TRANSPORT AND INFRASTRUCTURE COUNCIL

Australian Transport Assessment and Planning Guidelines

Worked Example: W1 Public Transport
1.2 New fixed track facility

May 2018

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1. Problem description

This case study illustrates the economic appraisal of a proposal to develop a new fixed track facility such as a train or LRT line or a busway with a dedicated right of way. The new facility will be in a corridor currently served by on-street bus services. The case study illustrates the range of cost and benefits that should be considered, the basis for each category of cost and benefit, and the interpretation of the data on costs and benefits.

2. Options

A single Project Case option is considered relative to the Base Case.

The Project Case option was identified in prior assessment as having high potential of strategic alignment and rapid appraisal of a number of options. Other high potential options can also be appraised in a similar manner to the option considered here.

Base Case

Option 0: Do minimum: The Base Case is a 'do minimum' option in which the quality of on-street bus service in the first year of the appraisal period is maintained. Even with a small amount of bus priority that could be implemented, this requires additional buses (and associated bus-hours and bus-km of service) to accommodate modest growth in patronage associated with rising population and to respond to increasing traffic congestion that will reduce average bus travel speed. There are no opportunities for an alternate scheme with somewhat more substantial investment that could provide a reasonable alternative Base Case.

Project Case options

Option 1: New fixed track facility (train, LRT or busway)

3. Benefits and costs

Table 1 lists the benefits and costs and whether they have been monetised in this worked example.

The initiative is expected to lead to the following impacts (all incremental from the Base Case to the Project Case):

- Ongoing costs for maintenance of the fixed infrastructure and for changes in the cost of providing public transport service
- Reduced travel time for existing public transport users and those that shift from cars to public transport
- Reduced travel time for remaining road users due to the mode shift from car to public transport, and the shift of public transport services from on-road operation to its own right-of-way
- A reduced need for car ownership and car parking due to the shift of some former car drives to public transport
- Reduced road crashes and environmental costs due to reduced car use from the shift to public transport after also allowing for crash costs and environmental costs that result from providing a larger quantity of public transport

- Some disruption to road traffic during construction of the initiative.

Travel time disbenefits may be incurred by cars, trucks and remaining on-road buses due to reduced lanes or space availability if the new fixed track or facility is integrated into the existing road layout without expanding or widening. If this impact applied, it would flow through to the cost-benefit analysis as a monetised disbenefits to non-public transport users.

Table 1 Monetised and non-monetised benefits and costs

	Monetised	Non-monetised
Benefits		
Travel time savings for public transport users	✓	
Travel, car and parking savings for car users who shift to public transport	✓	
Travel time savings for remaining road users	✓	
Safety and environmental benefits	✓	
Residual value	✓	
Disruption during construction (disbenefit)	✓	
Costs		
Fixed infrastructure costs	✓	
Operating and maintenance costs	✓	

4. Inputs and assumptions

4.1 General

Base year and price year: Prices are in mid-2014 prices and are discounted to a base year of 2015.

Real discount rate: 7% for the main central analysis, with sensitivity tests of 4% and 10%.

Construction period years: 4 years – 2016 to 2019.

Operations to commence in 2020.

Investment cost:

All costs in the appraisal are incremental to the Base Case – practitioners are encouraged to also show Base Case and Project Case numbers used to calculate the incremental change between the two cases:

- Fixed infrastructure: $635 million
- Public transport fleet: $95m in 2019, and a total of $121m during the remainder of the appraisal period (some of which are reinvestments as discussed below)
- Land (resale of excess land): minus $28m in 2020.

Fixed assets

The initiative involves expenditure on land and fixed infrastructure such as earthworks, track, stations, power and other control systems as needed. It also requires design and project management services.

The initiative requires the purchase of some large allotments of land due to the shape of the allotments and a need for some space to accommodate site offices and construction equipment. Much of this land can be sold at a premium upon completion of the construction when it is no longer needed and has higher value due to its proximity to public transport stations. Hence, there is a large negative cost in the year that follows completion of capital works (2020).

Public transport fleet

An initial fleet of new public transport vehicles is to be purchased for the initiative. (If the initiative was a busway, a new fleet of dedicated buses would be purchased, with none of the on-street buses used to provide services in the corridor being suitable for use on the busway.) This fleet is purchased in the year prior to initiative completion (2019). It is estimated that fewer of the current on-street buses will be needed in the corridor with the initiative, with account for the remaining value of the redundant buses included in the appraisal – the buses can be used elsewhere in the public transport system, and the avoided cost attributed to the current initiative is therefore based on the residual value of the buses. There will also be an avoided need in the Project Case to purchase additional buses that would have been needed to accommodate small rising patronage in the corridor in the absence of the initiative.

Over the appraisal period there is an occasional need to purchase additional vehicles for the new facility to accommodate growth in patronage and to replace vehicles that may reach the end of their economic life during the appraisal period (though the latter will generally only occur in the case of a busway). Hence, additional capital costs are incurred following initial implementation of the initiative.

Asset (economic) life:

Fixed assets

Ten categories of asset with lives that range from 15 years for items such as signalling to infinite to items such as land.

Public transport vehicles

Depends on the mode chosen. For a busway, the life of buses is typically 20 years.

Appraisal period: The implementation period (4 years) plus 30 years of operation.

Reinvestment:

The economic life of both some of the fixed assets and the public transport vehicles is less than the 30 years of operation in the appraisal period, and so there is a need for periodic re-investment in these assets. For fixed assets, this expenditure is included in the 'Fixed infrastructure maintenance and replacement' column in Table 2, and is described in more detail below.

Residual value methodology: A residual value was calculated for any asset with part of its economic life remaining at the end of the appraisal period. The straight line depreciation method was adopted using the following formula:

$$\text{Residual Value (Straight Line Depreciation)} = \text{Capital cost} \times \frac{\text{Asset Life Remaining After Evaluation Period}}{\text{Asset Life}}$$

Residual values are included as benefits in the last year of the appraisal period (2049).

The resulting residual values were $387m.

Fixed infrastructure maintenance and replacement:

Fixed infrastructure requires routine and periodic maintenance. The economic lives of some assets will come to an end during the appraisal period and will require replacement. Estimated expenditure for these items has been based on specific engineering estimates of the cost of routine maintenance and the cost and intervals for periodic maintenance.

Public transport operations:

Public transport operating costs have been based on the default values set out in the Guidelines (i.e. based on estimates of the number of each mode of public transport vehicle, and the distance travelled and hours of use of each vehicle in the Project Case relative to the Base Case). The cost of periodic rehabilitation (i.e. mid-life refurbishment) of public transport vehicles, based on an average annualised cost, is also included in this column in Table 2.

4.2 Travel demand

The estimation of travel demand effects, and benefits, of the initiative have been based on data obtained from a computerised travel demand model. The model assessed conditions with and without the proposed initiative for an average working weekday for 2018, 2023 and 2033. The model held the total number of trips per day constant but allowed the mode of travel (which included walking, private vehicle drivers and, separately, passengers, public transport and freight), destination and route of trips to change. The model also estimated changes in the kilometres of travel for each transport mode. For the new public transport facility, the model indicated the former mode of travel in the base case.

Growth rates: As reflected in the travel demand model outputs

Benefits are estimated for 2018, 2023 and 2033. Data for intermediate years is based on a constant percentage growth, with values after 2027 based on extrapolation. Note that this is a simplification in that if demand continues to grow, crowding disbenefits would need to be accounted for as capacity was approached and reached.

4.3 Benefits

The benefits of the initiative were calculated using data from a computerised travel demand model. The model assessed conditions with and without the proposed initiative for 2018, 2023 and 2033. The values for each category of benefit for intermediate years were derived using a constant average annual growth rate between the modelled years.

Given that the new facility is in a corridor currently served by public transport, ramp-up in the shift in travel demand is expected to be rapid though still present. Ramp up cannot be addressed through modelling and was therefore based on a consensus view that benefits in the first year of operation will be two-thirds of the benefit estimated by interpolation to allow for this effect. Benefits after 2033 were assumed to grow at three-quarters of the rate in the preceding period to reflect the potential for slowing population growth in the catchment area of the initiative.

Travel choices in the model have been based on the perceived cost of travel. Perceived user benefits (i.e. consumer surplus changes) were calculated for each origin-destination pair in the model by mode of travel and then aggregated by model of travel. Unperceived direct travel benefits were taken into account through resource corrections – reported in the 'reduced unperceived car operating costs' column in Table 2. Other benefits, including savings in car ownership, parking, safety and environment, were based on travel demand data from the model.

Perceived user benefits – car and public transport users

The calculation of benefits perceived by travellers was based on origin-destination matrix data extracted from the computerised travel demand model. Specifically, the change in consumer surplus for a given mode was estimated based on the difference in the quantity of travel and the perceived cost of travel between the Base Case and Project Case for each origin-destination pair in the travel demand model using the rule-of-a-half to take account of changes in the number of trips. That is:

$$\text{User benefit} = 0.5 * (\text{Trips}_{PC} - \text{Trips}_{BC}) * (\text{Perceived travel cost}_{BC} - \text{Perceived travel cost}_{PC})$$

where BC and PC denote Base Case and Project Case respectively.

This was done separately for public transport users, car users and travel by commercial vehicles. The benefits to car users who remain on the road system in the Project Case is shown in the column titled *Perceived User Benefits*: *Car users*. It reflects the road decongestion that occurs as a result of a shift of some car users in the Base Case to public transport in the Project Case. The benefits to those who use public transport in the Project Case (i.e. including those who transfer from the current on-street bus system to the new facility, those who remain on the current on-street bus system, and those who shift from car and walking to public transport) are shown in the next column in Table 2 (i.e. the column titled *Perceived User Benefits*: *Public transport users*). Benefits accruing to freight vehicles is included in a later column of Table 2.

Reduced car ownership and parking costs

The shift from car to public transport is expected to allow some people to avoid the need to own cars. The benefit has been calculated using the approach set out in Part M1 of the ATAP Guidelines. That is:

- The number of two-way trips that former car drivers make on public transport with the initiative, multiplied by
- The sum of (the one-off benefit of an avoided need to own a car and the one-off benefit of an avoided car park). The one-off benefit to each car driver attracted to public transport of an avoided need to own a car and the associated avoided car park occurs for each year of the appraisal period, reflecting that the number of car drivers attracted to the new facility rises over time due to rising traffic congestion.

Increase in public transport fare revenue

The literature provides two explanations for this benefit:

- In the traditional economic literature, it is explained as a benefit to the service provider. The increase in revenue, minus the increase in operating costs, combine to produce an increase in 'producer surplus' (IA 2017).
- Another explanation is provided by the public transport literature where it is referred to as a resource correction benefit. This is needed because the fare is necessarily included in the perceived cost of travel by public transport users in the computerised travel demand model—public transport users treat it as a cost when considering whether to move to public transport and it thus reduces the resource benefit estimated previously for these users. The benefit is based on the increase in fare revenue in the Project Case relative to the Base Case.

Reduced environmental costs

Reduced environmental costs have been estimated based on changes in vehicle-km of travel by type of vehicle and road, and default values for unit environmental costs such as those indicated in the Part PV5 of the ATAP Guidelines.

Reduced accident costs

Reduced accident costs also result from changes in vehicle-km of travel by type of vehicle and road. The benefit is based on default unit crash cost values such as those indicated in the Part PV2 of the ATAP Guidelines.

Disruption during construction (disbenefit)

Disruption to road traffic is expected to occur during construction of the initiative. The size of this disbenefit has been estimated based on the increase in travel time expected to result from the closure of some lanes for certain periods and the value of time of car, public transport users and freight vehicles. The change in travel time has been estimated using the computerised travel demand model through a reduction in the capacity of affected road links.

5. Benefit and cost time streams

The annual monetised benefit and cost time streams are shown in Table 2 and Figures 1 to 3.

Table 2 Benefit and cost time streams

Year	Costs ($m)[1]					Benefits ($)											Net benefit ($m)
	Capital cost		Ongoing costs[2]		Net cost	Perceived user benefits		Other benefits									
	Fixed assets	Public transport fleet	Fixed infra-structure mainte-nance	Public transport operations		Car users	Public transport users	Reduced unperceived car operating costs	Reduced car ownership & parking costs	Reduced commercial vehicle travel costs	Increase in public transport fare revenue	Reduced environ-mental costs	Reduced accident costs	Disruption during construction	Residual value	Total	
2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	54	0	0	0	54	0	0	0	0	0	0	0	0	0	0	0	-54
2017	216	0	0	0	216	0	0	0	0	0	0	0	0	-12	0	-12	-228
2018	274	0	0	0	274	0	0	0	0	0	0	0	0	-28	0	-28	-302
2019	91	95	0	0	186	0	0	0	0	0	0	0	0	-4	0	-4	-191
2020	-28	0	0	9	-18	2	7	5	2	1	5	1	1	0	0	25	43
2021	0	0	2	9	11	4	10	8	3	1	8	2	2	0	0	38	27
2022	0	0	2	9	11	5	14	8	4	2	9	2	2	0	0	47	36
2023	0	0	2	9	11	7	20	9	5	2	10	2	2	0	0	58	47
2024	0	0	2	9	11	7	22	9	5	3	10	2	2	0	0	61	50
2025	0	0	2	9	11	7	23	9	5	3	11	2	3	0	0	63	52
2026	0	0	9	10	19	8	25	10	5	3	11	3	3	0	0	66	47
2027	0	0	2	9	11	8	27	10	5	3	11	3	3	0	0	69	58
2028	0	0	2	9	11	8	29	10	5	3	12	3	3	0	0	72	61
2029	0	39	2	12	52	9	31	10	6	3	12	3	3	0	0	76	24
2030	0	0	2	12	14	9	33	10	6	3	12	3	3	0	0	79	66
2031	0	0	15	15	30	9	35	11	6	4	13	3	3	0	0	83	53
2032	0	0	2	12	14	10	38	11	6	4	13	3	3	0	0	87	73
2033	0	0	2	12	14	10	51	11	6	4	14	3	3	0	0	102	88
2034	0	73	2	16	91	10	55	11	7	4	14	3	3	0	0	107	16
2035	0	0	2	16	17	11	59	12	7	4	14	3	3	0	0	112	95
2036	0	0	9	20	29	11	63	12	7	4	15	3	3	0	0	117	89
2037	0	0	2	16	17	11	67	12	7	5	15	3	3	0	0	123	106
2038	0	0	2	16	17	12	72	12	7	5	15	3	3	0	0	129	112
2039	0	9	2	17	27	12	78	12	7	5	16	3	3	0	0	136	108
2040	0	0	2	17	19	12	83	12	7	5	16	3	3	0	0	143	124
2041	0	0	43	21	64	13	89	13	8	5	16	3	3	0	0	150	86
2042	0	0	2	17	19	13	95	13	8	6	17	3	3	0	0	158	139
2043	0	0	2	17	19	14	102	13	8	6	17	3	4	0	0	166	148
2044	0	0	2	17	19	14	110	13	8	6	18	3	4	0	0	175	156
2045	0	0	2	17	19	14	118	13	8	6	18	3	4	0	0	185	166
2046	0	0	11	22	33	15	126	14	9	6	19	3	4	0	0	195	161
2047	0	0	2	17	19	15	135	14	9	7	19	3	4	0	0	206	187
2048	0	0	2	17	19	16	145	14	9	7	19	3	4	0	0	217	198
2049	0	0	2	17	19	16	155	14	9	7	20	3	4	0	387	616	597
PV[3] Share	67%	14%	4%	15%	100%	10%	49%	12%	6%	4%	14%	3%	3%	-4%	5%	100%	

Notes: (1) All figures (except share) are in undiscounted $m units, expect for the PV row which shows discounted values. (2) Includes periodic maintenance/refurbishment. (3) Present value using a discount rate of 7%.

Figure 1 Total benefits time stream

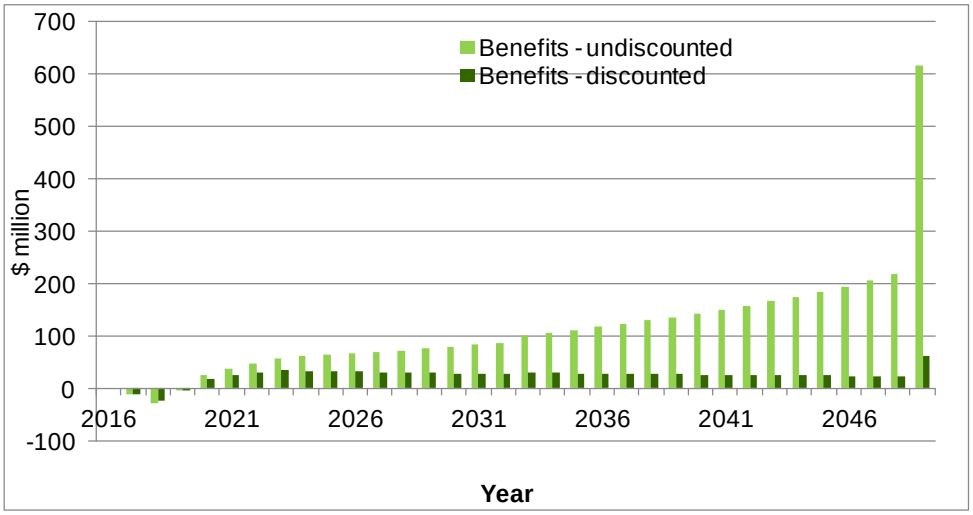


Figure 2 Total costs time stream

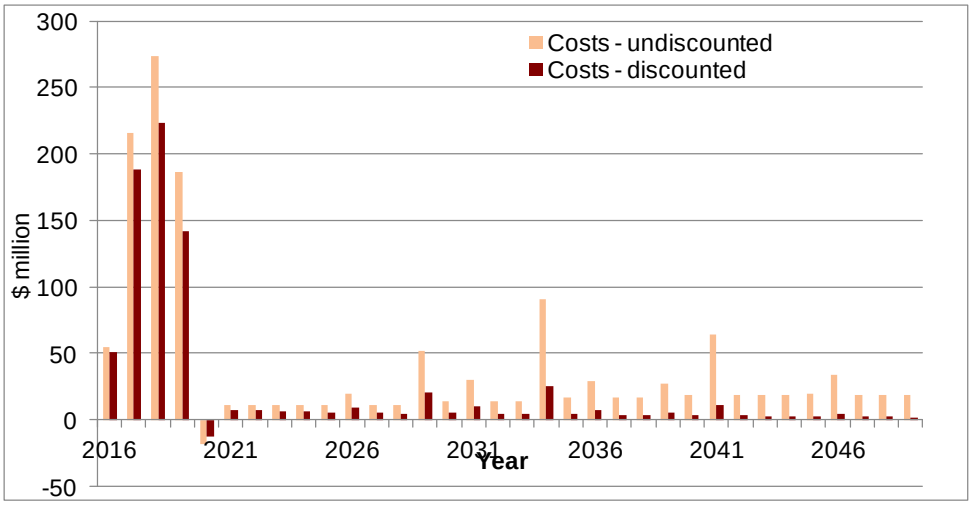
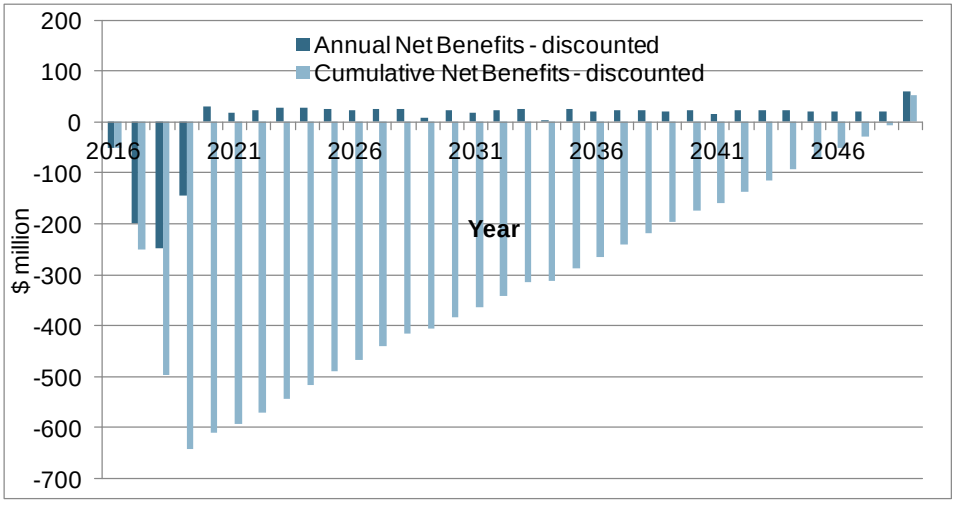


Figure 3 Net benefits time stream



6. Results summary

Table 3 Discounted benefit and cost results – Central assessment (7% discount rate, input value best estimates)

Benefits, $m	
Perceived user benefits:	
Car users	80
Public transport users	401
Reduced unperceived car operating costs	95
Reduced car ownership & parking costs	52
Reduced commercial vehicle travel costs	31
Increase in public transport fare revenue	113
Reduced environmental costs	23
Reduced accident costs	25
Disruption during construction	-37
Residual value	39
Costs, $m	
Fixed infrastructure capital costs	513
Fixed infrastructure operating and maintenance costs	110
Incremental bus capital costs	32
Incremental bus operating and maintenance costs	117
Results	
PVB, $m	823
PVIC, $m	545
PVOC, $m	226
PVC = PVIC + PVOC	771
NPV = PVB – PVC	52
BCR1 = PVB / PVC	1.07
BCR2 = (PVB – PVOC) / PVIC	1.10
FYRR	3.5%

Table notes:

1. All figures are $ million present value except for BCR and FYRR. All benefit and cost components are calculated as the incremental change between Base Case and Project (Option) Case

2. PV stands for present value; PVB is the PV of economic, social and environmental benefits, includes residual value, and excludes operating and maintenance costs; PVOC is the PV of operating and maintenance costs; PVIC is the PV of investment (i.e. capital) costs

3. BCR definitions BCR1 and BCR2 are both used by Australian jurisdictions – see ATAP Part T2 section 10.

Table 4 Sensitivity testing results

	PVB	PVIC	PVOC	NPV	BCR1	BCR2	IRR	FYRR
Central assessment (7% discount rate, input value best estimates)	823	545	226	52	1.07	1.10	7.5%	3.5%
Sensitivity Tests[(4)]								
1. Use a discount rate of 4%	1511	606	336	570	1.61	1.94	7.5%	3.8%
2. Use a discount rate of 10%	481	498	163	-181	0.73	0.64	7.5%	3.3%
3. Increase capital costs by 25%	823	681	226	-84	0.91	0.88	9.3%	2.8%
4. Decrease capital costs by 5%	823	518	226	80	1.11	1.15	12.7%	3.7%
5. Increase O&M costs by 10%	823	545	249	30	1.04	1.05	11.7%	3.4%
6. Decrease O&M costs by 10%	823	545	204	75	1.10	1.14	12.3%	3.7%
7. Increase benefits by 10%	906	545	226	135	1.17	1.25	10.4%	4.0%
8. Reduce benefits by 25%	618	545	226	-154	0.80	0.72	7.7%	2.4%

Table notes:

1. The asymmetric changes reflect a common tendency for the cost of initiatives to be higher than expected and the benefits to be less than expected

7. Results discussion

The results in Tables 3 and 4 show the initiative:

- Is economically justified in the central analysis (7% discount rate and best estimates for input values) with an NPV of $52 million and a BCR of around 1.1
- Is not economically justified for the following cases: a discount rate of 10%; capital costs increased by 25%; benefits reduced by 25%
- The economic justification is marginal when capital costs are increased or benefits are decreased
- Is economically justified in other sensitivity tests.

The appraisal shows that the economic justification of the initiative is sensitive to both overestimation of benefits and underestimation of costs. This means that estimates of benefits and capital costs need to be carefully scrutinised before a final decision to proceed with the initiative is taken.

8. Supporting calculations and formulas

The calculation of benefits outlined above were undertaken in accordance with Part M1 Public Transport of the ATAP Guidelines. However, detailed supporting calculations of benefits are not presented here. To do so is difficult because, in this appraisal, most of the benefit calculations were undertaken within the demand model.

References

IA (Infrastructure Australia) 2017, *The Infrastructure Australia Assessment Framework Guidelines*, http://infrastructureaustralia.gov.au/projects/make-a-project-assessment.aspx

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