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An important note for the reader

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Abbreviations and acronyms

AO	approved organisations (comprises regional councils, territorial authorities and other approved public organisations, as specified in the Land Transport Management Act 2003, s.5)
APT	Auckland passenger transport (model)
AT	Auckland Transport
BPM	New Zealand Bus Policy Model (subject of this report)
CBD	central business district
ECan	Environment Canterbury (Regional Council)
EEM	*Economic evaluation manual* (vols 1 and 2) (NZTA 2010)
GB	Great Britain
GW	Greater Wellington Regional Council
IP	interpeak
IWA	Ian Wallis Associates Ltd (author of this report)
MED	Ministry of Economic Development
MoT	Ministry of Transport (New Zealand)
NGTSMA	*National guidelines for transport system management in Australia* (Australian Transport Council 2006)
NZTA	New Zealand Transport Agency
PSG	Project Steering Group
PT	public transport
PTOM	Public Transport Operating Model (under development by MoT in conjunction with regional councils and bus operators)
R&M	(bus) repairs and maintenance
RC(s)	regional council(s)
RPTP	regional public transport plan (requirements specified under the Public Transport Management Act, 2008)
SGC	SuperGold card (entitles 'seniors' to free travel at specified periods)
TLA	territorial (local) authority
WPTM	Wellington Public Transport Model (under development)
WTSM	Wellington Transport Strategy Model

Contents

Executive summary

Project overview, objectives and scope

This research report to develop the New Zealand Bus Policy Model (BPM or 'the model') was undertaken by consultant Ian Wallis Associates Ltd for the NZ Transport Agency (NZTA) Research Programme.

The overall project objective was to develop a methodology and computer (spreadsheet)-based model for application in assessing levels of demand, operational requirements, costs and financial performance for scheduled bus services in New Zealand. The BPM is essentially route based (with routes able to be grouped into corridors, areas, etc) and allows for disaggregation of results by day (weekday/Saturday/Sunday) and time period (peak, interpeak, evening).

The BPM is designed for two main groups of applications:

- as a service performance diagnostic tool, ie to examine the performance of the existing services (by route, time period, etc) in operational, market and financial terms
- as a scenario analysis tool, to assess the impacts on the bus system and its performance of changes to the bus system itself (eg to services, fares or unit costs) and/or changes in external factors affecting the demand for bus travel (eg changes in fuel prices, impacts of population and urban development changes).

The BPM was developed in close conjunction with and piloted by Greater Wellington Regional Council. Council staff have tested the model on both of the above groups of applications.

BPM structure and components

Input data. The starting point for the BPM is a database of the existing system (for the operation or area of interest) at the required level of disaggregation (eg by route and by day/time period), including the following:

- operations data, eg route distances, running times, service frequencies
- market demand data, eg passenger boardings, passenger fare revenues
- unit operating costs (by area/operator), eg costs related to bus kilometres, bus hours and peak bus numbers: these may be derived directly for the operation in question, if suitable data is available, or estimated from other sources, eg benchmarks.

Methodology – operations and demand analysis. The operations data is analysed to develop statistics on bus kilometres, bus hours and bus requirements by route and by time period for the existing system, on first a daily and then an annualised basis. Similarly, patronage and revenue statistics are derived from the market demand data. In both cases, usual practice would be to calibrate these annual estimates against known control totals from operator or other sources.

Methodology – costing. An 'avoidable costing' approach is used to estimate annual operating costs for each route group and time period by applying the unit cost rates to the relevant operating statistics.

Application – existing system appraisal. Application of the above methodology to the existing system database will result in annual estimates, by route and time period, of operations statistics, operating costs, patronage and fare revenues. Hence numerous performance ratios can be derived, including on operational performance (eg average operating speeds), on loadings (eg patronage/bus kilometre), on costs (eg costs/bus kilometre) and on overall financial performance (eg cost recovery rates, subsidy/passenger).

Application – scenarios assessment. The BPM may be applied to assess the effects of a wide range of 'scenarios', involving changes from the existing situation, in terms of:

- service levels (eg service frequencies, span of operating hours)
- operations (eg changes in running times)
- fare levels, concession fares, etc
- unit operating costs
- external transport/economic factors (eg fuel price changes).

Such changes may affect operational requirements, unit costs and patronage and revenue aspects. The BPM incorporates a demand elasticity function with respect to the user 'generalised costs' of travel: this adjusts demand (patronage) in response to changes in access and egress time, waiting time (depending on service frequency), in-vehicle time and fare levels.

The model is set up to assess such scenarios relative to the existing situation (or relative to each other), and report on changes in operations and costs, patronage, etc (by route and time period as appropriate).

BPM applications and end users

The model may be used for a wide range of applications relating to both appraising existing system performance and to assessing alternative scenarios, including the following:

Existing system appraisal:

- existing system performance analyses – operational, market, cost and overall financial performance, at various levels of (dis)aggregation
- allocation of services to contracts – appraisal of implications of alternative allocations of services to contracts or operating units
- development of service hierarchy structure – providing route performance statistics to assist in the development of a hierarchical ('layered') network structure.

Scenario assessment:

- service frequency changes – including adjustments to span of service hours
- network restructuring assessments
- changes in running speeds – for example, resulting from bus priority measures or faster boarding times
- changes in fare levels and fare structure
- changes in fuel prices – in terms of their impacts on demand (hence on service levels) and on operating costs
- budgetary planning – facilitates examination of multiple scenarios and 'what if' analyses.

In the New Zealand context, it is envisaged that the BPM and its outputs will be of potential interest to three main groups of users:

- public transport (PT) planning and contracting authorities – principally the regional councils
- PT operators – primarily bus operators
- PT regulatory and (national) funding authorities- principally the NZTA, but also potentially other authorities interested in public transport performance.

Each of these three groups is likely to have interests in at least some of the applications noted above, often at differing levels of (dis)aggregation.

Potential BPM enhancements

The current BPM (at the time of preparing this report) is at a relatively early stage in its maturity. Based on user feedback to date and the consultant's own ideas, a number of potential model enhancements have been identified that would enable the model to better meet the range of needs of current and expected end users: these are detailed in the report.

Abstract

A methodology and computer-based model was developed to analyse the performance of urban bus services in terms of their operations, market indicators and financial performance.

The main input to the methodology and model is a database of existing bus services, disaggregated by route and time period, and including operating statistics, patronage, fare revenues and unit costs. .

The NZ Bus Policy Model operates at a route level and has two main applications:

- as a service performance diagnostic tool, ie to examine the performance of existing services in operational, market and financial terms
- as a scenario analysis tool, to assess the impacts on the bus system and its performance of changes to services, fares or unit costs and/or changes in external factors affecting the demand for bus travel (eg changes in fuel prices, impacts of population and urban development changes).

The model uses MS Excel software. It was developed and piloted with the public transport planning and funding authority in Wellington, New Zealand. The main end users of the model are expected to be government authorities involved in the planning and funding of urban public transport services and the operators of these services.

1 Introduction

1.1 The project

This research project was to develop a NZ Bus Policy Model (BPM or 'the model'), as part of the NZ Transport Agency (NZTA) Research Programme 2009/10. The project was undertaken by Ian Wallis Associates Ltd (IWA) (Ian Wallis) in association with Tulip Consultancy (Daan Schneiders).

1.2 Project objectives and overview

The overall project objective was to develop a BPM for application in assessing levels of demand, operational requirements, costs and financial performance for scheduled bus services in New Zealand.

The model starts from a database of the existing bus services (in a region or sub-region), including data on operating statistics: patronage, passenger kilometres and fare revenue, and unit costs. This data is typically disaggregated by geographic dimension (eg route or route group and area) and temporal dimension (eg weekday vs Saturday vs Sunday, AM peak vs inter-peak vs PM peak vs evening). Starting with this database, the model may then be used for two main groups of applications:

- as a service performance diagnostic tool, ie to examine the performance of the existing services (by route, time period, etc) in operational, market and financial terms
- as a scenario analysis tool, to assess the impacts on the bus system and its performance of changes to the bus system itself (eg to services, fares or unit costs) and/or changes in external factors affecting the demand for bus travel (eg changes in fuel prices, impacts of population and urban development changes).

1.3 Project context and requirements

The project was developed to address the following requirements and potential areas of application that were not well met (or not met at all) by previous tools available to regional councils, bus operators and the NZTA:

- Increased emphasis was needed, at both national (NZTA) and regional levels on the financial (including farebox recovery) performance of public transport (PT) services at both aggregate (region-wide) and disaggregate (eg by route and time period) levels.
- There was a need for consistent methods to appraise PT service performance (in operational, market and financial terms) at a corridor and route level, as an important input to service reviews being undertaken by regional councils, including studies into major PT system enhancements (eg in the Wellington case, the Wellington City Bus Service Review and the Wellington PT Spine Study).
- As part of the development and implementation of the proposed Public Transport Operating Model (PTOM), there was a need to assess financial (farebox recovery) performance of the services at a 'unit' level, on a basis that was consistent both between units and over time (annual updates).
- Better revenue forecasts were needed at a regional level, particularly given the change from net cost to gross cost contracts in a number of regions.

- There was a need for better and more consistent budget planning tools in general, particularly in an environment of relatively volatile fuel prices, with fuel price movements affecting both the costs of service provision and patronage levels (which in turn impact on service-level requirements).

1.4 BPM end users and piloting

It was anticipated the primary users of the BPM would be regional councils, the NZTA and potentially bus operators (refer section 4.3 for more detailed discussion).

It was agreed the model would be initially developed and piloted with Greater Wellington Regional Council (GW), and tailored to its data sources, existing systems and priority requirements. The consultants therefore worked particularly closely with GW staff throughout the model development process. (Further details of this piloting experience are given in section 4.2 and appendix E.)

It is intended that, following this piloting stage (now completed), the model can be adapted to meet the data, systems and requirements of other regional councils and potentially of bus operators and the NZTA.

1.5 Report structure

Following this introductory chapter, the remainder of this report is structured as follows:

- Chapter 2 provides an overview of the BPM and its potential applications, and describes its input requirements, its outputs and key model methodology features and relationships (at a non-technical level).
- Chapter 3 outlines the model's architecture and software aspects, and the key steps in its application and the outputs obtainable.
- Chapter 4 discusses various aspects relating to the model's application and implementation, including: experience with the GW pilot application, discussion of the model's applications and end users, guidance on implementation aspects, and options for its access and distribution.

A number of aspects are covered in more detail in appendices. In particular, appendix A comprises a user manual, to provide detailed support to BPM users in preparing their model inputs and specifying and interpreting their outputs.

2 BPM overview, scope and structure

2.1 Scope of chapter

This chapter provides an overview of the model and its potential applications, and describes its input requirements, its outputs and its key features and relationships.

To the extent appropriate, the descriptions in this chapter are given in generic terms, applicable to the model in general rather than the specific formulation for the GW pilot case. However, in some places the descriptions are specific to the GW pilot project, for ease of understanding. Modifications may be needed to the model and in particular its input formats, to meet the needs of other authorities and their desired applications.

2.2 BPM overview

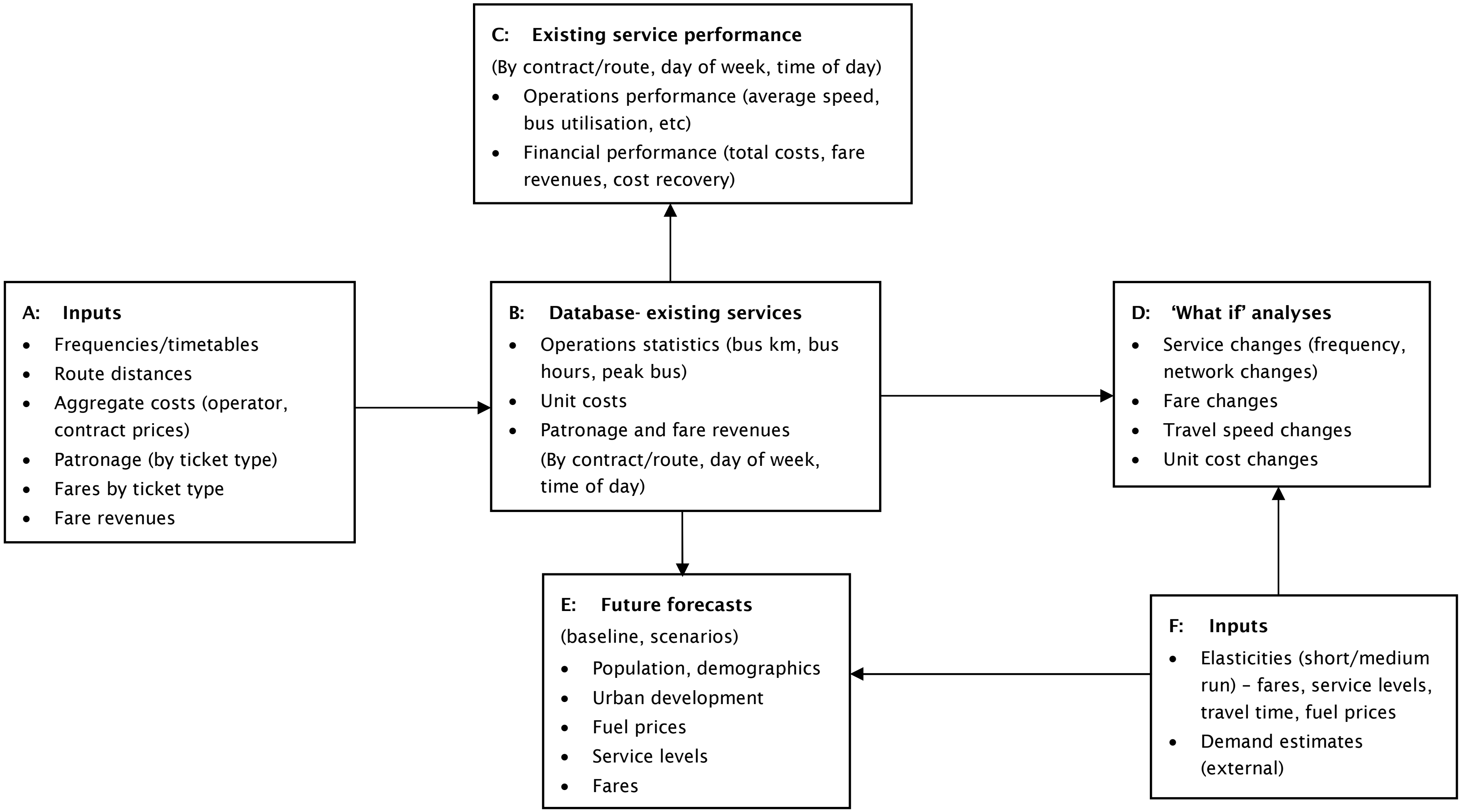
The conceptual structure of the BPM is illustrated in figure 2.1:

- The 'kernel' of the model is a database of the existing bus services in the region/area under examination, covering operations, patronage, fare revenues and cost data at the required level of (maximum) disaggregation (box B). This database is derived from input data at this level of disaggregation (box A).
- One of the primary areas of application of the model is, by manipulation of this database, to analyse the performance of the existing services at the required level of disaggregation, in terms of operational, market and financial performance (box C).
- The other primary area of BPM application is for scenario ('what if') analyses. These applications again start from the database of the existing services (box B) and then construct a modified database representing the scenario under consideration: the differences between these two databases represent the effects of the scenario. Such applications may be divided into two sub-categories:
  - scenarios involving changes to the services directly, eg changes in service levels, bus running times, fares, unit costs (box D)
  - scenarios involving changes external to the bus system, but which impact on levels of bus use (in the shorter or longer term) and hence may lead to changes in services (box E)

  Modelling the impacts of scenarios in both these sub-categories requires the formulation of various relationships between changes in supply characteristics (eg levels of service) and in external factors affecting demand (eg fuel prices) and levels of bus usage (box F).

These applications and the associated BPM methodology are described in more detail in subsequent sections of this chapter.

Figure 2.1 New Zealand Bus Policy Model – outline model structure and scope



2.3 BPM 'dimensions'

Table 2.1 sets out the typical 'dimensions' (levels of disaggregation) for the BPM database of the existing services and hence for the inputs to this database.

Table 2.1 Model 'dimensions'

Category	Typical dimensions	Notes
Geographic area	• Typically all bus services within a region; but maybe cover only a sub-region where separate data available (eg Tauranga, Hutt Valley).	• In pilot project, all bus services in GW area (including Wairarapa) were covered).
Modes	• Bus initially • Potential for addition of rail, ferry modes subsequently.	• GW has expressed desire for model to be extendable to cover rail and ferry (also cable car) modes. • BPM has been set up to allow for these additional modes; but development of specific model parameters (eg cost functions) has not been undertaken to date.
Services	• Route • 'Unit' (PTOM terms)	• A 'route' is generally taken as the basic unit of disaggregation. • Generally to include route variants with main route.[a] • To include both commercial and contracted services (separate or combined) as appropriate. • Then possible to aggregate routes as required, eg into contract areas, operating sub-regions, operators, etc. • The 'unit' concept, as developed for PTOM, comprises a group of routes (operating over all days and time periods) that serve a particular market or geographic area.[b]
Vehicle type	• Flexible – generally separate vehicle types with significantly differing capacities or cost structures.	• Buses would typically be divided by size categories (3-axle, standard, midi, mini – to be defined in detail) for modelling and costing purposes. • In the Wellington context, also separate by fuel type (diesel vs trolley), given their different cost structures
Time 'slices'	• Top level: weekday, Saturday, Sunday • Second level – weekday: typically night, pre-AM peak, AM peak, interpeak, PM peak, evening • Second level – Saturday/Sunday: typically night, morning, afternoon, evening.	• Public holidays generally allocated to day types according to level of service provided. • Annualisation factors incorporated to expand from daily to annual statistics. • 'After midnight' services typically comprise the 'night' time slice. • Precise period boundaries to be determined primarily based on levels of service offered.[c] • Breakdown of Saturday/Sunday services by time 'slice' may not be necessary, given weekend services typically account for only c.15% of total costs.
Data period	• Generally to base on data representing annual statistics.	• Usually based on most recent financial year for which data is available (actual or budget/plan forecasts), and ensure consistency with 'aggregate' annual statistics. • Possible to use shorter data periods (eg quarterly, monthly) but dependent on availability of data (especially patronage and revenues) and application requirements.

Notes:

[a] Need to define in detail what 'route variants' are to be categorised separately (eg peak express services), what with the main route.

[b] 'Units' would be listed in the relevant regional public transport plan.

[c] GW expressed a particular interest in being able to use the BPM to assess the effects of increasing service 'spans' (hours of operation) and increasing existing service levels in 'low demand' periods.

The following points should be noted in particular:

- For analysis and reporting purposes, services may be grouped (eg across route groups and time periods) as specified by the user, subject only to the level of disaggregation at which the base data is available. For example, if the base data is available by individual route, day and time periods within each day type, then the model's outputs could be reported by route group (eg by corridor/area, PTOM 'units', by operator, etc) and by all day types and time periods combined.
- At this stage the model focuses on bus services only. However, it has been set up so that it could be extended to cover other PT modes (urban rail, ferry, etc) relatively easily. Such an extension would involve additional work on operating cost functions, vehicle capacities and most likely demand functions (eg fare and service elasticities).
- The model does not have a spatial (network) dimension, and is thus not able to 'model' any network or demographic effects. These would need to be assessed externally and the resultant estimates could then be input to the model for further performance, etc analyses (refer section 2.6.5 for further discussion).

2.4 BPM outputs and applications

2.4.1 Existing system appraisal

The BPM has been designed to readily provide the following types of appraisal of the existing system by any of the dimensions specified in table 2.1:

- operations performance, eg average operating speeds, bus utilisation (bus hours/peak bus, etc)
- market performance, eg average boardings/bus trip, boardings per route
- financial performance, eg operating costs, fare revenues, SGC revenues[1] and net cost per passenger by route and time period.

Some sample performance outputs are provided in appendix B.

2.4.2 Scenario analyses

The BPM has been designed to assess the impacts of a wide range of 'scenarios', defined in terms of changes to the existing system. Table 2.2 summarises the types of changes which the model is designed to assess.

When undertaking scenario analyses, it is possible to provide outputs at the same level of disaggregation as the dimensions of the existing service database (table 2.1), or at greater levels of aggregation (as specified by the user).

As indicated above, some scenarios may relate to potential changes to the bus services directly (eg fare or service changes) or to external changes affecting the usage of bus services (eg fuel price changes, population changes), which may in turn lead to changes in the services themselves. Both types of changes may impact in the shorter term (eg service changes, fuel prices) and/or primarily in the longer term (eg population and demographic changes).

[1] SGC = SuperGold card (entitles 'seniors' to free travel). In the case of net cost contracts, operators are reimbursed in relation to SGC passengers carried, based on an agreed formula.

Table 2.2 Range of scenarios that may be addressed by the BPM

Scenario heading	Notes, comments re inclusion
A Service changes	
A1 Hours of operation	• Yes
A2 Service frequency	• Yes
A3 Route network	• Yes, subject to the availability of suitable demand estimates from external sources (refer section 2.6.5). Variations to existing routes included under this heading.
B Operations and service quality changes	
B1 Operating speeds	• Yes (eg resulting from bus priority measures or rescheduling).
B2 Vehicle type	• Yes – principally in terms of cost impacts.
B3 Service reliability	• Not incorporated at this stage (need methodology for quantifying reliability in existing and scenario situations, together with its impacts on patronage).
B4 Crowding	• Not incorporated at this stage although BPM outputs can highlight routes and time periods with potential crowding (need to establish relationships between average load, bus trip and passenger perceived 'generalised costs' of travel).
C Unit operating costs	• Yes (refer section 2.6.2 and appendix D).
D Fare changes	
D1 Overall fare levels	• Yes – for situations involving 'across-the-board' fare changes.
D2 Fare structures	• For situations where fare changes differ by geography (eg number of zones) or market segment (eg adult vs concession) – model is likely to need enhancement for such analyses at a detailed level: such analyses would be dependent on the availability of patronage data by appropriate geographic/market segments.
E External economic (price and income) effects	
E1 Fuel prices[a]	• Yes – depends on having relevant estimates of cross-elasticities of bus demand with respect to fuel prices (such estimates are available for Wellington).
E2 Parking charges	• Potentially, subject to availability of appropriate cross-elasticity estimates (not incorporated at this stage).
E3 Other price/income effects	• Subject to further investigation and availability of external estimates for impacts (eg effects of employment levels on patronage).
F Demographic and urban development changes	• Subject to further investigation/discussions and availability of appropriate data. Likely to be most appropriate to model impacts of such changes on PT patronage externally (eg through WTSM, WPTM in the Wellington case) and then import results into BPM.

Note:

[a] The relevant prices here are those for fuel used for car travel; generally petrol prices would provide a reasonable proxy for car fuel prices, although noting that an increasing proportion of the car fleet uses other fuels.

2.5 BPM input data and methodology – existing system appraisal

Table 2.3 sets out the BPM input data typically required for establishing the existing system database and for analyses of existing service performance. These data requirements are divided into three main categories:

- service supply (operations) data – by route and time period, contracted vs commercial, and vehicle type/size
- market demand (patronage and fare revenue) data – by route and time period.
- unit cost data – vehicle size category, fuel type, etc.

Given all the specified input data, the model then provides routines to derive performance statistics relating to service supply and market demand by route, time period, etc. This aspect is fairly straightforward in principle, although the routines may need to be adjusted to interface with the format of the inputs available.

Assessing the operating costs of any specified service supply is not so straightforward and a number of issues arise. Issues typically arising and the way these are addressed in the BPM are outlined in appendix D.

2.6 BPM input data and methodology – scenario assessments

The range of scenarios that may be addressed is set out in table 2.2. Each scenario type will have impacts directly on one or more of the table 2.3 categories (ie service supply, market demand and revenues, unit costs), as summarised in table 2.4. In the case of scenarios that affect demand, there may also be a flow-on (indirect) impact on supply if the operator/authority chooses to respond by adjusting the service in response to the changes in demand[2].

The following sub-sections set out the input data required and methodologies adopted in the model to assess the impacts of scenarios against each of these three impact categories. Each scenario has been assessed relative to a 'base' scenario: generally this base would be the existing system, but the model has been designed so that the user can specify an alternative base against which the scenario is to be compared.

[2] The BPM does not incorporate such flow-on adjustments automatically: these would be left to the discretion of the model user.

Table 2.3 Model input data – existing system

Category	Data description	Sources, notes
A Service supply (by route and time period, vehicle type, etc)	A1 Route distance A2 Trip time and speeds (running time/layover) A3 Service frequency A4 Operations annualisation factors A5 Annual service operating statistics – bus km, bus hours, peak buses	• Items A1 – A5 generally available from publicly available data (eg timetables) from regional council (RC) sources (eg passenger enquiry database) or otherwise from operator sources. • Data usually input as daily statistics (by time period), then converted to annual statistics based on the number of days in the year with each level of service (weekday, Saturday, Sunday).
	A6 'Dead' running factors	• Item A6 generally not available from public sources – may be obtainable from operator sources. Desirable to make separate estimates of factors for bus hours and bus km, and for peak vs off-peak periods.
B Market demand (by route and time period)	B1 Passenger boardings B2 Passenger fare revenues B3 Passenger kilometres (or zones travelled)	• These items may not generally be held by RCs at the required level of detail – although those regions with fully integrated ticketing systems may be exceptions (eg Canterbury, Waikato). In other cases, RCs may have sufficient information to make approximate allocations of boardings etc by route, day type and time period[a]. • Data expected to comprise passenger boardings, passenger km, average fares (and SGC reimbursement amounts) by route and by time period[b]. • If BPM is to be used for detailed modelling of fare structure options, likely to need more geographic-specific data (eg passenger movements by boardings and alighting zones). • Note there may be confidentiality issues regarding general release of market demand data.
C Unit operating costs	Unit operating costs (by bus type), with the following breakdown: • time-related (bus hour) costs • distance-related: fuel • distance-related: other • bus-related operating • operating overheads • bus capital charges • profit margin • route infrastructure costs (eg trolley wires repair and maintenance if applicable).	• Cost structures and unit costs may be estimated from a range of sources (eg contract price information, contract variable rates, previous benchmarking analyses). • Bus capital costs would generally be translated into an average annualised capital charge over the effective vehicle life (refer appendix D). • Costs would normally include an allowance for operator profit margin, expressed as a % on all operating costs (margin rates based on RC contract or other experience). • Desirable to develop a cost model and set of unit costs that are consistent with gross income of operators (funding payments from RCs and fare revenues) for either the most recent full financial year or most recent quarterly period. • Within any region, it may be appropriate to estimate separate unit costs by bus size category (if 'non-standard' buses comprise a substantial proportion of the fleet) and possibly by bus fuel type (eg diesel vs trolley), possibly by terrain ('hilly' vs 'flat' routes) and maybe by operator.

Notes:

[a] Under the proposed PTOM contractual arrangements, RCs will be able (on request) to obtain detailed data from the operators on passenger numbers and fare revenues.

[b] Desirable to separate SGC ('free') passengers.

Table 2.4 Impact categories by type of scenario

Scenario heading		Impact categories		
		Service supply	Unit costs	Demand and revenue
A1/2	Service level	*		*
A3	Route network	*		*
B1	Operations	*		*
B2/3	Service quality	*		*
C	Unit costs		*	
D	Fares			*
E	External economic			*
F	Demographic/urban development			*

2.6.1 Service supply impacts

Generally, the assessment of the impacts of any scenario on service supply is quite straightforward, provided the scenario impacts can be expressed in terms of the specified service supply measures for the existing system (table 2.3, items A1–A3, B1–B4).

The BPM has been designed so that:

- the user can input either the absolute supply data for the scenario (eg bus kilometres, bus hours, peak buses – by route and time period), or the change in supply data relative to the defined base.
- the model can then produce absolute operating statistics for the scenario and their difference from the base statistics.

2.6.2 Unit cost impacts

The unit cost module comprises:

- a set of variable unit cost rates applicable (in the medium term) to supply changes[3]
- a methodology/procedures for applying these unit rates to estimate the cost impacts of any defined supply change (defined in terms of annual bus kilometres, bus hours, etc as in table 2.3).
- an auxiliary methodology/procedures for analysing the costs of an existing system, by route and time period, etc.

The unit cost methodology is described in more detail in appendix D.

2.6.3 Demand and revenue impacts – PT service changes

A demand module has been developed to encompass all the impacts of scenarios on the 'generalised costs' (fares, travel time, quality aspects) of bus trips from the user perspective and hence on the demand (patronage) for these trips.

[3] These unit cost rates include components for bus capital charges (on a long-run average basis) and 'normal' profit margins.

This module uses a well-established approach to assessing the demand impacts of changes in PT services. The user generalised cost/demand module follows the approach used in the Australian Federal evaluation guidelines (Australian Transport Council 2006). Key features of the module include:

- an expression for the generalised costs (or generalised time) of PT trips, including terms for:
  - fares
  - access time
  - waiting time (expected)
  - waiting time (unexpected, due to service unreliability)[4]
  - in-vehicle time
  - transfer time
  - on-vehicle crowding[5].
- a set of values of time for each of the relevant trip components
- a set of 'generalised cost' elasticities of demand. These may be disaggregated by:
  - peak vs off-peak vs weekend periods[5]
  - short term vs longer term effects[5]
  - longer vs shorter distance trips (if data available)
  - adult vs concession passengers (if data available).

In the context of this project, we consider this 'generalised cost' methodology is superior to a methodology using separate component elasticities (eg for fares, service frequency, in-vehicle time).

The methodology for this module and the key 'default' parameter values is detailed in appendix C.

2.6.4 Demand and revenue impacts – other economic changes

Some of the potential scenarios will affect PT demand (patronage), not through changes in the 'generalised costs' of bus travel but through changes in the generalised costs of competing modes or in the overall propensity to travel. This applies principally to scenario E: external economic effects (table 2.2). In practice, the most important of these effects is likely to be changes in fuel prices, but other economic impacts (eg changes in CBD employment or parking charges) may also be significant.

In relation to any changes in the generalised costs of competing modes, the BPM adopts a 'cross-elasticity' formulation, for example an X% increase in fuel prices would result in a Y% increase in bus travel, where Y/X represents the cross-elasticity of bus travel with respect to fuel prices. As above, such cross-elasticities may be disaggregated by market segment (particularly peak vs off-peak) and time period (short term vs long term), to the extent that the evidence is available.

The current model incorporates an estimate of the cross-elasticity of bus travel demand with respect to (real) petrol prices, for both peak and off-peak periods. These estimates are based on evidence from

[4] The current module does not incorporate terms relating to service (un)reliability and crowding: these could be incorporated subsequently, providing data on levels of reliability and crowding is available.

[5] Currently, the model incorporates default parameters only by time period (peak vs off-peak) and by short vs long-term effects. Other parameters could be added if relevant data is available.

Wellington (city). If estimates are required for other centres, then either the Wellington estimates could be used or additional market research and patronage data analysis would be required.

At this stage, the model does not incorporate any estimates of the cross-elasticity of bus travel with respect to parking charges. Very little evidence on such cross-elasticity values exists in New Zealand: if estimates are required, then additional market research (primary or secondary) would be needed.

2.6.5 Demand and revenue impacts – network and demographic changes

Here we summarise the suggested approach to addressing scenarios that affect 1) the structure of the PT network; and 2) changes in demographics and urban development (refer table 2.4, items A3, F). The model does not have a spatial (network) dimension and is thus not able to represent network and demographic effects; it will be necessary for these effects to be 'modelled' externally, with the results (in terms of changes in bus patronage on defined routes, etc) then being imported into the model.

For scenarios that affect the PT network, we anticipate external modelling of their effects would be undertaken, using the regional transport model (if available) or other spreadsheet-based models. For Auckland, the Auckland Public Transport (APT) Model would be appropriate. For Wellington, the regional Wellington Transport Strategy Model (WTSM) and/ or, when completed, the regional Wellington Public Transport Model (WPTM) would be appropriate.

For scenarios involving changes in population, demographics and urban development, again it would generally be appropriate to use either the regional transport model and/or the regional PT model (where available).

For both types of scenarios, region-specific routines would be required to export the regional outputs from the regional (public) transport model and import these into the BPM.

3 BPM architecture and operation aspects

3.1 Scope of chapter

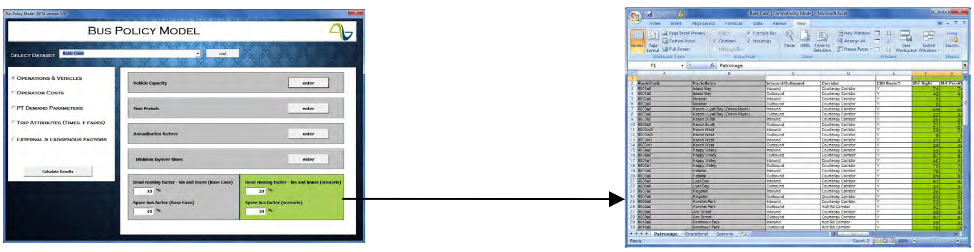
This chapter provides an overview of the model architecture and software aspects, the key steps in model operation and the types of outputs provided. It is intended for the general reader. The *User manual* (appendix A) provides a more detailed description of the BPM and its applications, while appendix B provides examples of the range of outputs available.

3.2 BPM architecture

BPM is set up as an Excel application. The application contains all calculation functionality, chart generation and parameter settings. The application itself does not contain any network or route data. It needs to be linked by the user to a dataset containing all route data: the user needs to pre-populate this dataset in a specific format. A template file is therefore included.

Figure 3.1 Application connected to external data set

Application (opened first, then linked to data set)	Data set



All network and route information is separated from the calculations, which allows the user to run different scenarios multiple times without affecting the core data of the network.

It also enables the owner of the tool to make changes to the tool and redistribute it to users without the need for the user to re-enter their data.

3.3 Steps in model application

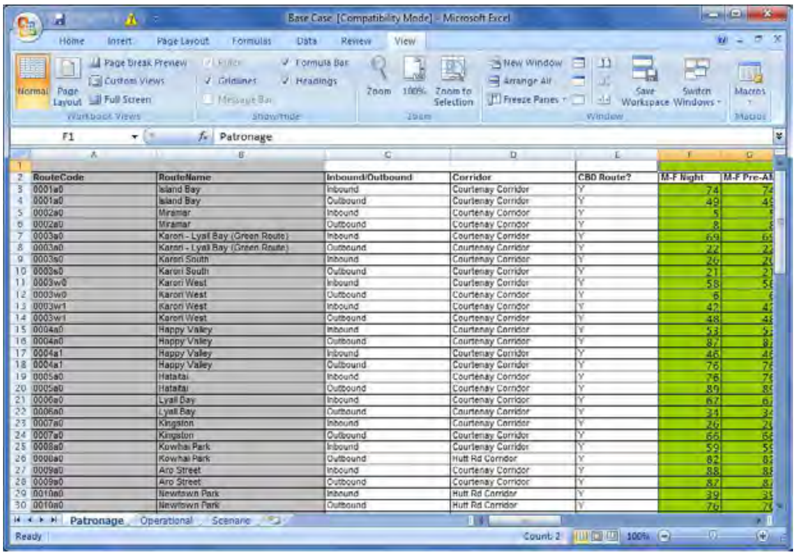
The following sub-sections describe, at a high level, the four main steps involved in the application of the BPM and calculation of the results.

3.3.1 Step 1: Enter route data in template

All data relating to routes is entered directly into a worksheet:

- passenger data (number of passengers, average fare)
- operational data (vehicles used, trip times, etc)
- scenario data (changes to fares, frequency and trip time).

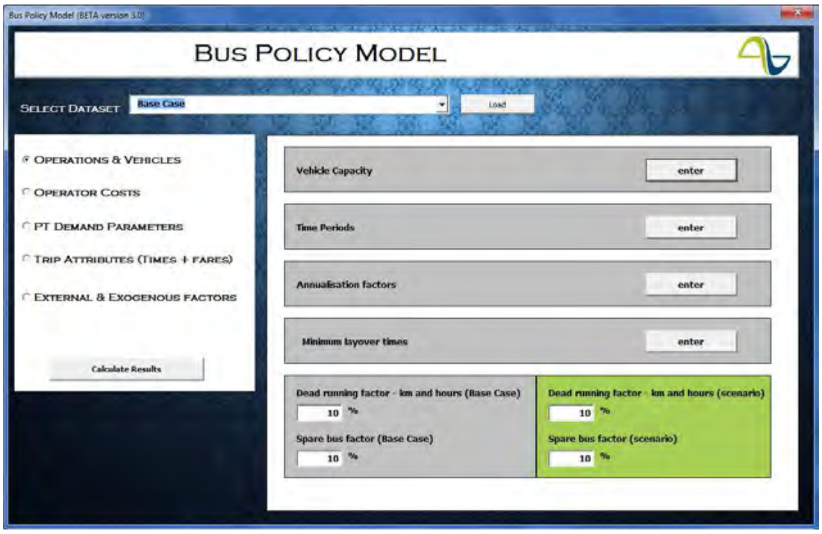
Figure 3.2 Route data entry sheet



3.3.2 Step 2: Run BPM application and connect to data file with route data

After opening the tool the form below appears. From the top box the user may chose the data set they want to use for their calculations.

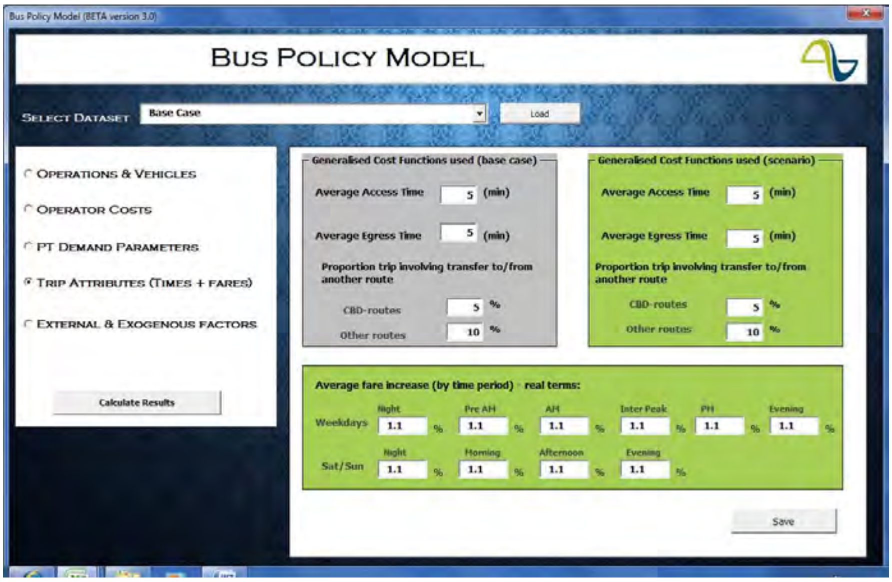
Figure 3.3 Bus Policy Model opening screen



3.3.3 Step 3: Enter network settings for current data and scenario into BPM application

- Information of non-route specifics is entered through the dashboard (layover times, time period definitions, average waiting times, elasticities, etc).
- The user sets all the parameters to apply to the uploaded route data (in the grey boxes).
- The user sets all the scenario parameters to apply to the uploaded route data (in the green boxes).
- The user sets elasticity values for use in the generalised cost function.

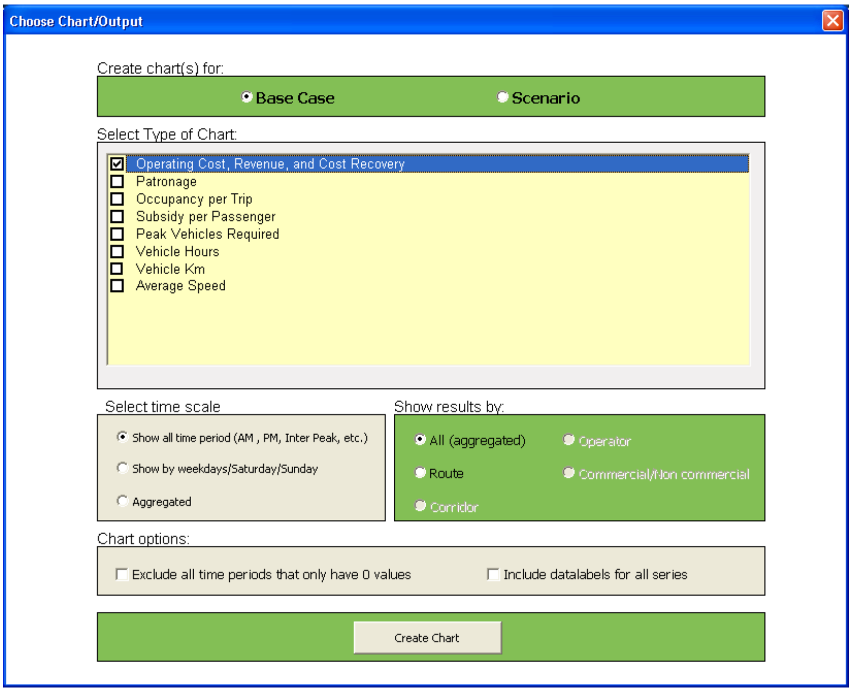
Figure 3.4 Generalised cost inputs



3.3.4 Step 4: Calculate results

- The user chooses the type of custom reports required.
- The user chooses the level of detail they want to report on.
- The user is then shown a preview of the chart(s) generated.
- The user chooses if they want to save these reports (in tabular and chart form).

Figure 3.5 Report specification



3.4 Scenario analysis

The BPM offers the ability to calculate patronage effects of changes in waiting time, frequency and many other parameters.

3.4.1 Cost changes

The BPM accepts operating costs for the base scenario and for the selected scenario. These numbers will appear side by side in the model; it shows the base costs using the original cost settings for running the base network alongside the cost for running the network using the scenario costs.

The model offers the possibility to compare cost impacts of changes in:

- operating costs (per kilometre, per hour, per annum)
- dead running
- spare buses
- minimum layover times, etc.

3.4.2 Patronage changes

The BPM provides the option of assessing the effects of expected changes in patronage. The changes can be entered relative to the base case on a network level or on a route level.

3.4.3 Changes in demand factors

The BPM is able to estimate changes in demand (patronage) resulting from changes in a wide range of parameters. This is done through elasticity-based relationships, which relate changes in demand to:

- changes in the 'generalised cost' of PT travel – through a demand elasticity function relating demand to the generalised cost of PT travel, and/or
- changes in the generalised costs of alternative modes, through cross-elasticity functions[6].

Using these relationships, the effects on demand of changes in the following parameters may be assessed:

- fares
- petrol prices
- access/egress time
- percentage of passengers changing services
- model parameters (eg value of in-vehicle time, transfer penalty).

3.5 BPM calibration

Each bus system has its individual characteristics and the BPM needs to be calibrated to reflect these.

[6] Further discussion of the 'generalised cost' approach and of direct demand elasticity and cross-elasticity functions is given in appendix C.

It is therefore necessary to run the model first with data for which the outcomes are known. The user can then use the known system-wide annual operating statistics (usually bus kilometres, bus hours, peak buses) and system-wide annual operating costs (including allowances for bus capital charges and profit margin) in calibrating the model.

After running the model, the output can be matched with the known system-wide data. Any changes should be factored and then fed back into the model. This can be done in several ways, by:

1 adjusting the 'dead running' factors (relating principally to bus kilometres) to match known aggregate bus kilometre statistics

2 adjusting the layover times (to match the bus hour and peak bus requirements)

3 adjusting the percentage spare vehicles (to match the total fleet requirements)

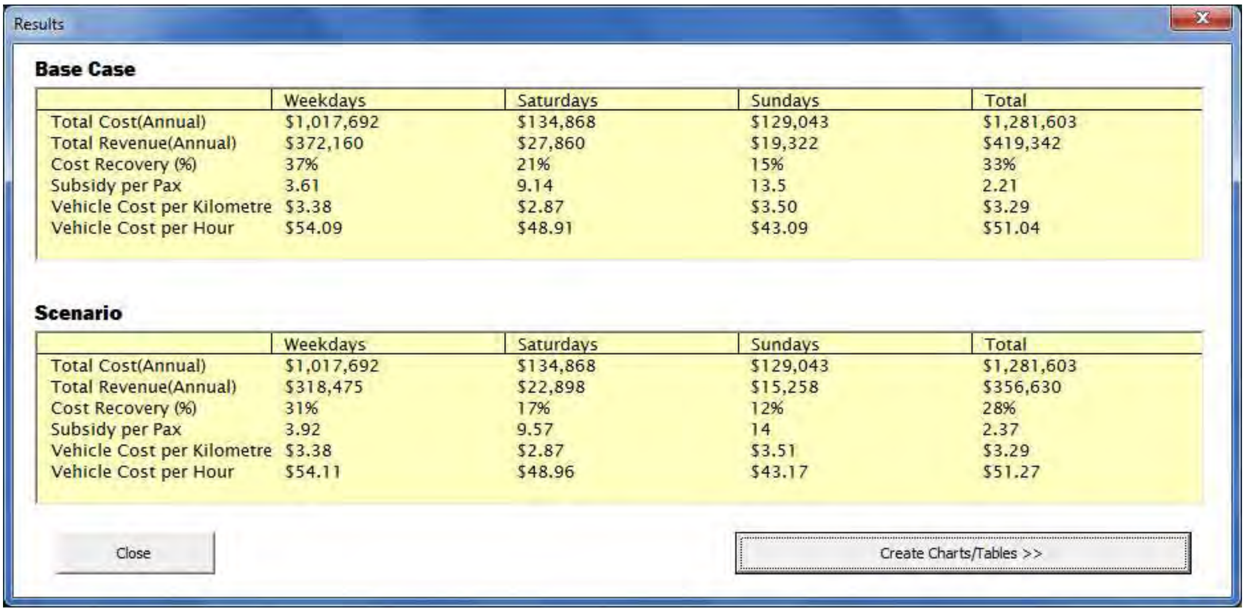
4 adjusting the unit operating costs (to match the total system costs).

Once the adjustments are made, the model should be run one more time to check if the outcomes match the real situation in the region. Once this is the case, the model can be used and does not have to be calibrated further.

3.6 Outputs

After running the BPM the results screen will appear, as shown below, providing a high-level overview of the results.

Figure 3.6 Output summary results


Results

Base Case

	Weekdays	Saturdays	Sundays	Total
Total Cost(Annual)	$1,017,692	$134,868	$129,043	$1,281,603
Total Revenue(Annual)	$372,160	$27,860	$19,322	$419,342
Cost Recovery (%)	37%	21%	15%	33%
Subsidy per Pax	3.61	9.14	13.5	2.21
Vehicle Cost per Kilometre	$3.38	$2.87	$3.50	$3.29
Vehicle Cost per Hour	$54.09	$48.91	$43.09	$51.04

Scenario

	Weekdays	Saturdays	Sundays	Total
Total Cost(Annual)	$1,017,692	$134,868	$129,043	$1,281,603
Total Revenue(Annual)	$318,475	$22,898	$15,258	$356,630
Cost Recovery (%)	31%	17%	12%	28%
Subsidy per Pax	3.92	9.57	14	2.37
Vehicle Cost per Kilometre	$3.38	$2.87	$3.51	$3.29
Vehicle Cost per Hour	$54.11	$48.96	$43.17	$51.27

Close

Create Charts/Tables >>

The user is presented with the key results from their calculations for the base case and the scenario (all broken down between weekdays, Saturdays, Sundays and total):

- total cost
- total revenue
- cost recovery

- subsidy per passenger
- cost per kilometre
- cost per hour.

The model allows for the above parameters to be combined and aggregated so that tables and charts can be generated flexibly.

4 BPM application and implementation aspects

4.1 Scope of chapter

This chapter addresses various aspects relating to the application and implementation of the BPM:

- Section 4.2 outlines the experience with the piloting of the model with GW (commentary from GW staff is provided in appendix E).
- Section 4.3 summarises the potential applications of the model and discusses their relevance to the various groups of likely end users.
- Section 4.4 provides guidance on the structure, implementation and operation of the model, to assist new or intending users.
- Section 4.5 outlines options (for consideration by the NZTA) for the distribution of the model and for the provision of feedback from its users.
- Section 4.6 sets out a number of potential enhancements to the current model that have been identified to date, which would warrant further consideration to ensure the model will best meet the needs of its current and future users.

4.2 Wellington pilot application

As noted earlier (section 1.4), the BPM has been developed in close cooperation with and piloted by GW, and has been interfaced with its existing systems and data sources. The consultants have worked particularly closely with GW planning staff throughout the development process.

To date, GW has used the model for two main applications:

- analysis of the operational, market and financial performance of all bus services operating in the Wellington city area, disaggregated by route/route group
- costing and comparative assessment of bus service improvement options in one part of the Wellington region.

GW staff have provided an independent commentary on their experience with piloting the model and their applications to date: this is set out in appendix E.

4.3 End users and potential applications

In the New Zealand context, we envisage the BPM and its outputs will be of potential interest to three main groups of users:

1. PT planning and contracting authorities – principally the regional councils
2. PT operators – primarily bus operators (in relation to the current model)
3. PT regulatory and (national) funding authorities – principally the NZTA, but also potentially the Ministry of Transport (MoT) and other parties interested in PT performance.

Each of these three groups is likely to use the model in different applications and at different levels of (dis)aggregation. The following provides a brief overview of potential applications for each group.

4.3.1 PT planning and contracting authorities (regional councils)

Potential uses of the BPM for these authorities are summarised in table 4.1.

We consider these authorities are likely to be the primary users of the model; it has the potential to be a major tool assisting their work in the areas of performance diagnostics, contract/unit design, service planning and budgeting.

4.3.2 PT operators

To a considerable extent, the potential applications by PT operators (bus operators with the present model) overlap with those of the planning/contracting authorities: this will particularly be the case if the proposed partnership model, PTOM, is adopted, under which service planning will be more of a joint regional council/operator function than has been the case hitherto.

The BPM may also assist operators at the more 'operational level, for example in examining the case for additional/satellite depots in order to reduce dead running – although for detailed appraisal of such changes additional tools (eg scheduling packages) may also be required.

4.3.3 PT regulatory and funding authorities

The NZTA is the main central government agency that is a potential user of the BPM, although MoT may also come into this category and agencies such as the NZ Treasury and the Ministry of Economic Development (MED) may take an interest in the outputs from BPM applications (without being direct users themselves).

Currently, the NZTA's monitoring of PT performance is based, to a considerable degree, on end-of-year reporting by the regional councils on market statistics (patronage, passenger kilometre, fare revenues) and financial statistics (net expenditures by work category). This reporting is focused at the region-wide level, with regional councils not obliged to provide information at a more detailed level (eg for each major centre within a region).

The BPM could potentially facilitate more detailed and consistent performance reporting by regional councils to the NZTA (assumed on an annual basis). The NZTA could specify to regional councils what information it requires and could also (if it wishes) specify key assumptions to be applied in deriving this information (eg demand elasticities for forecasting applications), so as to ensure the information provided by regional councils is on a consistent basis.

Performance aspects in which the NZTA may have particular interest include:

- aggregated performance comparisons, at regional and sub-regional/centre levels, eg:
  - average operating speeds
  - gross operating cost/bus kilometre
  - average loadings/trip
  - average fare per passenger (or passenger kilometre)
- commerciality ratios, by 'unit' on a consistent basis
- financial forecasting, for budgeting purposes, using consistent assumptions and parameters across all regions
- identification of routes or units with poor financial performance (eg low average boardings, low farebox recovery, high subsidy per passenger).

Table 4.1 Potential BPM applications – regional councils

Application	Notes
1 Performance analysis of existing system	• May include: – operational performance (average speeds, vehicle utilisation, etc) – market performance (average loadings, fare revenue per passenger, passengers/bus km, etc) – cost performance (cost/bus km, cost/passenger, etc) – overall financial performance (farebox recovery ratio, average subsidy/passenger, etc). • Such analyses could be undertaken at various levels of (dis)aggregation chosen by the user, and dependent on data availability (eg by route, by PTOM 'unit', by sector/sub-region, by service type).
2 Allocation of services to contracts	• Can provide a systematic basis for assessing the implications of alternative allocations of services between contracts (route groups, areas or 'units'), including assessment of the financial (eg cost recovery) and other performance of the resulting contracts.
3 Categorisation/analyses by service type	• Can provide a systematic basis for categorisation of services by service type (eg RTN vs QTN vs LCN[a], with aggregation of performance statistics by category and diagnostic analysis of performance within and between each category.
4 Network restructuring assessments	• Assessment of options relating to network/corridor restructuring, new routes, route extensions/shortenings, etc[b]. • Could assess impacts on operational, market, cost and overall financial performance (as item 1 above).
5 Service frequency optimisation	• Assessment of range of implications of changes in service frequencies by route and time period (eg operating costs, patronage, fare revenues, loading levels). • Likely to be particularly valuable in terms of peak service frequencies (optimisation to match loading levels) and for evening/weekend services (including extension of service spans).
6 Running speeds	• Includes assessment of impacts of bus priority measures and other measures affecting bus running speeds and reliability.
7 Fare level and fare structure changes	• Assessment of the market (patronage) and financial performance (farebox recovery, etc) effects of changes in overall fare levels and fare structures. • For assessment of complex fare structure changes, the model is likely to need enhancement to better reflect mix of trips by passenger type, trip length, etc.
8 Fuel price changes	• The model is able to assess both the cost and demand impacts of changes in fuel prices: – impacts on operator costs (costing module identifies fuel costs as a separate cost item) – impacts on patronage and hence service loadings and potentially on peak/off-peak service-level requirements.
9 Budgetary planning	• The model can provide a systematic basis for examining multiple scenarios and undertaking 'what if' analyses, as inputs to the forward budgeting process (eg up to 5–10 years).

Notes:

[a] RTN = rapid transit network, QTN = quality transit network, LCN = local connector network. Terminology as adopted for Auckland (AT) and Wellington (GW) in reference to the 'layered' network approach adopted in both regions.

[b] As noted (section 2.6.5), the BPM does not have a spatial (network) dimension: thus any patronage etc effects resulting from network restructuring need to be assessed externally to the model and the resultant estimates then input to it.

We see little merit in the NZTA trying to use the model at a detailed level (eg for examining performance by route or day and time period), as this would duplicate work which is more appropriately undertaken at the regional level. However, the NZTA may have an interest in using the model at a more aggregated level, probably by region and/or centre, for a variety of applications such as:

- budget estimation (say for up to 5–10 years), based on various 'what if' scenarios
- high-level appraisal of fare levels and fare structures
- appraisal of alternative farebox recovery policies and measures related to these
- development and assessment of the implications of service guidelines (possibly with a view to the development of a service-level policy akin to its farebox recovery policy)
- appraisal of current cost efficiency levels across regions, and examination of the scope for and implications of improving cost efficiency (including the possibility of setting national benchmarks).

4.4 Guidance on implementation aspects

4.4.1 Implementing the BPM

The BPM is a completely self-supporting piece of software that can be readily distributed to potential users either by email or on a DVD. It was delivered to the NZTA on a DVD, and can be installed simply by copying the application onto a computer.

The software is immediately ready for use: the only requirement is that the user has Excel installed on their computer.

Software components

As outlined in the *User manual* (appendix A), the software consists of two components: the application and the data file (refer section 3.2).

The software architecture is designed so as to keep the application consistent for all users, while generally the data files will be different for all users. The application (containing all calculations and reporting) contains no data. After opening the application the first step for the user is to choose the data file they want to analyse. The application will then apply the parameter settings to the data file and consequently calculate patronage, costs, etc.

Application

The application is the central calculation unit containing all network settings. It is a static piece of software that will be identical to all users. The model is pre-filled with default parameter settings that may be varied by the user. The main network parameters are for:

- unit operating costs
- time period definitions
- waiting time, access and egress time
- demand elasticities
- scenario settings (fuel increase, fare increase, etc).

Note: The NZTA could choose to lock all settings in the applications to ensure consistency throughout New Zealand. Users would then be unable to change any settings relating to unit costs, elasticities, etc.

4.4.2 Database setup

The BPM does not contain any route data; all data is kept in a user specific file that sits on the user's computer. This data file will be different for each user. It contains their specific route, corridor or network information. The only requirement the BPM application demands is a specified data structure.

The required data structure is provided in the template data file. As long as the data filled in by an organisation complies with the template structure, the application will be able to read the data file and calculate the required outputs (patronage, costs, etc).

All data necessary for the model's calculations is available through the following sources:

1 Published timetable information:

  a route name

  b route length

  c trip times

  d number of services

  e hours of operation.

2 Local authority internal financial information:

  a average fare (based on payments made)

  b cost per bus type (based on contract payment unit cost).

3 Local authority internal specifications:

  a corridor definitions

  b time period definitions

  c bus type

  d central business district (CBD) or non-CBD route

  e percentage commercial routes

  f operator per route.

4 Operator information:

  a average fare (includes commercial services)

  b patronage per route

  c cost per bus type (as per contract unit price).

The time base of the above mentioned data sources may differ: some data might be available on a yearly basis, others on weekly, daily or time period base. It is important to note all data needs to be entered on the same level of detail. Users can determine for themselves which level of detail is most appropriate.

4.4.3 Level of detail required

The template is designed to enable information to be captured at a detailed level of disaggregation (eg by route, day type and detailed time periods). If the user is unable to provide data at the most detailed level or does not require such disaggregate outputs, they may choose to fill in more aggregated information. The only requirement is that this is done consistently for all inputs.

4.4.3.1 Time periods

All patronage and operational information can be entered by individual time period (the model is set up with six weekday periods and four Saturday/Sunday periods). If the user does not have information available or does not require outputs at this level, they can choose to only populate one or several of the fields. As long as this is done consistently, the model will be able to cope with this.

Example: The user has patronage available only at a whole day level (weekdays, Saturdays, Sundays). The model's most detailed level allows the user to fill out each time period of each weekday. The user chooses to only fill out the first time period (Monday – Friday night) and put the total weekday patronage in that field. They now also need to put all weekday trips and trip times in the box for Monday – Friday night and leave all other weekday time periods empty of trip data.

4.4.3.2 Patronage

The patronage may or may not include concession patronage and/or SGC patronage. The user can choose if they want to include either of these in the total patronage. If they choose to do so, the average fare in the sheet 'Patronage' needs to reflect this.

4.4.3.3 Scenario time frame

The BPM does not specify any time frame for the scenarios under consideration. It is up to the user to ensure all scenario information entered applies to the same time frame.

Example: The user wants to see the effects of fare increases of 4% pa (arithmetic) for five years (ie 20% in total). The user could choose to keep the fuel prices unchanged (in real terms) for the five-year period, but it might be more realistic to increase these at a certain percentage rate as well, to reflect the likely situation in five years' time.

4.4.4 Database management

The user data needs to be saved in the same directory as where the BPM is located. The enables the user to choose the database they want to analyse once they have opened the model.

Every time the user runs a scenario a new database is created. This is a copy of the original database with all user scenario settings applied. When the user runs a scenario they need to make sure the name of the new database reflects the contents of the scenario.

Note: The tool allows the user to analyse the results of existing data files. In order to locate the required existing data file it is again important to have a clear, descriptive name.

4.4.5 User education and training

While the BPM has been developed with the aim to be as user friendly as possible and is provided with a *User manual*, most users seem likely to need some guidance when using the model for the first time. The user needs to understand the purposes of the tool, its limitations, types of input needed and types of output the user can expect.

Also important is appreciation of the effects of setting and changing parameters. To fully comprehend this part of the model, the user would need some knowledge of PT cost structures, generalised cost formulations, demand elasticity application, etc (although noting that much of the required knowledge is given in appendices C and D of this report).

4.5 BPM distribution and software management

4.5.1 Distribution options

Three main options could be considered by the NZTA for distribution of the BPM:

1 Through DVDs, directly to selected persons/organisations

2 Through the shared regional drive, available to all authorities/individuals having access to this

3 Through the internet, available to all.

Option 1

If the NZTA wants to protect and limit the use of the model, it would be best to distribute individual copies through the use of DVDs. These DVDs would also contain a template for use in filling out network data, and could be mailed to selected persons or organisations. There is however no guarantee the DVD will not be copied and distributed further. Another disadvantage of this approach is the loss of control over the software. If the NZTA wants to change anything in the program, it would need to redistribute the software to all parties.

Option 2

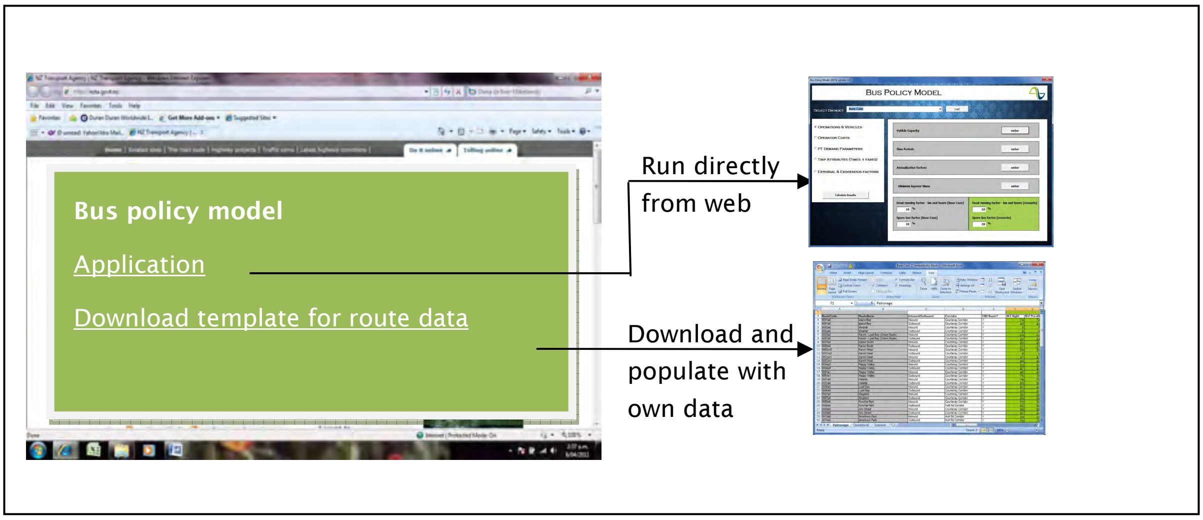
The NZTA has a regional drive on its network that is accessible to all approved organisations (AOs). This drive allows the NZTA to publish documents and applications to all regions at once while keeping control over the software. The documents and applications can be published as read only and can be protected for alteration only by the NZTA's National Office or even selected persons. The NZTA could put the BPM on this regional drive together with a template to use for filling out network data.

This option allows the NZTA to keep control over the software while AOs are using it. The AOs are the only ones that would be able to see and use the software unless they copy it and distribute it further. The NZTA could protect their copy by numbering all issued copies and ensuring the installation of the data involves a robust procedure with supervision and assistance from the NZTA.

Option 3

The NZTA's main website (www.nzta.govt.nz) could be used to make the model freely available: anybody in the world could gain access and use it. Users would also need to download a template to fill out their individual data.

Figure 4.1 Structure of web-based application



By publishing the BPM through the web, the NZTA would keep control over the software and could replace it with an updated version at any time. If for example cost indices were updated, the model could be adjusted to reflect this. When the user opens the web application the next time the new indices would be applied.

Note: For option 2 and option 3, the present model would need to be slightly amended to better accommodate system-specific requirements.

4.5.2 User feedback options

4.5.2.1 Getting data feedback

The tool could be adjusted in such a way that the BPM output generated by a user could be sent back to the NZTA after running the model. The model would calculate the output and show it to the user while at the same time it would (or could) send a copy to a nominated email address at the NZTA.

The model could also give the user the option to choose which data they want to send to the NZTA.

This option could be available independently of the way the software is distributed.

4.5.2.2 Getting general feedback

The model could be configured to send emails to selected email addresses. This option would allow the NZTA to get feedback on the functionality and performance of the tool. A button on the main screen could allow the user to write a short text and send it to a non-disclosed email address within the NZTA.

4.6 Potential model enhancements

The BPM, which is the subject of this report, has been successfully piloted with GW and is now proving a useful tool to assist GW staff in addressing a variety of policy issues. We consider the current model meets the original project objectives and expectations, as set out in the proposal.

However, a number of potential enhancements to the current model have been identified – from discussions with GW and other parties, from comments made by the peer reviewers and from the consultant's own ideas.

Table 4.2 lists these potential enhancements, with brief comments on the scope of each. At this stage, no attempt has been made to prioritise these aspects or to estimate the resources likely to be required to implement each aspect. In some cases, further appraisal would be required as to whether an enhancement would be worthwhile, prior to any decision to proceed with it.

Table 4.2 Potential model enhancements

Aspect/scope	Comments
A Enhancements to costing module	
1 Develop alternative cost allocation bases, allowing the user to choose most appropriate basis for each application	• Three bases proposed: a current – avoidable costs for each non-peak period, with all remaining (including joint) costs allocated to peak periods b avoidable costs for each (including peak) period, with remaining (joint) costs separately identified (including the periods to which they relate) c distributed costs for each time period, ie as b), but in addition joint costs distributed across time periods to which they relate in a 'neutral' manner.
2 Provide for charts to show breakdown of operational costs by cost component	• Currently operational costs are shown as a single amount – some authorities have indicated preference to disaggregate by component.

Aspect/scope		Comments
B	**Analyses by PTOM units**	
1	Incorporate a 'unit selection form'	• Would allow users to allocate routes to units, giving greater flexibility for reporting results by unit.
2	Display unit statistics in key results	• Provides display of results by unit immediately after model running.
3	Unit-by-unit reporting enhancements	• Provides summary reports by unit on patronage, revenues, costs, farebox recovery. • Also allows user to save all unit output charts into a single file (rather than need to create results unit by unit).
C	**Enhancements to output reports and charts (general)**	
1	Present base case and scenario data in same chart	• Currently these are output in separate charts.
D	**Incorporation of other modes**	
1	Adaptation/extension of current bus-based model to accommodate rail and ferry modes	• Would warrant more detailed consideration as to what model variations would be required (eg operational analysis, vehicle capacities, cost functions, demand functions, etc) and extent of work involved (refer section 2.3).
E	**Interface with PT network models**	
1	Further investigation, followed by development (if appropriate) of automated interface between multi-modal/PT models in the main regions (APT, WPTM) and BPM	• In cases where network changes are involved, this would allow their impacts on PT performance (by route, unit, etc) to be more readily assessed, without need for manual transfer of data between models. • This could allow for automated and enhanced PT performance reporting whenever the regional PT models are run.
F	**Incorporation of enhanced demand analysis functions**	
1	Provisions for assessing impacts of service reliability changes	• Would involve data collection and analysis methods to quantify effects of unreliability (unexpected journey time) in both base and scenario cases. • Given these, impacts on user generalised costs and demand levels could be estimated (refer table C.3).
2	Provisions for assessing impacts of crowding	• Would require methods to estimate extent of crowding from current data on average passengers/trip over each time period. Also then need to incorporate crowding function into the generalised cost/demand function.
G	**Incorporation of more detailed patronage data**	
1	Provision for additional data on passenger patterns by route and time period, and hence the assessment of fare structure and similar changes	• Additional data likely to be numbers of passengers on route and time period by category (adult, concession, etc) and by boarding-alighting zone: could then apply different fare changes and different elasticities by boarding-alighting zone. • Would need further investigation as to feasibility and implications – may not be best approach to assessing alternative fare structures.
H	**Incorporation of service etc optimisation methods**	
1	Optimisation of service levels to match demand	• At present this has to be done by manual inspection and iteration. Could potentially be replaced by an automated approach, provided that optimisation function can be defined (eg patronage/trip).
2	Optimisation of services and fares to meet farebox recovery (and other financial) targets	• Similar to above – current manual system could potentially be replaced by an optimisation routine.

5 References

Australian Transport Council (2006) *National guidelines for transport system management in Australia. Vol 4: Urban transport* (sections 6.2/6.3).

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Transport Research Laboratory, TRL (2004) *The demand for public transport – a practical guide.*

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Appendix A: User manual

A.1 Introduction

This *User manual* describes the workings of the software application developed for the NZ Bus Policy Model (BPM or 'the model') research project, as part of the NZ Transport Agency (NZTA) Research Programme.

The project was undertaken by Ian Wallis Associates Ltd (IWA) in association with Tulip Consultancy.

The model starts from a database of the existing bus services (in a region or sub-region), including data on operating statistics; patronage, passenger kilometres and fare revenue; and unit costs. These data are typically disaggregated by geographic dimension (eg route or route group/area) and temporal dimension (eg weekday vs Saturday vs Sunday, AM peak vs inter-peak vs PM peak vs evening). Starting with this database, the model may then be used for two main groups of applications:

- as a service performance diagnostic tool, ie to examine the performance of the existing services (by route, time period, etc) in operational, market and financial terms.
- as a scenario analysis tool, to assess the impacts on the bus system and its performance of changes to the bus system itself (eg to services, fares or unit costs) and/or changes in external factors affecting the demand for bus travel (eg changes in fuel prices, impacts of population and urban development changes).

The manual guides the user step-by-step through the BPM software application.

The manual should be used in conjunction with appendices C and D of the main project report, as these contain the technical details of the functions, assumptions and elasticities used in the model.

A.2 Application and data structure

A.2.1 Overview

The BPM is set up as an Excel application. The application contains all calculation functionality, chart generation and parameter settings. The application itself does not contain any network or route data. The application needs to be linked by the user to a dataset containing all route data. The user needs to pre-populate this dataset in a specific format. A template file is therefore included.

Figure A.1 Application connected to external data set

Application (opened first, then linked to data set) **Data set**

All network and route information is separated from the calculations, which allows the user to run different scenarios multiple times without affecting the core data of the network.

It also enables the owner of the tool to make changes to the tool and reissue it to users without the need for the user to re-enter their data.

A high-level description of the four steps necessary to calculate results is given below.

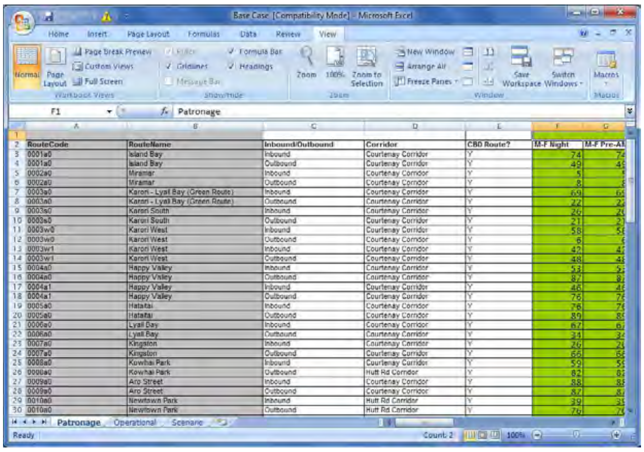
A.2.2 Four step process description

A.2.2.1 Step 1: Enter route data in template

All data relating to routes is entered directly into a worksheet, ie:

- passenger data (number of passengers, average fare)
- operational data (vehicles used, trip times, etc)
- scenario data (changes to fares, frequency and trip times).

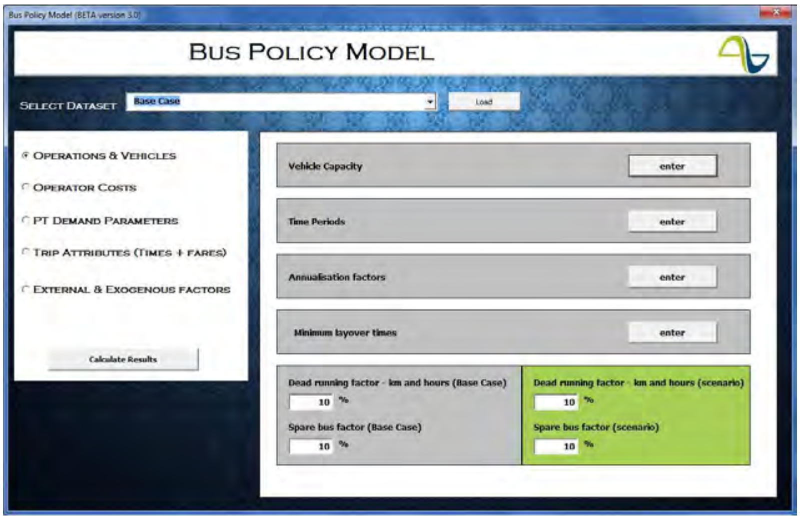
Figure A.2 Route data sheet



A.2.2.2 Step 2: Open BPM application and connect to data file with route data

After opening the tool the form in figure A.3 appears. From the top box the user chooses the data set they want to use for the calculations.

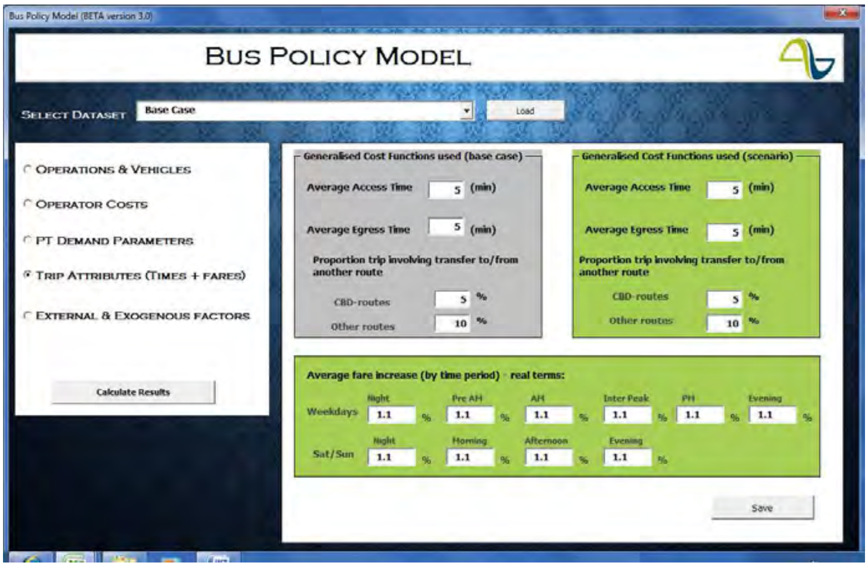
Figure A.3 Model opening screen



A.2.2.3 Step 3: Enter network settings for current data and scenario into BPM application

- Information on network-wide parameters is entered through the dashboard (layover times, time period definitions, average waiting times, elasticities, etc)
- The user sets all the parameters to apply to the uploaded route data (in the grey boxes)
- The user sets all the scenario parameters to apply to the uploaded route data (in the green boxes)
- The user sets elasticity variables for use in the generalised cost function.

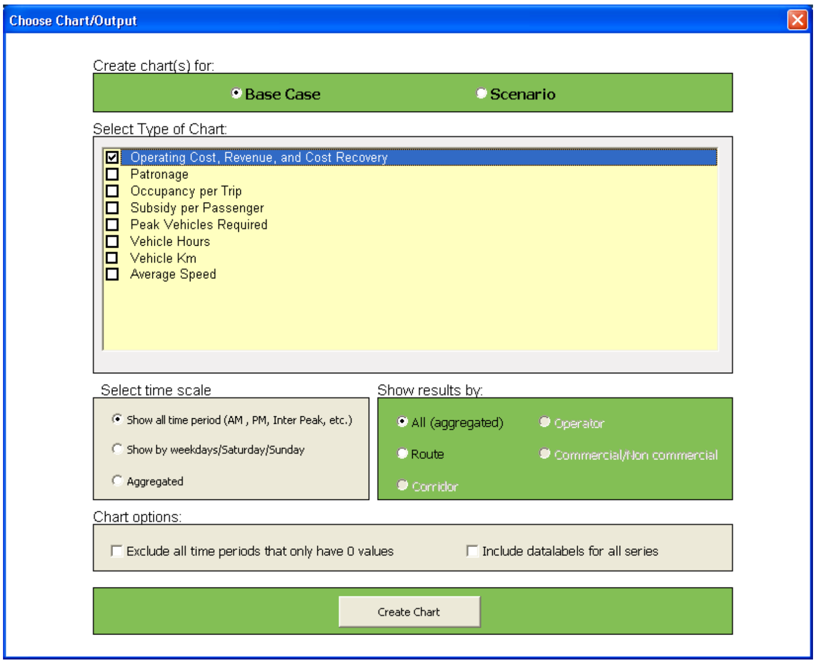
Figure A.4 Generalised cost inputs



A.2.2.4 Step 4: Calculate results

- The user selects the type of custom reports required
- The user chooses the level of detail they want to report on
- The user is then shown a preview of the chart(s) generated
- The user chooses if they want to save the reports (in tabular and/or chart form).

Figure A.5 Report specification



A.2.3 From base case to scenario

The BPM provides the option to calculate patronage effects of changes in wait time, frequency and many other parameters.

A.2.3.1 Cost changes

The user can enter vehicle costs for the base scenario and for the selected scenario being examined. These numbers will appear side by side in the model, which shows the base costs for running the base network using the original cost settings alongside the costs for running the network using the new, altered costs.

The model offers the possibility to compare the cost impact of changes in:

- unit operating costs (per vehicle kilometre, vehicle hour, vehicle pa)
- dead running
- spare buses
- minimum layover times.

A.2.3.2 Patronage (exogenous) changes

The BPM provides the option to examine the effects of expected changes in patronage resulting from exogenous factors (eg population changes). Such changes can be entered relative to the base case on a network level or on a route level.

A.2.3.3 User cost changes

Any changes in the PT level of service offered, or the service levels/costs by competing modes, will affect demand (patronage). The effects of such changes are calculated within the model, mostly through elasticity functions:

- The effects of changes in the user (generalised) costs of bus travel on patronage are assessed through a generalised cost elasticity approach. Such changes include changes in:
  - fares
  - access/egress times
  - on-bus travel times
  - transfer penalties.
- The effects of changes in the user (generalised) costs of travel by alternative modes (principally car) are assessed through demand cross-elasticity functions. Particularly important here is the market response to changes in fuel (petrol) prices, by travellers switching between car and bus use.

Further explanation of the approach and elasticity functions used is provided in appendix C of the project report.

A.2.4 Model calibration

Each bus system has its individual characteristics and the BPM needs to be calibrated to reflect those.

It is therefore necessary to run the model first with data for which the outcomes are known. The user can then use the known system-wide annual operating statistics (usually bus kilometres, bus hours, peak buses) and system-wide annual operating costs (including allowances for bus capital charges and profit margin) in calibrating the model.

After running the model the output can be matched with the known system-wide data. Any changes should be factored and then fed back into the model. This can be done in several ways:

1. Adjusting the ‘dead running’ factors (relating principally to bus kilometres) to match known aggregate bus kilometre statistics
2. Adjusting the layover times (to match the bus hour and peak bus requirements)
3. Adjusting the percentage spare vehicles (to match to the total fleet requirements)
4. Adjusting the unit operating costs (to match total system costs).

Once the alterations are made, the data should be run one more time to check if the outcomes match the real situation in the region. Once this is the case the model can be used and does not have to be calibrated further.

A.3 Entering worksheet data

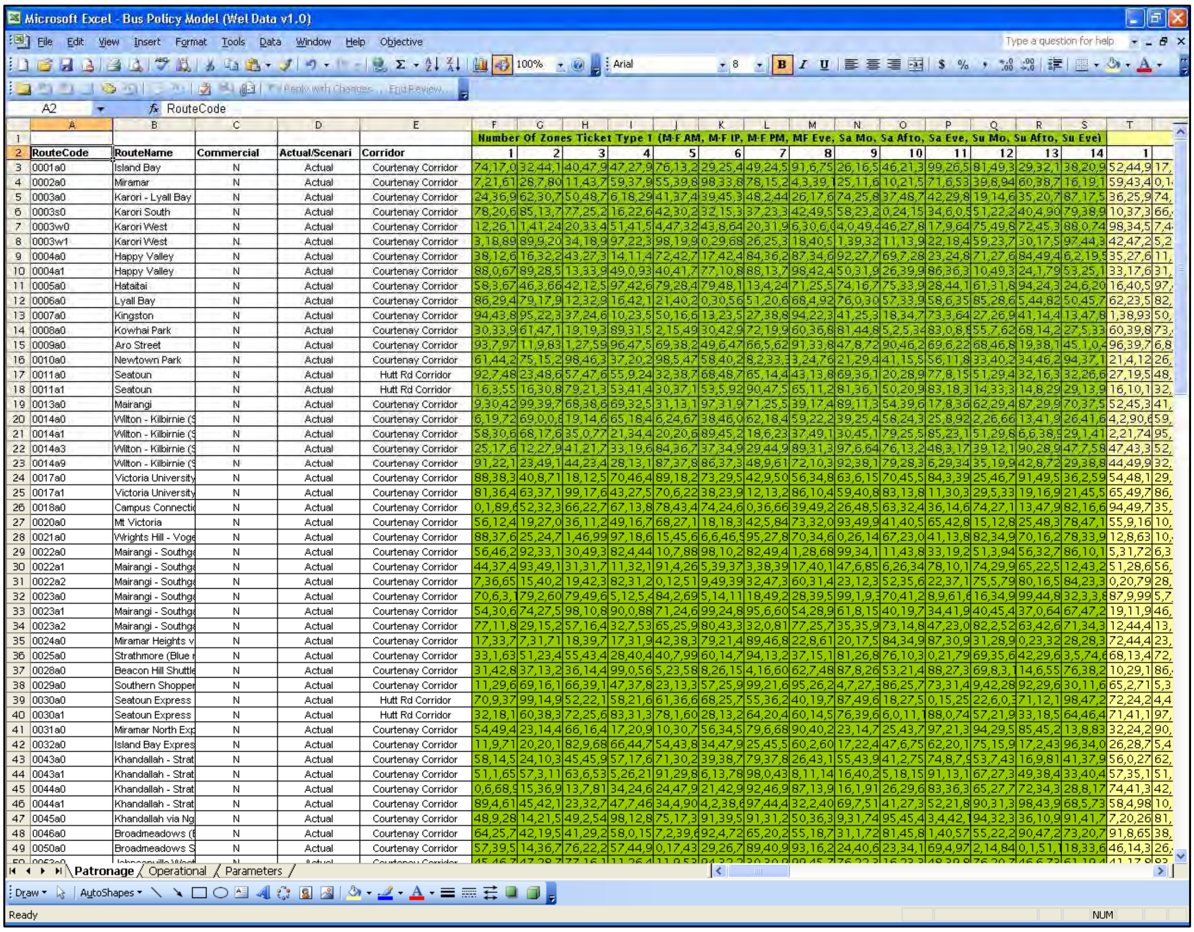
A.3.1 Overview

The route data needs to be entered directly into a template workbook. This workbook allows users to copy/paste information from their own data sources into the workbook (a front end application would make that process more difficult). (NB: The front end will be used later to enter the network settings.)

Three different sheets in the workbook need to be populated for the model to work:

- Patronage – holds all data relating to patronage (passengers per day and zone)
- Operations – holds all data relating to operations (timetable, route length, etc)
- Scenario – holds all data relating to scenarios (changes in patronage by route, etc).

Figure A.6 Route data sheet (patronage)



A.3.2 Common data

A.3.2.1 Data categories

The 'Patronage', 'Operations' and 'Scenario' sheets all contain the same four basic categories:

Table A.1 Patronage data categories

Category	Description
Route code	Unique code identifying individual route (combination of characters and integers)
Route name	String representing the name of an individual route
Inbound/outbound/both	Identifies if the route is in the inbound or outbound or round trips (both directions)
Corridor (or unit)	Identifies the corridor or unit the route belongs to
CBD route (Y/N)	Identifies if a route runs to/from or through the CBD

The information in the first five columns is linked for the three worksheets and should only be altered in the first sheet (the Patronage sheet). When the Patronage sheet is updated the other two sheets (Operational and Scenario) will automatically have the same entries in those columns. This should not be altered as the application identifies the routes through these entries.

A.3.2.2 In/out-bound versus round trips

While the BPM may be applied to either inbound or outbound trips separately, or to round trips, it is recommended to put round trips in the sheet. Routes split into 'Inbound' and 'Outbound' will not be combined into one route; as the model is not designed to combine in and outbound trips, all routes would be scheduled separately by direction and vehicle numbers would be likely to exceed a realistic level.

If the user starts from input data for in and outbound trips separately, it is recommended to first combine the two directions into one round trip (adding number of trips, length of trip, etc) before the data is entered into the model.

A.3.3 Patronage specific route data

The following information is to be entered on the sheet 'Patronage':

1 Patronage for each route and time period

2 Average fare for each route and time period.

Average fare needs to be calculated by the user outside the model. The values need to be based on total farebox revenue divided by total patronage, by time period by route (if available).

The following time periods are to be used:

M–F night: weekdays nights (nights from Sunday/Monday to Thursday/Friday)

M–F pre-AM: weekdays before AM peak

M–F AM: weekdays AM peak

M–F IP:	weekdays inter-peak
M–F PM:	weekdays PM peak
MF eve:	weekdays evening
Sat night:	Saturday night (night Friday/Saturday)
Sat mo:	Saturday morning
Sat aft:	Saturday afternoon
Sat eve:	Saturday evening
Sun night:	Sunday night (night Saturday/Sunday)
Sun mo:	Sunday morning
Sun aft:	Sunday afternoon
Sun eve:	Sunday evening

A.3.4 Operational specific route data

The following information is to be entered on the 'Operational' sheet:

1 Percentage commercial trips for each route and time period
   - a This number should indicate the percentage of trips with a time period that is run commercially. The number needs to be between 0 and 100.
   - b The percentage commercial is only used for data segmentation of the results and does not influence the costing side of the model.

2 Operator
   - a This field names the operator that runs (the majority) of the trips within the time period.
   - b The operator name is only used for data segmentation of the results and does not influence the costing side of the model.

3 Vehicle type
   - a This field should depict the vehicle type that runs (the majority) of the trips within the time period.
   - b The vehicle type is later used to establish the cost of running the service as each vehicle type will have its own cost.

4 Route length
   - a This field provides the route length in kilometres for the each individual route (inbound or outbound or both).
   - b The route length is later used to establish total bus kilometres operated on each route and time period and hence the kilometre-related costs.

5 Hours of operation

a Describes the hours which the route operates on weekdays, Saturday and Sundays.

b The start time of the first and the start time of the last trip need to be entered.

c The hours of operation are used by the model to calculate the frequency of buses in a specific time period (combining hours of operations with number of services).

6 Number of services

a The number of trips within a time period. Use the start time of the trip to determine what time period the trip runs in, except for the PM period, where the end time of the trip is used to determine if the trip is a PM peak trip.

b The number of services is used by the model to calculate the frequency of buses in a specific time period (combining number of services with hours of operations).

7 Trip time

a The average running time of the trip within the time period. The time needs to be entered in number of minutes.

b The trip time is used to calculate the in-vehicle time per passenger (combining trip time with average proportion of the route time travelled per passenger).

A.3.5 Scenario specific route data

The third and final sheet contains information that will be applied to the other sheets in order to assess the effects of a scenario.

Information in the 'Scenario' sheet provides the basis for assessing the impacts of changes in the following:

1 Patronage levels

a Patronage growth per route and time period. This percentage should only cover the growth due to external factors (like new developments): it should not include growth due to service increases, fare increases, fuel prices) as this is already taken in account by the model through elasticities (refer section A.2.3).

b The default value of these fields is 0.00%.

2 Number of services

a Number of services of the route in the scenario. The effect of frequency changes will be calculated using these numbers.

b The default value of these fields is the number of services entered in the operational data sheet.

3 Trip time

a The average running time of the trip within each time period. The time needs to be entered in minutes. The effect of in-vehicle time changes will be calculated using these numbers.

b The default value for these fields is the trip 'base' time entered in the operational data sheet.

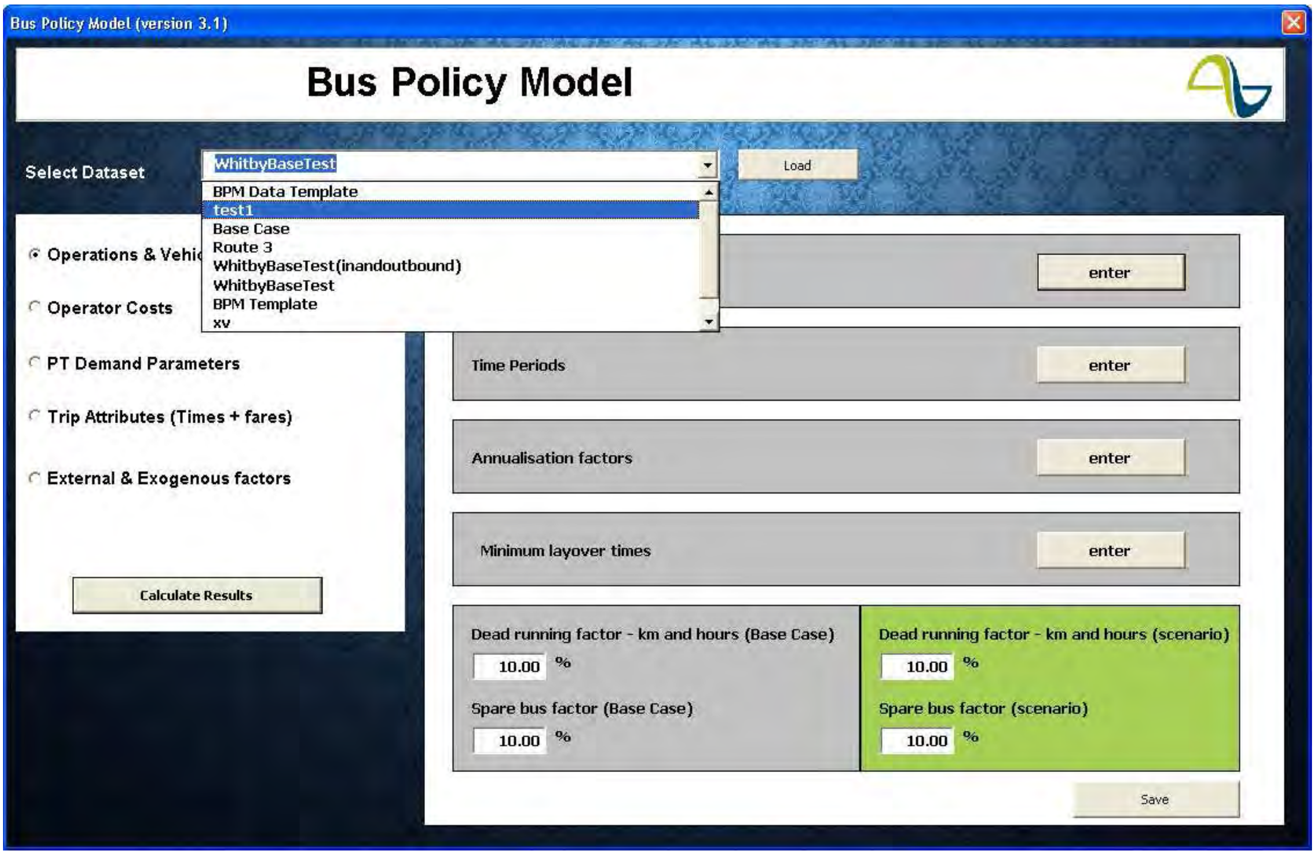
A.4 Entering network data - overview

The dashboard application is the 'control centre' for all parameter settings.

All settings relating to the network are kept in the dashboard application; all route-specific information is kept in the spreadsheets

The dashboard provides the option to enter settings for both the current network and for scenario analysis.

Figure A.7 Model dataset selection



The initial screen for the BPM shows the option to select a dataset.

The datasets listed refer to the workbooks with route data. It contains the workbook with the data entered in the previous step (as described in section A.3). The list will grow after running scenarios as a workbook with scenario results will be created.

Note: After applying a scenario the user can choose the scenario workbook and apply a new (second) scenario to the scenario workbook.

The initial screen also shows the following options on the left-hand side:

1 Operations and vehicles

2 Operator costs

3 PT demand parameters

4 Trip attributes (times and fares)

5 External and exogenous factors.

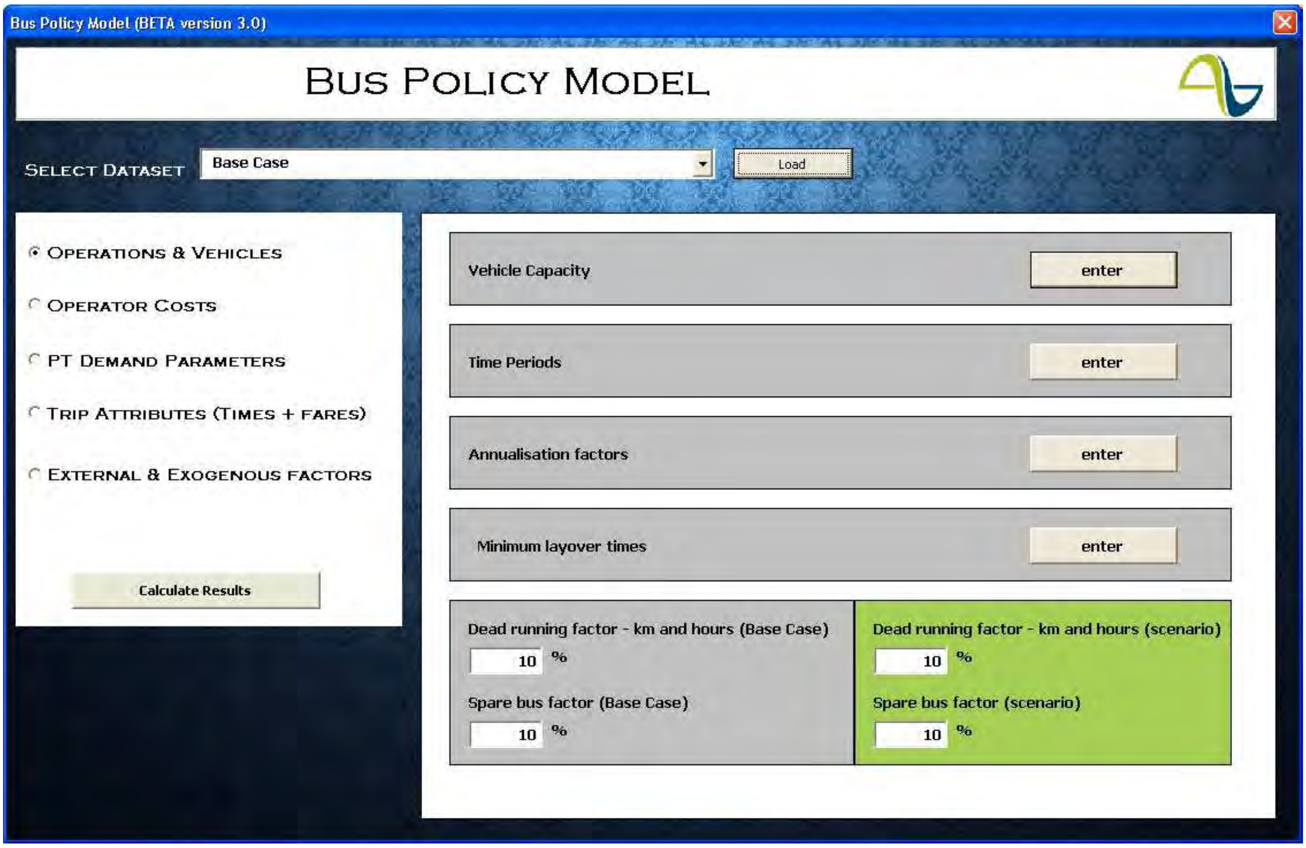
Each of these options is described in the following sections.

A.5 Operations and vehicles

The network characteristics are used to define the specific network settings of an individual user.

The parameters in the grey areas relate to the current network as entered in the chosen data set. The parameters in the green areas relate to the scenario and are applied as changes to the current network.

Figure A.8 Network operations and vehicle data inputs



The settings are categorised into:

1 Vehicle capacity

2 Time periods

3 Annualisation factors

4 Minimum layover times

5 Dead running factor (current and scenario)

6 Spare bus factor (current and scenario).

Each of these categories is explained further below.

A.5.1 Vehicle capacity

The information relates to the capacity of the different vehicle types (sizes) used in the network. Input is the number of seats per unit for each vehicle type (articulated, 3-axle, standard, trolley, midi, mini).

A.5.2 Time periods

In order to define the time periods for analysis required by the user, the start and finish time of the following time periods need to be entered in the worksheets:

- weekdays – night, pre-AM peak, AM peak, off peak, PM peak
- weekends – night, morning, afternoon, evening.

A.5.3 Annualisation factors

The user can specify the number of days of the year that different levels of service are operated, in terms of numbers of weekdays, Saturdays and Sundays according to the timetable.

A.5.4 Minimum layover

Minimum layover required between any two trips run by the same vehicle. The user can enter three different values dependent on the duration of a trip:

- Trip times between 0–20 minutes
- Trip times between 20–40 minutes
- Trip times between 40+ minutes.

These numbers will be used when calculating the number of vehicles required per route and time period.

A.5.5 Dead running factors (hours and kilometres)

These factors define the additional proportions (percentages) of bus hours and bus kilometres that need to be allowed for (additional to the timetable operations) to cover all non-service running to/from the depot and between routes. These factors are typically derived by comparing an operator's total annual bus hours and bus kilometres estimates with the corresponding estimates for the timetable services only.

These factors are required for both the base case and scenario: they would typically be the same in both cases, unless the effects of varying the dead running proportion are being investigated (eg in the event of introduction of a new depot, or change in the operator providing the services).

The default dead running factor adopted (for both bus hours and bus kilometres) is 10%, ie for each 100 bus hours or kilometres operated to provide the timetable, an additional 10 hours or kilometres are involved for 'dead' running.

A.5.6 Spare bus factor

Similar to the above, this factor defines the ratio between the total (active) bus fleet used for an area/operator and the maximum number of buses required in operation at any one time to provide the operator's schedule (ie including dead running). The difference between the two figures allows for both 'traffic' spares (eg bringing in a replacement bus in cases of breakdown) and 'engineering' spares (ie buses unavailable for use due to maintenance requirements).

The default spare bus factor adopted is 10%, ie for each 10 buses involved in peak period operation, one extra 'spare' bus is required.

A.5.7 Calculation of operations statistics

Based on the user-defined inputs for any route and time period of:

- hours of operation
- number of services
- running time
- route length.

BPM derives statistics for vehicle hours, vehicle kilometres and peak vehicles (by route and time period) to operate the daily timetable as follows:

- vehicles required $= \dfrac{\text{(travel time + min layover)}}{\text{headway}}$

  or if (travel time + min layover) > hours of operation

  = number of services operated

- vehicle hours = vehicles required * hours of operation
- vehicle kilometres = number of services * route length
- peak vehicles = maximum of the sum of vehicles required over any individual time period.

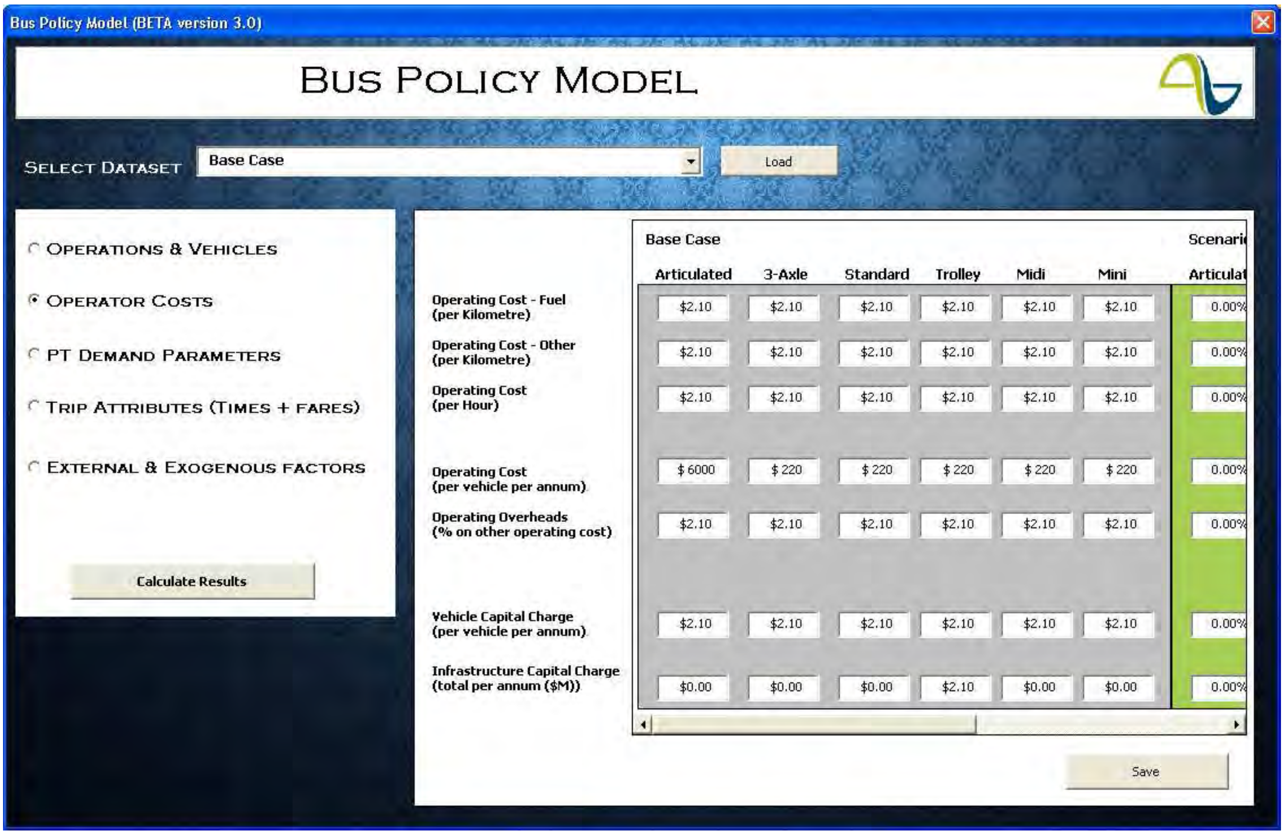
These timetable vehicle hours and vehicle kilometres statistics are then annualised in the model by multiplying by the annual numbers of days by each day type (weekdays, Saturdays, Sundays – section A.5.3). The dead running factor (section A.5.5) is then applied to allow for non-service running.

The system peak vehicle requirement is also calculated as the maximum, over all time periods, of the sum of the vehicles required for each route, for each time period. (Other than in very exceptional cases, this maximum will occur in either the weekday AM peak or PM peak period.) The spare bus factor (section A.5.6) is then applied to determine the total bus fleet requirement.

A.6 Operator costs

The category 'operator costs' captures the gross costs (including profit margins) for operators associated with providing the services.

Figure A.9 Unit costs data inputs



The unit cost values to be entered are categorised into:

1 Operating costs – fuel per bus kilometre

2 Operating costs – 'other' per bus kilometre

3 Operating costs – per bus hour

4 Operating costs – per vehicle per annum

5 Operating overheads – including profit margin, expressed as a percentage of the above operating costs

6 Vehicle capital charge – per vehicle per annum

7 Infrastructure capital charge – total per annum (in million dollars).

Unit costs are to be entered for each relevant vehicle type category (cells for vehicle types not used may be left blank).

After unit cost rates are inserted for the base case, the screen can then be scrolled to reveal the settings for the scenario (green box). For the scenario, the percentage changes in the numbers in the base case can be entered.

Further details on the operator costing basis used and the default unit cost values are provided in appendix D.

The model calculates total annual operating costs (by vehicle type) from the operating statistics and unit costs through the following formula:

Operating cost = [(Cost per kilometre (fuel +other)) * vehicle kilometres

+ (Cost per hour * vehicle hours)

+ (Cost per vehicle per annum * vehicles required)]

* Operating overheads (incl. profit margin) factor

+ Vehicle capital charges * vehicles required

+ Infrastructure maintenance and capital charges.

A.7 PT demand parameters

A.7.1 Overview

The BPM demand module is used to: 1) estimate the ‘generalised costs’ of the typical bus trip (by route and time period) as expressed by the user; and 2) then estimate changes in patronage resulting from changes in generalised costs between the base case and scenario, by applying a demand elasticity function with respect to the change in generalised costs.

The generalised cost function used is as follows:

Generalised cost = $F + V*[(T_A * W_A) + (T_W*W_W) + T_I + P_T* T_P]$

GC = total generalised cost

F = fare ($)

V = ‘standard’ value of time ($/min of in-vehicle time)

T_A = access and egress time between origin/final destination and the PT facility (mins)

W_A = weighting on access/egress/transfer time

T_W = waiting time at a bus stop for initial boarding (mins)

W_W = weighting on waiting time

T_I = in-vehicle time (mins)

T_P = transfer penalty to reflect the inconvenience associated with a transfer (in equivalent in bus travel time (mins)) where a transfer occurs

P_T = percentage transferring to/from another route.

The default values used for the key input parameters to this generalised cost function are as follows:

V = \$7.20 (peak)

V = \$6.00 (off-peak)

T_A = 5

W_A = 1.5

T_W = 0.72*(headway^0.75), where headway = hours of operation/number of services

W_W = 1.5

T_I = 60% of (1-way) trip time

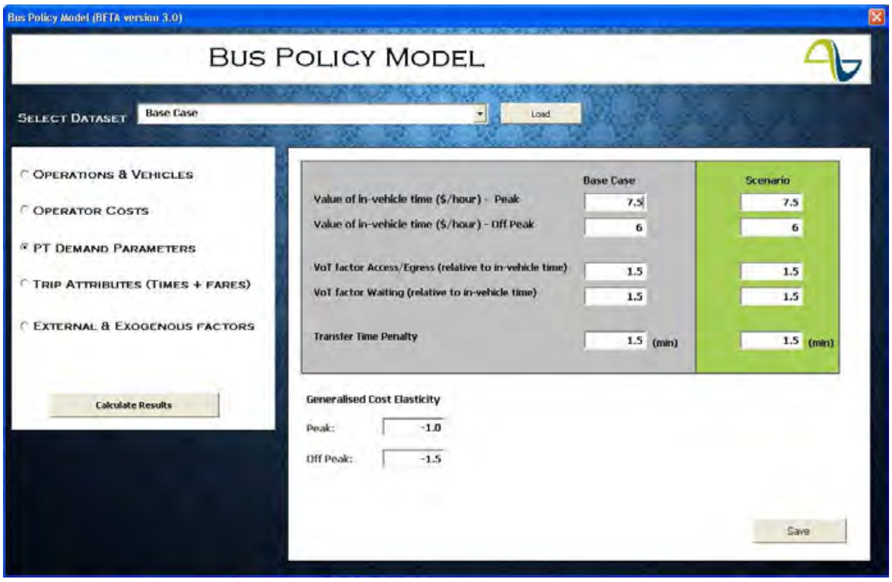
T_P = 7 min

P_T = 5% (CBD routes), 10% (non CBD routes).

These various paramters may be set/varied for the base case and for the scenario using the PT demand parameters option, as described below.

Further details on the generalised cost methodology and the application of these parameters are given in appendix C[7].

Figure A.10 Demand parameter data inputs



[7] Note that there are some minor differences between the formulation and parameters given in appendix C and those used in the model as described in this section.

A.7.2 Value of in-vehicle time

This number represents the 'base' value of passenger time ($/hour) for in-vehicle travel. The value can be set separately for peak and off-peak periods.

This factor is used to convert the various components of travel time (expressed in minutes) to monetary values, for use in the generalised cost assessment.

A.7.3 Value of time factor – access/egress

This factor represents the ratio between the user value of time for access/egress (walking to/from the bus stop) and the value when travelling in the bus. The factor is typically between 1.5 and 2.0.

A.7.4 Value of time factor – waiting

Similar to the access/egress factor, this factor represents the ratio between the user value of time spent waiting for the bus and the value when travelling in the bus. Again, the factor is typically between 1.5 and 2.0.

A.7.5 Transfer time penalty

This figure represents the perceived inconvenience to users of having to transfer between routes. It is expressed in terms of equivalent in-vehicle time (minutes) and is additional to any actual walking and waiting time involved in the transfer.

Typical values found are in the range of 5–10 minutes, but depending on the 'quality' of the transfer (eg weather protection, real-time information availability).

A.7.6 Generalised cost elasticities

This parameter reflects the 'responsiveness' (elasticity) of patronage to changes in the user generalised costs of travel. It may be specified separately for peak and off-peak periods.

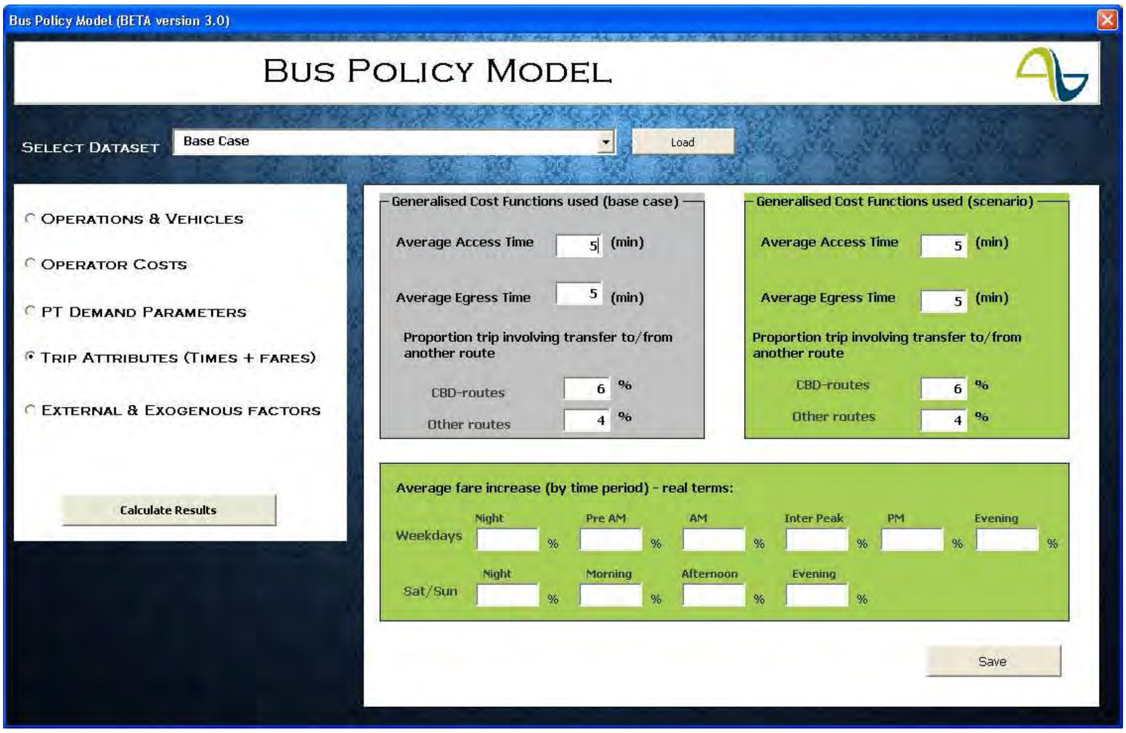
For example, a typical generalised cost elasticity in off-peak periods is -1.5. This implies that a 10% increase in the user generalised costs of bus travel would result in a 15% reduction in off-peak patronage.

Further discussion of the generalised cost elasticity parameters and the default elasticity values adopted is provided in appendix C.3.

A.8 Trip attributes (times + fares)

The category 'trip attributes' captures the following network settings around fare and time associated with individual trips.

Figure A.11 Generalised cost data inputs



A.8.1 Average access/egress time

This value represents the sum of the time spent at the start of the trip in travelling from the trip origin to the bus stop and the time at the end of the trip from the alighting bus stop to the trip destination. Values are required for both the base case and the scenario, allowing the user to assess the implications of changes in route structure on access/egress times.

A.8.2 Proportion of trips involving transfer

This parameter represents the proportion (percentage) of all trips (measured by passenger boardings) that involve a transfer between routes. The percentage can be specified separately for CBD routes and non-CBD routes, and also separately for the base case and the scenario.

These percentages are applied to the costs associated with transfers (walk, wait and transfer penalty) to estimate the average transfer-related costs over all trips. A change in the transfer penalty proportion will directly affect these average costs.

A.8.3 Average fare change

This parameter is the average fare change (increase or decrease, in percentage terms) for each time period. All fare changes are to be calculated in real terms (ie adjusted for any CPI change between the 'before' and 'after' periods).

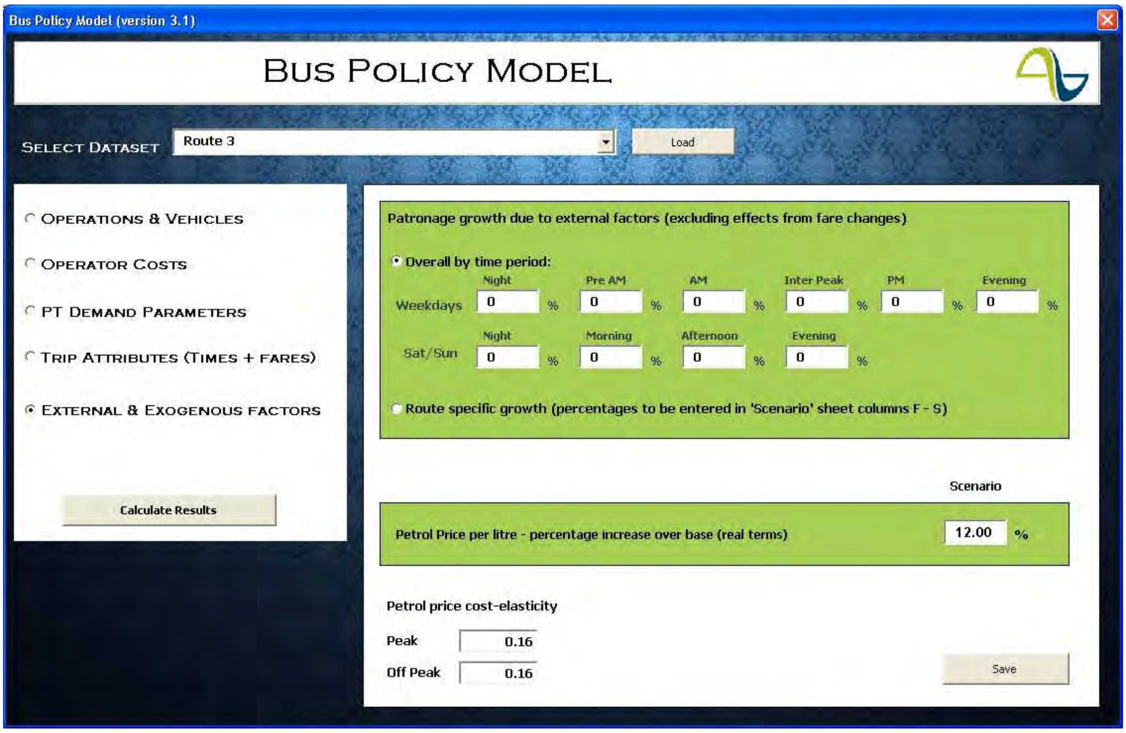
The specified fare changes are applied to the base case fares to calculate fares applying to the scenario.

The average fares are one component of the generalised cost formulation: through this mechanism, the model will estimate the change in patronage resulting from any fare change between the base case and the scenario.

A.9 External and exogenous factors

The final input screen describes the factors exogenous to the PT system that may change and affect bus patronage.

Figure A.12 External factors data inputs



A.9.1 Patronage growth

Allowance for exogenous patronage growth (or decline) can be made in one of two ways:

- At a network level – specify in the 'External and exogenous factors' sheet the network-wide percentage changes in patronage by day and time period (as illustrated).

- At a route level – enter route-specific growth factors, by time period, directly into the scenario worksheet, as described earlier (section A.3.5).

In both cases only patronage growth due to external factors should be included; any patronage impacts from changes in fares, fuel prices, frequency, etc. will already be taken in account by the model.

A.9.2 Fuel price changes

The user may specify the (expected) percentage change in fuel prices for the scenario relative to the base case. The fuel price increase needs to be in real terms (inflation adjusted) to ensure the elasticity is applied correctly.

The required fuel prices are those representative of the New Zealand car fleet: in practice, retail petrol prices may be used as a close proxy for this.

A.9.3 Fuel price elasticity

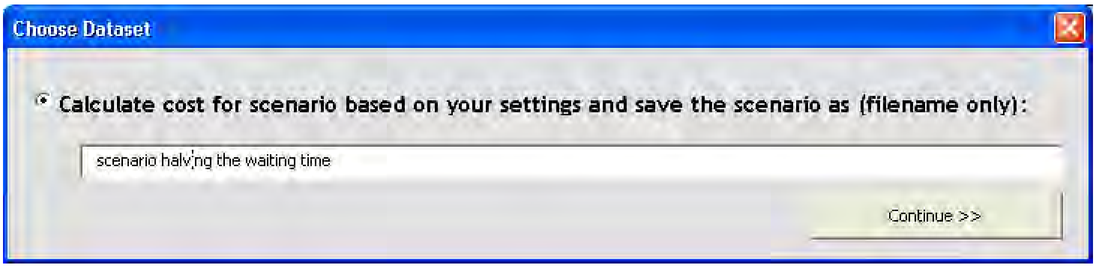
This parameter represents the proportionality between changes in fuel prices and changes in patronage. Elasticity values can be set for peak and off-peak separately. Further discussion of fuel price elasticities and their application is given in appendix C.4.1.

A.10 Results

After the user is satisfied with the parameter settings for the option and the scenario, the calculate button can be executed. The following screen will appear, prompting the user to provide a filename for their results.

A.10.1 Naming the output workbook

Figure A.13 Scenario file naming screen



It is important the user provides a clear and descriptive name for their dataset as it will help to recognise the parameter settings in the future. As noted earlier (section A.4.1) the outcome of the scenario will be available to the user in the dataset list (allowing the user to check their results in the future or apply a (new) scenario to the scenario workbook).

Note: The file with scenario results will from now on appear in the initial data selection drop down (in the above example case the file will be named 'scenario halving the waiting time.xls')

A.10.2 Output worksheet structure

The results file (named by the user) will be saved in the same directory as the initial base case scenario sheet. The output file is a copy of the base case with some alterations.

Note: All results are available through the BPM tool, the user does not need to investigate the worksheets directly. For the completeness of this manual the data structure is however provided below.

The differences between the base case and the scenario file are as follows:

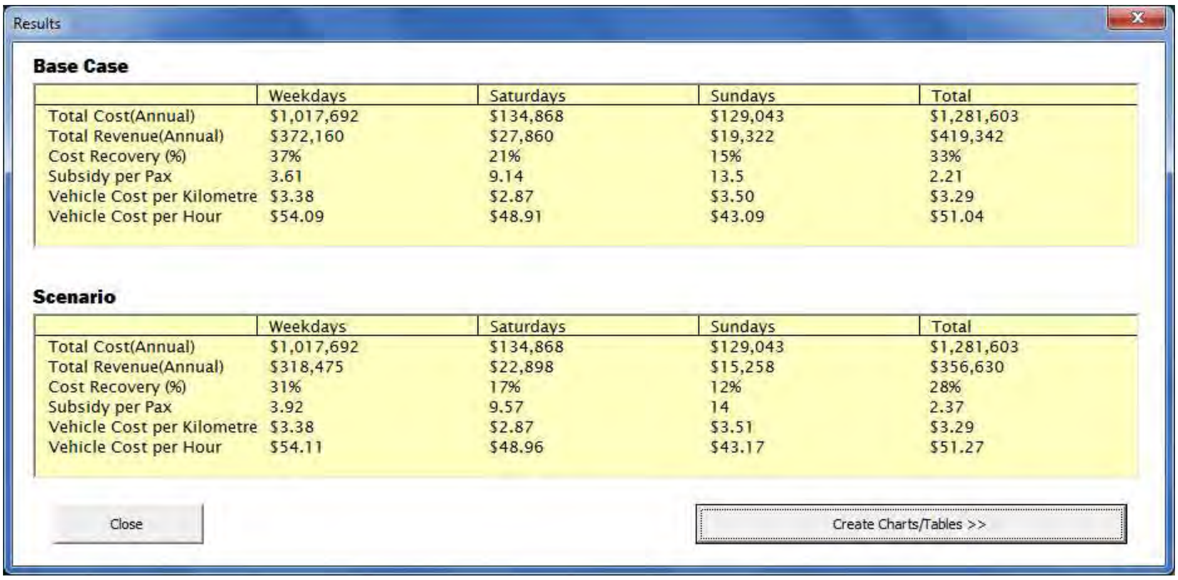
Table A.2 Output worksheets – base case and scenario differences

Sheet	Difference base case and scenario
Patronage	All patronage and fare numbers in the scenario are based on base case with the scenario settings applied (percentage change).
Operational	All trip times and number of services in the scenario are based on base case with the scenario settings applied (percentage change).
Sheet	**Difference base case and scenario**
Scenario	All scenario numbers as applied to the base case are included in the base case workbook. The scenario workbook has a blank scenario sheet (this is only populated when the user applies a scenario to the scenario)
Parameters	The parameter sheet has two values for all parameters (base case and scenario). These are replaced by the scenario value only in the scenario worksheet (the scenario becoming the base case).
Results	The results of the base case are in the base case workbook, the results for the scenario are in the scenario workbook. Both might be the same (if all scenario settings are left as base case settings)

A.10.3 Key results

After running the calculations, the results screen will appear, showing a high-level overview of the results.

Figure A.14 Output summary results


Results

Base Case

	Weekdays	Saturdays	Sundays	Total
Total Cost(Annual)	$1,017,692	$134,868	$129,043	$1,281,603
Total Revenue(Annual)	$372,160	$27,860	$19,322	$419,342
Cost Recovery (%)	37%	21%	15%	33%
Subsidy per Pax	3.61	9.14	13.5	2.21
Vehicle Cost per Kilometre	$3.38	$2.87	$3.50	$3.29
Vehicle Cost per Hour	$54.09	$48.91	$43.09	$51.04

Scenario

	Weekdays	Saturdays	Sundays	Total
Total Cost(Annual)	$1,017,692	$134,868	$129,043	$1,281,603
Total Revenue(Annual)	$318,475	$22,898	$15,258	$356,630
Cost Recovery (%)	31%	17%	12%	28%
Subsidy per Pax	3.92	9.57	14	2.37
Vehicle Cost per Kilometre	$3.38	$2.87	$3.51	$3.29
Vehicle Cost per Hour	$54.11	$48.96	$43.17	$51.27

Close

Create Charts/Tables >>

The user is presented with the key results from their calculations for the base case and the scenario (all broken down in weekdays, Saturdays, Sundays and total):

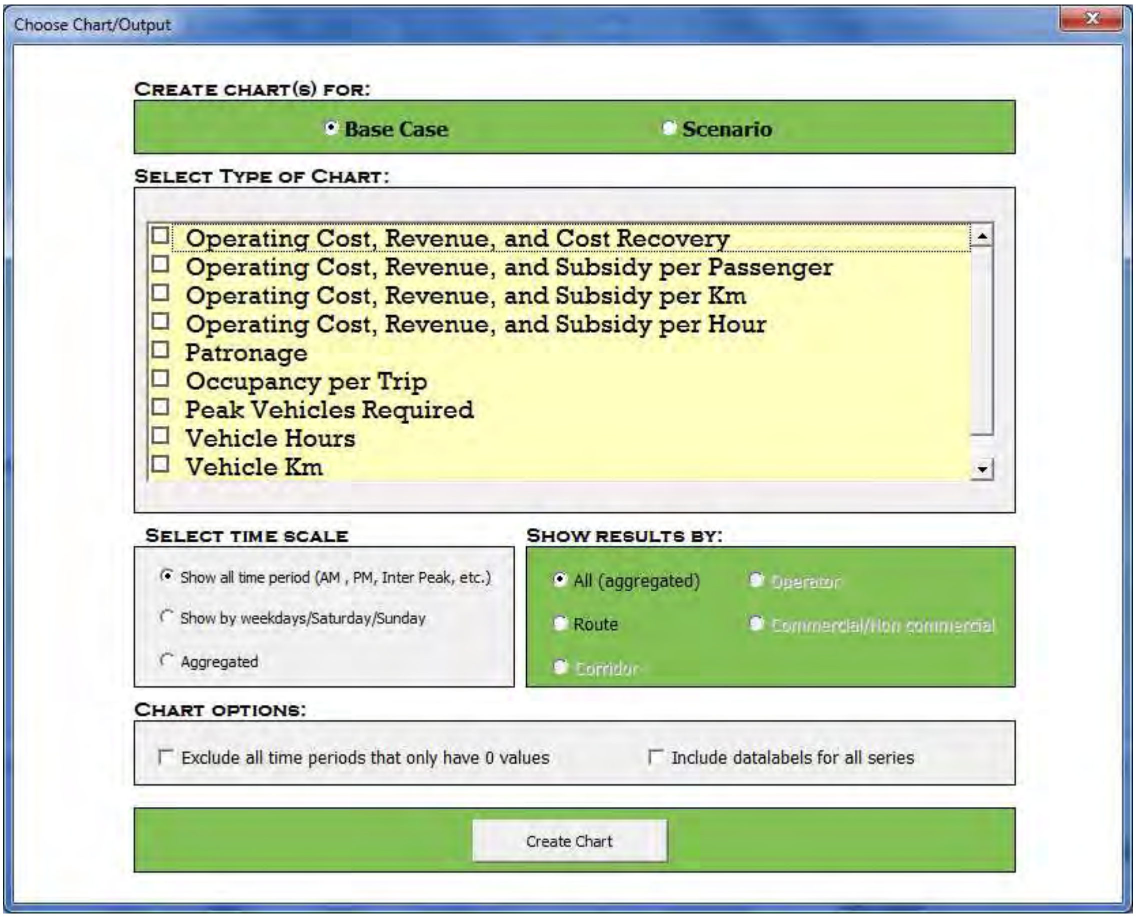
- total cost ($)
- total revenue ($)
- cost recovery (%)
- subsidy per passenger ($)
- cost per kilometre ($)
- cost per hour ($).

If the user wants to further manipulate the numbers, they need to go to the next screen 'Create charts/ tables'.

A.10.4 Creating charts/tables

The user is able to create fully flexible and user-defined charts.

Figure A.15 Report specification screen



The main settings the user can choose are:

- base chart(s) on base case data or on scenario data
- type of chart(s) (defining the kind of data the chart needs to include)
- time scale (show all times, days, or aggregated)
- show results per route or aggregated over the whole data set

A.10.4.1 Base case versus scenario data

The user can select if they want to create a chart based on the base case data or the scenario data.

A.10.4.2 Time scale

The user can specify the time periods they want to report on. The time periods will appear on the x-axes of the output chart.

The options to choose from are:

- all time periods (weekdays (night, pre AM, AM peak, interpeak, PM peak, evening) and Saturdays/Sundays (night, morning, afternoon, evening)
- weekdays/Saturday/Sundays
- aggregated (all days together).

Note: All values are based on yearly totals. For example: when showing weekday morning peak patronage, the chart will show total annual patronage in the morning peak on weekdays.

A.10.4.3 Show results

This option allows the user to bundle the outcomes into the following:

- all (all routes are combined and shown as one entry)
- route (each route will be shown in a separate chart)
- corridor (each corridor or unit will be shown in a separate chart)
- operator (all routes of one operator will be shown in a separate chart)
- commercial/non-commercial (all routes are bundled by type of contract and shown in a separate chart).

A.10.4.4 Show labels

All values of the series in the charts will be shown.

A.10.4.5 Exclude 0 values

If all values of all series in a certain time period are zero, they will be excluded and not shown in the chart.

A.10.5 Saving the results charts

All the above reports can be saved by clicking the save button in the bottom left hand corner. This will save each chart in an individual Excel document, as tables as well as charts.

A.10.6 Output examples

Examples of each of the possible types of output charts and tables are given in appendix B.

The user may create multiple charts at one time by selecting more than one chart from the list of chart options.

A.11 Contacts

The BPM project was undertaken by Ian Wallis Associates (Ian Wallis) with the computer program aspects developed by Tulip Consultancy (Daan Schneiders).

If you have any questions, comments or need more information, please contact Daan Schneiders or Ian Wallis (details below).

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Appendix B: Output examples – charts and tables

Each of the possible type of charts is described below (an example of each chart type is included in the following pages).

The user can create multiple charts at once by selecting more than one chart from the list.

Overview table (table B.1)

Table showing all key statistics for the base case or scenario. The statistics include:

- peak vehicles required
- bus hours
- bus kilometres
- patronage
- cost recovery
- subsidy per passenger.

All outputs are given on an annual basis.

Operating cost, revenue and cost recovery (figure B.1)

Chart showing the dollar amount of operating cost and revenue as separate columns for each chosen time period. The chart also includes a line showing the cost recovery (the revenue divided by the operating cost). The line is plotted on the right, secondary axis.

Operating cost, revenue and subsidy per passenger (figure B.2)

Chart showing average operating cost per passenger, revenue per passenger and subsidy per passenger in chosen time periods. Subsidy per passenger is defined as the difference between cost and revenue per passenger.

Operating cost, revenue and subsidy per kilometre (figure B.3)

Chart showing average operating cost per (bus) kilometre, revenue per kilometre and subsidy per kilometre in chosen time periods. Subsidy per kilometre is defined as the difference between cost and revenue.

Operating cost, revenue and subsidy per hour (figure B.4)

Chart showing average operating cost per hour, revenue per hour and subsidy per hour in chosen time periods. Subsidy per hour is defined as the difference between cost and revenue per hour.

Patronage (figure B.5)

Chart showing patronage by chosen time periods.

Occupancy per trip (figure B.6)

Chart showing average occupancy (passengers) per trip in chosen time periods. Based on the user input this can be segregated into one-way or two-way trips.

Peak vehicles required (figure B.7)

Chart showing total number of vehicles required within each time period. The vehicles required are calculated by taking the maximum of the vehicles required per route within each of the chosen time periods.

Vehicle hours (figure B.8)

Chart showing total number of hours (per year) vehicles are in service per chosen time period.

Vehicle kilometres (figure B.9)

Chart showing total number of kilometres (per year) vehicles operate (in revenue service) per chosen time period.

Average speed (figure B.10)

Chart showing total vehicle kilometres divided by the total vehicle hours, by time period.

Table B.1 Overview

BPM DEMONSTRATION ANALYSIS--GO WGN Route 3 (Karori--Lyall Bay)																	
Day	Time Period	Start	End	Service Frequency (Trips/hr)	No of Trips (1 way)	Trip Time -1 way (hours)	Round Trip Time (hours)	Peak Bus	Bus Hrs (in service)	Bus Kms (in service)	Ave Pax/ Trip (1 way)	Ave Rev/ Pax ($)	Tot Pax	Tot Rev ($)	Tot Costs ($)	Cost Recov (%)	Subsidy/ Pax ($)
										Distance=					*30.49*		
										18					*1.22*		
															183.81		
W/day	Early AM	6.25	7	4	6	0.82	1.81	7.24	5.43	108	13	2.90	156	452	297	152%	-1.00
	AM peak	7	9	7	28	0.97	2.11	14.77	29.54	504	22	2.60	1,232	3,203	1,513	212%	-1.37
	I/peak	9	16	6	84	0.90	1.97	11.82	82.74	1512	22	2.20	3,696	8,131	4,361	186%	-1.02
	PM peak	16	19	9	54	1.05	2.27	20.43	61.29	972	22	2.60	2,376	6,178	6,806	91%	0.26
	Evening	19	23.5	2	18	0.70	1.57	3.14	14.13	324	12	2.70	432	1,166	825	141%	-0.79
	Tot Daily				190			20.43	193.13	3420			7,892	19,131	13,801	139%	-0.68
	Tot Annual	*250*			47,500				48,283	855,000			**1,973,000**	**4,782,700**	**3,450,311**	***139%***	***-0.68***
Saturday	Morning	6.5	12	4	44	0.87	1.91	7.64	42.02	792	18	2.40	1,584	3,802	2,244	169%	-0.98
	Afternoon	12	19	4	56	0.87	1.91	7.64	53.48	1008	18	2.40	2,016	4,838	2,856	169%	-0.98
	Evening	19	24	2	20	0.73	1.63	3.26	16.3	360	10	2.40	400	960	935	103%	-0.06
	Tot Daily				120				111.8	2160			4,000	9,600	6,035	159%	-0.89
	Tot Annual	*52*			6,240				5,814	112,320			***208,000***	***499,200***	***313,796***	***159%***	***-0.89***
Sunday	Morning	6.5	12	4	44	0.87	1.91	7.64	42.02	792	16	2.40	1,408	3,379	2,244	151%	-0.81
	Afternoon	12	19	4	56	0.87	1.91	7.64	53.48	1008	16	2.40	1,792	4,301	2,856	151%	-0.81
	Evening	19	24	1	10	0.73	1.63	1.63	8.15	180	8	2.40	160	384	467	82%	0.52
	Tot Daily				110				103.65	1980			3,360	8,064	5,567	145%	-0.74
	Tot Annual	*63*			6,930				6,530	124,740			***211,680***	***508,032***	***350,735***	***145%***	***-0.74***
All	**Tot Annual**				**60,670**				**60,626**	**1,092,060**			**2,392,680**	**5,789,932**	**4,114,842**	**141%**	**-0.70**

Figure B.1 Operating cost, revenue and cost recovery

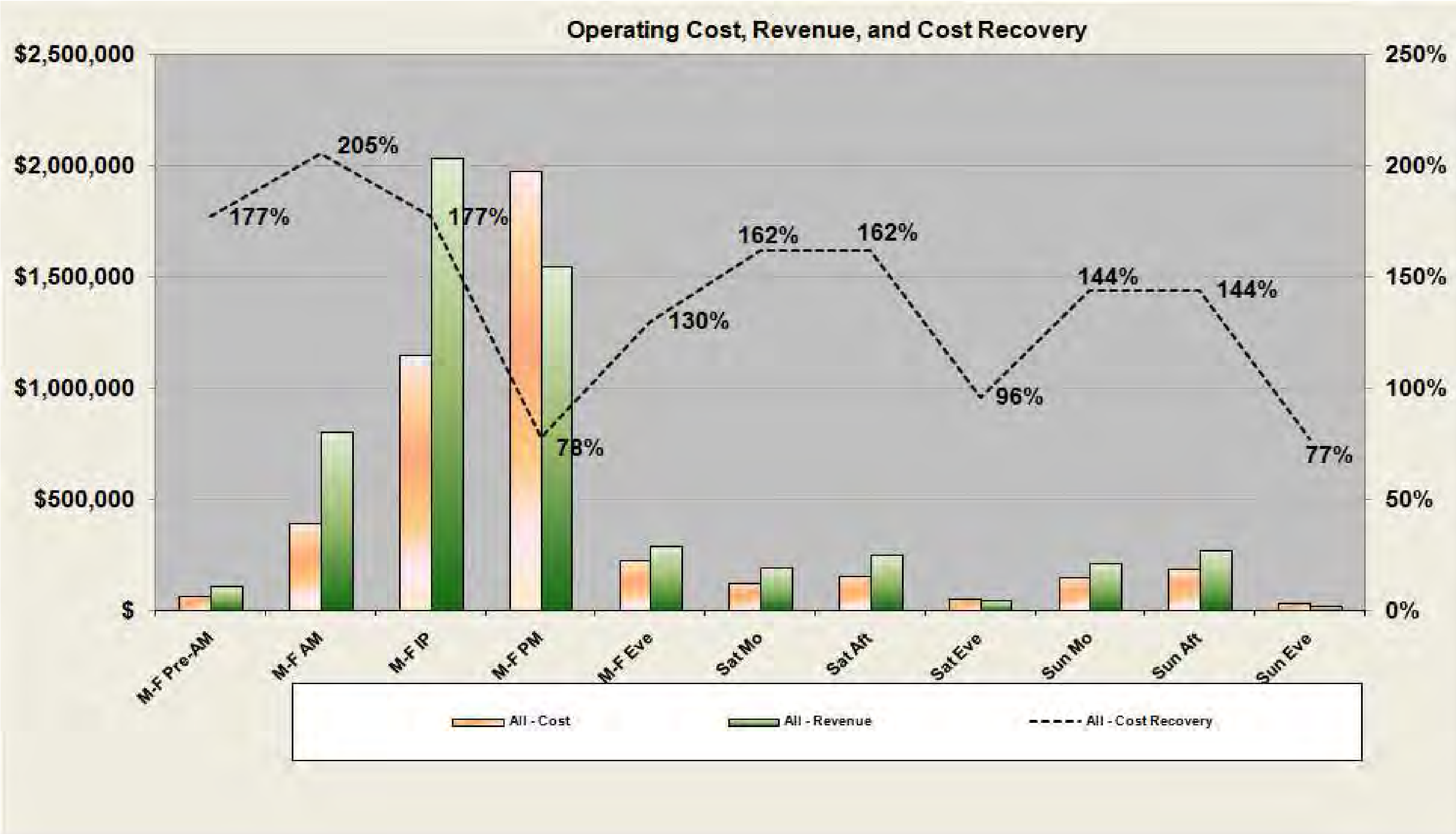


Figure B.2 Operating cost, revenue and subsidy per passenger

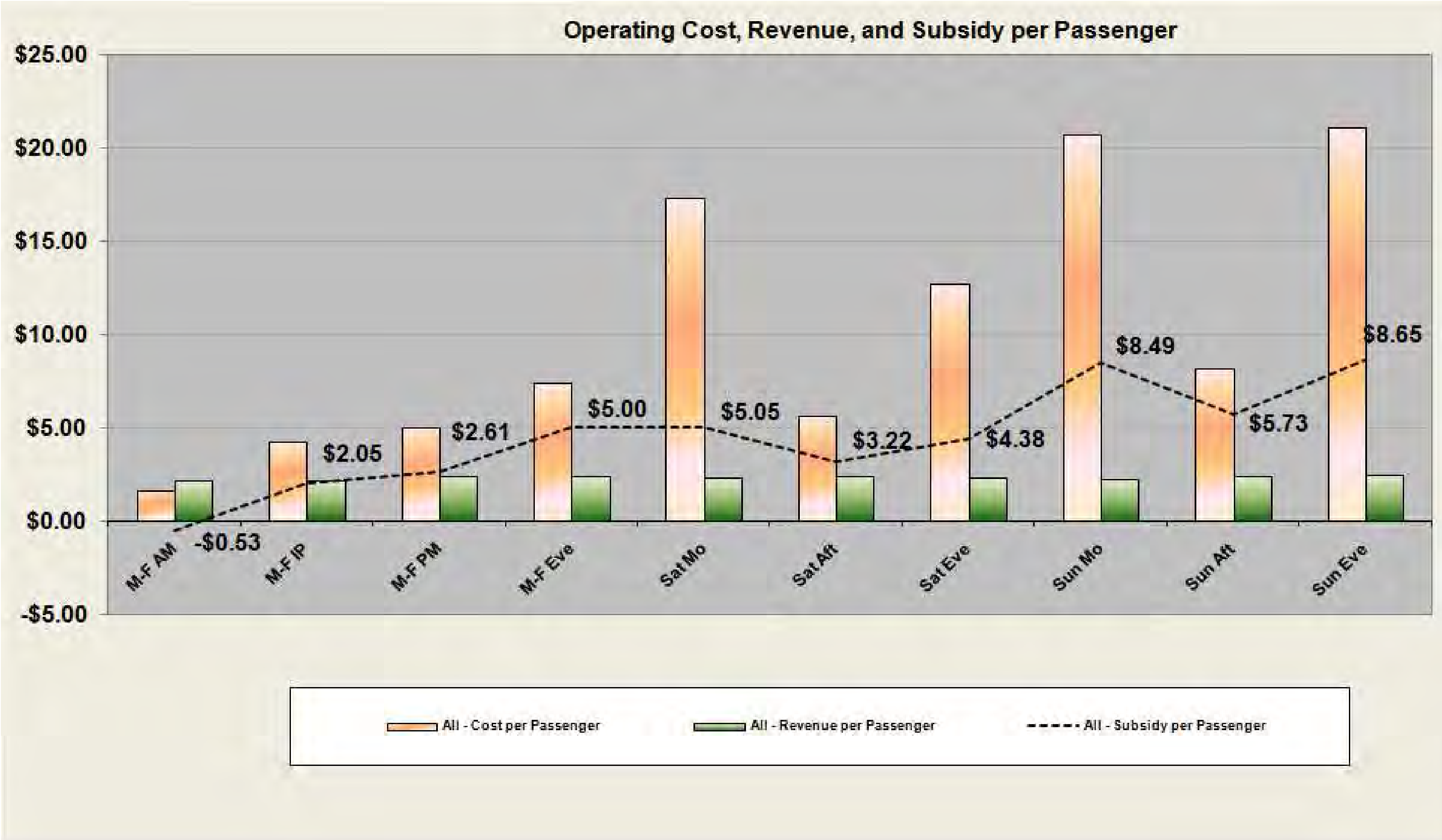


Figure B.3 Operating cost, revenue and subsidy per kilometre

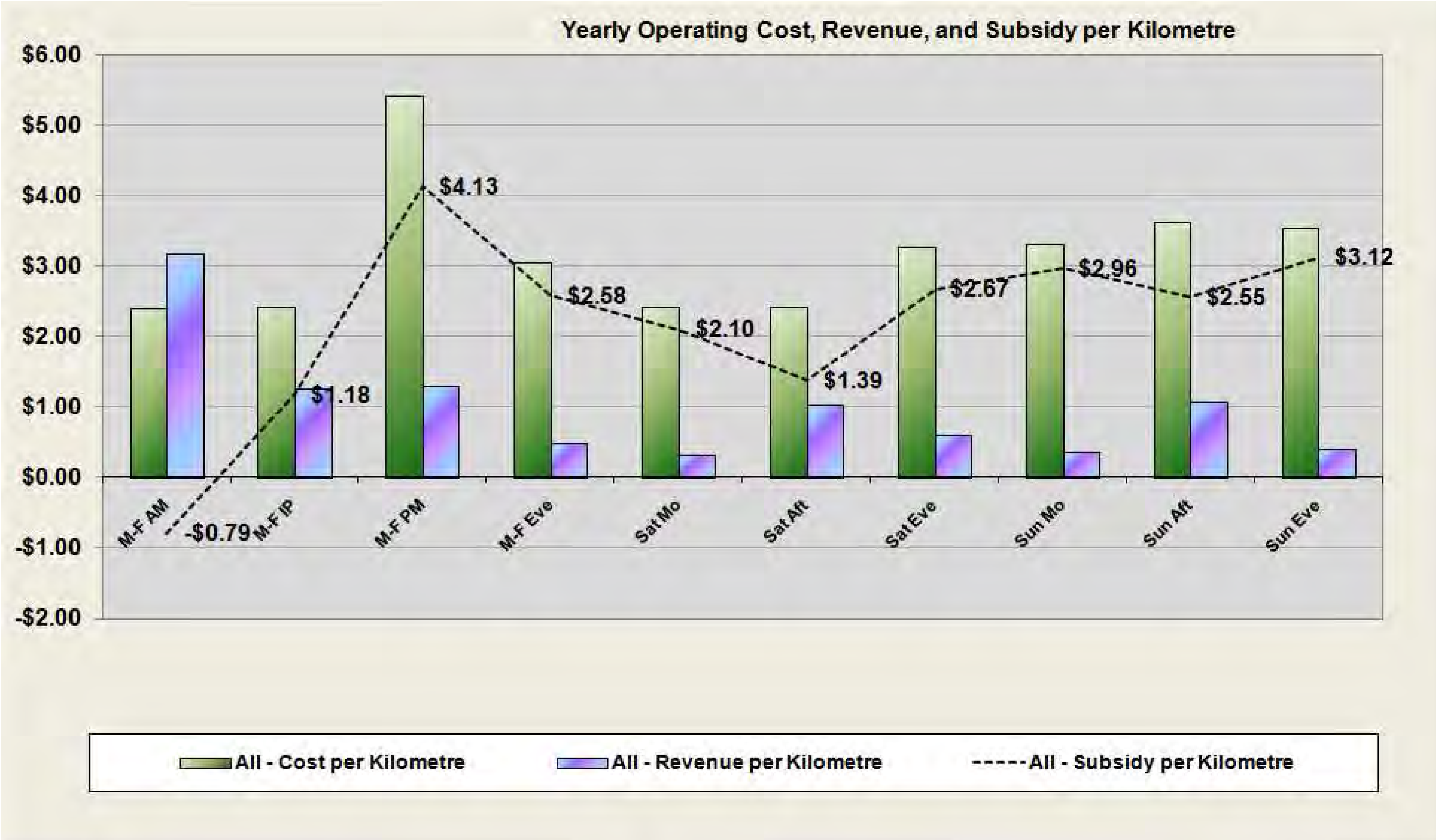


Figure B.4 Operating cost, revenue and subsidy per hour

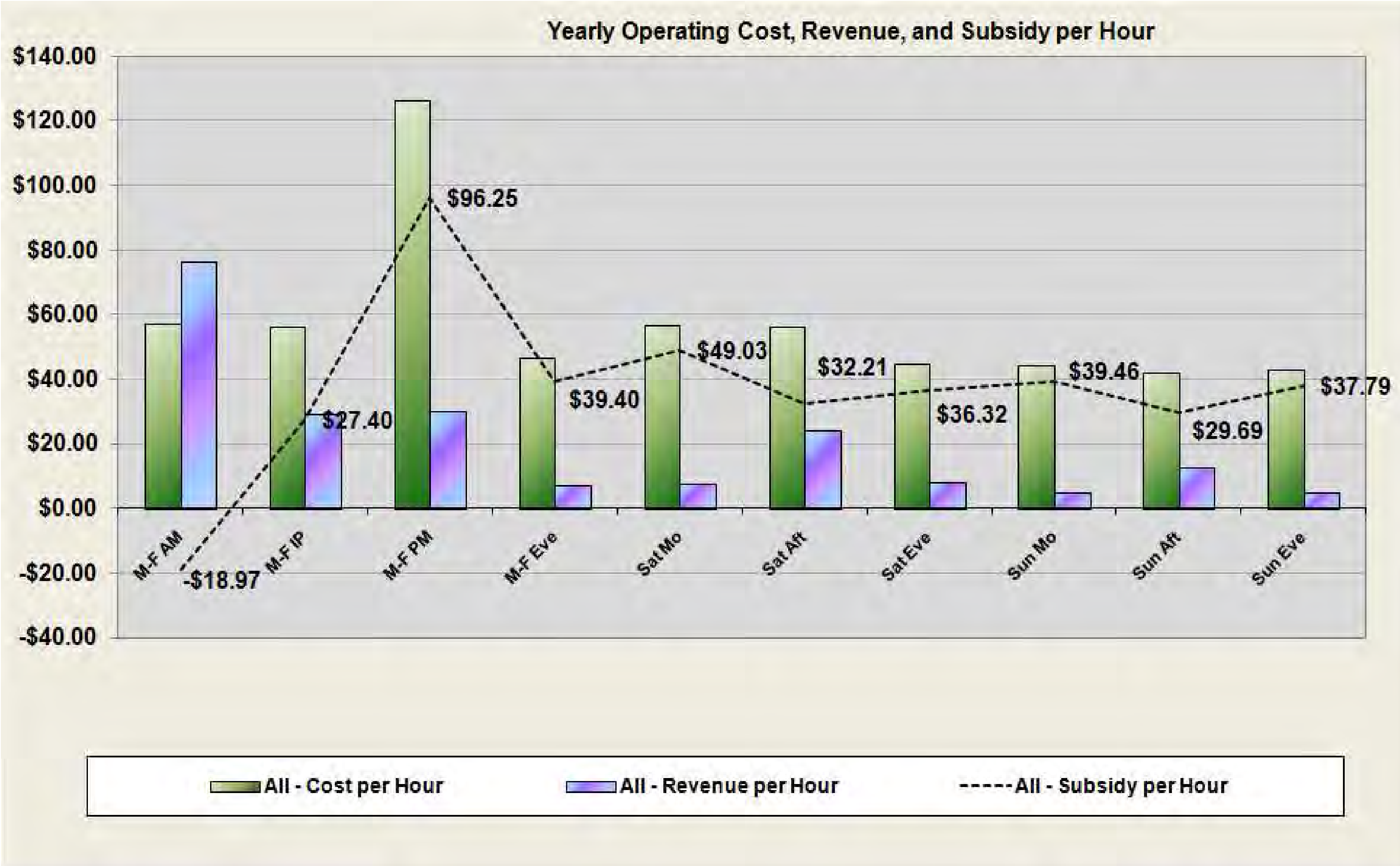


Figure B.5 Patronage

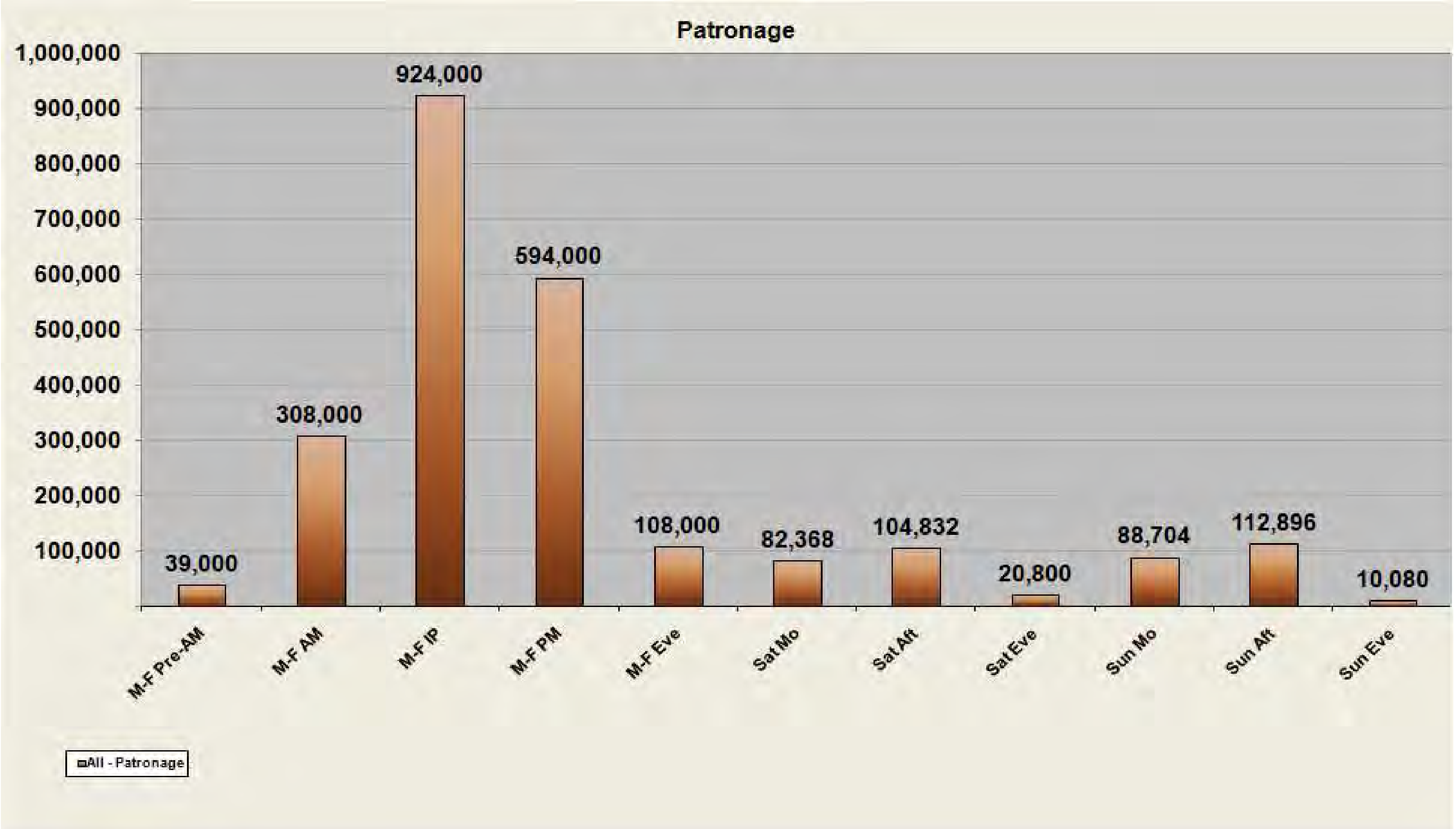


Figure B.6 Occupancy per trip

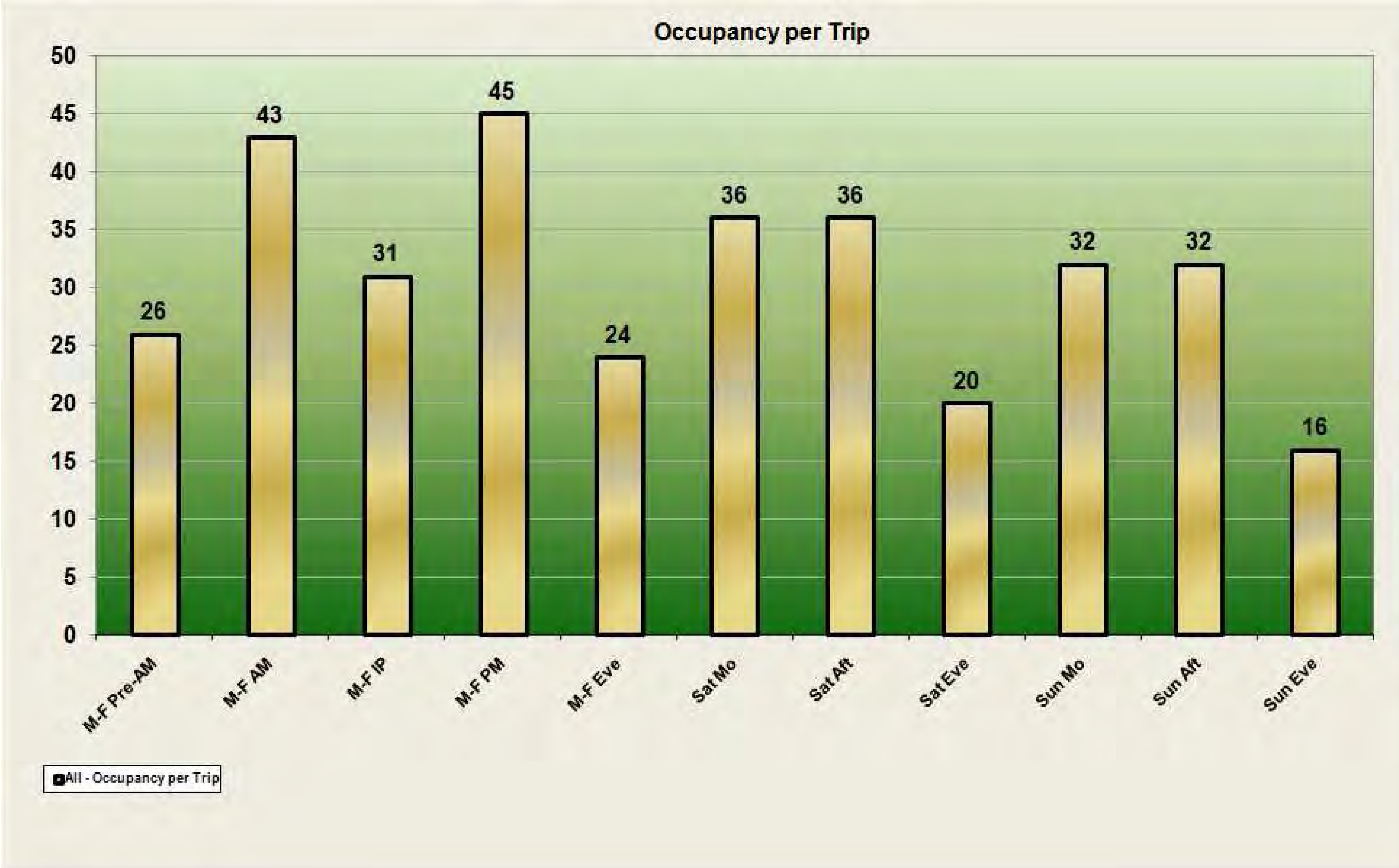


Figure B.7 Peak vehicles required

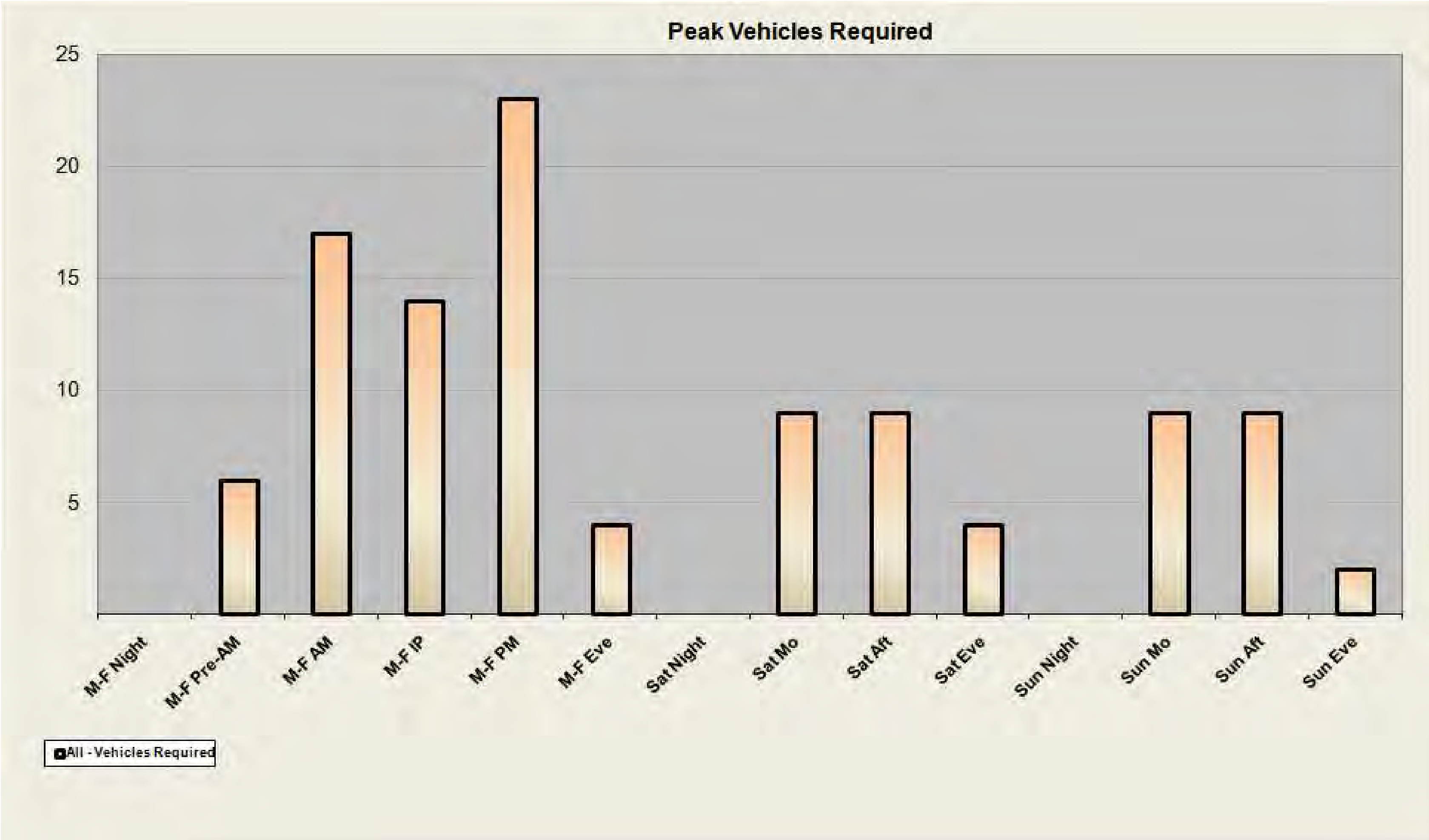


Figure B.8 Vehicle hours

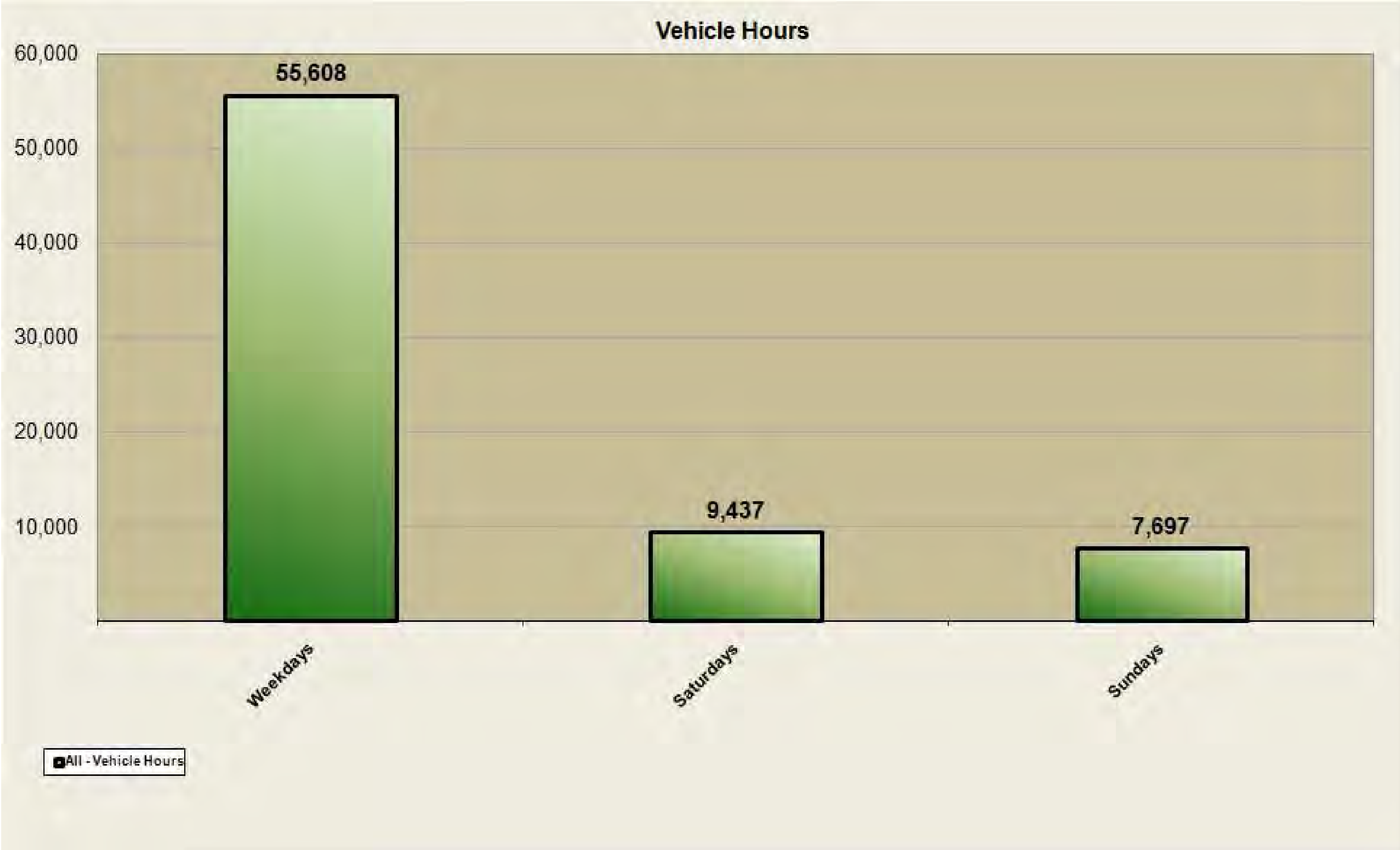


Figure B.9 Vehicle kilometres

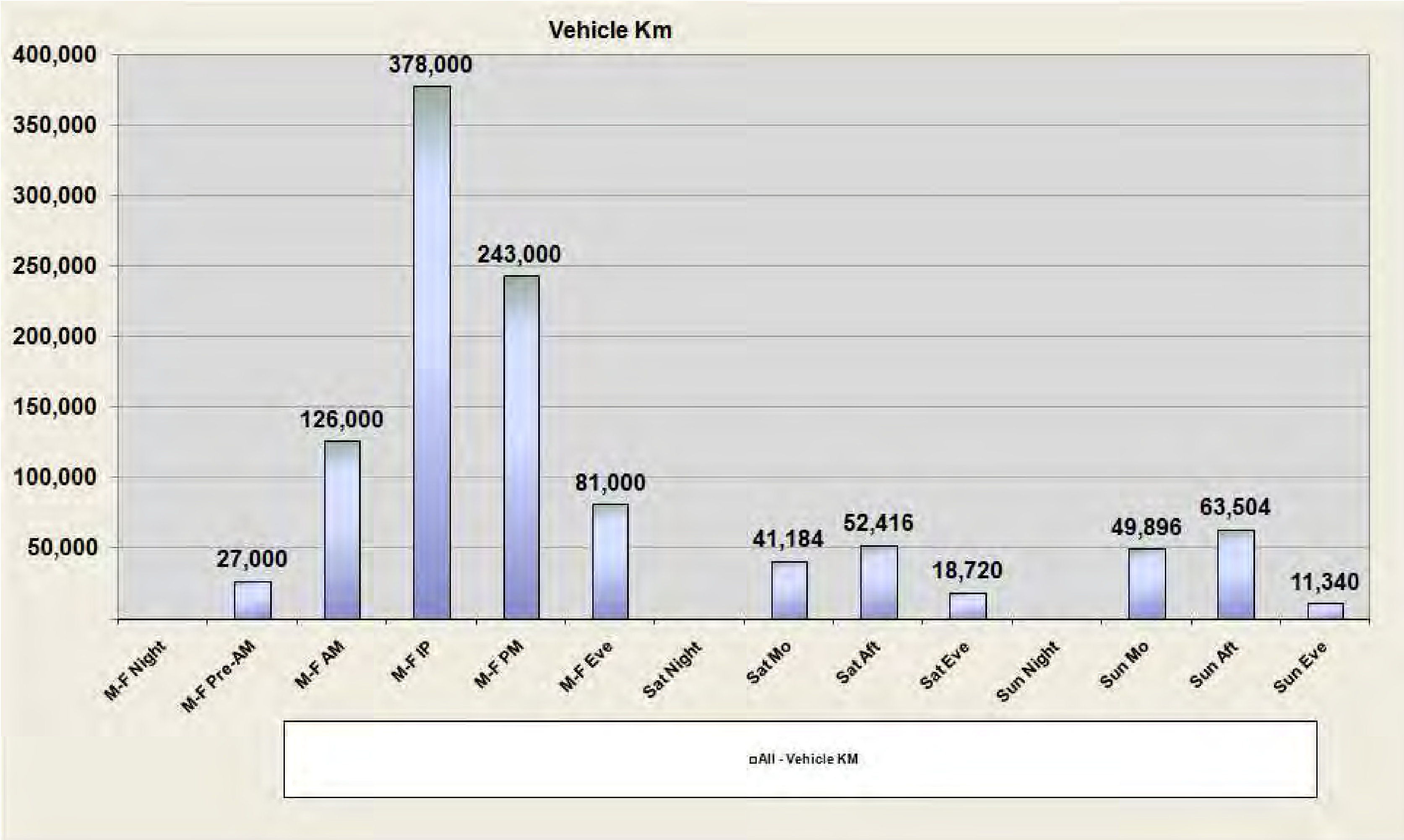
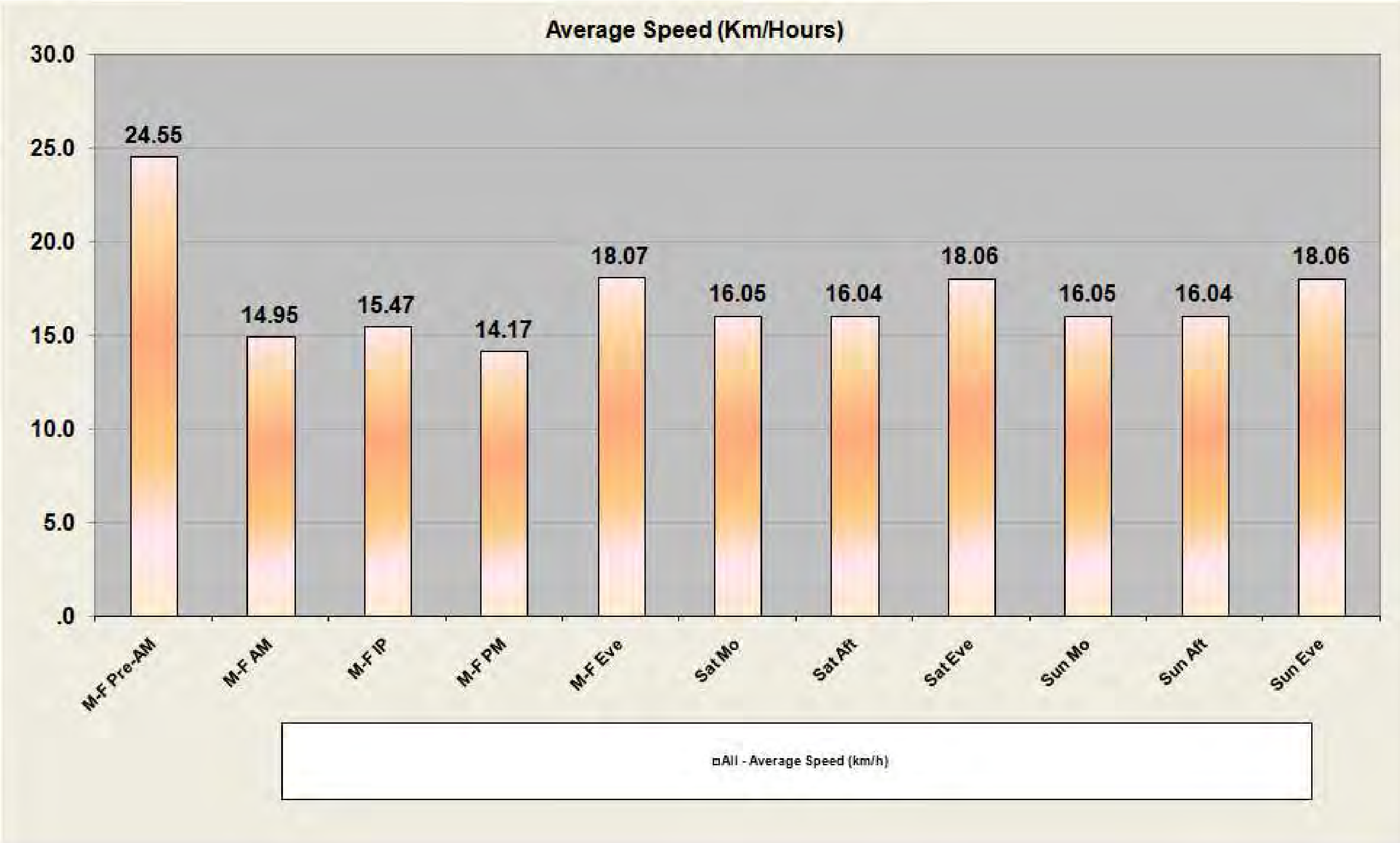


Figure B.10 Average speed



Appendix C: User travel cost and demand functions

C.1 Introduction

This appendix details the functions incorporated in the NZ Bus Policy Model (BPM) to assess the changes in PT demand that would result from changes in:

- the characteristics of the PT system as experienced by the user, ie service levels, service quality factors and fare
- the factors external to the PT system that affect PT demand, principally changes in the price of alternative modes (petrol prices, parking charges, other motoring costs).[8]

The appendix is arranged in three main sections:

- C.2 PT user travel cost functions and unit values
- C.3 Demand response to PT system changes
- C.4 Demand response to external changes.

Much of the material in this appendix is drawn from the *National guidelines for transport system management in Australia* (NGTSMA) (Australian Transport Council 2006) adopted by the Australian Federal Government, which includes extensive sections on evaluation methods for urban PT services. Reference is also made to the NZTA (2010) *Economic evaluation manual* (EEM) (principally volume 2), which generally provides less detail on the relevant aspects[9].

C.2 PT user travel cost functions and values

C.2.1 Generalised user cost function for PT travel

Travellers make travel decisions based on their perceptions of the total 'cost' of their travel, where this cost includes monetary amounts paid (and perceived as being incurred) and a range of other quality and service factors such as the time, comfort, reliability, security and cleanliness of travel. The cost is usually described as the generalised cost of travel, but may also be called the perceived cost of travel or the behavioural cost of travel. The generalised cost of travel represents users' willingness-to-pay for a trip, and hence is a key input to any assessment of how the demand for travel (by PT or other mode) will change as the perceived costs of travel change.

In the case of public transport, the generalised (perceived) cost of travel may be expressed as follows:

$$GC = F + V*[(T_A*W_A) + (T_W*W_W) + (T_R*W_R) + (T_I*W_I) + N_T * \{T_P + (T_{AT}*W_{AT}) + (T_{WT}*W_{WT})\}]$$

where

GC = total generalised (perceived) cost

[8] The effects of other 'external' factors that might affect PT demand (eg population changes, employment changes) are essentially estimated external to the model and input as factors: these are not addressed here.

[9] There is a reasonable measure of consistency between EEM and NGTSMA in most of the aspects relevant here, although not on all points.

F = fare ($)

V = 'standard' value of time ($/min of, say, in-bus time or some other benchmark)

T_A = access/egress time ie between an origin/final destination and the public transport facility (mins)

W_A = weighting on access/egress time (to reflect its perceived valuation relative to in-bus travel time)

T_W = (expected) waiting time at a bus stop or train station for initial boarding (mins)

W_W = weighting on expected waiting time (to reflect its perceived valuation relative to in-bus travel time)

T_R = unexpected waiting or travel time (associated with service unreliability)

W_R = weighting on unexpected waiting or travel time

T_I = in-vehicle time (mins)

W_I = weighting on in-vehicle time to reflect quality attributes (relative to in-bus travel)

N_T = number of transfers

T_P = transfer penalty to reflect the inconvenience associated with a transfer (in equivalent in-bus travel time (minutes)) where a transfer occurs

T_{AT} = access/walk time on transfer

W_{AT} = weighting on transfer access/walk time

T_{WT} = waiting time on transfer

W_{WT} = weighting on transfer waiting time.

The following two sub-sections provide appropriate unit values for the various parameters in the above generalised cost formula, for the purposes of assessing demand changes in the BPM.

C.2.2 'Standard' values of time

The 'standard' value of in-vehicle time for public transport users is a key input to the generalised cost function and hence the demand assessment process. The methodology adopted expresses the values of travel time for other situations (eg walking, waiting) in terms of this standard in-vehicle time; further this standard value provides the basis for translating all time components into money, and hence combining with fares into the total generalised costs for a trip.

For BPM purposes, we define the 'standard' value of in-vehicle time as that applying to seated in-bus travel (values for in-vehicle travel for other PT modes are related to this standard value by the factor W_I, as described below).

In order to arrive at a 'standard' value (as defined), we examined the values derived in three sources, as follows:

1 EEM (NZTA 2010, volume 1, table A4.1). This gives the following values for seated bus/train passengers (NZ$/hr, July 2002 prices):

- commuting $4.70
- other (non-work) purposes $3.05
- work purpose $21.70

It has been recognised in previous work for Land Transport NZ/NZTA (IWA 2007) that these values for commuting and other purposes appear to be on the low side, when compared with values in other developed countries, and relative to car driver and car passenger values adopted in New Zealand and Australia.

2 NGTSMA (Australian Transport Council 2006). Table C.1 sets out the values included in the Australian guidelines. These are derived from a considerable number of (mainly) Australian studies, mostly based on stated preference methods.

3 NZ research on PT reliability. This research project (Vincent 2008) derived values for in-vehicle times from stated preference market research in Wellington and Auckland, as summarised in table C.2.

In making a best estimate of an appropriate 'standard' value of in-vehicle time for users of New Zealand urban bus services, given these three sources, we note that:

- the EEM values are generally recognised to be on the low side
- all three sources indicate that peak/commuter values are higher than off-peak values, although the extent of the difference varies
- the most recent New Zealand research on the topic is that in Vincent (2008), and this research (table C.2) appears to be of high quality.
- the Australian values (Australian Transport Council 2006) (table C.1) are generally somewhat higher than the New Zealand values (table C.2), although not in all cases (eg rail values).[10]

For model purposes, we have adopted the following 'standard' in-vehicle time values as 'default' values (NZ$2010):

- peak $7.20/hour (12¢/minute)
- off-peak $6.00/hour (10¢/minute)
- overall $6.60/hour (11¢/minute)

These values are based principally on:

- an average 2006 value of NZ$6.00/hour (between the Wellington and Auckland bus values in table C.2)
- an inflation adjustment of 10% to translate this 2006 value to 2010 prices
- a spread of the peak and off-peak values of around ±10% of the average value (based on the data from tables C.1 and C.2).

[10] To a close approximation, table C.1 values may be translated 1:1 to NZ$2006 (taking into account purchasing power parity adjustments).

Table C.1 'Standard' values of time – Australian guidelines[(a)] (values in A$/hour, 2006 prices)

PT mode[(b)]	Overall	Peak	Off-peak
All	$10.00	$10.80	$9.20
Bus	$8.80	$9.35	$8.25
Rail/LRT	$10.25	$11.20	$9.30
Ferry	$11.80	$12.90	$10.70

Notes:

(a) NGTSMA, section 6.2.1. Values reflect the average incomes of PT users and the different mix of trip purposes in peak and off-peak periods.

(b) The guidelines recommend that the 'all' modes values are generally used, but that the mode-specific values may be used for particular situations.

Table C.2 Values of in-vehicle time – New Zealand reliability research[(a)] (values in NZ$/hour, 2006 prices)

Measure	Average in-vehicle time values	Notes
Weighted average value:		Disaggregate model values
• with constant term	$8.56	
• no constant term	$6.86	
Unweighted average value	$10.20	
Weighted average value by mode:		Disaggregate model
• Wellington rail	$12.38	
• Wellington bus	$5.73	
• Auckland bus	$6.97	
Weighted average values by purpose:		Disaggregate model
• work	$8.96	
• education	$7.53	
• other	$8.12	

Note: (a) Values derived from Vincent (2008, appendix B).

C.2.3 Other user cost unit values

Consistent with the generalised cost formulation, table C.3 provides recommended default values for all other unit cost parameters. These values are expressed in units of 'generalised time' and may be converted to units of generalised cost by multiplying by the standard values of in-vehicle time derived above (refer formula in section C.2.1).

The values given are based on the NGTSMA values, with some adjustments and simplifications made as considered appropriate for this project. We note that these values are designed for the bus situation: if rail or ferry are to be subsequently incorporated in the BPM, then further consideration will be required (primarily in regard to the treatment of relative in-vehicle time values).

Table C.3 User generalised cost unit values[a]

Item[b]	Default values (GT minutes)	Variations, notes
Access GT Access time (T_A) * Access weighting (W_A)	Actual access/egress time 1.4 (normal)	Could adjust to 1.2 for short walks (<5 mins), 1.8 for long walks (>20 mins)
Expected wait GT Expected wait time (T_W) *Wait weighting (W_W)	$0.72*H^{0.75}$ 1.4 (normal)	H = average headway
In-vehicle GT In-vehicle time (T_I) * In-vehicle weighting (W_I)	T_I = Actual in-vehicle time W_I = VLF	VLF (crowding factor): 1.0 seated, 1.4 normal standing, 2.0 standing crush load. Other factors may be required here for rail, ferry modes (to address later if required).
Transfer GT [No of transfers (N_T) * Transfer penalty (T_P)] + [Transfer walk time (T_{AT}) * Transfer walk weighting (W_{AT})] +[Transfer wait time (T_{WT}) * Transfer wait weight (W_{WT})]	Actual number of transfers 7 GT minutes Actual walk time 1.4 $0.72*H^{0.75}$ 1.4	Could adopt: (i) within mode: 5 for same facility, 7 for different facility; (ii) between mode: 7 for same facility, 10 for different facility. H = average headway of second service
Unexpected wait/journey GT[c] Unexpected wait/journey time (T_R) * Unexpected wait/journey weighting (W_R)	Actual average lateness 3.0	Alternatively apply weighting 6.0 to unexpected wait time at stop, 1.5 to unexpected in-vehicle time.

Notes:

(a) based on NGTSMA table 1.6.1, with some simplifications

(b) GT = generalised time.

(c) unexpected wait/journey GT (relating to service reliability) has not been incorporated in the BPM at this stage, given the lack of systematic data on bus service reliability in most centres.

C.3 Demand response to PT system changes

This section addresses how PT demand (patronage) would vary from its 'base' level in response to changes in the generalised cost (GC) of the PT trip, as defined in the earlier sections. Consistent with the GC approach, we define a set of GC elasticities, for application in deriving the change in patronage resulting from any change in trip GC, according to the following formula:

$$P_I/P_O = (GC_1/GC_0)^E$$

where:

P_O is the 'base' patronage (trips) and GC_0 the 'base' generalised cost for these trips

P_1 is the new patronage (trips) resulting from a change in generalised costs to GC_1

E is the elasticity of demand with respect to the trip total generalised cost.

We adopt the following (default) values for the generalised cost elasticity (E):

- short run (9–12 months after change): peak -1.0, off-peak -1.5
- medium run (approx five years after change): 50% greater than short run value, ie peak -1.5, off-peak -2.25.

These values are based on a range of evidence and experience, and in particular the following sources[11]:

- *National guidelines for transport system management in Australia* (Australian Transport Council 2006). This proposes short-run values as above (-1.0/-1.5) with long-run values (7–10 years after the change) approximately twice the short-run values.
- *NZTA research report 248* (Review of passenger transport demand elasticities) (Wallis 2004). This indicates short/medium-run GC elasticity values in the range -0.9 to -1.5; and suggests long-run elasticity values generally around twice short-run values.

C.4 Demand response to external changes

This section addresses how PT demand will vary according to changes in the generalised costs of the main alternative mode (ie the private car). We consider two main components of the variable costs of car use, ie fuel (petrol) prices and parking charges.

C.4.1 Fuel (petrol) prices

The measure of relevance here is the cross elasticity of demand for PT travel with respect to (real) petrol prices[12]. The most recent relevant study on this measure is an analysis of Go Wellington bus patronage over the period 1999–2007 (IWA 2008). This found that the cross elasticity with respect to petrol price averaged 0.16, with minimal variation between time periods (peak, off-peak, weekends): this is essentially a short/medium-run value. This value is very consistent with the typical average value given in Wallis (2004); however, this suggests peak values two to three times off-peak values, which is not borne out by the Go Wellington analyses.

Wallis (2004) also reviews the evidence on how long-run elasticities compare with short-run values. He notes the long-run response may well be lower than the short-run response, given the scope for other adaptive behaviours – but found little hard evidence on this. For present purposes, the BPM adopts a default value of 0.16 for both short-run and long-run responses, for both peak and off-peak periods.

It is unclear, based on the evidence currently available, whether petrol price elasticity values in centres other than Wellington (city) will be higher than, lower than, or similar to those in Wellington. It is therefore suggested that the default cross-elasticity value of 0.16 should be used only with considerable caution in

[11] The estimates given in these sources are generally consistent with the (rather limited) New Zealand evidence on fare and service elasticities.

[12] We take petrol prices movements as a reasonable proxy for the price movements for the mix of fuels used by the New Zealand car fleet, the great majority of which are petrol powered.

other centres. It will be preferable to undertake market research in a sample of the other centres in order to establish local values with more confidence.

C.4.2 Parking charges

The measure of most relevance here is the cross elasticity of demand for PT travel with respect to (real) parking charges. It could reasonably be expected that such an elasticity would vary widely according to:

- trip purpose and length of stay
- quality of PT service available for the trip in question
- possibility of making the trip to an alternative destination (eg shopping trips).

The relevant evidence of which we are aware is summarised in table C.4, for the cross elasticity and for an alternative analytical approach applying the direct elasticity (for parking demand with respect to parking charges) and the diversion rate (proportion of deterred car users that would switch to PT). As noted in the table, the extent and quality of relevant evidence is generally very limited.

Table C.4 Evidence on responses to parking price changes[(a)]

Response measure	Summary of evidence
Direct elasticity (parking demand with respect to parking charges)	**Aggregate:** • Typical short-run values are -0.3 (range -0.1 to -0.6) for CBD commuter trips. • No clear evidence on long-run values. **Segmentation:** • Commuter elasticities lower for suburban than for CBD destinations (alternative modes less attractive) – limited evidence. • Non-commuter elasticities likely to be higher (alternative destinations available – although parking costs likely to be lower proportion of total GC) – limited evidence.
Diversion rates (proportion of car users affected by parking price changes that switch to PT)	• Regional CBD work trips c. 75% (limited evidence) • Suburban CBD work trips c. 50% (limited evidence) • Regional CBD non-work trips c. 50% (limited evidence) • Other trips n/a
Cross elasticity (% change in PT trips: % change in parking charges)	**Aggregate:** • Elasticity estimates in range 0.02 to 0.30, but often unclear to what market segment they relate. • No evidence on long-run vs short-run. **Segmentation:** • No clear evidence on segment differences, though would expect relatively high values for regional CBD work trips, relatively low for non-CBD/non-work trips.

[(a)] Summarised from Wallis 2004, tables 5.1, 5.3, 5.4)

In this case, we suggest the best approach is to apply direct elasticity and diversion rate estimates.

For commuter trips to/from the regional CBD, applying this approach would involve:

- direct elasticity -0.3 (short-run)
- diversion rate 75%.

It is not clear from the limited evidence available, how these factors should be varied for other trip purposes and/or other destinations.

Given the deficiencies in the evidence on this topic, we suggest that further research should be undertaken before any ‘serious’ testing through the BPM of the effects on PT patronage of changes in parking charges.

C.5 References

Australian Transport Council (2006) *National guidelines for transport system management in Australia* (NGTSMA). (Vol 4: Urban transport). Canberra: Australian Transport Council.

Ian Wallis Associates (IWA) (2007) *Review of value of time relativities in the Economic evaluation manual: main report – PT users and car users*. IWA report to Land Transport NZ.

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NZ Transport Agency (NZTA) (2010) *Economic evaluation manual*. Vols 1 and 2. Wellington: NZTA.

Vincent, M (2008) Measurement valuation of public transport reliability. *NZTA research report 339*.

Wallis, I (2004) Review of passenger transport demand elasticities. *NZTA research report 248.*

Appendix D: Operating costs methodology and inputs

D.1 Introduction

This appendix sets out the methodology and associated inputs used in the NZ Bus Policy Model (BPM or 'the model') for assessing operating costs for bus services in various situations, ie:

- assessing the incremental costs associated with changes in the level and characteristics of operations (eg service frequency changes, vehicle type changes)
- analysing the existing system costs by route or route group
- further analysing the existing system costs by time period (at a system-wide level or for specific routes).

The appendix is arranged in four main sections:

- D.2 Costing principles and cost structure
- D.3 Unit cost estimates
- D.4 Costing applications
- D.5 Adjustments for input price movements.

The methodology outlined is essentially generic for incremental costing and the analysis of existing service costs for any urban bus system, and hence could be applied in any New Zealand region. The unit costs presented are based broadly on typical cost levels (2009/10) for bus operations in New Zealand urban centres, but have been adjusted for reasons of commercial sensitivity.

D.2 Costing principles and cost structure

D.2.1 Costing principles and approach

The key components of the BPM costing methodology are:

- a set of long-run variable unit cost rates (per bus hour, bus kilometre etc), based broadly on typical costs experienced in the main New Zealand urban centres.
- a methodology to apply these unit costs to measures of operating resources (eg bus hours, bus kilometres etc), to analyse the costs of the existing system (by route, time period etc) and to estimate the incremental costs of any service changes for assessment.

The following summarises the model's approach to key aspects of this methodology.

D.2.1.1. Costs for inclusion

The model's costing module is designed to cover all costs included in operator operating contracts. The following points should be noted:

- All costs are included on a gross (rather than net) basis – fare revenue estimates are covered in other BPM modules.

- Costs not included here include regional council (RC)/territorial local authority (TLA) direct costs for administration and system-wide facilities provided directly by the RC/TLA (eg passenger information and enquiry services) – refer section D.3.2.
- Asset charges, which are generally covered through the operating contracts (eg for vehicles) are included (see below).
- An allowance for reasonable operator profit margins is also included, expressed as a percentage mark-up on all operating costs (refer later discussion).
- In the case of Wellington, the costs include the maintenance contract for the trolley bus overhead wiring system.

D.2.1.2. Cost variability

In estimating appropriate unit costs, a medium-long run perspective is taken. From that perspective, it is generally assumed that costs are 'fully variable' with the appropriate operating measure, ie there is no fixed cost component[13]. However, the methodology recognises that route infrastructure costs involve a substantial fixed component, independent of use, but variable with the extent of infrastructure involved (the costs for the Wellington trolley overhead wiring system are the main item included in this category).

D.2.1.3. Treatment of capital asset charges

The principal capital asset item generally covered through the contracts is for the buses themselves, which are owned directly by the operators.

For the bus assets, we estimate an appropriate long-run average annual capital charge, on an annuity basis, based on:

- current replacement costs (eg new bus prices)
- estimated life of replacement assets
- residual value (if any) at end of life
- a (real) interest rate of 7%.

Such an average charge estimate should be a good representation of economic costs over the longer-term, but may differ somewhat from charges incorporated in contracts in a particular year[14].

For Wellington, a similar approach is taken in regard to the trolley overhead wiring system, which is owned (and maintained) by Wellington Cable Car Ltd (WCCL) and funded through a contract with GW.

The appropriate capital charges for other minor assets (eg depots, plant and equipment) are relatively small, and are incorporated within other operating costs.

D.2.2 Cost categorisation

For BPM cost analysis purposes, all relevant cost items have been first categorised into one of eight main cost categories, as set out in table D.1.

[13] This is consistent with the wealth of evidence internationally that, in the medium/long-run, there are no (or very few) significant economies (or diseconomies) of scale in urban bus operations.

[14] Consideration was given to using lower capital charges for buses used principally for school services. However, it was decided not to differentiate school buses on the basis that: i) a large proportion of school buses are also used on route services; and ii) with new NZTA standards for 20 year maximum age for buses on urban services, any cost difference for 'school' buses is reduced substantially.

Table D.1 Cost categories and items

Category	Cost items included	Notes
A Operating costs – time	Drivers – wages and direct on costs[(a)]	
B Operating costs – distance: fuel	Fuel Oil, lubricants	• Separated out, given its importance in cost escalation
C Op costs – distance: other	Bus R&M[(b)] – wages and direct on-costs[(a)] – parts, materials and external services Road user charges Tyres and tubes	
D Operating costs – vehicles	Bus comprehensive insurance Bus registration, licensing Bus cleaning, fuelling Depot rental and rates	• Comprises items that are directly related to the number of buses in fleet. • Labour (where applicable), supplies etc. • For 'owned' depots, usually include an equivalent market rental here.
E Operating costs – overheads	Overhead labour – wages/ salaries and direct on –costs Overheads non-labour Minor assets (capital charges)	• All labour not included elsewhere • All other operating costs not included elsewhere • Covers depreciation/interest on assets other than vehicles, route infrastructure and depots/offices
F Profit margin	Profit margin or management fee	• Base on rates typically achieved in competitive markets
G Capital charges – vehicles	Bus assets	• Calculated in terms of average annual capital charge (annuity basis) – refer text.
H Maintenance costs and capital charges – route infrastructure	Maintenance and capital charges for route infrastructure assets (main item is trolley overhead wiring system in Wellington)	• Calculated in terms of average annual capital charges (annuity basis) plus annual maintenance costs

Notes:
(a) Comprises principally ACC, superannuation contributions.
(b) R&M = (bus) repairs and maintenance.

D.2.3 Cost allocation and operating resource measures

Table D.2 shows the allocation of each cost category to appropriate measures of operating resources, the key measures being bus hours, bus kilometres and buses.

These three measures are defined in table D.3:

- In deriving unit costs, the total costs in each category are divided by the appropriate estimate of total operating resources (table D.2).
- These estimates of total operating resources are generally derived from the in-service operations resources by allowing for out-of-service operations, as described in table D.3.
- Depending on the fleet mix being analysed, the bus kilometres and buses resource measures are disaggregated by bus type/size[15]. (In the Wellington context, the main issues are the distinction between 'standard' size (diesel) buses and smaller (mini/midi) buses, and between diesel and trolley buses.)

[15] The bus hour measure does not usually need to be disaggregated, as driver-related costs (per bus hour) are independent of bus type/size category.

Table D.2 Allocation of cost categories to operating resource measures

Cost category	Allocation/comments
A Op costs – time	Bus hours (total)
B/COp costs – distance	Bus kilometres (total) – by vehicle category
D Op costs – vehicles	Buses (total) – by vehicle category
E Op costs – overheads	% mark-up on categories A–D
F Profit margin	% mark-up on categories A–E.
G Capital charges – vehicles	Buses (total) – by vehicle category
H Maintenance costs and cap charges – route infrastructure	Treated as a fixed sum item at this stage (may need to reconsider for options involving increase/decrease in trolley bus route length).

Table D.3 Operating resource measures – definitions

Measures	Definition	
	In-service operations	Total operations[(a)]
Bus hours	• Total time that buses are engaged in service operations • In addition to terminus-terminus time, includes short breaks (up to 15 mins between trips (waiting at termini, etc) • May be derived from analysis of vehicle/ driver schedules.	• All time running between depot and start/end of route, and between routes. • Any extended periods on the road (with driver in charge) additional to in-service operations.
Bus kilometres	• Total distance rum by buses in service operations. • May be derived from number of timetabled trips and route lengths.	• All distance running between depot and start/end of route, and between routes. • Any other non-service running (eg to replace broken down buses, driver training, etc).
Buses	• Maximum number of buses required in use at any one time on a normal weekday in order to operate the scheduled services. • May be derived from analysis of vehicle/driver schedules.	• Additional ('spare') buses required in fleet to allow for operational requirements (breakdowns, etc) and maintenance requirements.

Note:

[(a)] Total operations statistics derived from in-service statistics plus additions noted in this column.

D.3 Unit cost estimates

D.3.1 Initial estimates

At this stage in the BPM development and its piloting (for the Wellington system), a set of unit operating cost rates have been developed which:

- are representative of urban bus operating costs in New Zealand (rather than any one centre)
- relate to 2009/10 average price levels
- are broadly consistent with contract costs and associated operating statistics as experienced by GW
- focus on the cost rates for 'standard' size diesel bus operations (without differentiating between diesel and trolley operations, except in regard to infrastructure maintenance).

The resulting unit costs are set out in table D.4, including comments on their basis/derivation.

D.3.2 Potential refinements

The unit costs given in table D.4 should be regarded as indicative only: it is preferable that unit costs are re-estimated separately in each region in which the BPM is to be applied (and consistent with known contract cost rates in the region).

As appropriate, these estimates should also address cost differences: 1) between diesel buses and trolley buses; and 2) for diesel buses of 'non-standard' sizes.

Once this 'calibrated' set of unit costs is available, they could then be 'indexed' for subsequent years, using the standard NZTA cost indexation formula or similar (refer section D.5 below).

For some purposes, the user may wish to include costs that are outside operator contracts, eg RC/TLA costs for administration and system-wide facilities that are provided directly by the RC/TLA. Where required, this could be done by either increasing the operating overhead cost rate (table D.4, category E) or adding a separate category for these administration costs.

Table D.4 Unit cost rates, 2009/10 prices (provisional, 'standard' diesel buses)

Cost category		Units	Cost rate	Notes, comments
A	Operating costs – time	$/bus hour	22.00	
B	Operating costs – distance: fuel	$/bus km	0.425	Based on typical diesel consumption of 37 litres/ 100km and price of $1.15/litre.
C	Operating costs – distance: other	$/bus km	0.452	Includes 0.152 for RUC (Type 2 vehicles, 2/11 tonnes GVW rating); 0.300 for bus R&M, tyres and tubes.
D	Operating costs – vehicles	$/bus pa	5000	
E	Operating costs – overheads	% mark-up on items A–D	10%	
F	Profit margin	% mark-up on items A–E	5%	Typical of profit margins on competitive urban bus contracts in Australia.
G	Capital charges – vehicles	$/bus pa	36,000	Based on typical new diesel bus price of $375,000, life 18 years, depreciation rate 12.0% pa (DV), interest rate 7.5% pa (real).
H	Maintenance costs and capital charges – route infrastructure (trolley system)	$ million pa	4.50	Covers i) maintenance and ii) annual capital charge, for the Wellington trolley electrical overhead system.

D.4 Costing applications

This section outlines the costing methodologies applied for the two main applications of the BPM, ie:

- Incremental analyses – 'what if' assessments of changes in costs associated with potential changes in the level and characteristics of operations and services.
- Existing system analyses – analyses of costs of the existing system and services, on a geographic basis (typically by route/route group) and/or temporal basis (typically by weekday vs Saturday vs Sunday, with weekdays split between peak, interpeak, evening, night periods).

In both cases, the methodologies involve the application of unit costs to measures of operating resources to derive costs (on an annualised basis).

D.4.1 Incremental analyses

The methodology for assessing the cost changes associated with any operational or service change essentially involves:

- estimating the required operating statistics with and without the proposed change
- multiplying these operating statistics by the relevant unit costs, to derive the total costs with and without the proposed change
- taking the difference between these two cost estimates, which represents the incremental costs (positive or negative) associated with the change.

This methodology may be applied to a variety of operational and/or service changes, provided these can be expressed in terms of operating statistics (with/without the proposed change), ie principally bus hours, bus kilometres and peak buses required by vehicle type/size category and by day of week/period of day. Examples of such changes include:

- service frequency on existing routes
- running times on existing routes
- route changes
- network restructuring on an area/corridor basis
- increase/decrease in vehicle size
- replacement of trolley buses by diesel buses, or vice versa.

In relation to such incremental cost assessments, we note that:

- for any service change outside the weekday peak periods, there would be no change in peak bus (and hence total fleet) requirements, and thus in bus capital charges
- for any change that affects only one of the two weekday peak periods, detailed consideration would be needed (in conjunction with the operators involved) as to whether any change in peak bus requirements and hence capital charges would result from service changes in the AM peak alone and/or the PM peak alone.

D.4.2 Existing system analyses

The methodology for analysis of the costs of the existing system, on a geographic and/or temporal basis, is similar in most respects to that for incremental analyses (above). It involves an ‘avoidable’ costing approach: this compares the total costs of the existing system with the total costs of the system less the specific service segments (by route and time period) in question. In practice, the avoidable resources for the service segment in question are first calculated, and then multiplied by the appropriate unit costs to derive the avoidable costs for the segment (on an annualised basis).

The method is straightforward in application to the costing of specific routes, and hence for splitting the system total costs between routes. In effect, the (avoidable) cost of each route is derived as the product of the (avoidable) resources involved (bus hours, bus kilometres, peak buses), multiplied by the appropriate unit costs.

For the (avoidable) costing of specific time periods (eg evening services, either system-wide or for a specific route), the above method is also applicable for all non-peak time periods. This can be used to provide (avoidable) cost estimates for (eg) interpeak, evening, Saturday and Sunday services.

If this methodology were similarly applied to peak period services, it would be found that not all the buses involved in providing peak services are 'avoidable' to the peak period: a substantial proportion of them are 'joint' between time periods, as they are also required for non-peak period services. Thus the methodology would result in avoidable cost estimates for each time period, with a residual 'joint' cost that cannot be allocated to any one specific period. While various more-or-less arbitrary methods may be used to allocate these joint costs across the various time periods concerned, the BPM does not attempt such allocation at this stage.

Hence the output of any analyses of the existing system by time period would be avoidable cost estimates for each off-peak period, with a residual amount representing all remaining costs, some of which are 'avoidable' to peak period services and others which are 'joint' between different periods.

This methodology was discussed with GW and agreed as the most appropriate for the Wellington pilot project: it was considered this would give the most useful information for GW's purposes, and would be particularly relevant to assessments of the viability of off-peak services and potential expansions/contractions of services at off-peak periods. (Alternative methodologies may warrant consideration for other BPM applications.)

D.5 Unit cost adjustments for input price movements

The BPM allows the user to adjust the base unit cost rates provided (table D.4) to assess alternative scenarios. This facility effectively allows the user to assess changes in total costs (on a system-wide or service segment level) as a result of movements in the various input price components (eg if fuel prices increase by X%). For such assessments, the user could input either specific increases to each unit cost component, or an across-the-board average increase.

The base unit cost rates shown in table D.4 relate to 2009/10 average prices. As the default mechanism for adjusting the base prices (in arrears), we would propose that the model adopts the NZTA quarterly price indices, either at an overall level or (preferably) for each of the index components. Once the index details are input, the model user could specify the year/quarter prices in which the outputs are to be provided.

For forecasting future costs (eg for budgeting purposes), the model user can input best estimates (or a range) of future increases in each of the base unit cost rates, and hence derive future years' costs on either a system-wide or segment basis.

Appendix E: Comments on model piloting experience (Greater Wellington Regional Council)

E.1 Introduction

The following notes on the NZ Bus Policy Model (BPM or 'the model') piloting experience were provided by Adam Lawrence of the Greater Wellington Regional Council (GW). GW was the development/pilot application of the BPM and this piloting work was largely undertaken by Adam Lawrence.

E.2 Overview

The BPM provides a simple and consistent but flexible approach to modelling the current performance and costs of bus services and the impacts of bus service changes. The BPM will complement more sophisticated models such as the Wellington Transport Strategy Model (WTSM) and the Wellington Public Transport Model (WPTM), which are complex and costly to run (in terms of time and money) and therefore can generally only be used to test a limited number of scenarios. The BPM readily allows the user to assess either system-wide or more localised scenarios and can be run multiple times to compare these.

E.3 Application and functionality

The BPM provides an opportunity and a framework for a more consistent approach to modelling public transport operating costs, as well as patronage and revenue impacts arising from changes in user (generalised) costs.

GW currently uses spreadsheet operating models similar to the operating cost side of BPM. However, these spreadsheet models are developed on an ad-hoc basis for specific purposes, ie a separate model for each service review/change.

The BPM enables operating costs to be modelled using benchmark figures, contract variation rates or for costs to be built up from first principles. This allows for easy testing of various cost functions such as sensitivity to changes in km rates vs changes in hourly rates. The model also provides a methodology for considering impacts (at a policy level) on patronage and revenue, which have previously been difficult for GW to consider.

Key applications for the BPM include, as above, assessment of the impacts of service changes on operational, market and financial performance. It can help achieve more efficient networks by assessing system-wide or more targeted changes and, where appropriate within the same level of operating resources (eg same number of buses or the same overall contract price). It can also estimate revenue impacts and can highlight trade-offs between cost levels on the one hand and patronage and farebox revenues on the other.

E.4 Data input

Operations data can be readily input into the BPM, at a greater or lesser level of detail, as chosen by the user. The model inputs allow the operations data from GW's Journey planner *database to be entered directly into the spreadsheet model using in-house export routines.*

Patronage and revenue data are required from operators and will generally require an adjustment/ factoring process outside the BPM to derive patronage and revenue figures consistent with region-wide (or operator-wide) control totals.

A strength of the BPM is its ability to provide cost and performance information not only by route/route group but also by day of week (weekday/Saturday/Sunday) and time of day. This is already providing GW with valuable information on the costs (on a marginal basis), revenues and funding levels (eg net funding per passenger) for off-peak services at different time periods: this information is beginning to be used in GW's service planning area, when considering such issues as increasing spans and varying frequencies of off-peak services (principally at evenings and weekends).

The BPM also allows the assessment of groups of routes and services (as defined by the user) and can help identify where there are potential benefits of grouping various services together and the cost implications. For example the model can be run for a small group of routes and then run with this group combined with another group of routes, to assess whether the costs of the two groups together are similar to the costs if they are operated separately. In this way the model can provide a useful insight into the specification of Public Transport Operating Model (PTOM) 'units' without the need to develop and apply a more sophisticated modelling application (eg using a full scheduling package).

In the future, with wider implementation of electronic ticketing (including tag on/tag off procedures), a new challenge may be how to analyse the wealth of data available so as to provide useful information for managers and planners/analysts, whether through BPM or other reporting mechanisms.

E.5 BPM interface

The BPM interface is easy to deal with, although some understanding of the model's structure and data input files is required to be able to use it.

A major benefit of the model is that it is based on Excel spreadsheets: all data fields and values are visible and able to be copied to other sheets for further analysis as may be required.

On occasions, the model can take several minutes to run through: after clicking 'GO' the user may not initially be aware of how long their computer may be tied up for.

E.6 Outputs/charts

The built-in chart outputs provide easy access to a standard set of tables/charts, which provide valuable information for the analyst. Some further enhancements of these standard outputs would probably be desirable to provide additional information. However, the main benefit may be in providing data tables that allow the user to generate their own charts or pivot charts. This would help when carrying out service reviews, each with its own issues and considerations and therefore difficult to specify in advance how best to use the data – although the BPM would provide a consistent way of getting to that point.

E.7 Current/future use

GW's first application of the BPM was for the assessment of service change options (routes, frequencies, etc) in one part of the Porirua area. The model was found to be very useful in this application, particularly by providing realistic and consistent estimates of costs for different service options.

GW is currently using the model to analyse the costs and financial performance of existing bus services (by area/route group) in the Wellington city area. The operating costs have been calculated although we are *still working out what detail to provide for route variants – should we allow differences between route lengths to be averaged out or should we include multiple route variants, in addition to inbound/outbound. The patronage and revenue side of the model is working but we need to factor the available data to known annual control totals, as we are using the monthly reporting data from operators (which is mostly at a route level) rather than requesting more data from operators.*

Once this work is completed, it should provide GW with valuable insights (not previously available) on the financial viability of the various routes/route groups and the services in different areas of the city.

The model will also provide an opportunity to model the 'service-level areas' defined in the Regional Public Transport Plan (RPTP). It will also allow GW to consider the costs of providing levels of service consistent with the service-level guidelines in the RPTP, ie to model this approach. We could then model the layered service approach with various different combinations of route groupings to determine the impacts of alternative allocations of routes, including consideration of the PTOM operating units, and therefore feed into decisions about the appropriate specification of services in each unit.

E.8 Potential BPM enhancements

Given the increasing use of Google Transit, a potential BPM enhancement could be to develop an interface with Google Transit to extract base operating data (route distance, travel time etc) and input it to the model.

As discussed with the consultants during the model development phase (and noted in the draft report), the BPM is not currently set up to assess the impacts of potential changes in fare structures (although it is adequate to assess the effects of uniform changes in fare levels, either system-wide or within an area/sub-region). Further consideration would be required of the best modelling methods for assessing more complex fare structure changes: these might involve enhancements to the model, to provide greater detail on zone-zone travel patterns on each rout; or may involve development of a separate model, with greater geographic capability (but lesser route-specific detail).

The model does not include rail or ferry modes although these services could be analysed using the existing framework (ie as if they were a bus but with different operating costs).

E.9 Conclusions

In conclusion, the BPM is a valuable tool that assists in both: i) analysing the operational and financial performance of its existing bus services (by route, day and time period, etc), which provides 'diagnostic' inputs to service planning, the allocation of services to PTOM units, etc; and ii) assessing the impacts of potential service changes (eg off-peak span increases or improved service frequencies) that could provide better value for money from the overall bus system.

I envisage that the BPM can potentially be a powerful tool for assessing the financial performance of PTOM operating units (at a policy level) on a consistent basis, both across units and on a year-by-tear basis.

In the future, we also anticipate using the model to assist in financial forecasting and scenario analyses (eg on the impacts of fuel price scenarios on both the supply/cost side and the patronage/revenue side).

It would be useful to extend the model to rail and ferry modes.

Appendix F: Review of the GB National Bus Model

F.1 Purpose and scope

In our proposal (IWA 2009) to develop a New Zealand Bus Policy Model, we noted that:

> *The proposed model will be broadly similar in scope to a model recently developed for the UK bus sector (for the UK Department for Transport and Commission for Integrated Transport). This UK model may be regarded as best practice in this field internationally (one of our Peer Reviewers played a major role in the development of this model). While our proposed model will be developed 'from scratch', we would examine the UK model and would adopt methods and formulae from it where appropriate. From an initial appraisal of the UK model, it is clear that some of its methods/ formulations will be applicable to the project, but that refinements would be desirable in some areas: the proposed model would throughout be developed for and calibrated to the NZ situation*[16]

This appendix provides our examination of the GB model (section F.2) followed by our comments on its relevance to this New Zealand project (section F.3). The material in section F.2 is taken from the report on the UK model prepared by the TAS Partnership Ltd (TAS Partnership 2007).

F.2 Model overview and features

F.2.1 Historic developments

The forerunners of the TAS 2007 model were developed through earlier assignments for the GB Department of Transport, in 1992, 1996/97 and 2003.

Essentially the model(s) were concerned with the examination of future policy options for the GB bus industry. This required understanding of the various complex and inter-related factors which together determine both the demand for bus travel and the costs of providing for this demand. The model(s) were primarily forward-looking, used for developing forecasts (with sensitivity scenarios) of demand, supply, costs, revenue, investment and industry profitability. They were designed for application at both the regional/area level and the national level.

Following completion of the 2003 work, the consensus view from the clients involved was that the model was a useful tool, but that further development and analyses would be desirable, in particular:

- to extend the model's forecasting capabilities (beyond 2010)
- to enable the model to be applied to different and smaller geographic areas
- to enable easier testing of possible scenarios
- to provide greater transparency as to its assumptions, and hence more readily enable easier testing of alternative assumptions.

A 'new generation' of the earlier model was thus commissioned, focusing on the above requirements.

[16] The original proposal referred to the UK bus sector and the UK Department for Transport as shown here. More correctly, it should have referred to the GB bus sector and the GB Department for Transport.

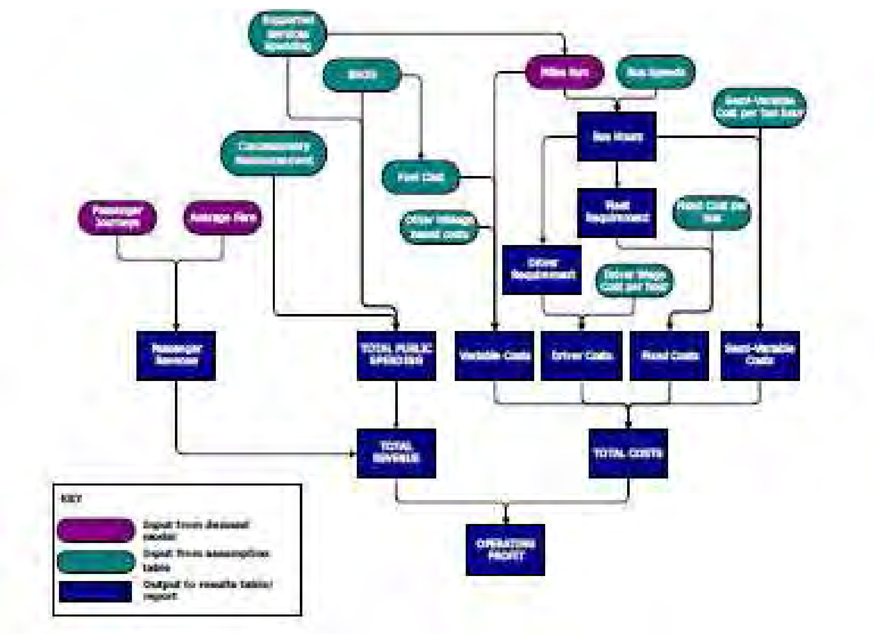
F.2.2 2007 model overview

The 2007 model covers the GB bus sector. It was designed to take data on a wide variety of topics and project their influence on industry finances by applying a series of assumptions and elasticities, each of which is fully auditable and capable of alteration to meet varying assumptions and changes.

Using this data, the model was to be capable of providing an overview of data and outturn at regional/national level and for each PTE. Given the correct inputs and appropriately detailed data, it could also be used to analyse and model individual towns and cities.

The model structure and methodology is summarised in figure F.1.

Figure F.1 Overview of finance and cost elements of the GB National Bus Model



F.2.3 Model coverage (temporal and geographic)

The model operates with annual data. It provides data (actual or modelled) for years 1991/92 – 2030/31. The model is capable of infinite extension, given assumptions on future economic and demographic scenarios. It will be appreciated, however, that all elements of the model become progressively less accurate as the years pass.

The model provides for several geographic breakdowns:

- London, English metropolitan counties, English shire counties, Scotland, Wales
- England – by Government office region
- by PTE area.

F.2.4 Historic data inputs

The model takes data from a wide range of sources, under the following headings:

- bus market statistics, eg patronage and passenger kilometres, fare revenue and concession reimbursement, fare indices, bus kilometres operated

- demographic etc data, including population, employment, GDP and car ownership
  - bus fleet data, relating to fleet composition, age profile, etc
  - funding for supported (contracted) services
  - bus industry financial performance data
  - operating cost analyses, including fuel costs, labour costs and average vs marginal cost analyses.

F.2.5 Demand elasticities

The demand module, a key component of the overall model, was based on estimates of demand elasticities with respect to real fares and service levels. These elasticities were initially developed prior to the 2007 project, but then refined in 2007 based in particular on the TRL 2004 report (TRL 2004). Elasticity values were selected from the ranges given in that report, based on the model calibrations against the historic data: these values may then be varied through sensitivity testing.

F.2.6 Data description

While the versions of the model prior to 2007 had been Excel-based, the increased complexity of the 2007 model was such that it was decided to switch to relational database software (Paradox) for the further model development.

Three types of data were held within the Paradox tables:

- historic data – annual data since 1991/92 (all in 2005/06 prices), enabling the user to commence projections from any base year
- assumptions data – covering assumptions on a range of aspects, and used as basis for calculating the model's projections, by year by geographic area
- scenario data – the model can support an infinite number of 'scenarios', ie different sets of assumptions for aspects such as GDP growth, cost inflation, change in service quantity and quality, etc. Results are stored separately for each scenario thus assisting comparisons between the results for different assumptions.

F.2.7 Output data

The model provides a series of output tables for each of the elements calculated, including:

- demand elements, such as passenger journeys, passenger kilometres and revenue
- resource elements, such as vehicle requirements, kilometres run and bus hours operated
- cost elements, involving a five-way breakdown of costs – driver costs (per bus hour), fuel costs (per bus kilometre), distance-based maintenance (per bus kilometre), semi-variable costs (per bus hour) and fixed costs (including vehicle ownership, per bus).

F.3 Relevance to this project

While there is some overlap in the scope of the GB project and this New Zealand project, this is not as much as originally anticipated:

- The GB project focuses on future projections of bus system performance characteristics (demand, supply, costs, etc) at an aggregated (annual totals by region etc) level.

- The New Zealand project focuses more on disaggregated performance, of both the existing system and variations to it, by route group, day type and time period, etc.

Hence the relevance of the GB project and the useful insights that could be gained from it for the New Zealand project are less than anticipated.

Further, while the GB project provides some interesting approaches and parameter values relating to aspects such as demand elasticities, cost structure etc, this project has the benefits of New Zealand (and, in some cases, Australian) data on these topics, which is generally more appropriate to use than GB values.

In relation to key areas of data inputs and modelling assumptions, we would comment as follows:

- Demand aspects. Our adoption of the 'generalised cost' modelling approach is expected to give superior (more consistent) results to the separate modelling of service level/quality and fare level aspects in the GB model. Further, the parameters we have adopted are based to the greatest extent possible on New Zealand (supplemented by Australian) parameter estimates.
- Cost aspects. The New Zealand project's breakdown of costs by component and their allocation against various operating resource measures differs somewhat from the method adopted in the GB project. While both methods have their merits, in the context of the New Zealand model requirements we consider there are some advantages in the method we have adopted.
- The GB study has not required any breakdown of costs by day type and time period (apart from its assumptions on the cost drivers for each of its cost components), so is of limited use in this regard.

In conclusion, we have not made any direct use of the GB project methodology, parameters, etc in the development of the New Zealand Bus Policy Model