BICYCLE FACILITIES FOR AUSTRALIAN CAPITAL CITIES

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ABSTRACT: *A case for providing bicycle facilities to encourage cycling can be made in terms of: transport efficiency, equity, amenity and reduction in cyclists road accident trauma. Facilities are currently inadequate for both safe movement and secure storage, thus deterring the greater use of bicycles. A low cost solution, to the provision of facilities for movement, is to base the network on existing quiet residential streets. To develop a continuous network however, it would be necessary to 'breach' discontinuities such as public reserves and private property with bike path easements. Bicycle networks should be developed to serve local travel to schools, work places, recreation facilities, shops and public transport terminals; with secure storage facilities provided at these activity centres. Preliminary costing indicates that the proposed system of routes, paths and storage facilities would cost just over $77 million. Operating cost savings that would accrue to current private motor vehicle users alone, predicted to transfer from car to bicycle for some short local trips, is calculated at just over $44 million per year. Accordingly it is concluded that a strong case exists for public investment in bicycle facilities.*

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1. INTRODUCTION

Throughout most of the world the humble bicycle is receiving increasing recognition as a important mode of personal transport. In many cities including Australian cities, a lack of safe and convenient facilities has however meant that as travel by bicycle has increased, so has cyclist trauma. In Australia in 1975, 81 cyclists were killed and 2,390 injuries were reported.* In Victoria in 1975 there were 16 cyclists killed with a dramatic increase to 38 deaths in 1976. Are yet more cyclists to be killed and injured before facilities are provided or are cyclists to be literally driven off the roads?

Inadequate facilities for cyclists, apart from the safety issue, also means that those too young or too poor to own a private motor vehicle have their mobility severely restricted and that the community is foregoing health and environmental benefits associated with cycling.

As a community we value efficiency, convenience, good health, a quiet and clean environment, and equitable allocation of resources. Bicycle transport has benefits that relate to each of these valued items (these benefits are outlined in Appendix A).

While this paper focuses on bicycle facilities it is also recognized that both the design of the bicycle (see Appendix B) and the education that cyclists receive must be improved. For example better bicycle braking and lighting systems have been developed but are not readily available and pedal clubs to educate young cyclists are being revived but as yet most cyclists receive no instruction.

It has been demonstrated in many overseas cities that bicycles, when provided for, can cater for a significant percentage of personal movement. The small city of Davis, California, U.S.A., is a useful model of what can be achieved in an automobile based society when bicycle facilities are provided. The work of Sommer and Lott (1971) documenting the Davis experience noted:

- a traffic count on a main street recorded 40% bicycles in the traffic stream;
- 80% of older children ride bicycles to school; and
- households substitute a bicycle trip for a car trip, on average every second day (i.e. approximately a 10% modal switch)

Poor though facilities may be, bicycles are used in Australian cities as the accident statistics indicate. In Melbourne, Pike and Conquest (1976) reported the following trip purposes:

* A study in Britain estimated that only 1 in 20 bicycle accidents are reported. A senior officer of the N.S.W. Police Accident Appreciation Squad estimates that only 1 in 10 casualty accidents are reported; Sommer & Lott (1973), note that in the U.S. also, available statistics grossly underestimate the number of non-fatal bicycle accidents.

Work	10% }	35%
School	25% }	
Shopping	19%	
To and/or for Recreation	34%	
Other	12%	

The above Melbourne figures can be compared to an extensive survey of cyclists (73% of respondents were adults) reported by Kroll and Sommer (1976) in the U.S.A., which recorded the following:

Work or School	51%
Shopping	4%
Recreation	38%
Other	7%

Thus commuting to school or work, and riding for recreation or to recreation facilities are considered the most common trips for [illegible] cyclists.

A systematic approach to all aspects of bicycle transport (i.e. facilities, the bicycle and riders), similar to the approach that has been developed for motor vehicle transport, is now needed.

This paper is a response to the general need for bicycle facilities and the particular need for these facilities to be justified. Studies have indicated that there are two main areas of need; firstly for movement protected from vehicular traffic, along continuous routes, as close as possible to desire lines; and secondly for secure storage facilities.

2. PLANNING

For the planning of bicycle facilities the components of a bicycle system can be conceptualized as relating to Movement (links, dual mode line haul, system nodes and breached barriers) and Parking.

2.1 MOVEMENT FACILITIES

Facilities for the movement of bicycles on a bikeway system can be subdivided into:

(a) System links or travelled way facilities, which include:

maps of safe but unmarked routes,
marked routes,
designated lanes,
bicycle priority streets ('Slow Ways'),
protected lanes,
separate paths,
special tracks, and
bicycle freeways.

(b) Dual mode (line haul) movement, facilities, that is:

bikes on buses,
bikes on cars,
bikes on trains, and
bikes on ferries.
(The simplest dual mode arrangement is a folding bike carried on the motorized mode by the cyclist).

(c) System nodes and intersections treatments which include:

warning signs,
channelization,
ordinary traffic Signals,
traffic signals with a special phase (like a pedestrian phase),
grade separation (underpasses are preferred), and
dual mode transfer terminals.

(d) Breached barriers: in the development of a system there will be system barriers such as; major roads, railway lines, rivers, and private property - to be 'breached' by bridges, underpasses or bikeway easements, as appropriate #

2.2 PARKING FACILITIES

Facilities for the safe, secure, convenient, and weather protected storage or parking of bicycles may range from:-

grooved concrete blocks,
tubular steel racks,
wall fittings,
cycle stands, to
bicycle lockers.

The most important feature of an effective storage unit is that it secures both wheels and the frame. It is also highly desirable that bicycle storage units be undercover, as close as possible to the cyclists destinations and in clearly visible locations to deter petty theft and vandalism.

2.3 BIKEWAY SYSTEM

As with a road system it is important that a bikeway system* be developed as a functional hierarchy. A simple hierarchy could be based on three levels:

(a) access ways with mixed traffic,
(b) bicycle collectors/distributors or intra area links, and
(c) bicycle arterials or regional strategic routes.

* Hawley (1975), pp. 55-61.
\# Parker (1976).

Access ways, (a) above, in residential areas could simply be mixed traffic residential streets with a low (40 kph) speed limit (see below). Access ways in high use, intense activity areas (e.g. shopping centres) would require special lanes.

Bicycle collector distributors and bicycle arterials, (b) and (c) above, could be developed using: - designated (by signs and pavement markings) residential streets; bicycle easements for breaching of system barriers as required; and protected or separate bike lanes where bicycle volumes are high and use of existing arterial roads can not be avoided. Where existing residential streets are used motor vehicles would be permitted but bicycles would have priority, e.g. exclusive central lanes as advocated by Claxton (1974), and a 40 kph or lower speed limit imposed.

As a guide to the development of a bikeway system studies in the literature recommend a basic grid with between 0.5 and 0.8 km.+ spacing. A relatively fine grid is required because the majority of trips are short, ie. less than 3 km. The basic grid could be developed by local governments relatively cheaply and quickly (i.e. within 12 months) utilizing the residential street system, while inter-L.G.A. arterial and strategic routes would tend to be more expensive and could be developed over a longer period (say 10 years).

2.4 USE OF RESIDENTIAL STREETS

The bikeway grid network could best be developed by the use of those existing streets which have low motor vehicle volumes. Shown below are the considerable lengths in each capital city of residential streets with sound sealed pavements, greater than 5.5m wide, and with less than 1,500 v.p.d., on which a bikeway grid could be based.

TABLE I

LENGTHS FOR POSSIBLE RESIDENTIAL STREET BIKE ROUTES

CITY	Suitable Length	Total Length of Residential Streets
	k.m.	k.m.
Sydney	5.700	8,370
Melbourne	5,850	8,140
Brisbane	1,980	3,570
Adelaide	2,400	3.620
Perth	1,960	2,910
Hobart	310	430
Canberra	470	620
	18,670	27,660

(Source: Australian Roads Survey 1969-74).

\+ Melbourne Street Directory 'Melways' shows motor vehicle routes through the suburbs, as marked by heavy black and red lines, at approximately this spacing. The red marked routes (alternative motor vehicle routes) are a good starting point for developing a possible bicycle route system.

To illustrate the potential for developing bike routes at the local level, examples of the lengths required and the lengths available for a variety of Melbourne suburbs are shown below.

TABLE II

EXAMPLES OF LENGTH REQUIRED
FOR BIKE ROUTES

City of:	Max. Length Required (1)	Suitable Length Available
	km.	km
Sandringham	50	100
Essendon	53	105
Richmond	20	19 (3)
Waverley (2)	135 (4)	290

Notes:

(1) Grid spacing of 0.6 km.

(2) Built up area only.

(3) Richmond, an old inner suburb, has many narrow streets and streets with heavy traffic. In inner suburbs such as this the solution would be to impose a 40 kph. speed limit on the whole suburb. That is, it would then be safe for <u>all</u> traffic to use the streets.

(4) A detailed study of Waverley, City of Waverley (1976), proposed a bikeway system of 133.6 km for a cost of $2,327,000. The problem with this study was that it was based on 48.9 km of bike <u>tracks</u> costing $2,132,000. Residential streets 84.7 km in length, were included in the plan for an estimated cost of $195,000 (for signs and traffic signals). That is <u>the 63% of the system on residential streets</u> was costed <u>at 8% of the total project cost</u>.

In the first instance the safest routes to schools and other activity centres could be mapped out along suitable existing streets by traffic engineers and practising cyclists. Maps* of safe routes could be published and distributed at schools and libraries.

Cycling conditions and the amenity of residential areas could be further improved by the introduction of a 40 kph speed limit on residential streets. There is no logic in having the same speed limit for all urban streets and roads with vastly different functions. A lower speed limit on

* It would however be better to also 'stripe' those routes on streets with higher traffic volumes and also to introduce parking bans. Maps, as produced in Philadelphia, U.S.A., would be much better than nothing being done at all.

residential streets is taken for granted in many American states. A lower speed limit on residential streets is considered a low cost and essential measure for safe cycling.

The development of a continuous bikeway system will inevitably be hampered by discontinuities in residential streets and barriers such as railway lines, freeways, creeks, and parks. In some areas, system continuity may also require the construction of striped or protected bike lanes on arterial roads or bike paths in medians or nature strips. Money spent on bike lanes and on the 'breaching' of such barriers, to give continuity to a system based on residential streets, will result in a far more efficient use of resources than the construction of a few lengths of costly separate bike paths. Limited funds could also be directed to installation of signals or underpasses across major roads at critical bikeway crossing points.

Where major roads have to be used for segments of bike routes, conditions could be greatly improved for cyclists by re-striping lanes, from for example 4x3.7m to say 4x3m <u>plus</u> 2x1.4m* lanes; the narrow kerbside lanes being for 'Bikes Only', with no vehicle kerbside parking permitted.

2.5 SYSTEM DEVELOPMENT

It is proposed that priorities for facilities should be determined by existing cyclists needs of:

- safety
- convenience (directness of route), and
- secure storage

It is further proposed that priority for facilities should go to children; they are the segment of the cyclists 'market' which suffers 60% of cyclist fatalities, whose bikes get stolen and vandalised frequently, who are too young to drive a car, and who cannot afford public transport for short trips.

The activity centres used by this segment of the bicycle user market include:

schools (particularly secondary and technical),
recreation centres (swimming pools etc.),
shops,
parks,
public transport terminals, and
libraries.

Cycling is also a recreational activity in its own right.

Thus what is needed are local <u>bikeway systems</u> for these users to get both from their homes to the above <u>activity centres</u> and between activity centres; conveniently and safely. The case for a <u>local</u> bikeway system is further supported by the fact that 27% of all urban travel is relatively short and <u>within</u> residential areas.+

* Lanes > 2m wide are however preferred by cyclists, Kroll and Sommer (1976).

\+ Commonwealth Bureau of Roads (1975), Table 5.5.

While initially considering the local level, metropolitan considerations need not and should not be neglected. Planning for local bikeway systems should be co-ordinated so that a metropolitan system is developed.

Other cyclists (over the age of 16 years) will also be able to make use of bicycle facilities from homes to and at:- shops, parks, recreation centres, and public transport terminals. The additional trip types* that would then receive attention are:- the work trip, simple recreation, and social trips. At the local level this will mean providing bikeway connections to employment centres and a comprehensive system through and linking residential areas. As noted above planning should be co-ordinated to provide a linked metropolitan system.

Planning for C.B.D. commuters also requires special consideration. A study by Hirsch (1973) in Philadelphia U.S.A. investigated the number of C.B.D. bound trip productions within concentric rings for different wedges to the C.B.D. Bikeways were then proposed for the wedges with the most C.B.D. bound trip productions within a 8 km radius. Similar procedures would seem applicable to Australian cities where transportation study data is available (and in suitable form). Facilities properly planned for and with the assistance of existing cyclists can reasonably be expected to both generate more cycle usage and transfers from other less efficient modes.

2.6 CRITERIA FOR ROUTE SELECTION

Cyclists are very much in favour of exclusive facilities such as bike lanes, yet they also have a very strong preference for quiet residential streets, provided they offer the same speed and directness as adjacent arterial roads. Indeed in some situations where quiet residential streets offered the same speed and directness as bike lanes on nearby arterial roads, a majority of cyclists used the undesignated quiet residential streets.

A residential street will be considered as a desirable route by cyclists when it has characteristics such as:-

- easy to reach
- provides a direct route
- route goes right to (or past) the destination
- light traffic
- presence of trees
- absence of Stop or Give Way signs,
- presence of Stop or Give Way signs on cross streets
- good street surface
- no hills
- activities to view (e.g. sports grounds)
- no obstruction by parked vehicles, and
- adequate width for bike lanes (lane $\geqslant$ 2m if provided).

* In a survey in Sydney, Gulczynski, (1976), parents of school children indicated that if safe routes were established they themselves would use these routes to schools as recreational bikeways.

The evidence on the safety effectiveness of signed routes and marked lanes is not conclusive. However some (41%) cyclists believe signs make a route safer, and most (71%) believe marked lanes improve safety.* Thus if signs and marked lanes do nothing else they will at least concentrate cyclists onto these routes that are safer for other reasons, and, if non-cyclist perceptions are similar to cyclist perceptions, encourage an increase in cycling. Furthermore while the safety advantages of lanes might relate more to associated measures, such as parking bans, speed limits and intersection controls, these associated measures would not be as effective or politically acceptable if bike lanes and/or signs were not also installed.

In summary, bicycle facility planning must aim to provide safe and direct routes for those trip purposes suitable to bicycle transportation; mostly on existing quiet residential streets; with system discontinuities breached; and secure storage facilities provided at activity centres. This approach is thus very different to the provision either of a few expensive separate bike paths or a very expensive coarse network, as has been advocated for some Australian cities.

3. COST ESTIMATE

Discussion on the merit and economics of bicycle facilities is severely hampered by a general lack of data. It is however possible to make "ball park" estimates of both costs and some of the benefits, to justify future detailed study.

As noted above a high standard bikeway system would approximate to a 0.6 km grid. Table III below shows the Capital City population; the length of bikeways required to provide the grid; the cost of the grid (assuming 90% of the bikeways are routes on residential streets and 10% are separate bike paths); and the cost of storage facilities.

Other costs that would be associated with the provision of bicycle facilities are the costs of planning and then maintaining the facilities. Planning costs are estimated at 5% of the capital cost. Annual maintenance costs are estimated at 10% of the capital cost, that is $7.8 million per year.

To put the capital cost of this proposal (just over $80 million) in perspective, it should be noted that total expenditure on road works in financial year 1976/77 was $817 million. If bicycle facilities were provided over a 5 year period the average annual expenditure would be some $20 million (planning, construction and maintenance), a modest sum in comparison to the $65 million in Australian Government grants for urban public transport (for the financial year 1976/77). On the basis of a 5 year construction programme, what is proposed would represent just under 2.5% of total road expenditure being directed to bicycle facilities.

* Sommer and Lott (1973).

TABLE III

COST OF BICYCLE FACILITIES

Capital City	Urban Population (1971) in thousands	Estimated Length of Bikeways Required	Bike Routes Length km	Bike Routes Cost $'000	Bike Paths Length km	Bike Paths Cost $'000	Storage Facilities	Storage Facilities Cost $'000	Total Cost $'000
Sydney	2,725	4,750	4,275	8,550	475	9,500	135,000	6,750	24,800
Melbourne	2,394	4,400	3,960	7,920	440	8,800	120,000	6,000	22,720
Brisbane	818	2,350	2,115	4,230	235	5,100	40,000	2,000	11,330
Adelaide	809	1,850	1,665	3,330	185	3,700	40,000	2,000	9,030
Perth	642	1,750	1,575	3,150	175	3,500	30,000	1,500	8,150
Hobart	135	370	333	666	37	740	5,000	300	1,706
TOTALS	7,523	15,470	13,923	27,846	1,547	31,340	370,000	18,550	77,736

Plus 5% Planning Cost 3,900

$ 81,636

Annual Maintenance $ 7,800

Notes on Table III

- The length of bikeways required was calculated as a function of the wholly urban area of each capital city by the simple formula $L = \frac{2A}{S}$ where L = total length in km
  A = area in km^2
  S = grid spacing in km

- Storage facilities required were calculated, as a function of urban population, at the rate of one storage unit per 20 people. This method of estimating was arrived at after consideration of the number of facilities that would be required at work places, schools, shopping areas, and recreation facilities, etc., less an allowance for existing parking facilities.

- Bike routes were costed at $2,000 per km and bike paths at $20,000 per km; 1976 prices.

- All calculated figures have been rounded off so as to indicate the approximate nature of the estimates.

4. BENEFITS

'Benefits', that would follow from the provision of bicycle facilities, can be related to the pursuit of such community objectives as: transport efficiency, equity, environmental amenity, health, safety and security. How the provision of bicycle facilities and an increase in bicycle use would contribute to these community objectives is outlined in Appendix I.

4.1 SCOPE OF ANALYSIS

The sections of the community that will be affected by a bicycle plan are shown in Figure I.

While the calculations that follow are concerned with Diverted and Transferred future bicycle traffic only, all of the various traffic components*are briefly noted below:

(a) Existing cyclists: (safety, comfort, convenience and travel time saving benefits).

(b) 'Generated' cyclists : (leisure and health benefits)

(c) Diverted and Transferred Traffic: (benefits equal to the difference between the cost of cycling and the cost of the previous mode).

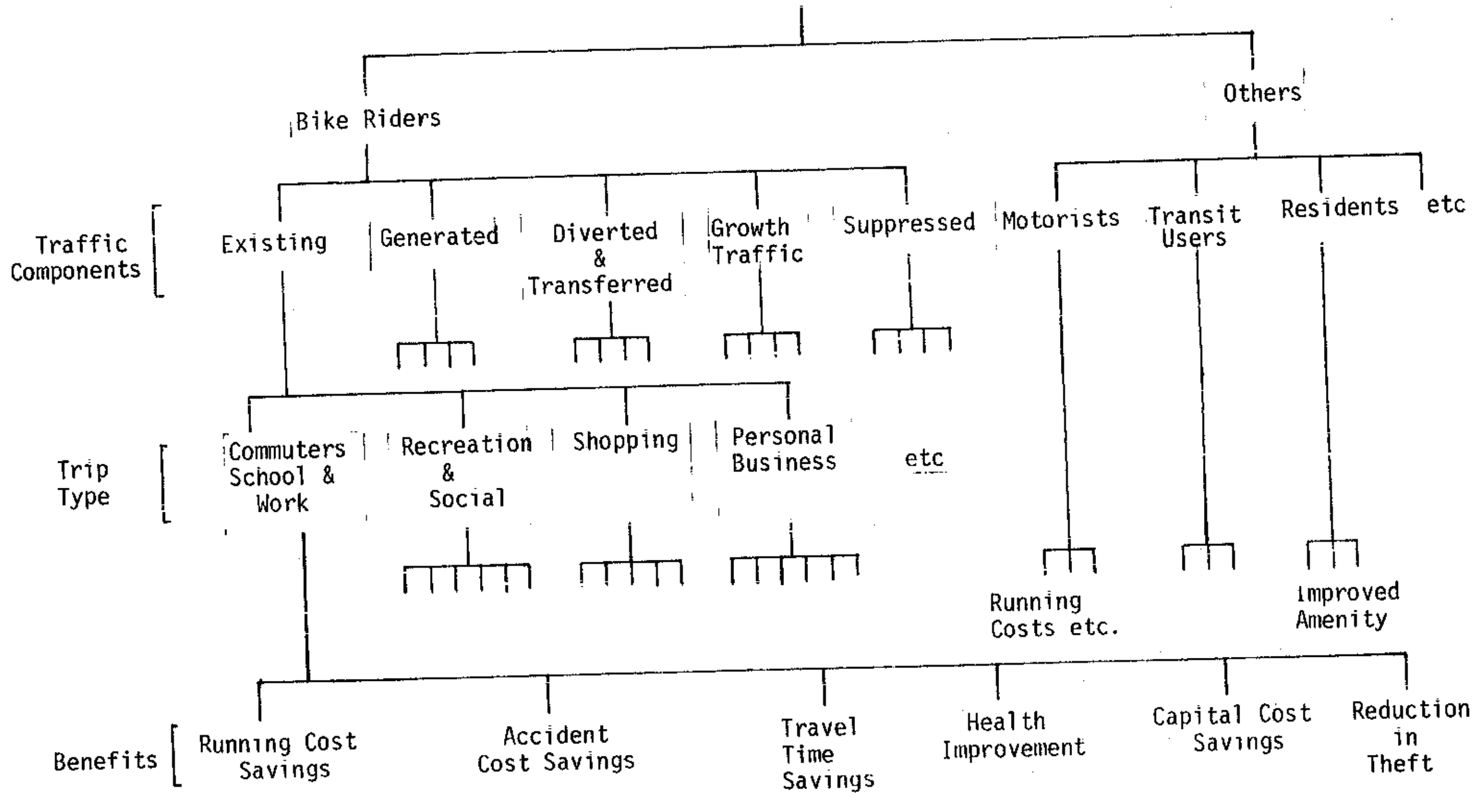
(d) Growth Traffic: benefits as for; (growth traffic should be significant).

(e) Suppressed demand : i.e. persons with poor mobility whose travel options are currently limited to infrequent public transport trips and activities they can access by walking.

A complete and thorough analysis would also treat separately each trip type of each traffic component, Fig 1. In the analysis that follows, each of four trip types are dealt with separately, for traffic diverted from private cars to bicycles; thus only some of the 'leaves' of the 'tree' of benefits are costed. In the future when more information becomes available (for example, from the Geelong Bikeplan Study) it should be possible to quantify more of the benefits that have been identified above.

* WINFREY, R. (1969) *Economic Analysis For Highways*, p.p. 474-478.

Fig. 1 Community Benefits



Before narrowing the analysis down to a consideration of diverted and transferred traffic from private car to bicycle, possible impacts on the rail, bus and private car modes were considered using Sydney* data:-

(a) Train - Journeys by train are generally much longer than for any other urban mode, the median journey length being approximately 15 km. The only exception is the journey to school for which approx. 45% are less than 6 km** in length. Safe and convenient bikeways may thus relieve the railways of part of the burden of carrying subsidized school children during peak hours.

(b) Bus - Half the work journeys by bus are less than 6 km in length and approximately 60% of non-work journeys are less than 6 km in length. Bus services could thus face competition from the bicycle mode for short commuting trips during peak periods. (As cycling has a lower total social cost than bus travel this possible future situation should not be rejected. Planning for buses should develop service for longer trips, increased off peak usage and integration with the bicycle mode).

(c) Private Car - There is significant scope for transfers from car travel to bicycle travel and no doubt significant *latent* demand for *similar* journeys by those who can not use private motor vehicles. For home based trips, 40% of trips were less than 6 km in length.

In summary the main mode to be affected by transfers to bicycle would be the private car, however there may also be some transfers from buses (buses tend to be inconvenient, slow and relatively expensive for short trips). Provided that safe bikeways are provided and secure storage facilities are located at destinations then the potential for trip transfers from cars and buses to bicycles will depend on such factors as; trip purpose, objects carried, trip length, time of day, age of trip makers, local topography and climate, cost differences between modes, and comparative door to door trip times. For example a 3 km journey to school or work would be suitable for bicycle travel because it is a regular daytime trip, frequently made alone, with only a few items to carry, and door to door travel time may even be less than that by car. However in hilly localities (grades of 5% or greater) then few will ride bicycles for any purpose except exercise.

* Sydney Area Transportation Study, Figures 6.4 and 6.5, 1971.

** Very few cyclists will ride more than 6 km for a one-way trip.

4.2 EXISTING SITUATION VS. PROPOSED SITUATION

The difference between the existing situation and the proposed situation are:

(a) A comprehensive bikeway system, including storage facilities, would be provided;

(b) Motor vehicle ownership patterns would not change but some motor vehicle users would purchase bikes;

(c) There would be differential transfers from car to bike for some short trips.

In the following paragraphs an estimate is made of the travel that could be made by bicycle instead of car and some of the benefits, in terms of operating cost savings, are then estimated. The procedure outlined could be applied to any specific area where detailed data are available.

4.3 CAPITAL COST CHANGES

For the following calculations it is assumed that there would be no capital cost savings for motorists and that some motorists may purchase a bicycle to make short trips (other car users already own bikes). Thus for a percentage of bike users in the proposed situation there will be the capital cost of a bicycle to be recovered over say a 10 year period at say $15 per year. Purchasers of bicycles are assumed to ride 2,000 km. per year, thus the capital cost is equivalent to 0.75¢ per km. But as only some of the private car users who will transfer would have to purchase a bicycle, (say 50%) for work trips and 20% for other trips then overall the additional capital cost is assumed to be equivalent to 0.38¢ per km. for work trips and 0.15¢ for other trips.

4.4 VARIABLE COST DIFFERENCE

The variable cost of operating an 'average' car is currently estimated at 4.5¢ per km. (Commonwealth Bureau of Roads estimate). On the basis of typical occupancies the variable cost per occupant is shown below in Table IV.

The variable cost of operating a bicycle is estimated at $5 per year or 0.25¢ per km. over 2,000 km.

TABLE IV VARIABLE COST DIFFERENCES

Trip Purpose	Average Occupancy	Cost per Occupant ¢	Cost of Bicycle Travel ¢	Savings per Kilometre ¢
Work	1.2	3.75	0.63	3.12
School	2.0*	2.25	0.40	1.85
Rec. & Social	2.5	1.8	0.40	1.40
Shopping	2.0	2.25	0.40	1.85

* passengers only.

4.5 USER COST DIFFERENCE

Savings (per kilometre) to persons who transfer to bicycles (for short trips) will thus be the difference in variable cost, including an allowance for those who have to purchase bicycles, as shown in the last column in Table IV above.

4.6 ESTIMATED POTENTIAL TRANSFER

Taking the total travel in Australian Capital Cities currently made by private motor vehicles, an estimate is made later of the percentage of this travel that could in the future be made by bicycle if a safe and convenient bikeway system and secure and convenient storage facilities are provided. Total travel in Capital Cities made by private cars and station wagons, exclusive of paid work trips, is shown in Table V.

TABLE V PRIVATE URBAN TRAVEL

Purpose	Travel million VKT	(%)
Work	9,520	34.5
School	1,380	5.0
Rec & Social	6,900	25.0
Shopping	6,070	22.0
Other	3,730	13.5
Total	27,600	100.0

Transfer potential is considered to depend on the following factors:-

(a) trip purpose suitability (S);

(b) trip lengths (L); and

(c) environmental factors (e.g. urban areas with steep hills, number of days with heavy rain and/or high winds) (E).

The suitability of the bicycle for different trip purpose is indicated by cyclist surveys in Australia and overseas; generally the bicycle is considered most suitable for commuting to secondary school, work and to or for recreation trips. The suitability factor is intended to comprehend such variables as age of trip maker, time of day trip is made and items carried. Table VI sets out my estimates of suitability.

* ABS., Survey of Motor Vehicle Usage, 1971, Table 1.

TABLE VI

SUITABILITY FACTORS

Trip Purpose	Suitability Factor (S)
Work	0.6
School	0.5
Rec. & Social	0.4
Shopping	0.3

Studies* indicate that cyclists are prepared to ride different distances for different trip purposes, with the suburban non C.B.D. oriented work trip being the longest. Set out in Table VII are estimates of reasonable bicycle trip lengths and the percentage of private car trips less than or equal to this length.

TABLE VII

BICYCLE TRIP LENGTHS BY PURPOSE

Trip Purpose	Trip Length (km)	Percentage of Car Trips ≤ this Length**
Work	5	20%
School	4	80%
Rec. & Social	3.5	30%
Shopping	3	40%

** S.A.T.S. Vol. 1, Fig. 6.4; 1971.

Cyclists are of course deterred by bad weather and hilly terrain. An allowance is therefore made in the environmental deterrent factor for the number of days with heavy rain and/or strong winds, and for the percentage of urban areas with hills. Degree of environmental deterrent will also vary with trip purpose. My estimates of environmental deterrent factors (the decimal fraction of those who consider the bicycle suitable for the trip purpose, who live close enough to their destination to ride and who are not deterred by topography and weather) are set out below:

TABLE VIII

ENVIRONMENTAL DETERRENT FACTORS

Trip Purpose	Environmental Deterrent Factors (E)
Work	0.7
School	0.7
Rec. & Social	0.6
Shopping	0.5

* Hawley (1975) pp. 95-111; also Pike and Conquest (1976) pp. 21 & 22.

The transfer potential is thus obtained by multiplying each of the factors in Tables VI, VII and VIII together, as shown in Table IX. The weighted average transfer for all trip purposes is 9%.

TABLE IX

TRANSFER POTENTIAL

Trip Purpose	Sx L x E	Transfer Potential
Work	0.6x0.2x0.7	0.08
School	0.5x0.8x0.7	0.28
Rec. & Social	0.4x0.3x0.6	0.07
Shopping	0.3x0.4x0.5	0.06

4.7 ANNUAL BENEFITS

The annual benefits that will follow the provision of bicycle facilities can be calculated by estimating the V.K.T. that will be transferred to bicycles from private cars (Tables V and IX) and by multiplying this estimated V.K.T. by the per kilometre difference in user costs (Table IV). The estimated annual benefits are shown in Table X below:

TABLE X

ANNUAL BENEFITS BY PURPOSE

Trip Purpose	M.V. Private Travel million VKT*	Transfer Potential	Unit Cost Savings ¢	Annual Benefits $ million
Work	9,520	.08	3.12	23.8
School	1,380	.28	1.85	7.1
Rec. & Social	6,900	.07	1.40	6.8
Shopping	6,070	.06	1.85	6.7
	23,870			44.4

* Vehicle Kilometers of Travel

The approximate annual benefits that would be available to each capital city are estimated in Table XI. The average transfer potential has been slightly varied to make some allowance for geographic and climatic condition variations between cities.

TABLE XI

ANNUAL BENEFITS BY CITY

City	VKT million	Avg. Transfer	Avg. Unit Cost Saving ¢	Benefits $ million
Sydney	8510	.08	2.13	14.5
Melbourne	7010	.09	2.13	13.4
Brisbane	2265	.08	2.13	3.9
Adelaide	2525	.10	2.13	5.4
Perth	2530	.10	2.13	5.4
Hobart	365	.08	2.13	.6
Canberra	540	.09	2.13	1.0
Darwin	125	.08	2.13	.2
	23870			44.4

5. CONCLUSION

To conclude these rudimentary calculations all that is left to do is to calculate the Benefit/Cost ratio, recalling that: impacts on time, accident and health costs are not considered; the benefits calculated relate to only those trips made by those new cyclists who were once private motor vehicle users; yet the costs relate to facilities that will be used by all future cyclists (that is the B.C.R. will be rather conservative).

The benefits are related to costs by the usual formula:

$$BCR = \frac{\sum_{y=1}^{y=10} (B - E)}{C}$$

where: B is net yearly savings in operating costs to those motor vehicle users who transfer to bicycle for some trips;

E is the annual expense associated with operating and maintaining the new bicycle system; and

C is the capital cost of the system

- Analysis period has been set at 10 years.
- A 10% discount rate has been used.
- The same benefits and expenses have been used for each of the ten years.

The B.C.R. has been calculated for each state capital city and is shown in Table XII. The costs for each city's system, assuming all construction costs are incurred in year one, are from Table III and the benefits are from Table XI.

TABLE XII SYSTEM B.C.R.'s

Urban Center	Discounted ΣB-E $ million	Capital Cost $ million	B.C.R.
Sydney	73.9	24.8	3.0
Melbourne	68.4	22.7	3.0
Brisbane	17.0	11.3	1.5
Adelaide	27.7	9.0	3.1
Perth	28.3	8.2	3.4
Hobart	2.7	1.7	1.6

COMMENTS

The difference in B.C.R.'s reflects mostly the difference between the density of urban development in the cities but also the different weather and topography.

It should be noted that the high BCR's indicated do not allow for the additional benefits that would accrue to; existing cyclists (e.g. accident reductions, less theft), travel time savings (e.g. to parents who would not have to drive their children to school), reduction in arterial road congestion, reduction in pollution, and the savings by disposal of some 'second' cars. The BCR's could thus be even more favourable.

The above analysis has been rudimentary in that all benefits have not been considered and average costs have been used, yet the analysis does at the very least indicate that detailed comprehensive studies are warranted for bicycle facilities in our capital cities.

In conclusion, facilities for the bicycle mode appear to have the potential to cater, in a highly efficient manner, for up to 10% of urban passenger travel; to improve mobility for the young and some other transport disadvantaged groups; to improve the health of the middle aged, middle class; and to bring economic benefits well in excess of costs.

For the potential benefits to be realized however, adequate funds must be directed towards bicycle facility programmes. As 1% of road travel is already by bicycle, as an absolute minimum 1% of next years road transport public expenditure should be directed to the planning and construction of bicycle facilities. In subsequent years expenditure should be increased to around 3% of total road transport expenditure.

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APPENDIX A

BENEFITS OF THE BICYCLE MODE

The bicycle has many attributes relative to criteria for society values.

(a) Efficiency:

- a bicycle uses less than one quarter the roadspace of a car;
- twelve bicycles can be parked in the space used by one car;
- a cyclist can travel three times as far as a pedestrian in the same time period for equivalent effort;
- for trips up to 7 km in length in urban areas, door to door travel times by bicycle can be quicker than by public transport or even private car;
- a cyclist transforms energy from food into movement more efficiently than any other form of animal or mechanically powered transport;
- a bicycle has a capital (manufacturing) energy requirement of only 1/150 that of a car;
- a bicycle only requires 1/70 the materials that it takes to manufacture a car;
- operating cost per km of a bicycle is 1/5 that of a small car;
- yearly ownership cost of a bicycle is 1/100 that of a small car;
- bicycle facilities will reduce the financial loss (to the community and individuals) that is associated with casualties and property damage from collisions between cyclists and motor vehicles;
- on busy streets where bicycle facilities are not provided and cyclists have to use either the roadway or the footpath, then the level of service for motorists and/or pedestrians respectively, can be significantly reduced.

(b) Equity:

- facilities for cyclists could be of advantage to the large percentage of the population that are mobility disadvantaged compared to private car owners. The mobility disadvantaged who could benefit from cycle facilities include : those that are too young to drive, adults in households where there is not one car per adult, those that cannot afford a car (including those who have a car but can not really afford one and consequently have to forego expenditure on non-transport essentials), and those that cannot afford the fares of public transport.
- cyclist (and pedestrian) needs have been ignored by massive public investment for motor vehicle facilities. Public expenditure on transport should be equitably distributed and not directed towards satisfying the demands of the car owning minority: It could be argued that at the very least, the monies set aside for transport should be shared in proportion to the percentage of users; i.e. pedestrians and cyclists should have 3% and 1% respectively of the transport budget spent on them, if not more initially to make up for past neglect.
- bicycles, and particularly tricycles, can provide a high level of mobility for people suffering from many physical infirmities (this is because of the bicycle's high mechanical efficiency and because much of the weight of the body is supported by the bicycle or tricycle).

(c) Environmental Amenity:

- no exhaust fumes;
- practically no noise;
- a machine of human scale;
- cycling is by its nature compatible with a clean, quiet, uncluttered environment. For many trips cycling can remove noisy and polluting motor vehicles from the urban environmental. This potential has been recognised by the U.S.A., Environmental Protection Agency e.g. bikeways to the C.B.D. are an integral part of the programme for air quality improvement in the city of Philadelphia.

(d) Health:

- cycling is one of the best forms of exercise for a wide age range, and
- cycling is mentally exhilarating.

(e) Safety:

- people, particularly children, are already riding bikes on inadequate facilities. The many serious injuries and fatalities could be dramatically reduced by the provision of adequate facilities (as proved in Davis U.S.A., and Stevenage G.B.). The potential safety related benefits are greatly underestimated by official statistics because many injuries are not reported. A bikeway system could greatly reduce the number of accidents experienced by cyclists.

(f) Security:

- secure storage to discourage bicycle theft and vandalism is vital. It is estimated that an individual's bicycle will be stolen, on average, once every ten years.

(g) Utility:

- bicycle transport is a mode of considerable flexibility and utility (e.g. as demonstrated in China).
- A city over dependent on motorized transport can be very easily crippled e.g. by fuel rationing.
- a folding bicycle (e.g. the Bickerton) that can easily be carried, is probably the most realistic 'vehicle' for dual mode use in conjunction with other motorized modes with more than two wheels.

(h) Community Involvement:

- because of low capital cost and the simple technology of bicycle planning, members of the community can actively participate in bike facility planning. The facilities so planned and implemented, because of their low cost, can be changed if the community wishes.

APPENDIX B

WHY THERE IS NOT MORE BICYCLE USE

While there are many reasons (see Appendix A) why the bicycle could and should be a significant means of mobility in urban areas, there are also reasons why the potential inherent in the bicycle has not been realized; these reasons relate to:

(a) Inadequate Facilities

- Safety - cycling on a busy road is a hazardous because of the high probability of injury or death to the cyclist following a collision with a motor vehicle. (In a Melbourne Survey (11) danger from traffic was the major reason why bike riders did not use their bikes more often).
- Theft - no satisfactory storage facilities that secure bicycles against theft have been installed in Australia. Bicycle theft is the second major deterrent to bicycle use - as was revealed in the Middle Park Case Study* and the Melbourne survey; (secure storage systems have been designed and are in use in America).
- Amenity - the fumes and bustle of motor traffic is unpleasant and unhealthy for the unprotected cyclist.
- Infrastructure - except for a few recent projects, over the last 20 to 30 years no new facilities for bicycles had been constructed and old facilities had fallen into disrepair and/or have been removed. The whole infrastructure for cycling that once existed has virtually disappeared.
- Convenience - no direct continuous routes, via quiet streets and bikeways, have been developed for cyclists. The only direct routes are along the major roads on which cycling is deterred by reason of poor safety and low amenity.

(b) Bicycle Design

- Luggage - with a few notable exceptions (viz the Moulton and childrens Choppers) the popular adult bicycle designs are modified 'racers' with no provision for carrying bags or parcels.
- Weather - the bicycle, unlike the car, affords no protection from the elements. Melbourne has only 18 days per year (on average) with heavy rain. (Wet weather over-clothing consisting of leggings, a cape, and a sou'wester are used in Europe but are not readily available in Australia).
- Hills - in a few sections of some Australian cities steep hills may deter some people from using bicycles. Manufacturers have tended to supply bicycles with close ratio racing type gears rather than wide ratio gears with some very low gears which would permit leisurely cycling up relatively steep grades.

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* Middle Park Case Study, internal report of the Commonwealth Bureau of Roads, 1975.

- Night - there are few lightweight reliable lighting systems readily available which make bicycles conspicuous at night. Cars are required by law to be sold equipped with lights, no such requirement exists for bicycles.
- Cost - while the bicycle is much lower in cost than a car to purchase, the retail cost of a bicycle on a per kilogram basis is twice that of a car.
- Reliability - bicycle tyres are prone to punctures and there are also problems with brakes, spokes, and cables.
- Design - the design of the bicycle may be sub-optimal; aerodynamic drag is high; the 'head forward' position may make injuries from collisions unduly serious and comfort could be improved by supporting the back in a 'lean back' position.
- Equipment - popular pad brakes and tyre driven dynamos have very poor efficiency in wet weather; better equipment has however been produced but is not used.

(c) Users

- Education - very little, if anything, is done to teach cyclists safe riding techniques and the rules of the road. If cyclist were made aware of and observed the rules of the road then they would receive more respect from other road users. Other road users must also be made aware of cyclists rights.
- Exercise - bike riding, although relatively 'light' exercise, is naturally shunned by those who despise exercise.

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