cost	Maintenance Cost
Pathways within road corridor											
	Footpath adjacent to road	✓	✓		✓✓	✓	✓	✓	✓	Low	Low
	Sealed shoulder	✓	✓		✓	✓	✓	✓	✓	Low-Medium (See Note 4)	Low
	Wide kerb-side lanes	✓	✓		✓	✓	✓	✓	✓	Low-Medium (See Note 4)	Low
	Shared bus / cycle lanes	✓	✓		✓	✓	✓	✓	✓	Low-Medium (See Note 4)	Low
	Peak period cycle lanes	✓✓	✓		✓	✓	✓✓	✓	✓	Low-Medium (See Note 4)	Low
	Exclusive on- road cycle lanes	✓✓✓	✓✓		✓	✓	✓✓✓	✓	✓	Low-Medium (See Note 4)	Low
	Segregated on-road cycle lane	✓✓✓	✓✓✓		✓	✓	✓✓✓	✓	✓	Low-Medium (See Note 4)	Low
Pathways separate to road corridor											
	Exclusive pedestrian path	✓✓✓	✓✓✓		✓✓✓		✓✓✓	✓✓✓	✓✓	Low-Medium	Low
	Shared ped/cycle path	✓✓✓	✓✓		✓✓	✓✓	✓✓✓	✓✓	✓✓	Low-Medium	Low

	Interventions / Options	Health	Physical Safety	Personal Security	Pedestrian Amenity	Cycle Amenity	Encouraging Mode Shift	Capacity	Travel Time Saving	Installation Cost	Maintenance Cost
	Segregated ped/cycle path	✓✓✓	✓✓✓		✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	Low-Medium	Low
	Exclusive cycle path	✓✓✓	✓✓✓			✓✓✓	✓✓✓	✓✓✓	✓✓	Low-Medium	Low
Path upgrades or retrofitting											
	Widening	✓	✓		✓	✓	✓	✓		Low	Low
	Resurfacing	✓	✓		✓	✓	✓			N/A	Low
	Ramps	✓	✓		✓	✓				Low	Low
	Steps	✓	✓		✓					Low	Low
Ancillary infrastructure											
	Lighting		✓✓	✓✓	✓✓	✓✓	✓			Medium	Low
	Seating	✓			✓✓✓	✓				Low	Low
	Water points	✓			✓✓	✓✓				Low	Low
	Landscaping (e.g. shade planting)	✓			✓✓	✓✓				Low	Low

	Interventions / Options	Health	Physical Safety	Personal Security	Pedestrian Amenity	Cycle Amenity	Encourag-ing Mode Shift	Capacity	Travel Time Saving	Installation Cost	Maintenance Cost
	Handrails / guiderails	✓	✓✓		✓✓					Low	Low
	Security cameras			✓✓✓			✓			Medium	Low
	Emergency points			✓✓✓			✓			Medium	Low
	Wayfinding Signage				✓✓	✓✓			✓	Low	Low
	Lift or escalators (grade separated crossing)		✓		✓		✓		✓	Medium	Medium
	Non-slip treatment	✓	✓		✓					Low	Low
Crossings											
	Dropped kerb		✓		✓	✓				Low	Low
	Blended or level kerb treatment		✓		✓	✓				Low-Medium	Low
	Refuge island		✓✓							Low	Low
	Ped platform (ie raised crossing)		✓		✓					Low	Low

	Interventions / Options	Health	Physical Safety	Personal Security	Pedestrian Amenity	Cycle Amenity	Encourag-ing Mode Shift	Capacity	Travel Time Saving	Installation Cost	Maintenance Cost
	Zebra crossing		✓							Low	Low
	Mid-block signals		✓✓✓							Medium	Medium
	Grade separated bridge or tunnel	✓	✓✓✓		✓ 5	✓ (See Note 5)	✓✓	✓	✓✓	High	Medium
	School patrol crossing (See Note 6)		✓✓	✓✓			✓		✓	Low	Low
	Gate controlled (e.g. at rail line)		✓✓✓							Medium	Low
Cycle path crossing treatments of side roads at priority intersections											
	Bent-out treatment		✓✓			✓	✓	✓		Medium	Low
	Straight treatment		✓			✓	✓		✓	Medium	Low
	Bent-in treatment		✓			✓	✓		✓	Medium	Low
	Refuge in the intersection		✓✓			✓	✓		✓	Medium	Low
Further crossing treatments at roundabouts											
	On-road with traffic		✓			✓	✓			Low	Low

	Interventions / Options	Health	Physical Safety	Personal Security	Pedestrian Amenity	Cycle Amenity	Encourag-ing Mode Shift	Capacity	Travel Time Saving	Installation Cost	Maintenance Cost
	Physically separated lanes – at grade		✓✓✓			✓✓	✓	✓		Low-Medium	Low
Further crossing treatments at Signalised intersections											
	Single stage signalised ped crossing		✓							Low	Low
	Head-start storage		✓			✓	✓			Low	Low
	Hook turn storage box		✓			✓	✓			Low	Low
	Left-turn treatments		✓			✓	✓			Low	Low
	T-intersection bypass		✓✓			✓	✓		✓	Low	Low
	Bicycle loop detectors					✓✓	✓		✓	Low	Low
	Push button cycle signals					✓✓	✓		✓	Low	Low
Other strategies											
	Ped signal coordination				✓				✓✓✓	Low	Low
	Count-down timers		✓✓		✓			✓		Low	Low

	Interventions / Options	Health	Physical Safety	Personal Security	Pedestrian Amenity	Cycle Amenity	Encourag-ing Mode Shift	Capacity	Travel Time Saving	Installation Cost	Maintenance Cost
	Scramble signals – all movements		✓✓		✓✓			✓	✓	Low	Low
End-of-trip facilities											
	Showers				✓	✓✓✓	✓✓			Low-Medium	Low
	Changing rooms				✓	✓✓✓	✓✓			Low-Medium	Low
	Bag Lockers			✓✓	✓✓	✓✓	✓			Low	Low
Bike parking											
	Stand or racks			✓		✓	✓			Low	Low
	Shared gated park area			✓✓		✓	✓			Low	Low
	Bike lockers			✓✓✓		✓	✓			Medium	Low

Notes:

1. Dependent on the level of treatment used e.g. simple bollards or signage at the end of street to an overall street refurbishing
2. Allowing for cyclists through the intervention
3. If used in conjunction with other physical devices e.g. signage or line markings
4. Dependent on if road widening is required
5. Dependent on the design of the infrastructure
6. While in operation with patrol

Appendix D CBA results formulas

General

- All benefits and costs in each future year of the appraisal period are discounted back to the base year
- The summation of all annual discounted present values of a stream of benefits or costs is called the 'present value' of that stream

Net present value (NPV)

- The NPV of an initiative is the difference between the discounted stream of benefits and the discounted stream of costs. The NPV is given by:

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

where:

- *t* is time in years
- *n* is the number of years during which benefits and costs occur
- *r* is the discount rate
- B_t is benefits in year *t*
- OC_t is infrastructure operating and maintenance costs in year *t*
- IC_t is investment costs in year *t*.

- A positive NPV means that the initiative represents an improvement in economic efficiency compared with the Base Case.

Benefit cost ratio (BCR)

There are two alternative definitions of BCR depending on whether one puts infrastructure operating costs in the numerator or the denominator.

$$\boldsymbol{BCR1} = \frac{\boldsymbol{PV(B)}}{\boldsymbol{PV(OC+IC)}} \qquad BCR2 = \frac{PV(B-OC)}{PV(IC)}$$

where $PV(x) = \sum_{t=0}^{n} \frac{x_t}{(1+r)^t}$

- A BCR greater than one implies a positive NPV.

Incremental BCR

- The incremental BCR (IBCR) is defined as:

$$IBCR = \frac{PV(B_2 - OC_2) - PV(B_1 - OC_1)}{PV(IC_2) - PV(IC_1)}$$

where the subscripts represent options 1 and 2, and option 2 has the greater investment cost. The IBCR is well-suited for comparing options involving different scales of initiative. Increases in the scale of initiative are worthwhile as long as the IBCR for each scale exceeds one.

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