

Introduction

This paper reports on a project conducted for the Victorian Department of Infrastructure in 2000.

The aim was to develop and demonstrate a practical analytical methodology for evaluating and ranking new bus service proposals, and particularly those involving the introduction of services into new areas. Two typical scenarios might be the extension of an existing weekday service into a developing area, or the introduction of ‘in-fill’ services in established areas on weekends.

The project was given a short timeframe owing to a backlog of proposals needing to be analysed in time for the capital bidding process. The emphasis, therefore, was on developing a simple approach, based on currently available data sources, which could be used as a planning aide by experienced operational planners to evaluate proposals in the metropolitan area.

The methodology also needed to be sufficiently *responsive* to cope with the ongoing influx of proposals from various stakeholder groups, and to provide a more uniform, objective and transparent basis for ranking proposals and handling competing internal and external priorities.

Ideally, the methodology would provide a basis for developing more robust approaches in the future covering the whole of Victoria.

The project offered three important challenges of general relevance to public transport agencies in major cities:

- To find a way to respond quickly to new urban developments in advance of traditional data sources (e.g. Census) becoming available,
- To fill a gap with a system that comes to grips with service design at the small-area level while reviewing and comparing needs over much broader areas, and
- To make bus route planning more responsive to latent demand which by its nature is more difficult to do than reacting to demonstrated demand (e.g. overcrowding).

Assumptions and simplifications

It was assumed that the service proposals could be valued on patronage changes and implementation costs. Other factors such as policy objectives and political issues would need to be dealt with separately.

This assumption reduced the scope of the problem to that of estimating patronage because costs can be calculated using existing techniques such as unit cost methods or schedules-based costing. In practice, however, patronage will depend on many factors concerning the markets and activity generators served, the quality of the service provided and the level of competition, particularly from cars, but also from other public transport.

For the purpose of achieving a meaningful ‘first-cut’ evaluation and ranking of proposals, a basic trip generation model with sensitivity to residential accessibility, population density, service frequency and age/employment profile was considered adequate.

The approach chosen reflects the fact that most bus trips in Melbourne are made to or from home and that access is largely by walking. Empirical analysis of travel data shows that, on average, around 64% of all bus passenger trips involve home-based, walk access/egress

(Victorian Activity and Travel Survey, 1994-1998). This figure rises to approximately 75% when additional linked bus trips are also included.

This implies that patronage on a typical bus route, existing or proposed, depends substantially on the presence of demand from a residential population within a tightly defined walking catchment. Such populations are readily identified and measured. On the other hand, because services are always proposed on the basis of serving a selection of schools, employment, shopping areas and transit interchanges, sufficient attraction is likely to be present and can be verified in the evaluation process. This lessens the need to model attraction explicitly.

Finally, it was assumed that residential demand would depend on demographic factors such as age and employment status, and on the service frequency. Other variables, such as household income, will also affect demand and may be included in the model at a later stage.

Analytical framework

Figure 1 illustrates the analytical framework described above. The diagram shows how characteristics of the population and bus service interact to influence two important determinants of patronage - residential accessibility to bus services and travel demand. Costs, on the other hand, depend more directly on service characteristics. Although not pursued in the project, this formulation could be further refined to relate frequencies to loading levels, waiting times and other service design standards. It was assumed for the project that these factors would be taken into account, externally, in the service design and costing process.

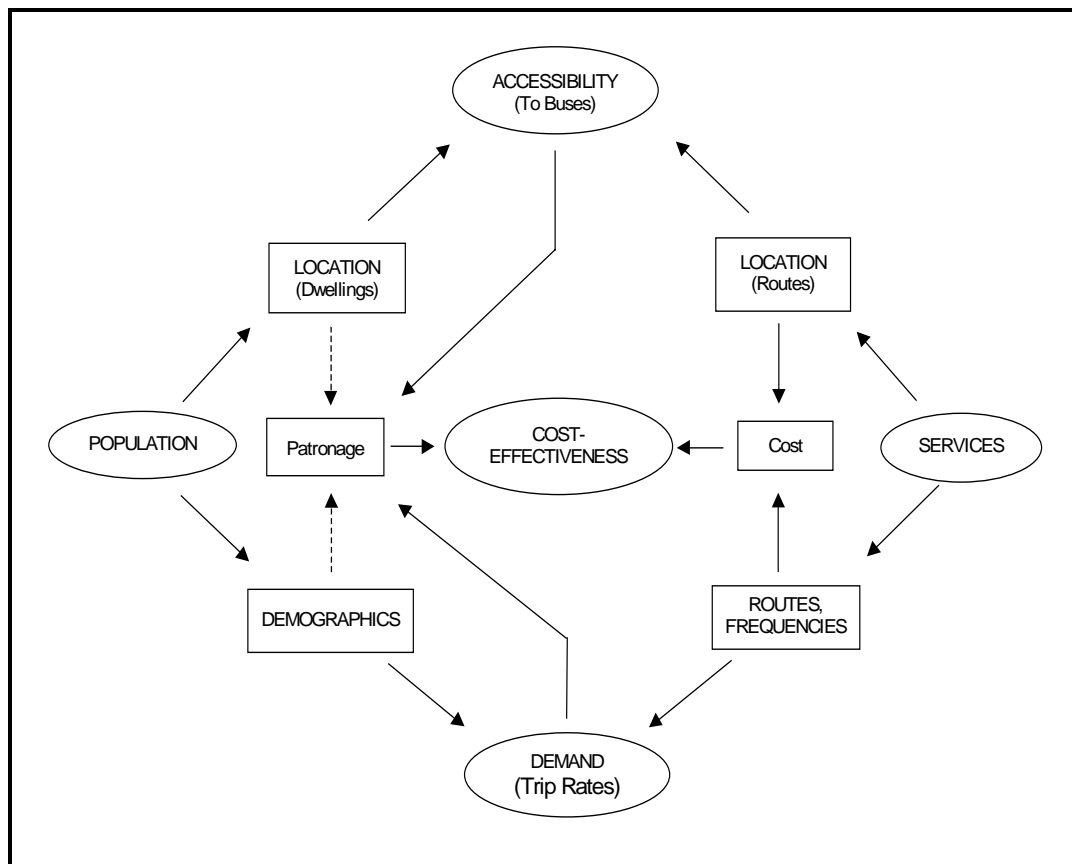


Figure 1. Analytical Framework

Despite its limitations, this framework was considered adequate for the intended application of the model. For a broader discussion, Richardson (1994) presents a comprehensive model featuring a wide range of factors influencing public transport planning and operations.

The framework for this project describes a catchment analysis. It suggests that a major component of patronage can be estimated by totalling residential demand within walking catchments around bus routes. Two development tasks were necessary to achieve this. First, the residential population needed to be located precisely enough to enable accessibility to bus services (i.e. inclusion in walking catchments) to be determined. Second, trip rates were required to arrive at demand estimates within each catchment.

The project also required an evaluation methodology based on the framework to be demonstrated. A two-tiered approach was adopted for this. First, areas in greatest need of new 'baseline' services were identified. These are termed 'priority areas'. Then, the framework was used to directly evaluate several types of service proposals using computer-based catchment analysis.

The four tasks needed to construct and demonstrate the framework are discussed next. It will be seen that many features of the work are not unique to this project. Patronage prediction using basic GIS (Geographic Information System) methods has been with us for many years (e.g. Hunt, Still, Carroll and Kruse (1986)). Over time, these methods have become widespread and considerably improved with advances in technology and data availability. For example, Hsaio (1997) describes a GIS, used to analyse pedestrian access issues, which accurately delineates pedestrian catchments in terms of the portions of the street network within 400m walking distance of the closest bus stop. Nevertheless, the present project should be of interest for its use of the State Cadastre as a spatial framework for the analysis, and for the approach used to estimate the current distribution of population. Sekhar (2000) asserts the accuracy of population estimates based on the Cadastre, and demonstrates the sizeable differences that alternative methods can sometimes produce.

Population – distribution and characteristics

The Cadastre as a framework

The State Digital Map Base (SDMB) Cadastre provided the spatial framework for the project. The Cadastre electronically maps all titled land parcels in Victoria, and can be used to store information about residential and other land-uses. Because the Cadastre is widely used in Government, it is well resourced and maintained, and constantly undergoing quality improvements and value-adding. The Cadastre provides an ideal framework for spatial analysis in land-use/transport planning. An excerpt from the Cadastre is shown in Figure 2.

The aim of the first task was to determine the distribution of population. This was achieved indirectly by estimating the number of dwellings in each parcel of the Cadastre. Storing this information in a copy of the Cadastre enabled catchment analysis to be performed with GIS techniques. The main steps in this computer-based process are outlined below.

Aggregate numbers of occupied private dwellings in each CCD

The Census was used to provide numbers of occupied private dwellings (OPDs) in each Census Collection District (CCD) in 1996. Quarterly ABS new dwelling approvals, post-

Census, were then aggregated and added to the Census figures to give updated estimates, excluding caravans and improvised dwellings, for each CCD.

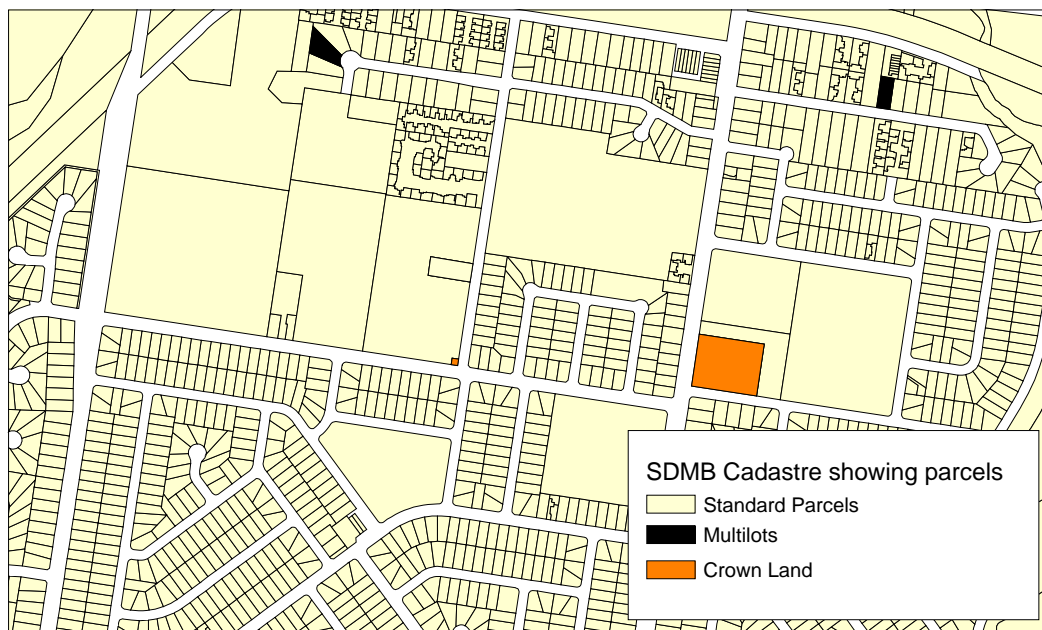


Figure 2. Excerpt from the SDMB Cadastre showing Parcels of Land

Private dwellings

In the next step, parcels in the Cadastre were 'prioritised' according to the likelihood of containing private dwellings. This was done using the State Planning Scheme, telephone¹ and postal² residential address files and information contained in the Cadastre itself. In this process, it was also possible to estimate the numbers of known or potential dwellings on many multi-dwelling parcels. Finally, business telephone addresses were used to indicate those parcels with a lesser likelihood of containing dwellings. Figure 3 illustrates the type of composite 'picture' resulting when this information is brought together in a GIS.

This process results in each parcel being tagged with one of seven priority ratings, ranging from "known to contain dwellings" to "unlikely to contain dwellings", and the estimated dwelling capacity. Figure 4 below provides a simplified illustration of how priority categories were assigned.

¹ DtMS MARKETING PRO

² The 'Postal Address' file includes known residential addresses and was produced with the assistance of both Australia Post and the Australian Electoral Commission (AEC). The addresses were validated as residential and accurate by confirming that they existed in Australia Post's postal address file and were flagged as having active enrolled voters according to the AEC's residential address database which was updated in mid-1999 just prior to Referendum 99.

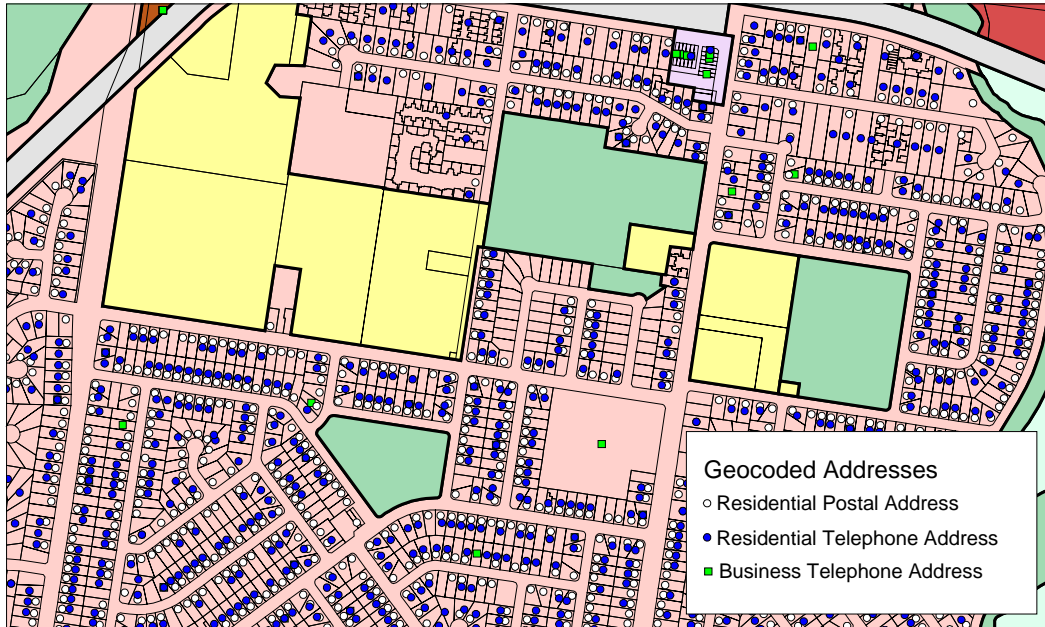


Figure 3. Cadastre overlayed with Planning Scheme and Geocoded Addresses



Figure 4. Priority Categories
(estimated numbers of dwellings in each parcel not shown)

Non-private dwellings

To the extent possible, businesses operating non-private dwellings were also located on the Cadastre using business telephone addresses³ and associated industry classifications (e.g. hostels, guesthouses, B&Bs, etc). These businesses are often associated with large numbers of non-private dwellings, which are not comparable with the private dwellings reported in the Census at the CCD level. Parcels containing such businesses were each arbitrarily assigned a single private dwelling (e.g. a caretaker), and any available estimates of non-private dwelling numbers were recorded separately.

Assignment of dwellings

Next, the numbers of OPDs calculated earlier for each CCD were assigned to parcels in the area. This was achieved by sorting the parcels within each CCD on several keys:

- priority rating,
- parcel area (5 categories),
- percentage of adjacent parcels "known" to be occupied, and
- on a random variable

and assigning the estimated number of private dwellings in the CCD to parcels in succession down the list to the limit of each parcel's estimated capacity. The effect of this process was to assign private dwellings in line with the priorities calculated earlier, but within each priority category to favour smaller parcels over larger ones and to promote a clustered urban development over a fully random pattern.

Caravans, improvised dwellings and non-private dwellings

The process described above did not include caravans owing to the difficulty in locating these through the address files. Consequently, caravans (estimated from the Census) were introduced into the Cadastre in a separate step by allocation to geocoded caravan parks.

In view of their negligible numbers and other factors, no attempt was made to account for improvised dwellings. Similarly, no attempt was made to estimate the numbers of residents in non-private dwellings. This task was beyond the scope of the project.

Population

The above process resulted in an electronic map of occupied private dwellings and any identified non-private dwellings (see example in Figure 5).

In the final step, population was estimated by attributing each private dwelling with the average household size for its CCD. Age distribution and employment status were also attributed to parcels in the same way.

³ DtMS MARKETING PRO



Figure 5. Estimated Distribution of Private Dwellings
(numbers of multiple dwellings not shown)

Trip rates

Aim

The aim of the second task was to determine how demand for bus travel was distributed across the metropolitan area. The task was approached in two steps. First, a set of relationships was derived linking demand (i.e. trip rates) to potential determinants - age, employment, bus frequency, availability of other public transport, time period and residential location. Then, these relationships were applied to the distribution of *population* in the Cadastre yielding the distribution of *demand*.

Trip rate relationships

To enable patronage levels to be estimated on any existing or proposed route, a set of trip rates was required. The term *trip rate* is used here to denote the number of bus trips expected to be made in particular circumstances per head of population if a bus service were available. For example, an average of 0.07 bus trips might be expected in the weekday peaks, from each employed person, aged 15 to 34, who resides in a bus-only catchment in inner or middle suburbs.

A category analysis was used to arrive at the trip rate relationships for the metropolitan region. The main data sources used were the Victorian Activity and Travel Survey (VATS), 1994-1998, and the Transport Research Centre's (TRC's) integrated public transport route/timetable files.

VATS provided detailed travel data including timing, modes, locations and purpose. It also provided demographic data for all respondents and their households. The TRC's route networks enabled catchments to be defined for buses, trams and trains, and the TRC's GIS bus timetables allowed scheduled bus frequencies at any location to be identified.

Using these data sources, all households surveyed in VATS and located inside bus route catchments were identified. The occupants of these households represent the potential market for bus travel. They were categorised by

- age group and employment,
- combined frequency of accessible bus services,
- accessibility to trams and trains, and
- residential location in the metropolitan area.

It was also possible to tally the numbers of bus trips made by VATS respondents in each category over different periods of the week. However, because the overall approach is based on directly predicting those trips using home-based walk access, it was necessary for the trip rates also to be based on these trips. Note that final patronage estimates therefore require the trips predicted using these trip rates to be factored up to reflect a judgement as to the additional usage of the route.

Once the home-based walk access bus trips were tallied, trip rates were determined for each category by dividing the observed number of trips by the category population.

The categories used in the analysis are summarised in Tables 1-4 and Figure 6.

The results of the trip rate analysis are too extensive to reproduce here. However, it is of interest to note that a relationship between trip rate and service frequency was not found. This may reflect the captive nature of bus markets under conditions generally found in the bus system. Service frequency was therefore omitted as a classification variable in the trip rate relationships. Similarly, owing to a lack of data in the inner region, inner and middle categories were combined.

Table 1 Time periods

Period	Time Periods
Weekdays	
Peaks	7:00 - 9:00 & 15:00 - 18:00
Day Off Peak	9:00 - 15:00
Late Off Peak	18:00 - 24:00
Saturday	9:00 - 24:00
Sunday	10:00 - 23:00

Table 2 Age/employment

Employed	Age
No	0 - 14
No	15 - 34
No	35 - 64
No	65 plus
Yes	15 - 34
Yes	35 - 64
Yes	65 plus

Table 3 Bus frequency

Table 3		Bus frequency			
Average Hourly Frequency averaged across both directions of travel		400m of bus routes	400m of tram routes	800m of train stations	
More than	Up to	Bus Only	Yes	No	No
0	1	Bus & Rail Only	Yes	No	Yes
1	2	Bus [Rail] & Tram	Yes	Yes	Yes/No
2	4				
4	10				
10	20				
20	-				

Table 4 Public transport catchments

Catchment Type	Dwellings within:
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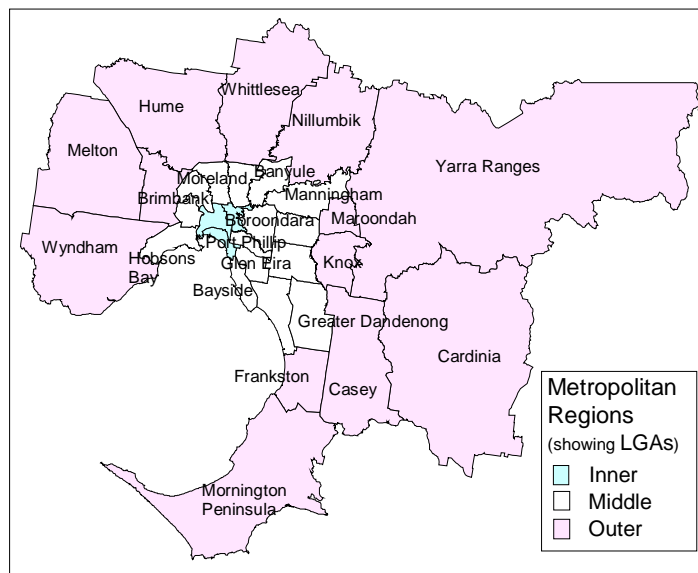


Figure 6. Metropolitan Regions

CCD trip rates

In the second step, trip rates were imputed to residential parcels in the metropolitan Cadastre by reference to CCD demographics, characteristics of the public transport network and the other independent variables.

To do this, trip rate relationships were first established for each CCD using the age/population distribution and the known metropolitan region. An example is given in Table 5 below.

Storing trip rates in this general form permits their use at a later stage for evaluating service proposals.

Finally, to assign the CCD trip rates to occupied parcels within the parent CCD, the trip rates needed to be factored by the known parcel occupancy.

Table 5 Trip rates for an individual CCD

Catchment Type	Weekdays			Saturdays	Sundays
	Peaks	Off Peak	Evening		
Bus Only	0.073	0.035	0.009	0.041	0.026
Bus & Rail Only	0.029	0.026	0.004	0.031	0.018
Bus [Rail] & Tram	0.029	0.020	0.005	0.023	0.060

It is important to note that these trip rates may be used to estimate *latent* demand in areas not served by public transport, or alternatively to estimate *satisfied* demand (i.e. patronage) on existing routes. Thus, every occupied parcel on the Cadastre was assigned a set of average trip rates.

Importantly, the trip rates also enable patronage changes to be estimated when bus services are changed.

Priority areas

Aim

In the third task, the framework was used to identify areas where new ‘baseline’ services were most needed and could feasibly be provided. This step is needed to address any bias in the generation of proposals and to ensure that proposals of a suitable standard are developed.

The task involved assessing latent demand in areas without walk access to *any* form of public transport, and using this information to identify and prioritise areas of high demand whose residents would benefit most from the introduction of new bus services. A two-step approach was used. In the first step, the problem was solved automatically using latent trip generation rates stored in the parcels of the Cadastre. Then, in the second step, the framework was used interactively to review and re-prioritise results bringing a wider range of considerations and experience to bear. This work should be carried out by experienced operational staff.

System-generated priority areas

Current public transport networks were used in this work. As in the trip rate analysis, 400m route buffers were generated for buses and trams, and 800m stop buffers for rail stations. To facilitate the spatial analysis, demand for land parcels situated outside these catchments was stored in a ‘pin’ map covering the metropolitan Cadastre.

A 200m grid was then cast over the metropolitan area and the demand measures aggregated within each grid for each of the main day types (i.e. weekdays, Saturdays and Sundays). This data structure provided a fine-grained representation of demand density across Melbourne.

The 200m grid system was then used to calculate demand in larger 800m x 800m cells. The larger cells were offset from each other vertically and horizontally at 200m intervals. In effect, this system of overlapping 800m cells was achieved by allowing every 200m cell in the metropolitan grid to store demand for a hypothetical 800m cell cast around it.

Although the overall aim was to identify areas where the benefits of providing service would be high, this could not be done without also considering efficiency. Capital is rationed and costs must be taken into account. For this reason, the 800m cell was used, instead of the 200m cell, as the basic building block for identifying needy areas. 800m represents the full corridor width (2 x 400m) served by a bus route. Cells built on this dimension notionally link supply and demand, and come closer to allowing potential demand per route kilometre to be estimated and compared in different areas. Similarly, the overlapping grid concept was adopted to improve the route-tracking potential of areas identified in this process.

Using the 800m cells, a simple sorting and labelling process was used to identify and rank regions of sizeable demand for each day type.

First, the 800m grids were sorted in order of descending aggregate demand and the sort order (or ranking) was recorded. These 800m rankings were then assigned to constituent 200m cells in order of descending priority and without re-assignment until demand levels were considered too low to support a bus route. In this way, individual 200m cells were effectively assigned to the highest ranked 800m cells. Next, high demand regions were delineated by labelling contiguous cells with a common region number representing the ranking of the 800m cell with the highest demand in the region. In this step, any parts of the regions overlapping public transport walking catchments were deleted.

Finally, the regions were ranked on overall demand density, such that the higher-ranking areas represented a 'prima facie' set of priority areas. The average demand density across each region was used in the prioritisation because it approximates the demand per route kilometre that new services in the area might encounter. In addition, the region numbering also provides a supplementary ranking based on the demand density in the highest-ranking 800m cell of each region. Figure 7 illustrates the appearance of several regions.

While it is not possible to show the distribution of the priority areas in this paper, it was found that unserved growth areas tended to be identified on weekdays, whereas unserved areas in established suburbs came to the fore on weekends.

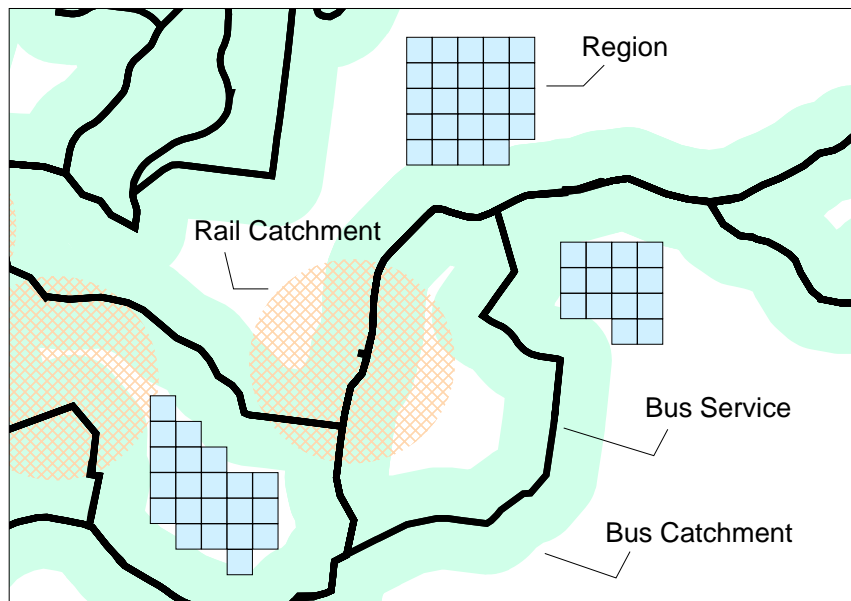


Figure 7. Regions of High Demand showing 200m Cells

I
nteractive review of priority areas

To this point, the identification of priority areas was system-driven and could, therefore, still benefit from a more broadly based, interactive review involving additional qualitative and quantitative considerations.

The interactive review was carried out using GIS tools to assist the planner to work through the priority areas reviewing conditions and altering priorities accordingly. For example, topographic layers were displayed showing accessibility barriers such as freeways, railways, waterways and so on. Similarly, several demographics not considered in the demand calculations but which have a bearing on demand were made available at the CCD level (e.g. income levels, car ownership, unemployment rates). The Residential Land Release Forecast is also used to display residential growth occurring or expected in local areas. Other considerations arising in this work include the size and distribution of unserved areas, the deployment of existing services, contractual constraints, and characteristics of local street systems (e.g. penetrability, circuitousness, traffic management measures, etc.).

The procedure requires each priority area to be considered separately. The system then 'zooms in' on the area and presents various topographical overlays to assist in the assimilation of local information. The user is able to review CCD demographics and to examine the distribution of demand at the parcel level. Finally, the user is able to record any thoughts relevant to his/her assessment of the area and to adjust the priorities accordingly.

Analysis of proposals

In the final task, the use of the framework for evaluating service proposals was demonstrated. This discussion outlines the process followed using a hypothetical example.

Proposal

The example involves extending several existing Monday – Saturday routes into a growth area on the city fringes. The existing situation is shown in Figure 8. It can be seen that a large residential area to the north of the study area is unserved by public transport and that existing routes do not provide access to a new retail shopping complex or an existing school. The proposed service alterations are shown in Figure 9. Route 1 would be extended to provide coverage of the northern area as well as taking over part of Route 2. In addition, both routes would be extended into the new shopping complex. Approximate annual costs of introducing these changes would be \$140,000 for weekdays and \$20,000 for Saturdays.

Functional review

The evaluation framework is proposed as a *planning aid* rather than as a self-contained model. It is intended to be used carefully by experienced planners on account of the many underlying assumptions and simplifications.

For this reason, it is important to review the functions that the proposed service changes are expected to perform early in the analysis and to make a prima-facie case for the proposal going ahead. Route designs need to be sensible and to a standard found elsewhere in the bus system.

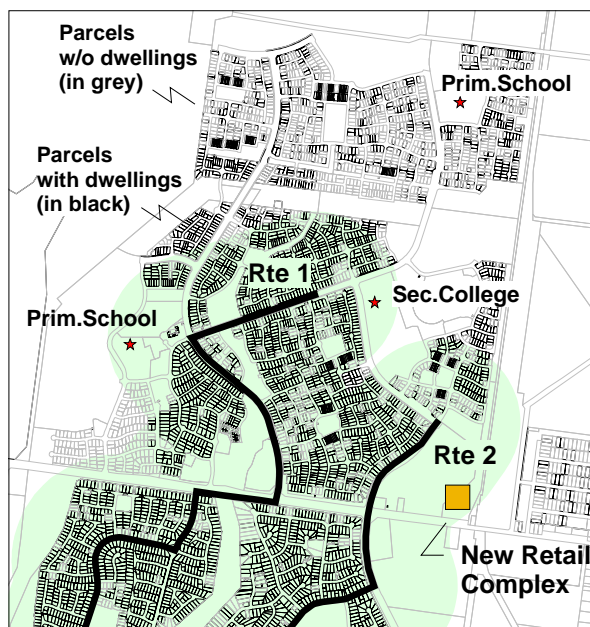


Figure 8. Existing Routes

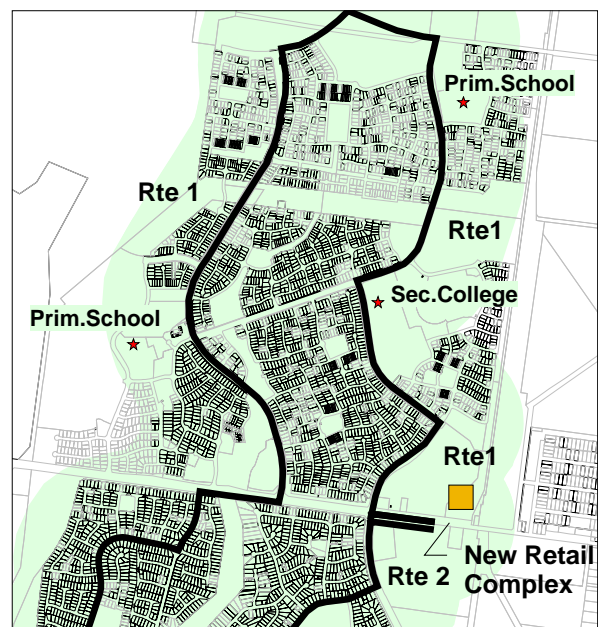


Figure 9. Proposed Route Changes

Further, just as in the analysis of priority areas, many factors should be reviewed when approaching the analysis and interpreting results. Again, the framework can be used interactively to do this.

Finally, it was found that articulating the functions performed under a proposal tends to draw the planner's mind across a wider range of service planning issues with the possibility that the proposal is adjusted or even abandoned.

Setting up the analysis

Preparing for the analysis requires setting up several files describing routes, catchments and demand. The process is semi-interactive. Network files (i.e. routes and catchments) used in the analysis of priority areas are used to describe current conditions. The current files are then copied and adjusted to represent the network under the various proposals. These files are referred to as 'base' and 'test' files, respectively.

The metropolitan demand file, containing trip rates and parcel conditions, is also used. For each proposal, an extract of the demand file is made covering the study area. The extract is then adjusted, using a computer program, to show conditions in each parcel under both 'base' and 'test' cases. Allowance is also made for storing any adjustments made interactively to conditions in the underlying Cadastre (discussed below).

Because the demand file (i.e. the extract) contains the satisfied demand in each parcel under 'base' and 'test' conditions, it can be used directly to estimate patronage gains (or losses) at the parcel level. For each proposal, these can then be aggregated to yield overall patronage changes, or allocated to accessible routes and summed within route catchments to yield route patronage changes. It should be noted that the allocation of parcel demand to competing routes is based simply on the number of routes accessible from the parcel.

Interactive adjustments to parcel conditions

A GIS tool was developed to enable parcel conditions related to occupancy and accessibility to be adjusted interactively in the demand file. Population adjustments may be needed to update the Cadastre for recent or expected growth, or simply to eliminate deficiencies found in the population estimates. Accessibility adjustments may also be needed to account for reduced patronage in an area due to significant pedestrian barriers (e.g. physical features such as rivers, railways and freeways, layout of the street system, and so on). This type of adjustment is particularly useful since buffers, rather than true walking distances, were used to define public transport catchments in the methodology.

The tool can be used in the following ways:

- To enable a planner, inexperienced in GIS, to create scenarios by combining the route, catchment and demand files discussed above and overlaying relevant planning and topographical files (eg planning scheme, residential forecast, street network, landmarks).
- To manage interactive adjustments on an area-wide basis to *parcels* in the Cadastre. The user is able to select an area and a subset of parcels to be adjusted, and modify the numbers of dwellings and residents in these parcels as well as parcel access factors. Figure 10 shows the tool being used to increase parcel occupancies in the central parts of the study area.
- To 'develop' a *green fields site* identified in the Residential Land Release Forecast (RLRF). The user selects an area with residential characteristics similar to those expected on the RLRF site. Conditions in the selected area are then summarised for the user to

consider. Next, the user nominates the RLRF site to be developed and the system returns an estimate of residual residential capacity based on the residential forecast and any dwellings already assigned to the site. The user then decides how many additional dwellings to introduce. Because there is typically no street system or projected subdivision in the RLRF site, the artificial dwellings are set out by the tool on a uniform grid and assigned the population and demand characteristics of the selected area. Figure 11 illustrates how a site, earmarked for short-term development in the northern part of the study area, could be 'populated' using the tool.

Patronage and revenue estimation

Having estimated changes in satisfied demand for each parcel, it becomes a straightforward matter to estimate aggregate patronage changes under a proposal.

This is done by considering parcels in bus catchments before and after a proposal's implementation (i.e. in 'base' and 'test' catchments).

First, under 'base' case conditions, the process considers each bus route catchment passing through the study area, and select any parcels that lose access to buses under the proposal. The residents of such parcels have a service in the 'base' case and lose it under the option being examined. The average 'base' patronage per route in these parcels is aggregated and recorded as lost patronage against the route being considered.

Next, the process considers catchments in the study area under proposed 'test' conditions and select only those parcels that acquire access to buses through the proposal. The average 'test' patronage per route in these parcels is also aggregated and recorded as gained patronage against the route under consideration.

Finally, subtracting the losses from the gains yields the net patronage increase for each route.

Population Adjustments

Action: ☒ Adjust ☐ Reset

Scope: ☒ Marginal ☐ Average

Access: Factor: Fixed: ☒

	Input	Current	Base
Occupied Lots:	<input type="text" value="0"/>	428 (47%)	428 (47%)
Dwellings per Occ. Lot:	<input type="text" value="1.002"/>	1.0	1.0
Persons per Dwelling:	<input type="text" value="3.172"/>	3.17	3.17
Lots without Dwellings:		480 (53%)	480 (53%)
TOTAL LOTS:		908 (100%)	908 (100%)
TOTAL DWELLINGS:		429	429
TOTAL POPULATION:		1,361	1,361

Figure 10. Adjusting Parcel Conditions

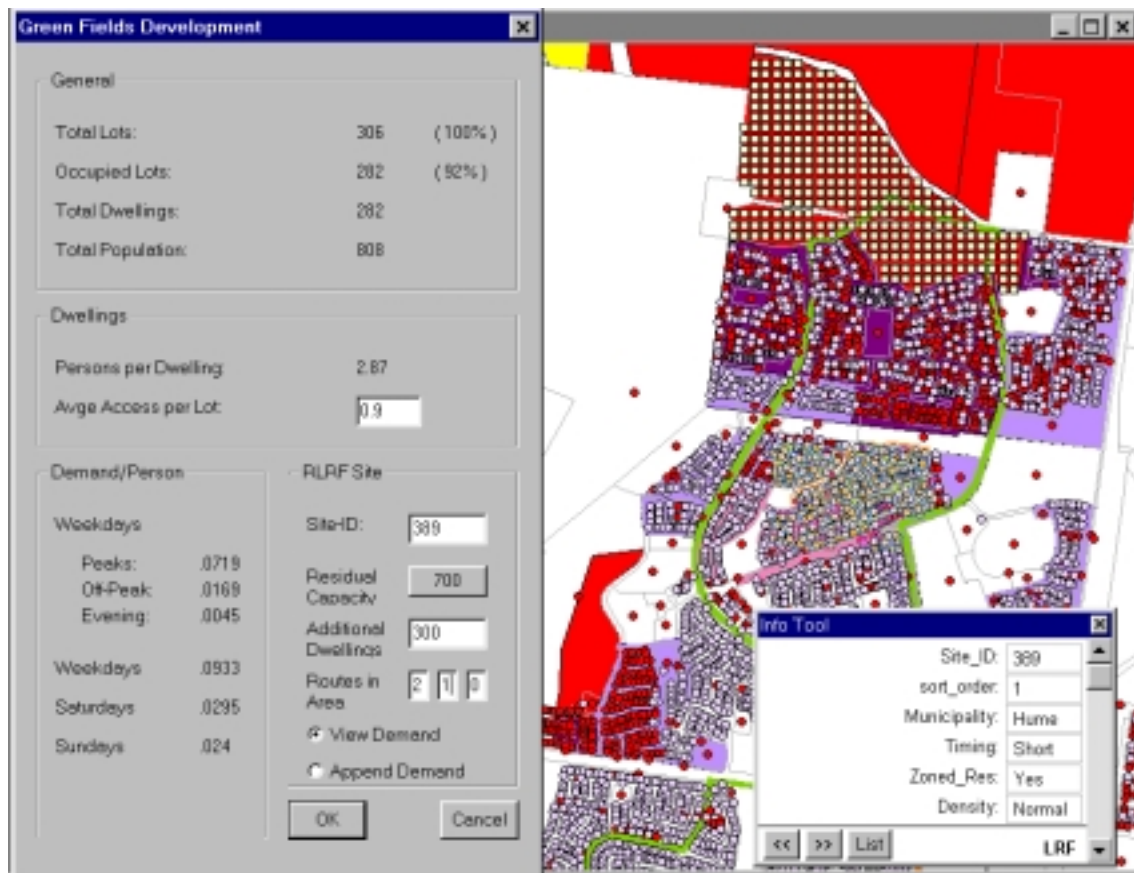


Figure 11. Developing a Green Fields Site

It should be noted that any patronage diverted from pre-existing routes to new routes, introduced under a proposal, is *not* counted in the estimated net patronage change. This is appropriate for evaluating and ranking services but not for estimating patronage per se.

This process also weights the calculated patronage changes by *average fare revenue* yielding net annual revenue changes attributable to the proposal.

Finally, taking into account the annualised cost of implementing each proposal, it is possible to estimate the subsidy per attracted trip. This subsidy can then be used for ranking alternative proposals.

Analysis results

Table 6 shows the patronage and revenue results produced for the hypothetical example. Note that no attempt has been made to account for non home-based walk-access trips for the example.

The field headings are generally self-explanatory but the reader should recognise that the scope of the outputs is limited by the incremental nature of the analysis. In particular, the results will often understate a route's full role because it only deals with residents who, through the proposal, either lose or acquire walk access to buses. These residents account for

all patronage changes in the analysis. Hence, Route 2 is not reported in the table because no residents in its catchments gain or lose access to service as a result of the proposed change.

The analysis procedure could be adjusted to estimate absolute patronage and revenue effects if desired. This might be useful for doing capacity checks.

Table 6 Analysis results for example

Route	Day Type	Persons	Dwell-ings	Parcels	Addition al Trips	Lost Trips	Average Revenue Per Boarding (\$)	Total Addi-tional Revenue (\$)	Lost Reve-nue (\$)	Net Addi-tional Trips	Net Addi-tional Revenue
1	Weekday	2,198	700	699	160	0	0.66	106	0		
	Saturday	2,198	700	699	63	0	0.90	56	0		
	Sunday	-	-	-	-	-	-	-	-		
	Per Year				44,760	0		30,408	0	44,760	30,408

Using this method to compare and select proposals for implementation requires the proposals to be ranked on cost-effectiveness, which can be measured using the fare subsidy per trip. This is calculated by subtracting annualised proposal costs from annual revenues. The summarised ranking results for several alternative proposals are shown in Table 7. The suggested ranking and selection process assumes that proposals are independent. If any proposals are dependent (including any that are mutually exclusive), it will be necessary to consider the additional complexities. In any event, proposals will be selected to maximise the numbers of additional bus trips generated for the available government budget.

Table 7 Cost-effectiveness ranking of several proposals

Proposal	Route	Type of Route Change	Attracted Trips	Lost Trips	Net Additional Trips	Net Additional Revenue (\$)	Annualised Cost (\$)	Subsidy / Trip (\$/trip)	Initial Ranking
1	1	Extended	44,760	-	44,760	30,408	160,000	2.90	2
2	3	New	118,162	-	118,162	80,210	200,000	1.01	1
3	6	Remove	-	9,664	-9,664	-6,558	1,100,000	5.22	3
	7	Remove	-	216	-216	-146			
	8	Remove	-	114	-114	-77			
	9	Remove	-	3,883	-3,883	-2,632			
	10	Remove	-	10,758	-10,758	-7,268			
	16	New	5,336	-	5,336	3,611			
	17	New	41,296	-	41,296	31,401			
	18	New	15,154	-	15,154	10,242			
	20	New	82,172	-	82,172	59,287			
	21	New	65,858	-	65,858	44,524			
	22	New	59	-	59	40			
	<i>Total</i>		209,875	24,634	185,241	132,423			

Before accepting the rankings, the analysis needs to be dissected and interpreted. This may result in a proposal being re-formulated to avoid aspects of poor performance. It is also necessary to consider whether any benefits or disbenefits, which may have been omitted, need to be given some additional weight (e.g. expected reliability or safety improvements). It is also particularly important to scrutinise the estimated costs of the proposals. For example, projected passenger loads may need to be estimated so that capacity can be checked, and consideration given to the likelihood that extra service will be needed in the short term. In this case, the results should be revised to reflect foreseen service increases.

Limitations and potential improvements

Trip modelling

Perhaps the greatest weakness in this work stems from the simplified use of trip rates to estimate latent demand and patronage changes. A better alternative would be to use a more conventional travel demand 'project' modelling approach.

In such an approach, a strategic transport demand model would conceptually sit above the cadastral framework. It would supply transit passenger flows by trip purpose, on a coarse spatial level, within/between transport zones. These flows would then be partitioned to isolate flows in the catchments under investigation. The Cadastre would also be enhanced to reflect the distribution of land use, including the main trip attractors, across the metropolitan region; this task is currently underway in the TRC. Finally, the detailed knowledge of trip generators and attractors, contained in the Cadastre, would be used to transform the strategic flows into catchment flows and patronage estimates.

This model would offer the following important advantages over the 'trip rate' approach:

- theoretically sounder
- better resolution of passenger flows along the route and hence, better ability to deal with capacity and route design issues,
- ability to forecast future patronage
- better ability to deal with competition between services and with the car
- ability to incorporate non-walk access directly.

Catchment definition

At present, the framework uses *route* "buffers" to represent walking catchments. A better approach would be to define *stop* catchments by using the street network to identify parcels within a given maximum walking distance of existing/potential stops. This improvement would make the method more sensitive to accessibility issues and allow the method to be used for evaluating stop placement and residential development proposals.

Access distance as a determinant of trip rates

The present approach does not allow for the trip rate to vary with changes in walk access distance. Instead, a constant trip rate is assumed everywhere within the catchment and a zero trip rate beyond. The problem could be overcome by estimating a decay function from VATS and applying it to the trip rate estimation process.

Household size

The methodology assumes a constant household size across all dwellings in a CCD. This assumption could bias results under certain scenarios (e.g. if there were more medium-density developments nearer arterial roads and, hence, nearer bus routes). This problem could be partially overcome by linking VATS data to parcels in the Cadastre and using it to estimate a correspondence between parcel properties and dwelling structures reported in the Census. Then, it would be possible at the CCD level to use the Census tables of "dwelling type against number of occupants" to assign *numbers of residents* to different parcel types more discriminately. This approach parallels the use of VATS to estimate trip rates for dwellings within a CCD.

Future directions

Extension to non-metropolitan areas

The Cadastral base has been prepared for all of Victoria. This permits the framework to be extended, with minimal additional work, into provincial centres such as Geelong and Ballarat.

It should be noted, however, that the estimated population distributions might not be as good in provincial centres because address files are less well developed in these areas. Further, in the short term, it would probably be necessary to rely on trip rates derived from metropolitan VATS data.

Residential land-use base

The methodology relies on being able to locate dwellings on parcels in the Cadastre. Unfortunately, this work is quite time-consuming and involves greater difficulties in rapidly developing areas where, as it happens, the interest in providing new bus services is keenest.

It would be worthwhile attempting to seek out and gain access to better sources of information on residential development (e.g. through water or power billing information, council rates notices). It should be noted, however, that privacy and commercial considerations are barriers in this area. Fortunately, the quality of the data sources used in this project is improving constantly.

Extension of methodology to trams

Subject to suitable trip rates being estimated, the technique is directly applicable to trams. It could be used to examine tram extensions, stop locations and so on.

Service Planning Guidelines and Performance Measurement

The framework could be used to quantify indicators used in planning and performance monitoring that rely on population measurement. These include criteria for the provision of public transport and for setting acceptable levels of service.

Conclusions

A methodology for evaluating and ranking of bus service proposals has been developed. The approach is GIS-based and makes use of a variety of electronic data sets only recently available for service and infrastructure planning.

The approach makes innovative use of the State Cadastre to conveniently store population and land-use information with a high level of spatial precision. This approach is ideal for many types of catchment analyses and could spawn spin-off applications in other sectors.

The methodology provides a short-range planning tool of a type that is useful for achieving greater effectiveness for this highly flexible and adaptive mode.

The new methodology promises to deliver the following benefits:

- A method for identifying areas in greatest need of basic services.
- A responsive and easily understood technique for evaluating new service proposals.
- A uniform basis for ranking proposals and handling competing internal and external priorities.
- A basis for responding to the proponents of new services, who compete for limited Government funds.

Disclaimer

The opinions and conclusions expressed in this paper are those of the author and not necessarily those of the Victorian Department of Infrastructure.

Acknowledgments

The author acknowledges the support given to this project by the Victorian Department of Infrastructure.

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