CHAPTER 11
COST, RISK AND ECONOMIC ANALYSIS

11 COST, RISK AND ECONOMIC ANALYSIS

CHAPTER SUMMARY AND RECOMMENDATIONS:

- The costs of delivering, operating and maintaining a project present a base for the risk analysis and subsequent risk adjustment of the costs, which in turn informs the economic analysis.
- Risk is inherent in any project, and it creates the potential for a range of possible outcomes to materialise over time. Identifying and quantifying project risks enables the potential overall cost to government to deliver a project to be estimated. In this way, the risk assessment informs the project's overall cost profile and ultimately helps guide the project's implementation plans.
- The risk analysis and cost estimates were developed for the Brisbane Metro, in line with the Department of Transport and Main Roads (TMR) Project Cost Estimating Manual (PCEM) (Sixth Edition): September 2015. The risk analysis was also guided by the Project Assessment Framework (PAF), Building Queensland's Business Case Development Framework, and the National Public Private Partnership (PPP) Guidelines.
- The risk analysis demonstrates that there are risks associated with the Brisbane Metro's delivery and operation. Where possible, these risks have been quantified to calculate a suitable risk contingency, at a P50 and P90 confidence level, to ensure costs are accounted for should these risks materialise.
- The nominal, P90 risk adjusted capital costs for the Brisbane Metro total approximately $944 million. Key elements of the estimate include station construction costs for the new Cultural Centre underground station, the purchase of 60 metro vehicles and tunnelling works on Adelaide Street.
- The nominal, P90 risk adjusted operating costs for Year 1 of operation of the Brisbane Metro total approximately $41 million.
- A peer review of the Brisbane Metro cost estimates was completed, as part of the wider constructability and delivery program peer review. The peer review concluded that the cost estimating approach undertaken was considered reasonable.
- An economic cost benefits analysis (CBA) has been completed for the Brisbane Metro. CBA is universally accepted as the preferred economic analysis technique to assess the relative priority of competing infrastructure investment. The application of CBA, uniformly and consistently, allows for the effective comparison of projects across Australia. A key advantage of CBA is that it is the only tool in the project investment decision which includes consideration of both community and public sector outcomes.
- A conservative Cost Benefit Analysis for the Brisbane Metro shows a benefit cost ratio (BCR) of 1.91. That is, for every dollar of total expenditure, the program is expected to return $1.91 of benefits to the Brisbane economy.
- The Brisbane Metro delivers significant ongoing economic benefits, particularly to public transport users and road users, which is attributable to the targeted capital investment on a brownfield asset which is combined with a redesigned, more efficient service network.

11.1 Purpose and Overview of this Chapter

The purpose of this chapter is to present the cost estimates prepared for the Brisbane Metro, including the risk analysis completed to inform the cost estimates. The approach, assumptions and results of the economic analysis for the Brisbane Metro are also presented, with an economic CBA completed to determine the BCR of the Brisbane Metro.

This chapter outlines:

- The methodology for the development of the capital and operating cost estimates for the Brisbane Metro
- The approach taken to complete the risk analysis for the Brisbane Metro
- The risk adjustments made to the base costs for the Brisbane Metro, through the qualitative assessment and quantification of risks
- The nominal risk adjusted capital and operating cost estimates for the Brisbane Metro
- The outcomes of the independent peer review of the cost estimates.
- The methodology used to complete the economic analysis for the Brisbane Metro, including alignment to various frameworks and guidelines
- The cost and benefit stream inputs into the analysis
- The results of the CBA, including a conservative BCR.

The costs of delivering, operating and maintaining a project present a base for the risk analysis and subsequent risk adjustment of the costs, which in turn informs the economic analysis.

Risk is inherent in any project; it creates the potential for a range of possible outcomes to materialise over time. Identifying and quantifying project risks enables the potential overall cost to government to deliver a project to be estimated. In this way, the risk assessment informs the project's overall cost profile and ultimately helps guide the project's implementation plans.

Figure 11.1 presents the evolution of the real, non-risk adjusted costs to nominal risk adjusted costs, and the inputs required to complete the adjustment.

Figure 11.1 – Brisbane Metro cost adjustment process

As the figure above shows, costs presented in this chapter are in both real and nominal dollars. Real dollars are dollars that represent prices at a specific date (ordinarily the 'base date') and are not risk adjusted. Real dollars are exclusive of adjustments for the time value of money, such as inflation, escalation or discounting, after that date. The risk analysis provides quantitative contingencies, and escalation is included to derive nominal (out-turn) risk adjusted costs.

11.2 Cost and Risk Analysis Methodology

11.2.1 Risk Analysis Methodology

The risk analysis for the Brisbane Metro has been completed in accordance with a range of guidance materials, including the PAF, Building Queensland's Business Case Development Framework, the National PPP Guidelines and TMR's PCEM (Sixth Edition): September 2015.

11.2.2 Basis of Cost Estimates

Cost estimates were developed for the Brisbane Metro, based on the principles outlined in TMR's PCEM (Sixth Edition): September 2015. The PCEM has been used to guide the cost estimates of all major projects in Queensland, including Cross River Rail, ETCS – Inner City and Gold Coast Light Rail Stage 2.

The basis of estimate for the capital costs, operating costs and lifecycle costs have been identified and agreed by the project team to be used in the development of the Brisbane Metro cost estimates.

11.2.2.1 Capital Cost Basis of Estimate

Table 11.1 summarises the basis of estimate for each major capital cost item.

DESCRIPTION	BASIS OF ESTIMATE
Stations	Adopted first principles and unit rate direct cost estimate of structures, architectural elements, utilities, services, Intelligent Transport Systems (ITS), signage and associated civil reinstatement works.
Carriageway tunnels portals	First principles direct cost estimate and allowances for services and architectural elements.
Carriageway structures	First principles direct cost estimate for similar structures and unit rates.
Other works	Allowances and unit rates.
Passenger and vehicle management system	Rates based on benchmarking.
Depot and layover facilities	Unit rates
Off-site overhead and profit	First principles
Vehicles	Based on available information on the metro vehicle.
Land acquisition	Land acquisition costs have been estimated by Council's Land Acquisition Team, including an estimate of land costs, external costs and internal costs.
Procurement and delivery team	Percentage of construction costs.

Table 11.1 – Brisbane Metro Capital Cost Estimate Assumptions

11.2.2.2 Operating Cost Basis of Estimate

Table 11.2 summarises the basis of estimate for each major operating cost item.

DESCRIPTION	BASIS OF ESTIMATE
Overheads and Support Costs	A staffing structure has been developed along with salaries including on-costs, shift allowances and overtime for full time equivalent staff and casual and part time employees.
Fleet Operations	Operations costs are based on first principles derived from service kilometres, service hours and fleet size.
Station and Busway Operations and Maintenance	Based on first principles and benchmarking.

DESCRIPTION	BASIS OF ESTIMATE
Events, Consumables and Cash Collection	Based on first principles and benchmarking.

Table 11.2 – Brisbane Metro Operating Cost Estimate Assumptions

11.3 Risk Adjustments

The quantitative risk adjustments were produced using Palisade's @Risk software. This software uses a Monte Carlo technique to develop an aggregated statistical cost risk profile.

The Monte Carlo technique was used to run one simulation, combining both planned and unplanned risks, based on a predefined number of iterations (10,000) to calculate a costed risk profile and determine appropriate risk adjustments.

11.3.1 Risk Adjustments

Quantitative risk adjustments for the Brisbane Metro capital costs have been undertaken at the P50 and P90 level. The P50 value represents an estimate of the project risk contingency, based on a 50 per cent probability that the cost will not be exceeded. Similarly, the P90 value represents an estimate of the project risk contingency, based on a 90 per cent probability that the cost will not be exceeded, resulting in a more conservative risk adjustment.

The total P50 risk adjustment and the total P90 risk adjustment for the Brisbane Metro align with the expected contingency ranges for a business case estimate, as discussed in the TMR PCEM.

As per the capital cost risk adjustment, quantitative risk adjustments for the Year 1 operating costs for the Brisbane Metro were undertaken at the P50 and P90 confidence level.

11.4 Escalation Adjustments

The final step to develop the risk adjusted capital costs for the Brisbane Metro is to add an escalation allowance. The sections below provide further detail on how these allowances are calculated.

11.4.1 Capital Cost Escalation allowance

Following agreement by all States and Territories with the Department of Infrastructure and Regional Development (DIRD), Queensland cost escalation rates were developed to be applied to all P50 and P90 cost estimates prepared for new infrastructure projects from 1 January 2017. Table 11.3 presents the yearly escalation rates, which were applied to the Brisbane Metro capital cost estimate.

FINANCIAL YEAR	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	BEYOND
Escalation Rate	2.8%	1.5%	3.9%	3.7%	2.4%	3.4%	5%

Table 11.3 – Escalation rates applied to the Brisbane Metro capital cost estimate

11.4.2 Operating Cost Escalation allowance

For the operating costs, an annual escalation rate of 2.75% was applied to all operating and lifecycle costs. 2.75% was used based on a standard 2.5% in line with inflation (which is consistent with recent projects such as Cross River Rail, Beerburrum to Nambour and ETCS – Inner City), along with an additional 0.25% uplift to align with Council's forecast operating cost growth.

11.5 Brisbane Metro Capital Costs

The capital costs for the Brisbane Metro are presented in Table 11.4. The estimates are presented in both nominal P50 and P90 costs.

DESCRIPTION	COST ($M)
TOTAL NOMINAL P50 CAPITAL COSTS	**$868**
TOTAL NOMINAL P90 CAPITAL COSTS	**$944**

Table 11.4 – Brisbane Metro Capital Costs

The new underground Cultural Centre station accounts for the largest portion of capital costs, which includes the construction of the station itself, as well as the transition structure from the underground station up to Victoria Bridge and the Queensland Rail underpass works.

Other costs include expenditure for public utilities works, a large portion of which are required for the relocation of several significant services, mainly as part of the Cultural Centre station works. The costs for the new systems to support the Brisbane Metro are also included.

The infrastructure costs for the Victoria Bridge strengthening and local widening and the North Quay/Adelaide Street/King George Square tunnel works combined account for the third most significant portion of capital costs.

The estimated costs for modifications to the existing stations are included along with Buranda Station, where more significant infrastructure works are required to lengthen the existing platform.

The estimate for Council's procurement and delivery team has been apportioned across the other project costs, and include Council's costs to obtain a reference design, procurement costs, early works, survey and geotechnical investigations, and delivery costs to manage Brisbane Metro through to completion.

60 vehicles will be purchased for day one of operations, and will operate out of a proposed new depot.

11.6 Brisbane Metro Operating Costs

The nominal, risk adjusted operating costs for the first year of operation of the Brisbane Metro is presented in Table 11.5. The estimates are for Year 1 of operations of the metro services only, which commence in December 2022.

DESCRIPTION	COST ($M)
TOTAL NOMINAL P50 CAPITAL COSTS	**$38**
TOTAL NOMINAL P90 CAPITAL COSTS	**$41**

Table 11.5 – Brisbane Metro Year 1 Operating Costs

The operating cost estimate for Brisbane Metro is based on an estimated average weekday service kilometres in Year 1 of operations, with a 15 per cent dead running allowance.

11.7 Cost Estimate Peer Review

A peer review of the Brisbane Metro cost estimates was completed, as part of the wider constructability and delivery program peer review (as presented in Chapter 9). The peer review concluded that the cost estimating approach undertaken was considered reasonable.

11.8 Economic Analysis

CBA is universally accepted as the preferred economic analysis technique to assess the relative priority of competing infrastructure investment. The application of CBA, uniformly and consistently, allows for the effective comparison of projects across Australia. As an important decision making tool, CBA can be used alongside other key project investment considerations such as affordability, funding, deliverability, and environmental and social impact evaluation. A key advantage of CBA is that it is the only tool in the project investment decision which includes consideration of both community and public sector outcomes.

The economic analysis draws from the outcomes of the customer and product analysis presented in Chapter 7, as well as the project costs and quantitative risk adjustments presented earlier in this chapter.

11.8.1 Economic Methodology

The economic analysis for the Brisbane Metro has been prepared in accordance with guidelines, including:

- Queensland Government Project Assessment Framework
- Building Queensland Business Case Development Framework
- Building Queensland Cost Benefit Analysis Guidelines.

The methodology used to estimate traditional transport costs and benefits is also consistent with the Australia Transport Assessment and Planning (ATAP) Guidelines, as well as methods applied in previous major transport projects in Queensland, including Cross River Rail (CRR), ETCS – Inner City and Beerburrum to Nambour. The general structure of the CBA process is presented in Figure 11.2 below.

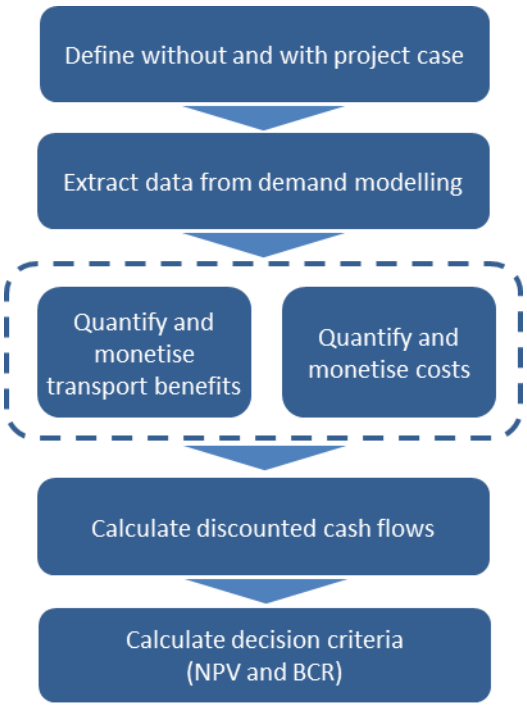

Figure 11.2 – Brisbane Metro economic CBA process overview

The economic appraisal period for the Brisbane Metro CBA is 35 years. This period includes a project delivery period of 5 years, beginning on 1 January 2018 and an operational period of 30 years.

Transport modelling data has been provided via the Brisbane Metro Transport Model, with data calculated using an Origin-Destination (OD) basis. Separate disaggregated outputs were provided for each OD zone in matrix form for a select number of variables, which were used to calculate car user reliability benefits.

11.8.2 Cost and Benefits Inputs

Cost estimates are included in the CBA as P50 estimates in real dollars, and are drawn from the costs presented earlier in this chapter.

Figure 11.3 shows the benefits streams considered as part of the economic appraisal for the Brisbane Metro.

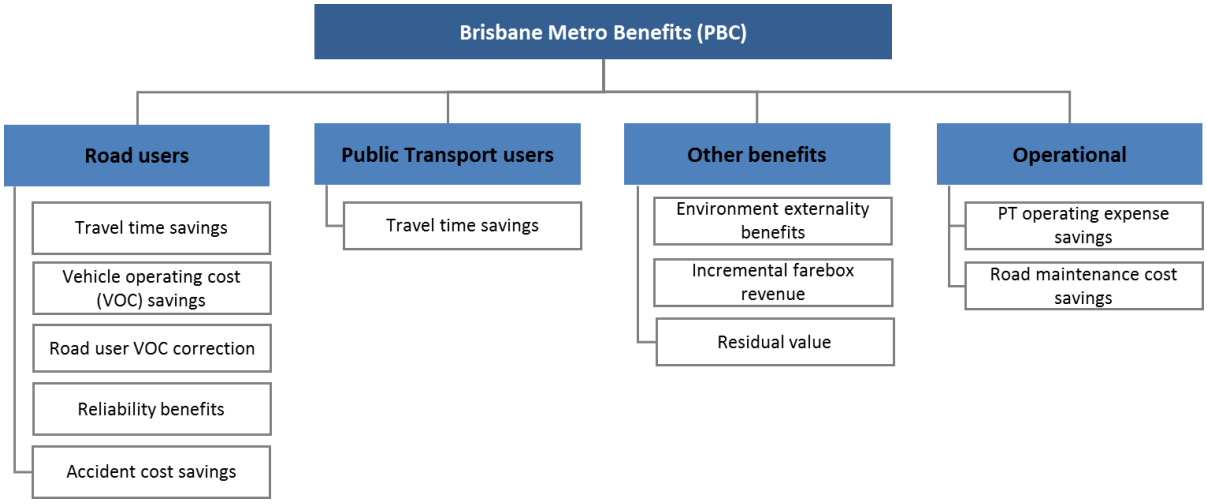

Figure 11.3 – Brisbane Metro benefit streams

The four benefits streams that were considered for the Brisbane Metro include:

- Benefits to road users, which can include a combination of travel time savings, vehicle operating cost savings, reliability improvements and savings from reduced accidents
- Benefits to public transport users in the form of travel time savings
- Other benefits, including resource corrections, such as environment externalities and incremental farebox revenue for public transport users
- Operational benefits, including operating and asset maintenance cost savings.

11.8.3 Cost Benefits Analysis Results

The Brisbane Metro requires a targeted capital investment on a brownfield asset which, by combining with a redesigned, more efficient service network, delivers significant ongoing benefits as reflected in the CBA results.

The conservative CBA for the Brisbane Metro shows a net present value (NPV) of $640 million and a benefit cost ratio (BCR) of 1.91. That is, for every dollar of total expenditure, the program is expected to return $1.91 of benefits to the Brisbane economy.

The value of the Brisbane Metro's benefits was calculated using the provided transport model outputs, and the benefits were calculated in incremental terms (i.e. the 'with' project case less the 'without' project case).

The transport model results indicate that large benefits are delivered due to Brisbane Metro. Travel time saving benefits to public transport users due to increased service frequency,

reliability and connectivity as a result of Brisbane Metro creates a mode shift where a number of road users move to public transport. This shift is then delivering a flow on benefit to remaining road users who benefit through reduced road congestion.

As discussed above, the four broad categories of Brisbane Metro benefits can be defined:

- Benefits to public transport users in the form of travel time savings
- Benefits to road users, which are a combination of travel time savings, vehicle operating cost savings, reliability improvements and savings from reduced accidents
- Operational benefits primarily due to reduced operating costs for the Transport for Brisbane (TfB) network but also a small reduction in road maintenance costs
- Other benefits, including resource corrections, the most significant of which is additional incremental farebox revenue for public transport users.

The greatest portions of benefits are delivered to public transport users and road users, and these are discussed in the sections below.

11.8.3.1 Benefits to public transport users

The benefits delivered by the Brisbane Metro to public transport users are measured as 'generalised' costs and reflect changes in access time, wait time, interchange time and in-vehicle time. The value of the generalised benefits to public transport users was calculated using the forecast travel times savings from the transport model and using a value of time of $16.39 per hour (real, 2016) for private travel and $53.19 per hour for business travel.

These benefits for public transport users can be attributed to the provision of a redesigned public transport service that offers:

- High-frequency services
- Shorter journey times across the metro and bus network
- Increased connectivity across public transport modes
- The ability to avoid delays caused by congestion due to dedicated, separated corridor infrastructure.

Public transport users will be required to change between buses and/or metro vehicles at a higher rate than without Brisbane Metro, but this inconvenience is offset by the reduced total journey time that switching to the high-frequency service delivers.

11.8.3.2 Benefits to road users

An improved public transport system that delivers the benefits described above can be expected to serve as an inducement for people to move onto public transport, delivering a mode shift away from private vehicles. This shift will benefit the 'remaining' road users due to reduced road congestion.

Large benefits attributed to private road users are reflective of the nature of the corridor most affected by the Brisbane Metro. The large region from Eight Mile Plains to the CBD will include a large number of 'remaining' road users who will benefit from Brisbane Metro once a proportion of current private vehicle drivers move onto the improved public transport system. The value of the travel time savings to remaining road users is based on the forecast travel times from the transport model and using a value of time of $20.82 per hour (real) for drivers and passengers in light vehicles, $48.71 per hour for medium vehicles and $77.68 per hour for heavy vehicles.

As well as travel time savings, private vehicle users save on vehicle operating costs (VOC) as a result of shorter vehicle travel times. Vehicle operating cost savings (as perceived by road users) is estimated from the transport model.

Private road users further benefit from reduced accident costs due to fewer vehicles on the road and enhanced journey time reliability. Reliability was calculated using the OD matrices extracted from the transport model in order to measure the change in the standard deviation of road users' total journey time.

The total value of benefits to private vehicle users, including reduced journey time, vehicle operating costs, reduced accidents and improved journey time reliability make up the majority of benefits, making road users the greatest beneficiaries of the Brisbane Metro.

11.9 Summary and Next Steps

Cost estimates were developed for the Brisbane Metro based on the principles outlined in TMR's PCEM (Sixth Edition): September 2015. The PCEM has been used to guide the cost estimates of all major transport projects in Queensland.

The nominal P50 risk adjusted capital costs for Brisbane Metro total $869 million, and the nominal P90 risk adjusted capital costs total $944 million.

The nominal P50 risk adjusted operating costs in year 1 of operations total $38 million, and the nominal P90 risk adjusted operating costs in year 1 of operations total $41 million.

A peer review of the Brisbane Metro cost estimates was completed, as part of the wider constructability and delivery program peer review. The peer review concluded that the cost estimating approach undertaken was considered reasonable.

The conservative economic CBA for the Brisbane Metro shows a BCR of 1.91. That is, for every dollar of total expenditure, the program is expected to return $1.91 of benefits to the Brisbane economy. The value of the Brisbane Metro's benefits was calculated using the provided transport model outputs, and the benefits were calculated in incremental terms (i.e. the 'with' project case less the 'without' project case).

The transport model results indicate that large benefits are delivered due to Brisbane Metro. Travel time saving benefits to public transport users due to increased service frequency, reliability and connectivity as a result of Brisbane Metro creates a mode shift where a number of road users move to public transport. This shift is then delivering a flow on benefit to remaining road users who benefit through reduced road congestion.