Motorcycle Transport

Powered Two Wheelers in Victoria

Report for VicRoads -on behalf of the Victorian Motorcycle Advisory Council

by **Oxford Systematics**
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VMAC

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Formal Disclaimers

MOTORCYCLE TRANSPORT – POWERED TWO WHEELERS IN VICTORIA

Report For VicRoads (On behalf Of the Victorian Motorcycle Advisory Council) By Oxford Systematics

To Whom It May Concern:

BACKGROUND:

The Roads Corporation is a statutory corporation in Victoria, Australia operating under the registered business name VicRoads. VicRoads serves the community by managing the Victorian road system and its use as an integral part of the overall transport network.

The Victorian Motorcycle Advisory Council (VMAC) is a broadly based advisory body established by the Victorian Government in 1998. It provides the Government with strategic advice on issues relating to the management and development of motorcycling in Victoria. VMAC's purpose is "to provide balanced advice on all aspects of motorcycling to Government and its agencies".

In April 1999, VicRoads (on behalf of the Victorian Motorcycle Advisory Council) awarded a consultancy to Oxford Systematics to assess the present and potential roles of powered two wheelers (PTW) in the total transport system. The objective of the consultancy was to provide a basis for developing a PTW strategy based on a balanced coverage of the mobility and accessibility contributions, as well as the operating and safety costs inherent in all road usage.

This report presents the results of the consultancy work.

DISCLAIMER

Every attempt has been made to ensure that the information in the report is accurate. However, the report content and conclusions have not been considered to date by VicRoads or VMAC. Accordingly, the report content and conclusions do not necessarily reflect the views and opinions of VicRoads or all Victorian Motorcycle Advisory Council representatives or their respective organisations.

GEOFF KLOOT
GENERAL MANAGER
TRAFFIC & ROAD USE MANAGEMENT

4 /12 /2000

Front Cover notes

The front cover picture was taken in Elizabeth Street, the oldest motorcycle precinct in the world and a tourist attraction in its own right. The location is opposite the Melbourne Central building and from the side of the strip where many motorcycle dealers park their machine stocks along the sidewalk. The tram, car, motorcycle, motorcycle and sidecar, scooter and bicycle in view indicates the mix of vehicles using the road, and shows three different types of powered two wheelers and vulnerable road users.

Contents

Glossary

AA	Automobile Association, UK
ABS	Australian Bureau of Statistics
ACEM	Association of European Motorcycle Constructors and Manufacturers
ANBI	Australian National Bicycle Information Base
ARRB TR	Australian Road Research Board Transport Research
AUSTROADS	A joint organisation owned by all the Australian Road Authorities
BMF	British Motorcycle Federation
CARB	California Air Regulation Board
CBD	Central Business District
CO	Carbon Monoxide, an exhaust gas
COBA	Evaluation Model used by the UK Department of Transport and the Regions
DoI	Department of Infrastructure, Victoria
EU	European Union
FORS	Federal Office of Road Safety
GIS	Geographical Information System (digital mapping)
HOV	High Occupancy Lane
JTW	The ABS Journey to Work Survey: part of the Population Census
LGV	Light Goods Vehicle
MICA	Motorcycle Intensive Care Ambulance
MRA	Motorcycle Riders Association
MUARC	Melbourne University Accident Research Centre
NVMOCs	Non-Volatile Methane Organic Compounds: exhaust pollutants
NOx	Oxides of Nitrogen, an exhaust gas
OECD	Organisation for Economic Cooperation and Development
PCU	Passenger Car Unit (a unit of capacity)
PTW	Powered Two Wheeler
SMVU	Survey of Motor Vehicle Usage
SOx	Oxides of Sulphur (x is the number of Oxygen atoms) an exhaust gas
TAC	Transport Accident Commission, Victoria
TOG	Victoria Police Traffic Operations Group
TRC	The Transport Research Centre in the Faculty of Business at RMIT University
UITP	International Association for Public Transport
Ulysses	A large Australia-wide motorcycle club for riders over 50
VATS	Victorian Activity and Travel Survey undertaken by TRC at RMIT University
VDAS	An Australian automatic traffic detection and counting system
VMAC	Victorian Motorcycle Advisory Council
VTPI	Victoria Transport Policy Institute

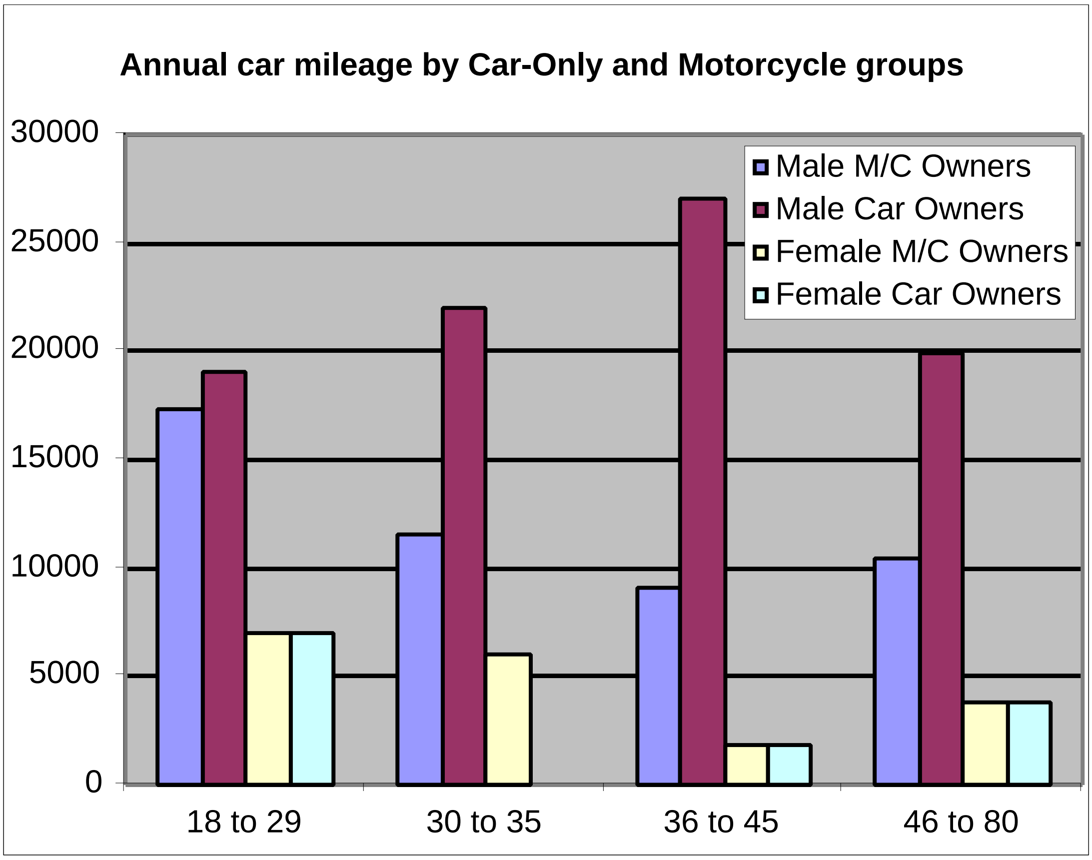
Executive summary

In April 2000 VicRoads (on behalf of the Victorian Motorcycle Advisory Council) issued a brief to produce a report on motorcycles, scooters and mopeds as transport modes. This tender was won by Oxford Systematics with some input from the Transport Research Centre and Dr Narelle Howarth.

Data from Australia and overseas was obtained, assessed for utility and reanalysed where appropriate to give a consistent picture of motorcycle use. Data on accident costs, pollution and emission values are brought together for evaluation consideration.

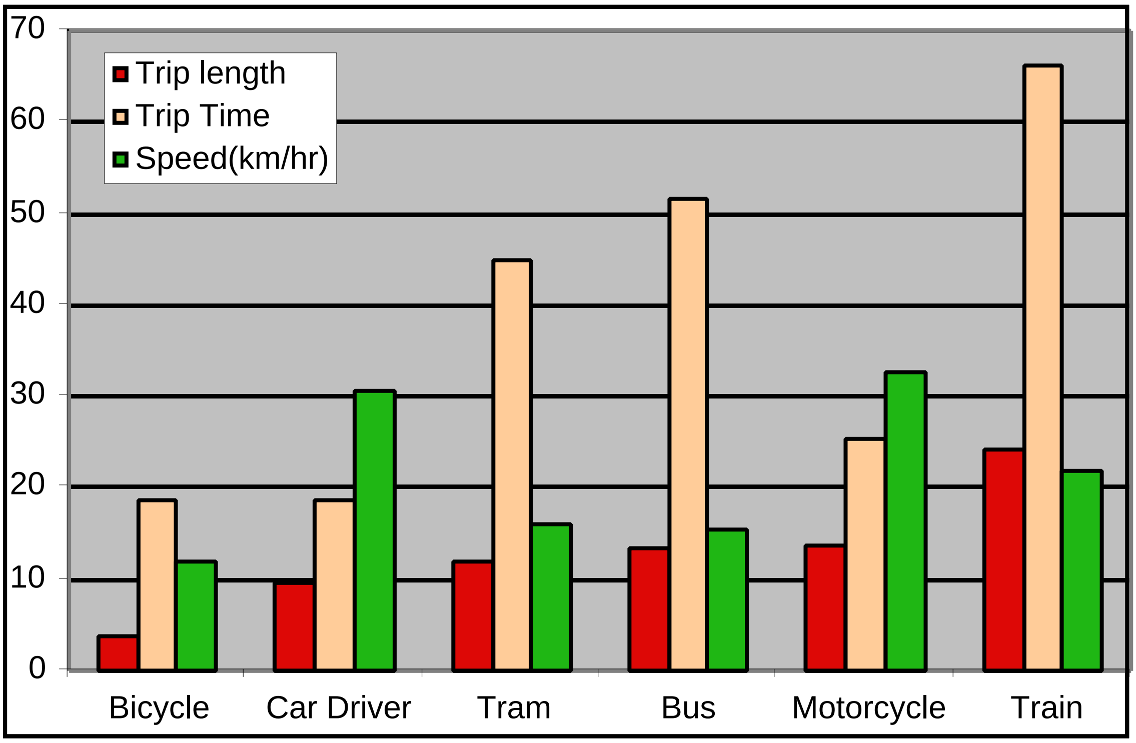
The overall levels of motorcycle flows in Victoria were found to be 0.5% of vehicle flows, and the relationship established between motorcycle crashes and motorcycle flows found by the Victorian Crash Control Study (Haworth, Smith, Brumen, & Pronk, 1997) was used to provide more discriminating estimates of motorcycle flow using GIS (Geographic Information Systems) methods, based on reported motorcycle crash data.

Fresh survey data was also obtained on motorcycle users and their ownership and use of cars and motorcycles/scooters. Motorcycle and scooter user choices were found to depend on ease of getting through traffic congestion, their economy and ability to park close to their destination and the intrinsic pleasure obtained by riding a powered two wheeler. It is not always a question of either motorcycle or car owner: the mileages done by car by motorcycles owners and nonowners are both substantial.



Annual car mileages by car-only and motorcycle owners by age and sex

The transport performance of motorcycles was confirmed by fresh analyses of the Melbourne transportation survey data.



Travel times and speeds by mode in order of trip length: VATS 1995-8

Motorcycles have the second highest average travel distance of all modes in Melbourne, and the highest average travel speed. They suffer the lowest travel delays. Bicycles reported encountering delays of an average of 1% of their total travel time, cars 0.5% - but motorcycles nil.

Many of the data items from consultation and survey analysis are included in a second volume of Appendices.

In order to be able to evaluate motorcycles and scooters in traffic, transport, regulatory, social, safety and environmental proposals parameters are required for each area of valuation. These have been brought together for operating cost, safety and emissions. Work to establish appropriate travel time and social factors still need to be developed.

There are several key areas where powered two wheelers have a significant role to play:

- More efficient road space utilisation
- More efficient parking space utilisation
- Reduced emissions
- Faster access
- Increased mobility

Work is required to address these possibilities, and this is summarised in the report.

There are a number of transport and traffic situations where motorcycles, scooters and mopeds (PTWs) offer or already provide realisable advantages.

Information

The consultation processes with Local Government has demonstrated that the available material to guide provisions for PTWs has been very sparse. The recent Austroads Guide to Traffic Engineering Practice – Motorcycle Safety, Part 15 was quoted as a useful safety and traffic engineering resource by several (Austroads, 1999), but was the sole resource quoted. The recent issue of a series of Motorcycle Notes by VicRoads (VicRoads, 1999; VicRoads, 2000a; VicRoads, 2000b; VicRoads, 2000c; VicRoads, 2000e; VicRoads, 2001) will help to address this limited access to workable guidance in selected areas.

This has materially hampered the development of a sound and informed framework for balanced PTW (powered two wheeler) assessments.

There are no professionally developed teaching units on motorcycle, moped and scooter issues which could be included in University, professional, commercial or technical short courses or degree programs. While many of the traffic, transport and economic evaluation issues are covered broadly in general units, there is a demonstrated need for a more focussed resource that brings the transport, traffic engineering, safety, social, economic and environmental materials together in a unified and usable form.

There would be advantages in making this information and teaching resource one that covered all three of the vulnerable road users (pedestrians, bicycles and motorcycles) in a unified manner as there are substantial common factors as well as crucial differences. Both would need to be highlighted: the combined bicycle/pedestrian course developed by the US Federal Highways Administration (FHWA, 2000) illustrates both the strength of this approach to providing resources and guidance in an accessible form for a broadly technical audience - and also emphasises the need to include all three vulnerable modes to make an effective unit that would both appeal to and inform planning, safety, transport and environmental communities involved.

The importance of this combined group in road safety terms alone would make this a valuable resource, and given the effectiveness that Local Government in particular show when provided with appropriate materials and presumably training access this would be a cost effective action.

Target areas for PTW measures

A number of areas have been identified in this report where motorcycles, mopeds and scooters offer realisable advantages:

• More efficient use of road space.

- Reassessments of existing dedicated lane utilisation; including transit, bus and cycle lanes; and assessments of compatibility and joint use regulation possibilities.
- Assessments and trials of advanced stoplines.

• Better accessibility

- Enhanced police, emergency services and medical access, requiring adjustments to the current Australian Road Rules to be re-established or maintained.
- Extension of existing motorcycle parking rights and facilities on and off the roadway will enhance accessibility of professional and ordinary motorcycle, moped and scooter users.

• Emission and pollution gains

- Switches from current cars to current motorcycles (or simply greater use of motorcycles with cars with both cars and motorcycles) offers a significant gain in fuel consumption as well as emission reductions, information on in-use motorcycle and scooter fleets and emission characteristics and evaluation criteria are needed to secure these gains.
- Improved car driver access to small modern scooters etc can also enhance such gains.

• Reduced parking space provision on and off street

- Costings of space overheads of each mode mix for different trip purposes: large portions of central cities are dedicated to on and off road car parking space: the effectiveness of altering this large commitment - even at the margin - offers gains in several different areas including road capacity.

• Improved mobility

- Specific valuation of the utilisation of time saved by using a motorcycle or scooter and recognising their superior performance in travel speed, operating costs, parking space and emission characteristics in addition to differential safety costs in economic evaluations could expand the access and mobility of appropriate groups in the community.

Specific areas that justify early attention

• Economic and environmental evaluation

- Motorcycle courier performance for business.
- Better focused and differentiated crash, user and time cost valuations.
- Environmental benefits including full life emission/energy use.

• Positive capacity management measures

- Assessments of filtering through traffic.

• Road space utilisation and allocation policy

- As part of a joint Vulnerable Road User policy
- Use of advanced stoplines
- Dedicated lanes

• Enhanced accessibility

- The activity patterns and costs of people using motorcycles
- Shopping, medical and personal services access by older people (30+)

There are numerous examples of specific steps that could be taken up, and a short list of some of these are given as Appendix 24 (ACEM, 2000). However, although there are many clearly under-assessed and under-used potential areas of motorcycle contribution, there are four things lacking:

- An integrated Vulnerable Road User Strategy with broader evaluation criteria than solely safety

- A sound set of economic, social and environmental evaluation factors to assess such policies

- Adequate monitoring information on powered and vulnerable two wheelers as a whole, ie data to correct the current unbalanced over-reliance on crash statistics.

- A coherent information and instructional resource covering the different aspects of all vulnerable road users with instructional support

These shortfalls demonstrate that powered two wheelers are currently inadequately integrated into the transport policy process as a whole.

The present report helps to address this gap by bringing together existing and fresh information on motorcycles, mopeds and scooters in this broader context.

1. The brief

VicRoads (on behalf of the Victorian Motorcycle Advisory Council) issued a brief to assess the present and potential roles of powered two wheelers (PTW) in the total transport system. The objective was to provide a basis for developing a PTW strategy based on a balanced coverage of the mobility and accessibility contributions as well as the operating and safety costs inherent in all road usage.

1.1 Our understanding of the brief

The brief required:

- Literature review of relevant Australian and overseas documents.
- The assembly of available information on motorcycle and scooter usage and users in Melbourne.
- The construction and documentation of a broad context within which PTWs may be considered, including environmental, safety and mobility factors.
- Identification of the factors influencing the use of PTWs
- Consideration of lifestyle needs and their influence on transport choice and opportunities.

Motorcycles are rarely treated as a separate mode in most traffic and transport strategies and proposals. Consequently limited information is available about motorcycles and scooters as transport modes. The brief seeks to collate the available information about motorcycles and motorcyclists from Australia and elsewhere, and develop estimates of PTW (motorcycle and scooter) usage specifically for Melbourne.

Fresh information is needed to assess the factors that affect motorcyclists choice of mode, and by implication also to address those that affect the decision to obtain a motorcycle in the first place. Fresh work is required to develop unit costs for motorcycle usage, both for operation and externalities, and to use these to assess the costs and benefits of increased levels of PTW use and clarify what factors might be addressed in a strategy to increase the use of PTWs.

1.2 Our approach to the work

Motorcycles are included in a limited number of transport surveys. However several specialist surveys have previously been done in Australia. Using these and overseas data can provide an overall picture of motorcycle, moped and scooter use, within which the current situation can be viewed. The word motorcycle will be used to include scooters and mopeds in the rest of this report, unless otherwise stated.

To consider motorcycles in a transport and traffic context requires details of the users, the different types of use that they make of their machines and the choices that they make concerning them. Several survey methods were used to obtain such information from Melbourne motorcyclists and scooter riders, and interviews were conducted with courier and other professional riders.

Motorcycle safety and transport is a concern for local and state governments and consultation letters were sent out to a wide range of such bodies. The contact details of the people with responsibilities for motorcycles was obtained and followed up to determine what policies were active, what provisions were currently made and what information was used on which to base these policies or actions.

The private and public costs of operating motorcycles and their effect on traffic flow and parking space are needed. Some data was obtained from the project surveys, but obtaining most of the information on which environmental assessments of motorcycles can be based also required overseas enquiries and a wide search through the field of sustainable transport.

The range of options for providing for motorcycles and making best use of their special capacities has been explored by seeking out and obtaining input from the various motorcycle transport policy studies that are only now beginning to become available in other countries.

1.3 Previous Australian work on motorcycles and mopeds as modes of transport

While the present project is the first Australian study to address powered two wheelers as full transport modes, there has been some limited earlier work on these lines, including analyses of transportation study data to examine motorcycle participation by different age groups and for different purposes, and patterns of usage across the day (Wigan, 1987). This early work was based on the very limited numbers of motorcyclists picked up in transportation surveys, but still gave a useful initial overall picture.

The full range of powered two wheelers was first addressed as a result of early work on moped users (Wigan & Carter, 1980a; Wigan & Carter, 1980b) and on the economics of light motorcycles in South Australia (Travers Morgan, 1982). The position now defined by VicRoads for the present work reflects the conclusions of Wigan & Carter, (1980a):

> "*While analysing the data for the present report, it became evident that the general assessment of mopeds was based almost entirely on potential accident involvements, and with little or no information on or weight given to exposure, fuel utilisation, or enhanced mobility – the primary objectives of travel. Better information in these areas is clearly necessary, and valuations of accidents, fuel usage, and mobility are now needed to ensure that balanced policies on mobility and safety develop with a full understanding of the costs of either increasing or decreasing the stringency of regulation on access to and use of mopeds. It will also be necessary to analyse and express household and individual mobility more in terms of <u>multiple</u> vehicle ownership and access in view of the increasingly difficult choices between mobility and safety involved. A similar approach to motorcycle ownership is also increasingly necessary*" (Wigan & Carter, 1980a)

The issues of road and lane space allocation now becoming significant were also addressed (for mopeds) at a similar date (Wigan, 1979). The Dutch experience with moped and bicycle lane design found that mopeds (as distinct from light motorcycles) were dimensionally closely similar and even the all up weights were not too different (Volmuller, 1978). The only adjustment reported to be required was to add 100mm to the clearances from objects in lane width specification. For many years mopeds and bicycles shared the same special lanes in Holland, although the changing mix of vehicle types and other road management pressures led to this practice being discontinued in October 1999[1].

The range of powered two wheeler types is very large, and the spectrum now extends beyond the light mopeds of the 1970/80s to powered foot propelled skateboards and scooters, through electrically assisted bicycles to mopeds, light scooters and onward to larger motorcycles of differing degrees of specialisation. Similarly bicycles and bicycle users have become more specialised, ranging from sedate occasional riders to specially dressed riders of advanced technology machines, and to electric and internal combustion-engined power-assisted[2] bicycles.

This wide variety of both powered and unpowered vehicles raises fresh questions about the best way to manage road and lane space on the pavement and off it, including the mixed use of transit, high occupancy vehicle (HOV) and bus lanes. A systematic policy or policies for managing road space would appear to be both timely and necessary, and in the interest of all road users.

2. Consultation processes

All Melbourne metropolitan councils were contacted by letter, as were selected interstate agencies and consultants (a list is given in Appendix 1). A systematic process of establishing electronic contacts was also executed. This approach progressively secured appropriate and directly usable materials and feedback (a list is given in Appendix 2). The process built upon UK and US contacts already known to the principal investigator. The process of interaction across the Internet has been a critical element in securing the appropriate materials reviewed and discussed in the present report.

Continuing contact of this type will materially assist VicRoads in developing policies and strategies to address Powered Two Wheelers.

The Melbourne-based responses from Local Government were almost entirely based on safety issues. A few had parking and traffic policies, but in general there was little awareness of motorcycle, scooter or moped user needs. This was apparently in part due to the lack of direct requests to councils for facilities for parking, traffic management or road repairs, and in part due to the previous paucity of usable materials and guidance from VicRoads or elsewhere. While the Austroads Guide to Traffic Engineering Practice - Motorcycle Safety Part 15 (Austroads, 1999) was mentioned by a number of councils, it is certainly not yet universally known, and the recent series of Motorcycle Notes (VicRoads, 1999; VicRoads, 2000a; VicRoads, 2000b; VicRoads, 2000c; VicRoads, 2000e; VicRoads, 2001) was still known to very few of the respondents.

[1] Personal communication: Harry Barber, Bicycle Victoria

[2] Power assistance of less than 200 watts does not affect the legal designation of such a vehicle as a ‘bicycle’ in Victoria

The rate of penetration of specialised materials on motorcycle and scooter needs and design suggests that greater resources applied to developing guidelines and training materials would be cost effective. Overall, improved documents and guidance materials and their consistent distribution to interested professional and end user parties would appear to be a cost effective way to gain greater PTW aware design and planning by Local Government. In very few cases was there any suggestion of hostility to catering more effectively for PTWs.

All city councils in the Melbourne area were sent a letter outlining the request for information on any of their policies that take motorcycles (and scooters) into account as road users independent of and with different needs to cars. Some of the specific responses are summarised below.

The general view of the city councils in the Melbourne area, with respect to motorcycles, is that they are treated as general road users, i.e., are seen as having the same needs and characteristics as motorcars. Of the councils that responded to the letter, there were notable exceptions to this view. Namely, the Cities of Monash, Kingston, Knox and Moonee Valley, and the Shire of Yarra Ranges. The general view is that councils do not have access to information that allows them to treat motorcycles separately to cars, but of the councils that do, the guides are used. If appropriate information was available and the councils knew of its existence, then it is very likely that this knowledge would be used effectively.

As stated above, there were a small but significant number of exceptions to the attitude toward powered two wheelers from Melbourne’s City Councils.

Councils reporting use of the AustRoads Guide were Knox City, Manningham, Melton, Monash and Whitehorse. When any new projects are undertaken in these municipalities, referring to this guide is now standard practice.

The City of Maribyrnong has developed a Road Safety Strategy that highlights the motorcycle crashes on major roads with a high percentage of heavy vehicles. The City of Darebin is currently developing a Motorcycle Safety Strategy. No requests have yet been received from motorcyclists for parking special facilities in contrast to requests for on and off road bicycle paths and for bicycle parking. The council currently addresses motorcycles as a safety issue, but would address any queries raised by motorcyclists. This lack of direct representation by motorcyclists requesting special facilities, road repairs or traffic management changes was noted by most councils

The City of Kingston holds monthly meetings with with the neighbouring Glen Eira and Bayside Councils (with an open invitation to Stonnington), the Victoria Police and a representative from the Motorcycle Riders Association (MRA). These meetings are for the discussion of any papers the councils are currently working on, and for any relevant input from the surrounding councils that may be affected by or included in the plan. This broad attendance is taken advantage of by the councils for possible policy ideas, and by using the meetings as ‘brainstorming sessions” for ideas that would not come to fruition if not for this unique environment.

The Shire of Yarra Ranges recently started to develop a Road Safety Strategy in response to the large number of accidents in the municipality, and concerns raised by

Victoria Police. The main sources for this information are Crashstats (VicRoads, 1996) and information collected by the Shire on accident location and type over a period of time. The Shire held a community meeting which included VicRoads, the MRA, and community representatives. Vehicle safety is being considered in terms of road condition, visibility, law enforcement, and driver (both car and motorcycle) behaviour. Victoria Police has increased law enforcement within Yarra Ranges to address the problem of increased accidents.

Black Spot locations have been the main police enforcement targets, resulting in convictions for speed and overtaking offences. However this strategy has not yet had much effect on motorcycle accidents. Yarra Ranges has several demanding road sections highly regarded by motorcyclists and heavily used by them, often at inappropriate speeds. When writing policy, the Shire of Yarra Ranges considers motorcycles as road users quite distinct from cars when planning and implementating parking facilities within the Shire. Motorcycles are considered along with cars when roads are being maintained or new roads are made.

There are similarly demanding road sections in other states that are attractive to motorcyclists. Gorge Rd in the Adelaide Hills (South Australia) was recently the subject of an extensive road safety audit which included interviews with riders. Road safety auditors were taken along the road on motorcycle pillion seats to obtain an insight into the very different view of the potential hazards seen by motorcycle riders. (Simons, Farndon, Kloeden, & McLean, 1999).

The common factor between the Local Government treatment of motorcycles is that safety issues are almost invariably the prime concern. However good use is made of broader based technical material once it is known to be available.

3. Information Assembly

3.1 Bibliography

Systematic assembly of the available information was a key task, and a literature review was undertaken of the available published materials on environmental, road design, user costing, travel demand and related factors for motorcycles and their users.

This bibliography has been built up from several different sources, and is held in both EndNote Library and text formats. The most useful single resource was the Silverplatter Transport CDRom series, published and updated quarterly on behalf of the OECD Road Research Program, the European Conference of Ministers of Transport and the Transportation Research Board. Access to this two-CDRom resource is available in Victoria via the holders in the libraries at VicRoads, ARRB TR and the Hargreaves Library at Monash University.

However, most of the useful material had to be located via a range of different personal contacts and networking, library, web search and direct enquiries to Australian and overseas individuals and organisations. Once again, many of the major potential resources – including the US Transportation Research Board Committee of

Motorcycles and Mopeds - proved to have information only on the safety aspects of the mode.

The overall picture is that there is very limited information or documentation of motorcycles and other powered two wheelers (PTWs) as transport modes. There is a very extensive safety literature, but little published work on the transport and traffic aspects of motorcycling and motorcyclists. This situation is strikingly similar to that for both pedestrians (Wigan, 1995) and bicycles although there is now a growing body of work on bicycles as a full transport mode(Cambridge Systematics & Bicycle Federation of America, 1999; Schwartz & Porter, 1999; Wigan, 1984). However, there is much to do before all three vulnerable modes are fully integrated into transport policy, practice and planning.

3.2 Literature review

Data on motorcycles is not easy to obtain. Urban data as a whole is problematic, and motorcycles are a small part of urban transport. One source of broad information is a forthcoming book comprising the UITP Millennium Cities Database for transport in 1995-6 in 100 cities, which is being built by Murdoch University for release in printed and CDRom formats in November 2000[3]. The data include the numbers of motorcycles, the vehicle kilometers of travel, and the passenger–km and emissions.

Insights into motorcycle-owning households can be obtained from overseas data. The London Research Centre ran special tabulations for the present project[4]. These are reproduced as Appendix 3. The patterns of usage frequency are those of a city with a high level of public transport.

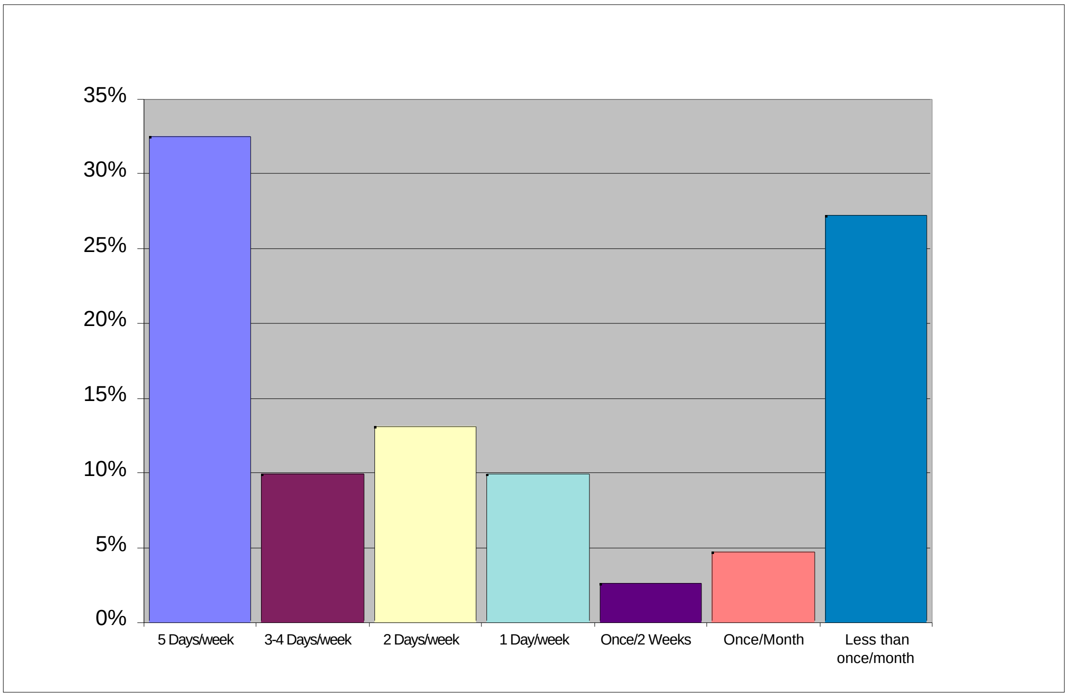


Fig. 1 Motorcycle use in London 1994

[3] personal communication J Kenworthy
[4] Helen Carter of the London Research Centre

The frequent assumption that motorcyclists travel by motorcycle every day is clearly not accurate. Motorcycles and scooters are used in context of other modes of transport. Evidently there are few households in London where only a motorcycle is available and must be used for all trips.

3.3 Emissions

Data on motorcycle emissions is very limited in Australia, and none of the relevant Australian reports covered motorcycles, mopeds or scooters in any detail.

Overseas sources were therefore necessary. Fortunately the specifications of motorcycles vary little across the world, with some variations in California. The summary table produced by London Transport Buses placed 1998 motorcycles close to fully catalyst equipped cars, and considerably better than cars not so equipped, which were considerably worse (Appendix 4). Light Goods Vehicles emissions (LGVs) are currently quite good.

The European Euro I, II, III, IV Standards are progressively improving emission production levels in Europe (See Appendix 5). These standards will inevitably influence Australia and have in principle already been adopted. Many Australian bus fleet operators are already purchasing Euro-rated vehicles. Although motorcycles are currently better than most vehicles, this will not remain true unless improved technology is applied to reduce motorcycle emissions. This is actively being pursued by the motorcycle industry (ACEM Pollution Research Group, 1998).

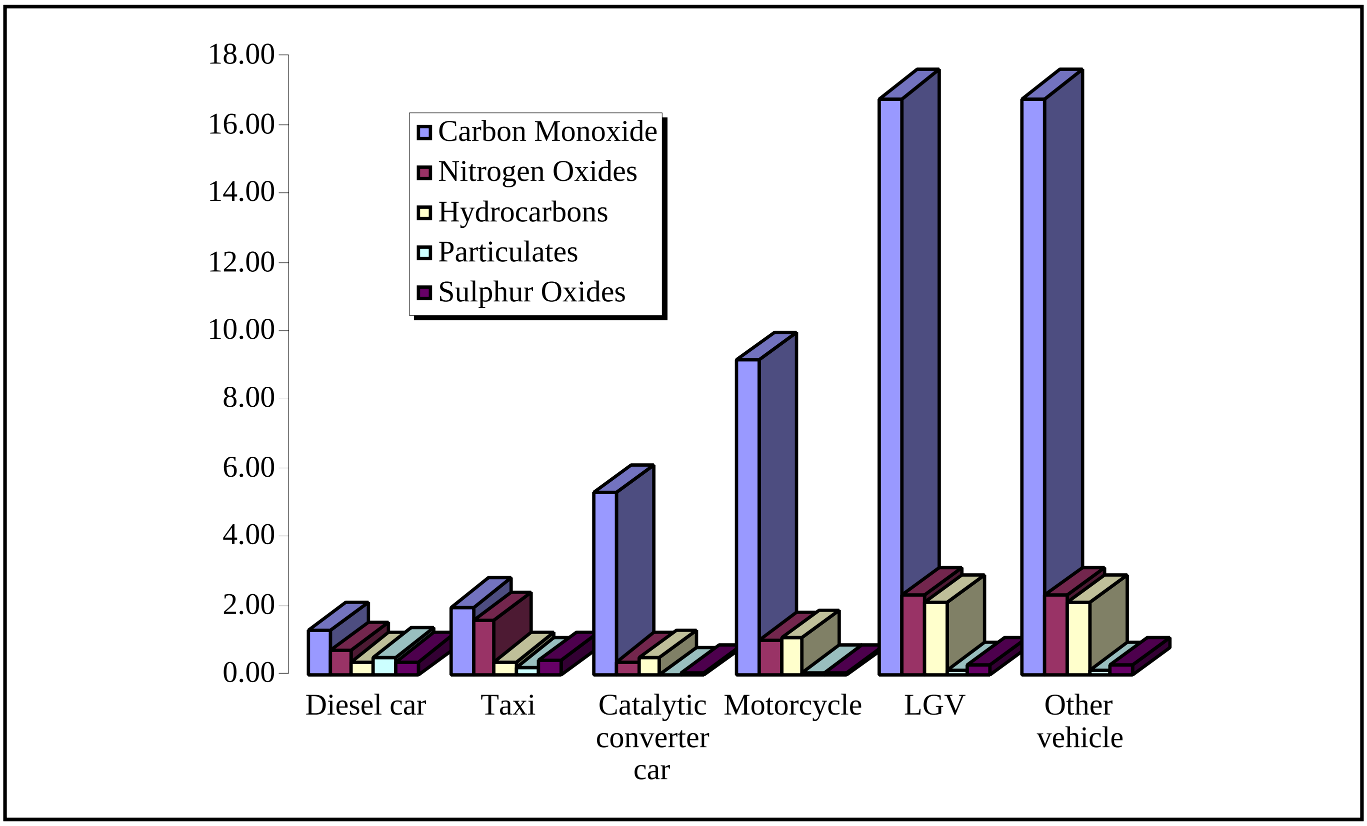


Fig 2. Motorcycle emissions in grams/passenger-km compared to the lowest polluting vehicles

The EU and the UK both specifically state that the very small contribution to emissions caused by motorcycles does not really warrant setting fresh standards for them. However the EU has also issued Directives with target emission specifications for mopeds[5] (low speed (<45km./h) sub-50cc PTWs) and for motorcycles[6]. Motorcycles cover a very wide range, and so the aggregation into a single group disguises the variations between mopeds, scooters and motorcycles of different sizes. Nevertheless the figures provide a useful basis for comparisons and a starting point for evaluation purposes.

Probably the most appropriate report to consider for future motorcycle emission issues for Australia is the work of ACEM in their response to the European Parliament Directive 97/24/EC(ACEM Pollution Research Group, 1998). This report covers tests carried out on a range of motorcycle sizes and types, and provides an excellent technical analysis of the likely emission reduction tradeoff and gains that can reasonably be expected in the near future. These tests were done on five different categories of powered two-wheeler power plants.

- <11kW,<125cc, 2-strokes
- <11 kW,<125cc, 4 stroke single cylinders
- >11 <25kW, 4 stroke single cylinders
- >11 and <25kW, 4 stroke multi-cylinders
- >25kW, 4 stroke, multi-cylinders

Assessments of the costs of emission reduction technologies and their cost effectiveness are covered. The very small contribution of motorcycles to vehicle emissions is noted, but the technical issues involved in the tradeoffs between Carbon Monoxide (CO), HydroCarbons (HC) and Oxides of Nitrogen (NOx) production are concisely summarised, and the optimum tradeoffs for two and four stroke motors are spelt out. A wide range of approaches to improving technical performance of motorcycle engines are explained, and the importance of non-technical travel demand management policies and measures (such as road pricing) are highlighted.

Motorcycles of all types require specific treatment in travel demand management and sustainable transport strategies.

Table 1. Materials composition: Medium sized motorcycle v economy car

Materials composition	Average Motorcycle weight(kg)	%	Economy car weight(kg)	%
Metals	127	85	760	76
Synthetics	23	15	240	24
Total	150	100	1000	100

(UK: Motorcycle Industry Council, 1999)

[5] EU Directive 97/24/EC: European Parliament and Council Directive of 17 June 1997 on certain components and characteristics)

[6] EU Directive 97/24/EC

Two reports summarise other emission/energy contributions over the full lifetime of the vehicle. The energy consumption and pollution produced in building and finally recycling the vehicle at the end of its life are significant elements in the lifetime energy and pollution production. Motorcycles on average require only 15% of the raw materials required for the manufacture of cars. Over 75% of a motorcycle is reused on other machines when it reaches the end of its useful life, and much of the remaining 25% is recycled by waste organisations leaving around 3% of the end of life motorcycle as residue (ACEM, Undated; UK: Motorcycle Industry Council, 1999).

Motorcycles use a small fraction of the materials required to create a car, and are almost completely recyclable. This suggests that concentrating solely on the production of pollution during the running of the vehicle will miss important tradeoffs.

This is equally true in the Victorian situation when public transport tradeoffs are considered: the pollution produced in creating the necessary energy for much of Melbourne’s public transport is derived from brown coal – a particularly prolific generator of greenhouse gases.

The Californian Air Regulation Board (CARB) has produced formal models (CARB, 2000) to evaluate mixes of all types of powered road transport. These are considered later under evaluation and costing issues

3.4 Usage variations

Motorcycles and scooters and mopeds are considerably more popular in other countries, although there are massive variations in the levels of ownership and use of powered two-wheelers within even such a comparatively small area as Europe. Key resources on motorcycles have been located that allow a reasonable picture of the users, usage and travel characteristics of motorcycles within Australia and outside in comparable situations in continental Europe and the UK.

3.5 Moped resources

Surveys of mopeds have been undertaken previously in Australia (Wigan & Carter, 1980a). They found that mopeds were attractive mostly to middle aged riders for utilitarian purposes.

Motorcycles and bicycles are the two vehicular categories of Vulnerable Road Users (pedestrians being the third). Motorcycles are used more than bicycles by males but less by females. There are striking similarities between the two single track vehicle modes:

- Both modes are used more by men than by women
- Both modes are given access to public transport lanes (albeit in different countries)
- Both modes ridden substantially for enjoyment, even when in a work application
- Both bicycles and motorcycles (and scooters and mopeds) are vulnerable in that a crash causes the rider to be more severely injured than the other party if a vehicle is involved.

- Both justify the compulsion to wear protective helmets to reduce serious head injury
- Dedicated protected road space is often provided for bicycles and other mopeds
- The size of lane required by both is very much the same (100mm extra for mopeds over bicycles)
- Both are strongly preferred by professional users in congested areas for their speed and access capabilities

The differences are mainly:

- Mass: bicycles are lighter than mopeds/scooters/motorcycles
- Bicycle riders have some rights to use pedestrian space as well as road space
- Powered two wheeled vehicles pay registration and insurance and are subject to considerably more stringent enforcement and penalties.

Clearly joint consideration of powered and unpowered two wheeled vehicles would be constructive in a wide range of road related issues and applications.

3.6 ABS Survey of Motor Vehicle Usage (SMVU)

The Australian Bureau of Statistics Survey of Motor Vehicle usage is carried out every few years. The SMVU was last published for 1995, although the most recent survey is due for publication in July 2000. The values derived for the average distances covered in 1995 have been adjusted downwards for cars and motorcycles in particular, due to new corrections for recall bias.

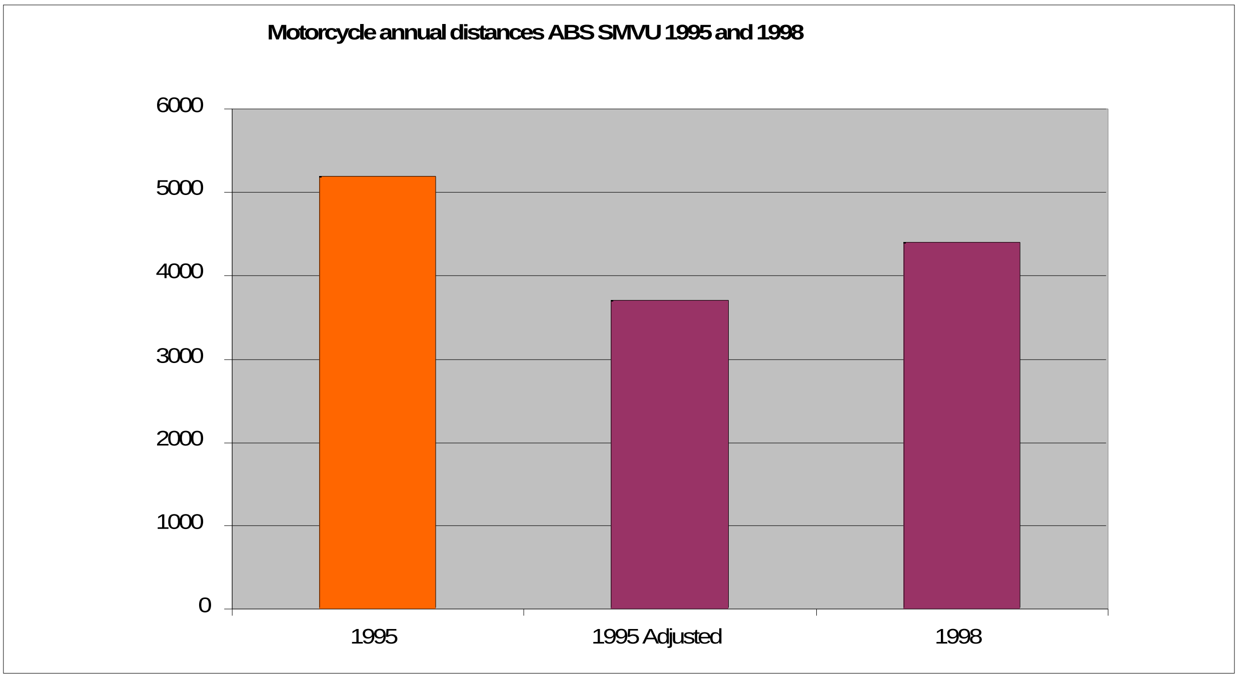


Fig. 3 ABS Survey of Motor Vehicle Usage: 1995 and 1998

The estimates for 1998 are therefore a slight increase on 1995, although when compared to the (unadjusted) 1995 values the km/year values would appeared to have declined a little over the three years. The reliability of the SMVU has recently been improved, but the full results will not become available until after the submission of the project report. The increase from 1995 to 1998 may be taken as reliable and with greater confidence than the previous results.

About 750 motorcycles were covered by the 1998 survey, and if a process of unti record reanalysis could have been considered by the ABS it is possible that the SMVU survey responses might have provided some very useful motorcycle usage. The principal investigator has proposed a possible protocol to allow such analyses to be carried out with full protection of confidentiality, and has discussed this with the appropriate ABS Director[7], and it may prove possible at a later stage to trial such an approach. However, it was not possible to pursue this in time for the present project.

3.7 Broad policy documents

A number of broad PTW policy-oriented documents have been produced in the UK and in Europe. The key such reports are

- The Sandwell powered two wheeler policy document in the UK (Tilley, 1998)

This was based on a survey in the West Midlands area, and then used as the basis for a forum of users and others to develop a full practical policy. The Sandwell document has seen extremely wide circulation, and has demonstrated both the need for such materials and the necessity to develop coherent policies for motorcycles.

It has subsequently been emulated elsewhere in the West Midlands (UK: Department of Engineering Services, 1999). Other similar reports are now beginning to appear.

It should be noted that a consistent Vulnerable Road User Mobility policy is really what is needed, as the accident cost of a pedestrian, bicycle or motorcycle/scooter accident are broadly similar.

- The Motorcycle Industry Council SMART report

This drew upon a wide range of work, and provides a professional and well laid out series of short briefs with references and photographs as well as data (UK: Motorcycle Industry Council, 1999).

This report is an excellent example of a polished and concise resource that would be useful to local and national governments when considering motorcycles, mopeds and scooters in a coherent transport context.

- The Association of European Motorcycle Constructors report (ACEM, 2000)

This report gathers a range of data and policies across the European Union (EU), and reports on a survey of 110 European cities probing what measures they were already taking in connection with motorcycles, scooters and mopeds.

[7] Personal discussions at the International Conference of Travel Behaviour Research July 2000 between the principal investigator and the ABS Director of Travel and Tourism Statistics.

4. Estimates of current levels of motorcycle usage in Victoria

Systematic investigations of the possible sources of existing data identified several partial data sources. Building on methods developed for the ANBI bicycle information base (Wigan & Smith, 1996), a small computer database has been built up to track the various sources of Australian motorcycle, moped and scooter transport and safety data (Appendix 6). This provided a readily accessible index of data sources and brief commentaries as part of the operation of the project.

4.1 ABS Population Census Journey to Work Surveys

The Australian Bureau of Statistics collects data on travel to work as part of the Population Census. As for all modes, the Journey To Work (JTW) is increasingly neither the most important nor the most frequent purpose for of travel. The absolute numbers are low (See Appendix 7 for 1991 data for motorcycle and scooter JTW trip origins over all Victoria). Females make up 9.1% of the motorcycling population riding to work, and Melbourne itself makes up 11% of all motorcycle trips to work recorded in the census, and of that fraction, 46% terminated in the inner area of Melbourne.

The density of motorcycle trips is low, and so any matrix of movements between local government areas - or even between larger units - are very sparse and contain many empty cells. Motorcycles share the problems of estimating patterns of movement for very small fractions of the traffic flow with heavy freight vehicles (Wigan & Rockliffe, 1998), but to an even greater extent. The 1991 JTW results in Appendix 7 make it clear that estimating motorcycle travel demand will require a similar combination of methods, including components of trip generation, mode choice and matrix estimation methods based on observed flows.

4.2 Previous exposure surveys undertaken for safety assessment purposes

Motorcycles have been primarily treated as a safety issue rather than as a means of transport. Most of the data available in Victoria is therefore safety-related. The reasons are clear: motorcycle users are one of the three most vulnerable road users with pedestrians and bicyclists. In 1998, motorcyclists comprised 11.5% of road users killed and 11.1% of road users seriously injured in Victoria.

When motorcyclists are injured in crashes, they are often injured more severely than other road users. Diamantopoulou, Brumen, Dyte, & Cameron, (1995) found that between 1984 and 1993, about 45% to 50% of motorcyclist casualties were fatalities or serious injuries, whereas only about 30% to 35% of all casualties were fatalities or serious injuries. In 1998, 42% of motorcycle rider casualties and 54% of all reported motorcycle pillion casualties were fatalities or serious injuries (Greenhouse Computing, 1999).

While the statistics for motorcyclists killed are likely to be quite reliable, significant under-reporting of injury crashes occurs. Diamantopoulou et al.(1995) found that single motorcycle crashes were more common in hospital admission data than in the State Traffic Accident Records, confirming this pattern. The other vehicular vulnerable road user category (bicycles) is also subject to substantial under-reporting of accidents and injuries.

Motorcycle rider and passenger fatalities in Australia have fallen from an average of 430 in the first half of the 1980s to an average of about 190 in the late 1990's (Federal Office of Road Safety, 1999). Yet little is known about the relative extents to which safety improvements and reductions in motorcycle riding may have contributed to this decrease.

There is little information available about the amount of motorcycle riding that is done and how that has changed from year to year. More detailed information about motorcycle exposure, such as the time of day that trips occur, the reasons for travel and rider demographics, is even more sparse. The only major national travel exposure survey covering all modes was carried out in 1985-6 for all people over the age of eight years (Anderson, Montesin, & Adena, 1989) (Adena & Montesin, 1988) (Instat Australia, 1988) (Socialdata Australia, 1987), but has not been repeated in the last 15 years.

The lack of adequate motorcycle travel data has hindered past efforts to understand motorcycle travel and to quantify the benefits and costs of measures to improve motorcycle safety. Most motorcycle travel studies have drawbacks in the method of sampling or inadequate sample size.

The populations of interest for the motorcycle travel studies comprise registered owners or licensed riders or riders who are recruited in the act of riding. It would be expected that travel estimates would be higher for the latter population since it excludes inactive riders.

Inadequate sample size often results when motorcycle travel is calculated from surveys designed to examine travel by all types of vehicles without an adequate stratified sampling design. For example, the substantial survey of motorised vehicle travel conducted for VicRoads in 1994 (Arup Transportation Planning, 1995) provided data on only 46 riders on metropolitan arterial roads, 53 riders in rural towns and 52 riders on rural highways.

Australia-wide analysis has shown that the fatality and serious injury rates per 100 million kilometres travelled in 1995 were more than 20 times greater for motorcyclists than car drivers (Federal Office of Road Safety, 1999). Yet these analyses were based on a relatively small sample of riders surveyed in the Australian Bureau of Statistics Survey of Motor Vehicle Usage. The data from Victoria came from only 138 motorcycle owners (171 surveyed, with an excellent response rate of 81%).

Galambos & Haworth, (1994) analysed the responses of 320 Victorian riders who completed a questionnaire designed by the Motorcycle Riders' Association of Australia. The response rate was very low (below 0.5%), given that about 70,000 questionnaires were mailed with licence renewals. Thus the extent to which the data provided by these respondents can be generalised to all licensed riders can be questioned.

A larger sample of motorcycle travel was obtained in June 1988 using a three-day diary mailed out to 2,400 riders with a learner permit or a probationary licence and another 2,000 registered owners of motorcycles in Victoria. There was a response rate of 30% (Research International Australia, 1988). As noted earlier, care must be taken in that this sample comprises potential riders, rather than active riders only.

Until the present project, the most recent Victorian study that collected motorcycle travel data was a 1997 case-control study of motorcycle crashes (Haworth et al., 1997). In this study, fifteen-minute counts were made of the numbers of motorcyclists and other vehicles that passed the crash site at the same time of day and week as the crash occurred.

Table 2. Motorcycle exposure data from some recent Australian studies

Exposure variable	Research International (1988)	VicRoads 1994 Exposure Survey	MRAA (1994)	ABS Survey of Motor Vehicle Usage 1995	Haworth et al. (1997)
Sample size	n=1320	n=151	n=320	n=138 in Victoria, other states unknown	n=1121
Population	learners permit or probationary licence holders or registered owners	riders during trips	licence holders or registered owners	registered owners	Riders passing crash sites
Total distance travelled by all motorcycles ('000 km per week)					
Australia				29,346	
Victoria				6,365	
Melbourne		792			
rural towns		99			
rural highways		1,326			
Distance travelled per rider per week (km)					
Australia				100	
Victoria			235	90	
all riders					Median 201-300
novice riders	140				Learner median 101-200 Probationary median 201-300
non-novice riders	160				Full licence median 201-300
Distance ridden by engine capacity	>500 cc ride further		>750 cc more likely to ride over 250 kms/wk		>750 cc ride further than other full licence holders
Frequency of riding	about 40% rode on any given day		75% rode daily or 2 to 3 times per week		78% ride 3 or more days per week

(Haworth et al., 1997)

A limited number of observational variables were collected for those motorcyclists who did not stop and those who stopped but declined to participate in the study. For those who stopped, additional information was collected, focussing on the current trip (including photographs and BAC if riders agreed). A follow-up telephone interview assessed longer-term issues such as training and licensing. Table 2 (Haworth et al., 1997) summarises motorcycle exposure data from some recent Australian studies.

The VicRoads 1994 Exposure Survey (Arup Transportation Planning, 1995) gave lower estimates of total distance traveled by motorcycles than the ABS Survey of Motor Vehicle Use for 1995 (Australian Bureau of Statistics, 1996). Haworth speculates that this may have reflected that the earlier study was conducted during the cold months of July and August when motorcycle riding is anecdotally considered to be less popular.

This may also have contributed to the lower percentage of travel by motorcycles observed in the VicRoads 1994 Exposure Survey. However, when the 1998 ABS recall bias corrections are applied to the 1995 SMVU data (see Fig. 3), then the annual distances covered are in closer agreement. The estimated distance traveled per rider per week was similar for the MRAA study and the current study. Both the Research International study and the current study showed that non-novices rode further per week than novices. Those studies which measured distance traveled per rider according to engine capacity reported greater distances for larger capacity motorcycles (greater than 500 cc or greater than 750 cc) than smaller capacity motorcycles.

The new survey carried out for the present project (‘Oxford 2000’) is reported in Section 5, and yields a raw unweighted average km/week for motorcycle riding of 222 km/week (n=140):, squarely in the middle of the range found by Haworth et al. (1997). Appendix 8 contains a full list of the definitions, mean values, standard errors and the maximum and minimum values recorded for all the variables in the Oxford 2000 survey.

The data presented in Table 2 do not indicate any unambiguous changes in the exposure patterns of riders from 1988 to 1996. While the ABS Survey of Motor Vehicle Use (Australian Bureau of Statistics, 1996) showed that the number of registered motorcycles in Australia decreased from a level of about 350,000 in 1982 and 1985 to about 280,000 in 1988, the numbers have remained almost constant since then. The values obtained by the SMVU up until the most recent survey (due to be updated in late July 2000) have very high standard errors, and the earlier surveys are not felt to be a good basis for further analysis.

However, the UK is well equipped with transport exposure data due to the regularly-run National Travel Survey, which provides passenger mileages for all modes of transport and their users. Combining this data with the reported accident data for powered two wheeled vehicles gives a picture of the vulnerability of the two road-based vulnerable road users: bicycles and motorcycles. Similar data is not available on a consistent basis for Australia. The casualty rates for bicycles and motorcycles are now almost the same, with a significant improvement in the motorcycle rates and small deterioration for bicycles over the 15-year period for comparison.

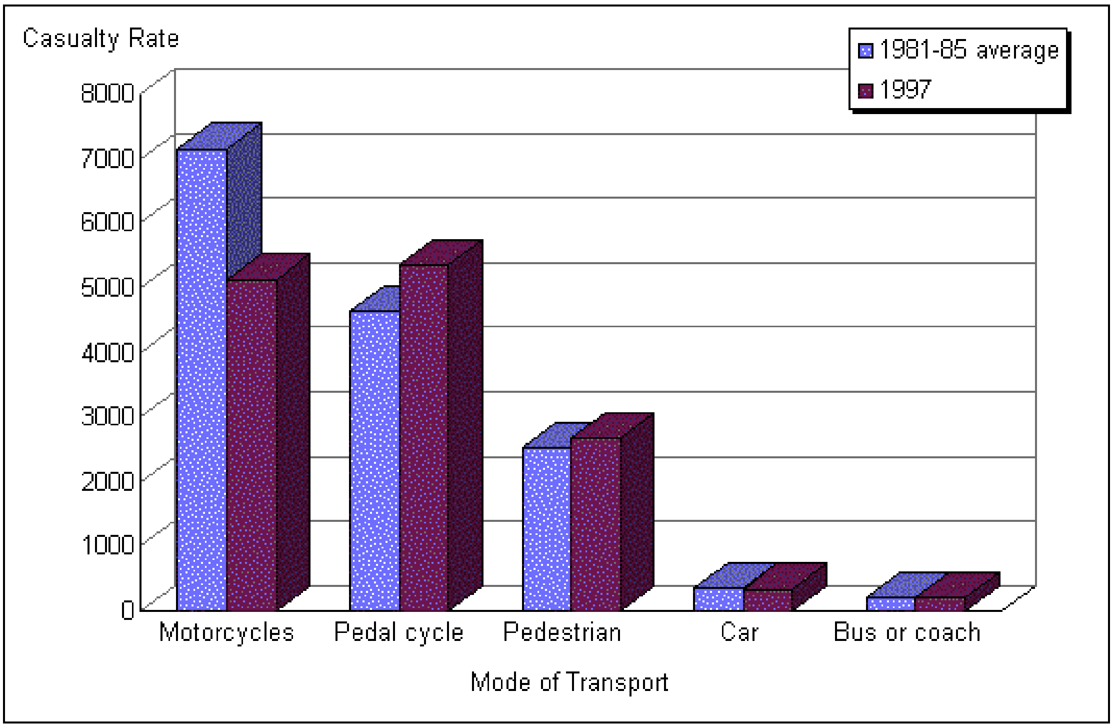


Fig. 4 UK Casualty Rates per Billion Passenger Kilometres by mopeds, motor scooters, motorcycles and motorcycle-sidecar combinations.

4.3 VicRoads traffic count data

VicRoads collects extensive traffic count data, using both manual classified counts and automatic vehicle detectors with length discrimination to pick out motorcycles. The automatic vehicle detection equipment used up until 1995 was the ARRB VDAS. This was set up to pick out motorcycles by their length in a software modification executed in the early 1990's. At most of the VDAS sites the numbers of motorcycles were comparable to the number of detected errors in the counting system, which strongly suggests that this technology was not sufficiently refined be used for motorcycle counting. An example of the VDAS data is given in Appendix 9. New and more sensitive techniques have become available, and as traffic contractors to VicRoads re-equip, automatic counting is expected to include motorcycles.

Recent automatic traffic counting equipment is capable of counting solo motorcycles reliably, but the tendency of groups of motorcyclists to travel together means that the patterns of detection often lead to their identification as a set of cars and trucks rather than as a number of motorcycles[8]. This is caused by overlapping machines and multiple vehicles moving across the counting point simultaneously. Consequently only visually based counting mechanisms and procedures will avoid this problem when seeking to discriminate reliably between individual motorcycles when they are moving as a group.

The manual data is collected in different ways:

- 4hr segments are all collected off-peak, from 10-12am and for 1-3pm on weekdays
- 12hr counts are done from 7am to 7pm on weekdays
- 24hr counts are also collected only on weekdays

[8] Personal communication: John Reid, Australasian Traffic Surveys

A full list of all these manual classified counts from Nov 1997 is given as Appendices 10 and 11. Motorcycles comprise less than 1% of the traffic flow in almost all cases. Any differences from the levels of weekend travel by motorcycles could not be detected by the manual counts as these were undertaken only on weekdays.

However the Victorian Case Control Study (Haworth et al., 1997) confirmed that there is a higher percentage of motorcycles at weekends – but also a lower absolute number on the road at that time.

Table 3 Motorcycles as % of traffic in VicRoads manual traffic counts (1997-0)

	Average % of Motorcvcles			Number counted		
Year	4hr	12hr	24hr	4hr	12hr	24hr
1995	0.30%			18		
1997	0.30%	0.40%	0.40%	40	4	36
1998	0.40%	0.90%	0.50%	181	30	90
1999	0.40%	0.60%	0.60%	166	72	48
2000	0.50%		0.50%	72		174
Over All periods		0.50%		All	757	

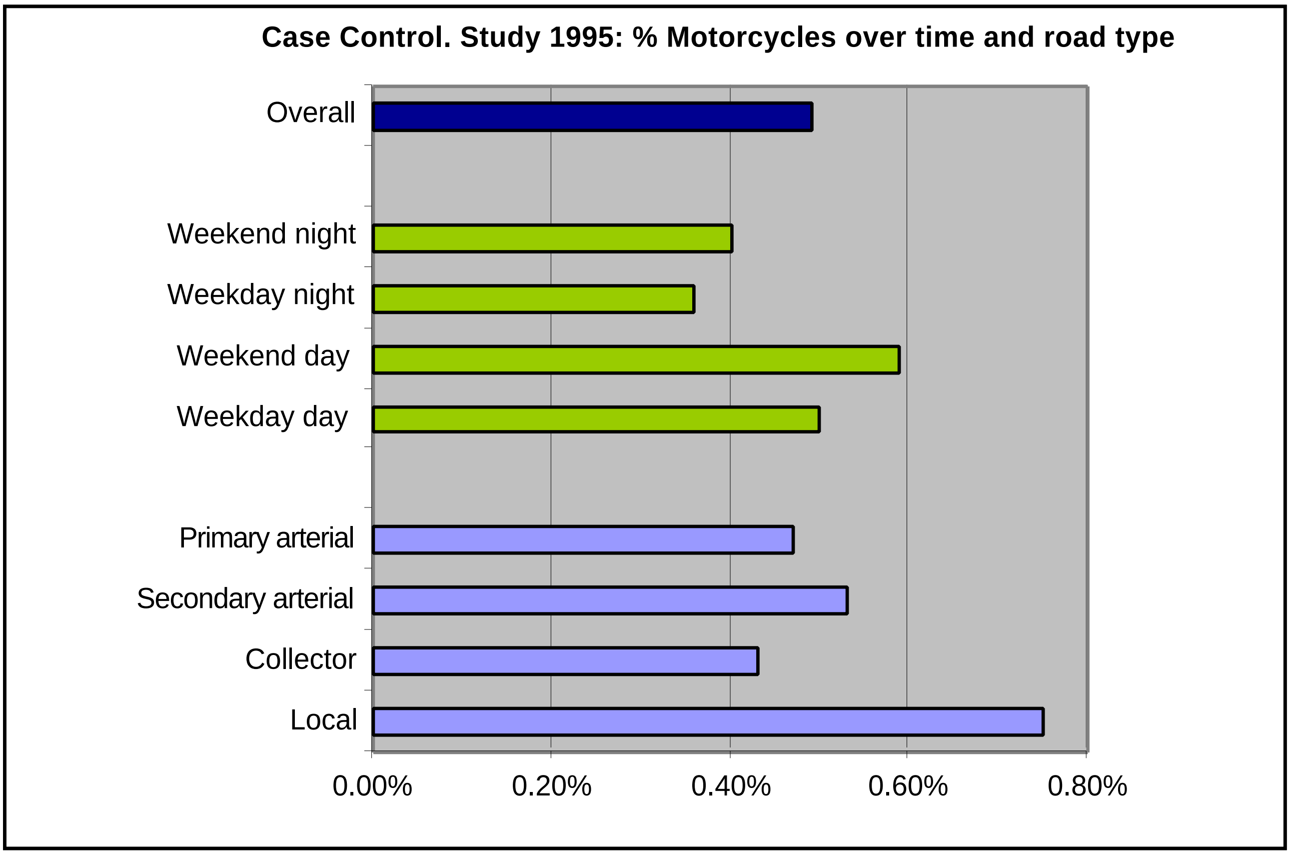


Fig. 5 Variations in 1995 motorcycle traffic flow as a percentage of total flow

Tables 3 and 4 both show that the overall traffic flow levels are consistently low, and reasonably consistent at about 0.5% of traffic flow at the sites examined by VicRoads and the 1995 case control data of 1121 motorcycles (Haworth et al., 1997). This provides a useful basic yardstick for motorcycle flows over the Melbourne network. The overall levels of traffic are reasonably consistent, and suggests that for traffic flow forecasting using a value of 0.5% of total vehicle flow will represent a good basic planning model for policy appraisal.

In support of this approach to motorcycle flow estimation, a UK video study of motorcycle and bicycle flows in Nottingham UK found that motorcycle flows were correlated to total flows, while bicycle flows were not (Bell & Dolphin, 1990).

Table 4 Motorcycles as % of total traffic in Case Control Study

% Motorcycles	Local Roads	Collector	Secondary Collector	Primary Arterial
Road Type	0.75%	0.43%	0.53%	0.47%
	Weekend		**Weekday**	
Day	0.50%		0.36%	
Night	0.59%		0.40%	
	Case Control	**Victoria**	**Australia**	
Overall	**0.49%**	**0.80%**	**0.90%**	

(Haworth et al., 1997)

The difference between motorcycle flows on primary arterials and collector roads is significant, otherwise no significant difference between any other pair of road types could be detected. The proportion of motorcycles at night was lower than during the day.

4.4 Accident data as a basis for motorcycle travel estimation

The case control study also examined relationships between the number of motorcycle accidents and the many factors covered in their surveys of the riders and the road environment. Only one factor could be determined to be significant.

Number of Crashes during the study = 6.5 x mean number of motorcycles observed per hour

This equation explained 79% of all the variance in the number of crashes per time period or per road type (Haworth et al., 1997) (p135). This means that motorcycle traffic flow estimate can, as at least a reasonable approximation, be estimated from the numbers of motorcycle crashes. For more refined work, any differences between the levels of reporting of motorcycle crashes in the Case Control Study and those recorded in the VicRoads continuing database of reported crashes would require an adjustment to this equation.

The VicRoads CrashStats accident system is available on the web and until recently was available only as a CDRom package (VicRoads, 1996). The accident sites database and the digital line database from Crashstats was loaded into a GIS

(Geographical Information System) package[9] and the central business district selected.

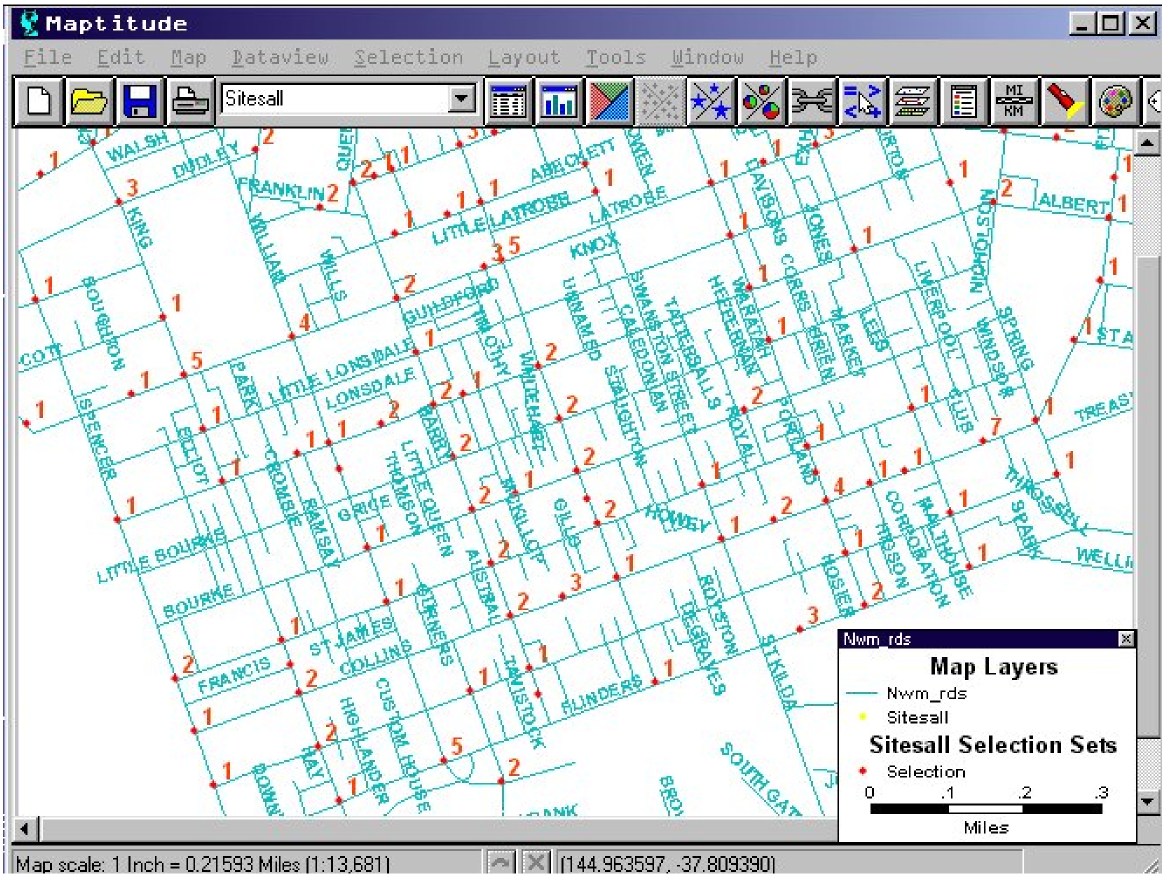


Fig. 6 Motorcycle crashes from 1991-1995 in the Melbourne CBD

Figure 6 shows the streets and the motorcycle accident sites, with the numbers of motorcycle crashes beside each crash site. The numbers of crashes apply to the whole period from 1991 to 1995, and the crash control study extended over a period of 15 months. The appropriate equation for traffic forecasting use on this basis is therefore:

Motorcycles/hr = No of motorcycle crashes in a year * 0.192

For the values in Figure 6, the number of crashes shown on a road section should be divided by 5 to get the annual reported crash rate from the values displayed. This approach depends on the underlying rates of motorcycle crash occurrences not moving very quickly but certainly provides another and useful means of estimating motorcycle flows at a more detailed level than the simple 0.5% deduced from the VicRoads manual counts. It should again be noted that VicRoads commissions manual counts for a range of different purposes, and even the 700+ summaries here do not necessarily represent the overall traffic flows in the city or the state

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[9] Maptitude by Caliper Corporation: this database was created by the principal investigator for the AURISA GIS in Schools Competition (Wigan, 1998)

The GIS can be used to calculate the numbers of motorcycle crashes along any length of road, and to compute the equation above and display the results as a visual map. This type of spatial model of motorcycle flows and crashes is also ideal for integrating motorcycle facilities when these are installed.

4.5 Data on motorcyclist choices from parking surveys in Central Melbourne

The motorcycle travel to the CBD is an area where much attention is justified. The CBD is the major economic activity area in Melbourne, and a major employment, personal services and shopping zone. The motorcycle trading area in Elizabeth St is the oldest motorcycle precinct in the world, and an international tourist attractor in its own right. Traders park large numbers of motorcycles along the wide footpaths and there are high levels of pedestrian movement, motorcycle and shopping activity.

Motorcycles have been permitted under State law to park on the footpath since 1986, but not to cause obstruction. While the conflicts have been very few and often associated with courier activity, the small number of documented complaints suggests that it has been a very successful policy, and one that has attracted a continuing level of additional economic activity to the CBD.

However, concerns continued in some quarters. In 1998 Melbourne City Council undertook a survey of motorcycles parked in the CBD (Melbourne City Council, 1998). This survey included the preferences for each mode, the reasons for riding motorcycles and the mode choice for different journey purposes.

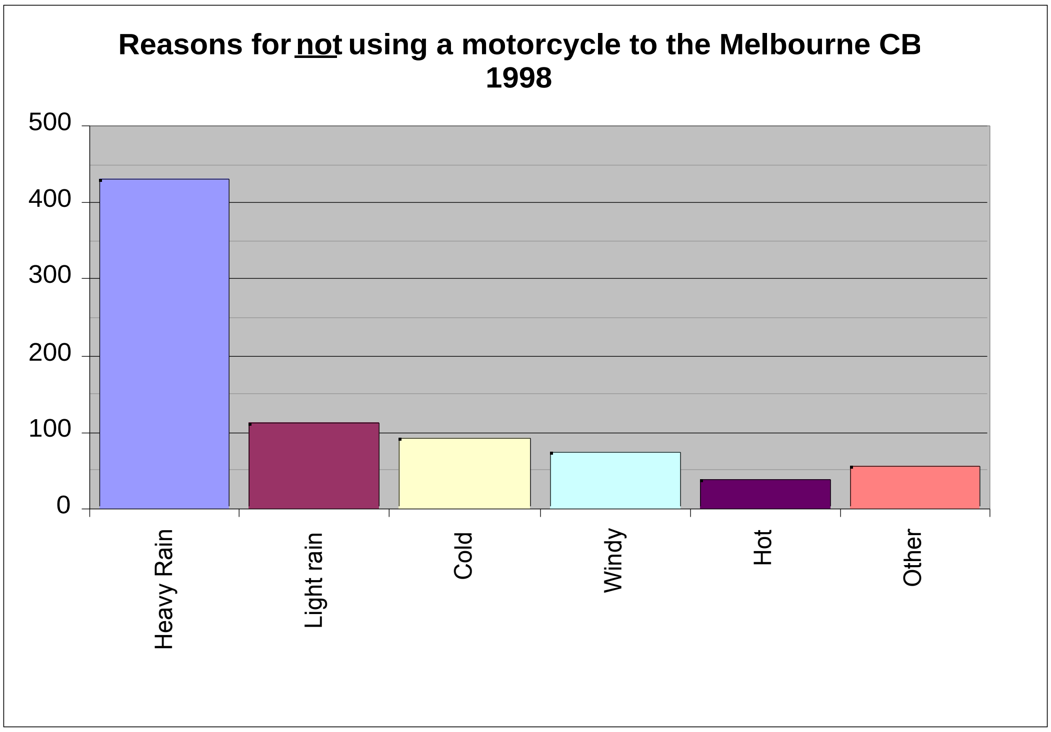

Fig. 7 The top two reasons for not choosing to use motorcycles (Melbourne 1998)

The parking issue was important, and two thirds of the respondents would ride less to the CBD or not at all if footpath parking was not available. 73% would visit the CBD more often if dedicated footpath parking was available in useful locations.

The survey sample was skewed to motorcyclists already parking on the footpath in the CBD, and a response bias towards maintaining such a facility would have been inevitable as this has been a controversial issue for motorcyclists and there was wide support from motorcycle organisations. This resulted in about 930 survey responses, but on other issues the surveyed population data could reasonably be expected to contain less potential bias.

It is not surprising that the top priority motorcyclists using the CBD is congestion. It is less obvious that travel time would be rated more highly than economy, and emphasises the need for motorcycle-specific valuations of travel time. When combined with the high levels of car access and the long average trip lengths for motorcycles, this suggests that motorcyclist may value their time at a higher than average rate. No data is presently available on motorcyclists time preferences.

Wet weather in the most important condition that causes motorcyclists not to ride, and this is consistent with the current “Oxford 2000” surveys.

Of the ‘other’ reasons for using a motorcycle to the CBD, ‘enjoyment’ was the most important.

Questions on choice of mode for shopping, entertainment and business in the CBD all listed motorcycles as the first choice and cars the second (in terms of numbers of respondents). Motorcycles are less popular at night and cars more so.

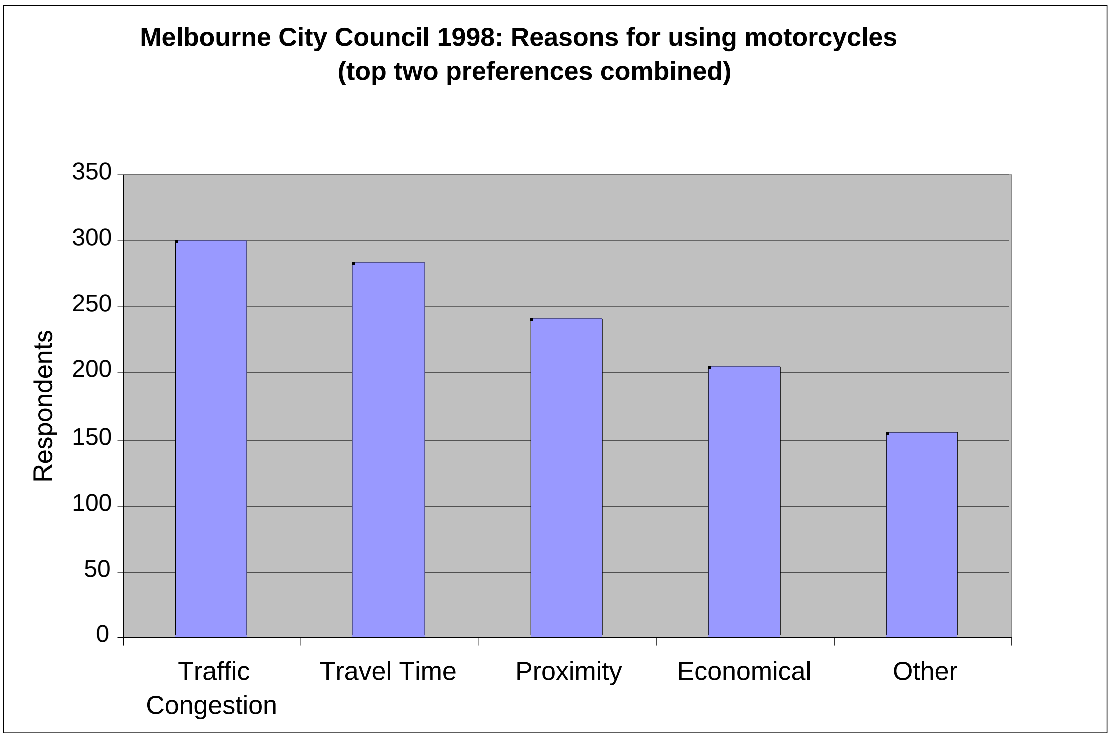

Fig. 8 Reasons for using a motorcycle to go to the Melbourne CBD

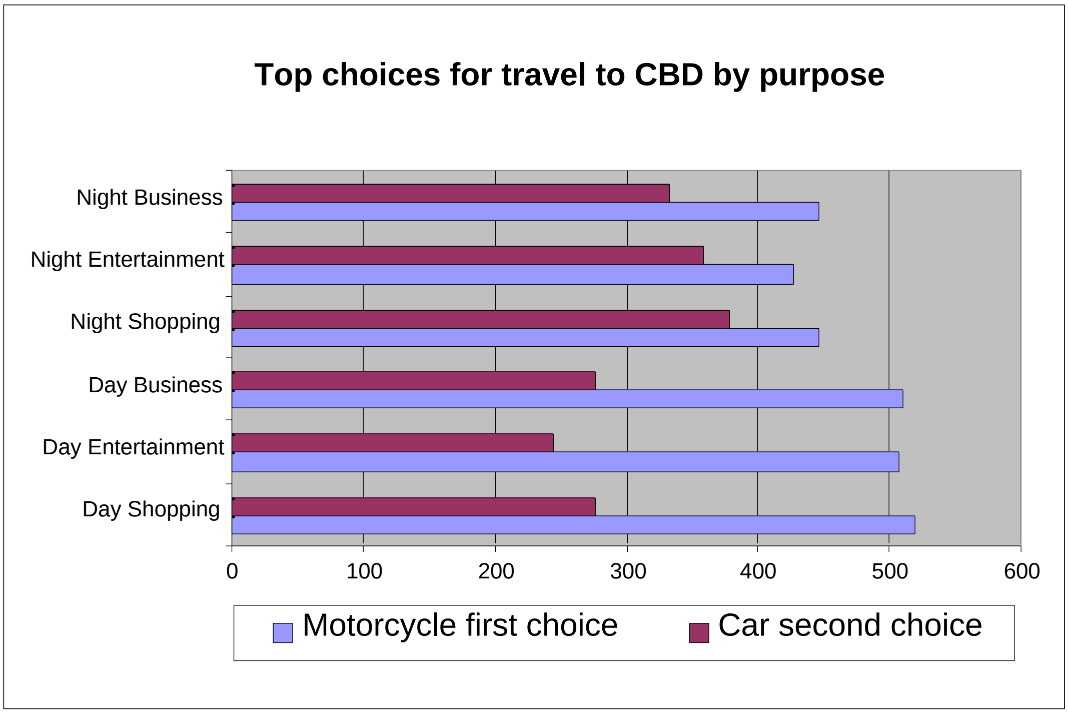

Fig. 9 Reasons for travelling to Melbourne CBD by purpose

These results rely upon a survey clearly targeted at motorcyclists already using their machines to go to the CBD, and with a strong potential for a self-serving bias in the responses towards the choice of motorcycle parking. However the results for reasons for *not* using a motorcycle, the patterns of mode preferences by purpose, and the relative priorities of time and cost are self-consistent and reasonable and less likely to be biased.

4.6 Data on motorcycle travel from the 1986 Australia-wide FORS Exposure survey

The most recent Australia-wide travel exposure survey was carried out in 1985-6 for the Federal Office of Road Safety (Anderson, Montesin, & Adena, 1989) (Adena & Montesin, 1988) (Instat Australia, 1988) (Socialdata Australia, 1987). This survey can be used to gain a broad perspective on travel by gender by all modes including walking (Wigan, 1995) and motorcycling.

This FORS survey covered all states and territories for people over the age of eight. The travel times and distances can be computed, and the mean speed of travel by each mode by each age can be deduced. As motorcycles are still predominantly a male mode, only the males were included in Figure 10.

The results are that overall motorcycles are the fastest mode of travel shown, followed by train, bus and bicycle in that order. This data includes a substantial amount of rural, country town and non-metropolitan travel, and all states and capitals. Consequently long distance train and bus travel are included under bus and train travel.

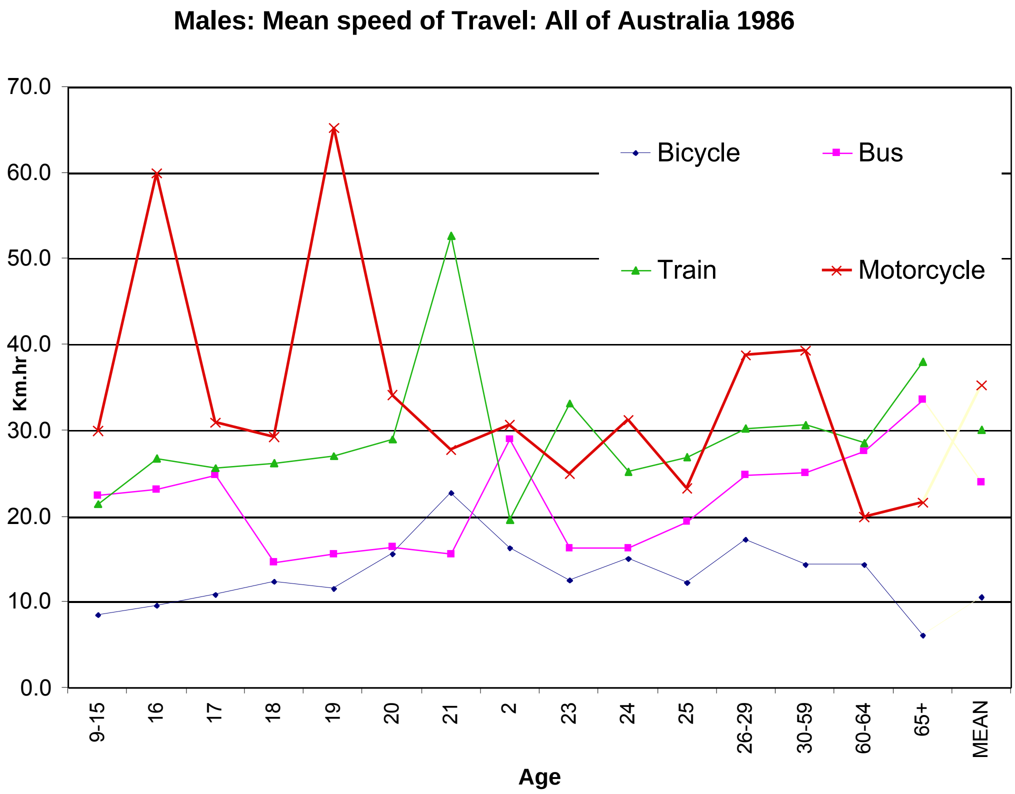

Fig. 10 Mean speeds of travel by mode by age for males: Australia 1985-6 (FORS National Exposure survey)

4.7 Data from the Victorian Activity and Travel Survey 1995-1998

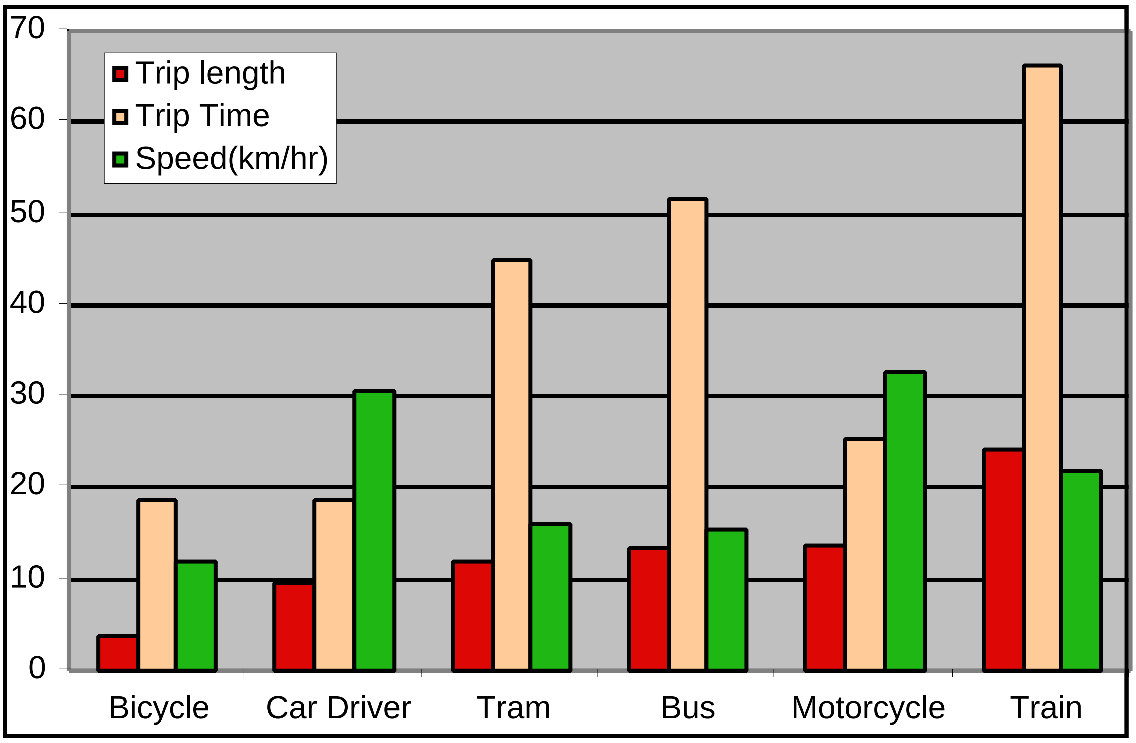

Fig. 11 Travel times and speeds by mode in order of trip length: VATS 1995-8

The most recent transportation data available for Melbourne is the Victorian Activity and Travel Survey (VATS) (Transport Research Centre, 1999). This survey does not contain perceived choice information, but can be used to place motorcycles in a similar context to the FORS survey specifically for Melbourne.

Figure 11 shows travel speeds and times in rising order of trip length. Bicycles demonstrate the shortest mean trip distance, and train and motorcycle the longest. Motorcycles, car driver and train trips are the fastest modes (in that order). This shows the effective ‘transport’ performance envelope of motorcycles where they cover the second longest mean trip distances and are also the fastest. This type of analysis summarises the ‘transport’ aspects of motorcycles in Melbourne and is perhaps the most concise way of placing motorcycles in an urban transport context.

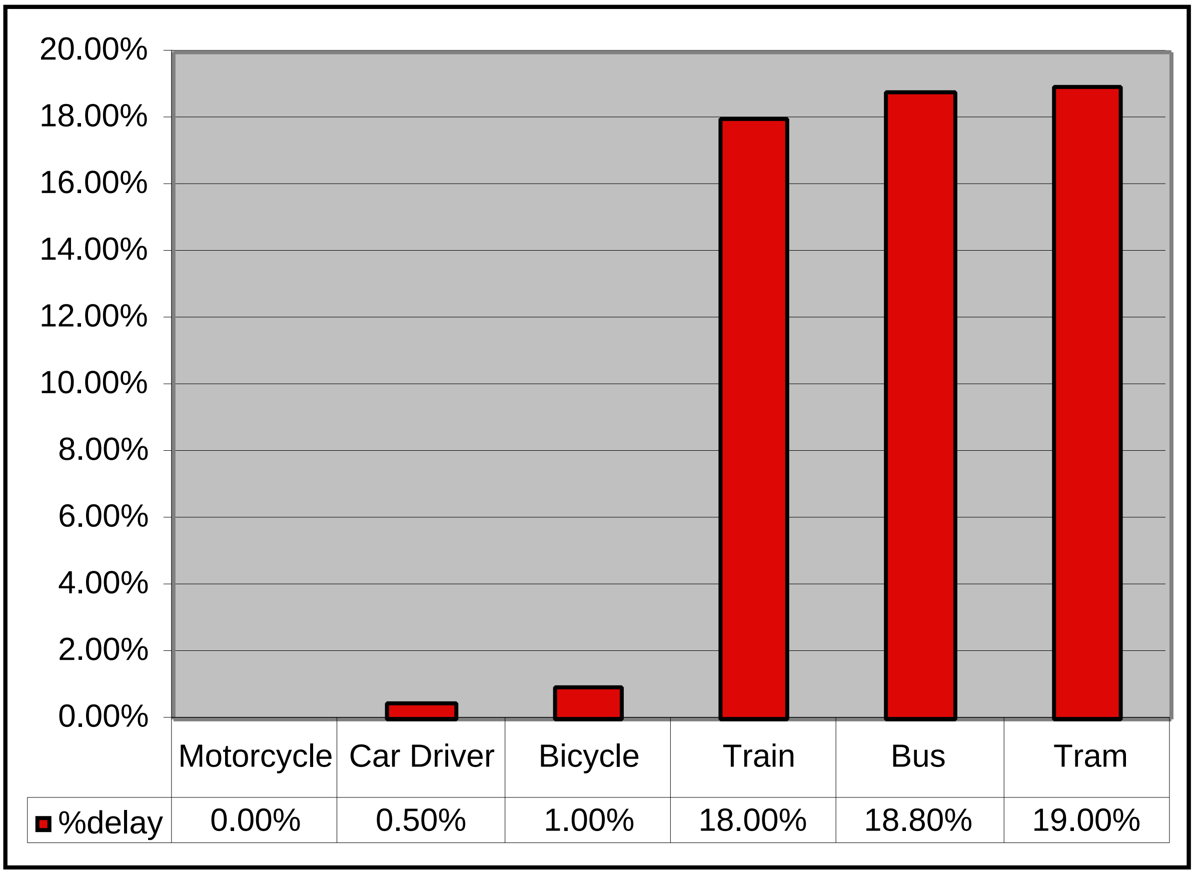

Fig. 12 Modes in order of % of delay as percentage of trip time: VATS 1995-98

VATS also allows the manner in which such transport performance is delivered to be explored. Figure 12 shows the percentage of travel time spent stopped or delayed by each mode. The public transport modes must stop to allow passengers to broad or alight, but the data includes the long distance and limited stop train and bus services.

Figures 11 and 12 (and the more detailed VATS data in Appendix 12) show that motorcycles deliver a high degree of transport efficiency in movement, and when allied to the ability to park in close proximity of their destination, this data tends to support the claims of riders that motorcycles are a very effective transport mode in what is has become a reasonably congested city.

5. New surveys on motorcycle, moped and scooter users in Victoria

The data in shortest supply for Victorian PTWs are operating costs, multiple vehicle ownership levels and patterns and the bases for choice between different available modes of transport for specific trips.

Previous surveys of motorcycle and moped users have had a fairly low response rate, unless a specific user group was surveyed with special encouragement to respond. The ABS has a very good record in this regard, but as discussed in the case of the SMVU, there still remains a need to do additional work on response corrections. The survey methods designed for the present project were tiered in design and progressed from random samples of households to targeted coverage of specific user groups.

The survey instrument was piloted with groups of motorcyclists through three cycles of design, comment and retest. The questions in the final design could be summarised on a single page as given in Appendix 13 (the cover letter follows in the same Appendix). Ethics approval was obtained from the RMIT University Business Faculty Ethics Committee. This approval covered the confidentiality of the data, the voluntary nature of participation, and a contact number for the use of anyone concerned about the content or having any questions about the survey. Only three calls were logged, and all were followed up with the respondent by the principal investigator.

The key objectives of this survey were to:

- Identify multiple vehicle ownership./access by motorcyclists
- Gain an appreciation of the reasons for choice of mode under different conditions
- Gain an estimate of perceived operating costs of motorcycles
- Obtain distances traveled and reported and unreported crashes

Motorcyclists are frequently highly committed to their chosen mode of transport, but the factors determining their choices have rarely been examined. There have some suggestions that the intrinsic enjoyment of the use of the motorcycle could be important (Rheinberg, 1991; Schulz, Gresch, & Kerwien, 1991). Consequently ‘just riding to enjoy’ was included when interviewing or mailing out to both motorcycle and car respondents.

5.1 Telephone and mailout surveys

The initial sample frame of 3000 households was drawn from the RMIT University Transport Research Centre (TRC) household index for greater Melbourne. Telephone interviews were embarked upon, but the response rate was very low. After 100 calls, only 28 responses had been obtained only two of which were houses containing motorcycles or scooters. These poor response rates are unfortunately in fair agreement with other surveys. The surveys with a defined response rate are listed in Table 5. In addition six motorcycle couriers were both interviewed and completed survey forms, Twenty-two responses were obtained by direct field recruitment in the CBD.

The cooperation of the motorcycle industry was secured, and a sample of 130 randomly selected Honda owners was drawn from a warranty registration database. Only a slightly improved response rate was obtained, but the high levels of unopened and returned envelopes suggested that the version of the warranty data base employed to provide us with the addresses had not been updated recently. A mailout to 60 Honda scooter produced a very low response rate and many returns of unopened survey envelopes. A similar mailout to 30 ItalJet scooter owners produced a good response and no returns of unopened survey envelopes.

Table 5. Motorcycle surveys: response summaries (Oxford 2000 Surveys)

Survey summary	Contacts	Motorcycle Responses	Car-only responses	Refusals	Motorcycle Success rate	Refusal rate
Telephone	100	2	26	72	**2.0%**	72.0%

	Contacts	Responses	Unopened Envelopes Returned	Success rate	Unopened Return rate
Telephone (Motorcycle responses only)	100	2	72	**2.0%**	72.0%
Honda Motorcycle and Scooter mailouts	190	16	58	**8.4%**	30.5%
VicRoads Call Centre motorcycle calls	500	83	8	**16.6%**	1.6%
Italjet Scooter mailouts	30	6	0	**20.0%**	0.0%

The most effective method of survey deployment proved to be the use of the VicRoads Call Centre to ask motorcyclists calling in if they were prepared to participate in the survey. If they agreed, then the prepared blank package had the address added and it was mailed to them. This method gave a far higher response rate, although still low in absolute terms. It was however the most successful and cost effective of the range of telephone and mail methods and sample processes used.

The telephone survey method yielded a 2% motorcycle response rate and a 26% car user response rate from 100 calls. Given a sample frame of 3000 telephone numbers this would have produce approximately 200 responses from motorcyclists in a valid random sampling frame, however the time taken to complete the 100 calls was several days due to the restricted hours in the day that responses could be obtained, and the elapsed period to obtain the full 3000 would have exceeded the whole project period.

The need to concentrate calls into a narrow window during the evening was a major factor. The failed contact calls during the day were mainly non-existent numbers, answering services, elderly people without transport or non-English speaking respondents. Telephone surveys are increasingly difficult to undertake, and all the survey methods other than direct contact (opportunity samples) met with the lowered response rates that have recently become widespread for many types of survey.

Two firms in the motorcycle distribution industry (Honda and ItalJet) cooperated by providing a sample of purchasers and their addresses. Two samples were sent out to purchasers in the last three years of Honda on-road motorcycles and scooters. The high unopened envelope return rates showed that the use of warranty databases for such surveys tend to become less productive as the time from the first purchase increases. Three other manufacturers (Yamaha, Aprilia, Piaggio, Triumph and Harley Davidson) offered assistance, but the end of the Tax Year and the onset of the New Tax System made it very difficult for them to provide lists required for the June mailings.

The lowest unopened envelope return rate (nil) and the highest response rate (20%) was obtained from the small mailing to recent purchasers of Italjet scooters. This could be attributed either to the recency of the purchase - ensuring that the returns as 'unknown' would be minimised - or that the population involved in scooter purchase (which, anecdotally, from scooter dealers, is genuinely different to motorcycle purchasers) and simply more likely to complete surveys. Discussions with scooter importers strongly suggested that the scooter purchasing population was indeed very different to that purchasing motorcycles.

The VicRoads Call Centre was the most effective survey option overall. Callers enquiring about motorcycle issues were asked if they would participate in the survey. Unfortunately, the VicRoads amalgamation of registration and licensing call handling meant that a significant number of callers were asking about penalties and points against their licences. The acceptance rate was therefore lower than expected, and there may be some biases in the sample from more frequent offenders. It was not possible to obtain statistics on the responses by such enquirers as the survey instrument was anonymous, and there is no way to link survey forms returned to any previous contact or person.

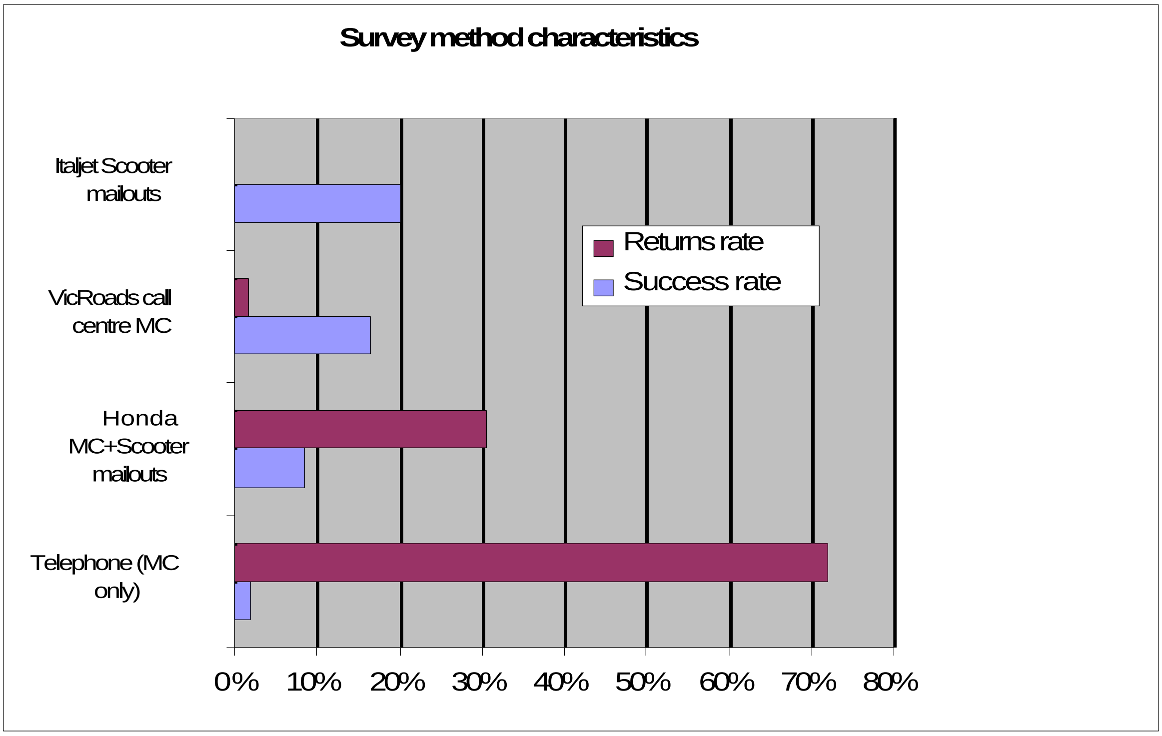

Fig. 13 Response and returns rates for the different techniques used

Opportunity samples were secured using field interception. It was noted that the use of an experienced motorcyclist altered the completion rate to 75-85% of all those approached. The mail return rate was also higher, at about 33% of those provided with survey forms, but who did not complete them on the spot. This technique appears to be the most cost effective, but has the limitation of requiring careful choice of sampling locations and timings to provide a sample that can be properly scaled to represent the full population of motorcyclists.

A total of 127 motorcyclist and 12 scooter riders had returned survey forms as the input for this report was closed. The data was coded, input to computer and verified using SPSS 9. Any personal information was deleted from the project version of these files. Three inbound query calls were received and responded to from the 800 survey forms sent out. These callers were concerned equally about the possibility of the information being used to "further disadvantage motorcycles, scooters or mopeds" and a wish to know how their personal address had been selected.

6. Motorcycle survey results (the Oxford 2000 Surveys for the present project)

The telephone survey was useful to secure a small sample was taken of non-motorcycle owning people. The annual mileage by car by the two groups (those in car-only and motorcycle owning households) was calculated by gender of the respondent.

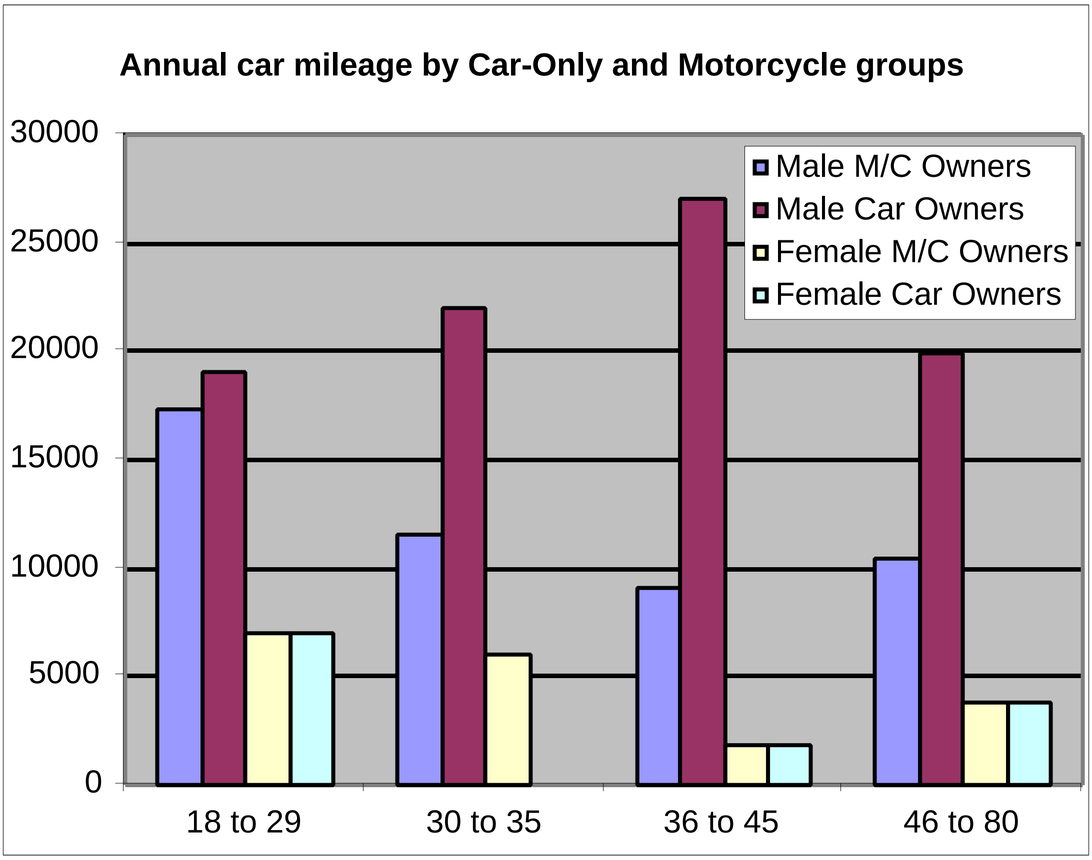

Fig.14 Annual car mileages by car-only and motorcycle owners by age and sex

The car-only samples are very small, but sufficient to show a significant difference (p <0.05) between the mileages reported by the two genders in both types of households. Females reported far lower car mileages at all ages, in both types of household.

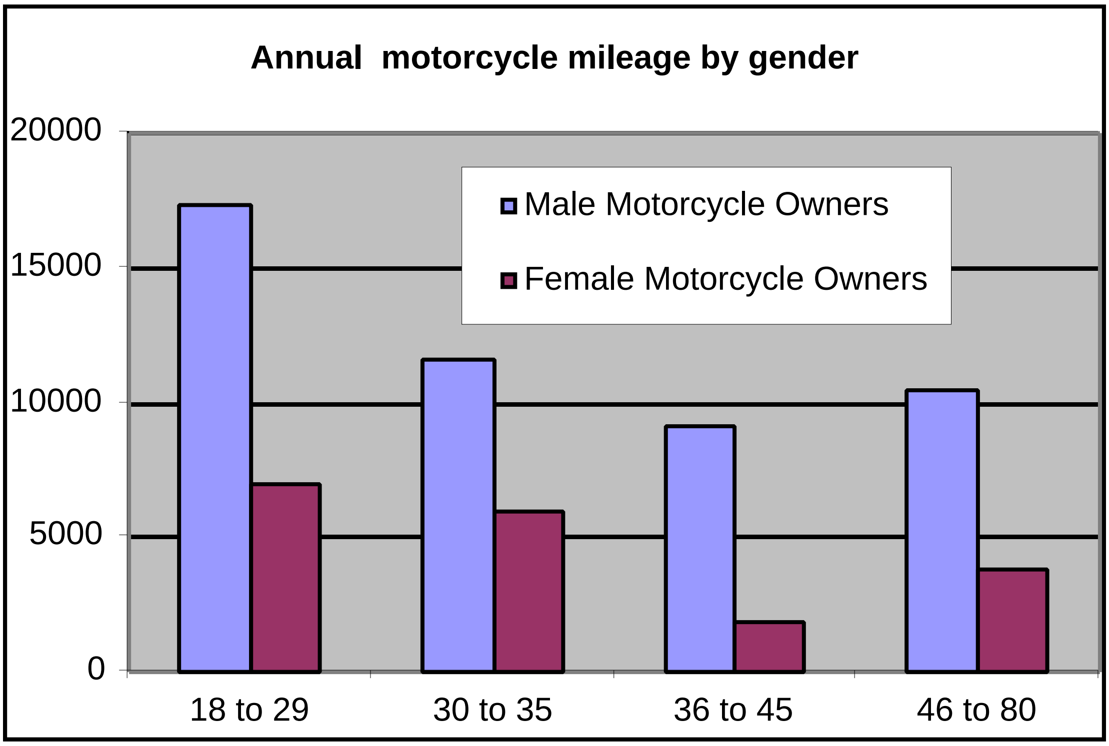

Fig.15 Annual motorcycle mileages by motorcycle owners by age and sex

Motorcycle owners of all ages appear to gain great enjoyment out of the process of riding. On the other hand public transport is virtually never used for pleasure. Clearly it is not simply for the joy of travelling, as their bicycle and car use shows. The motorcycle is a distinctive mode for these owners.

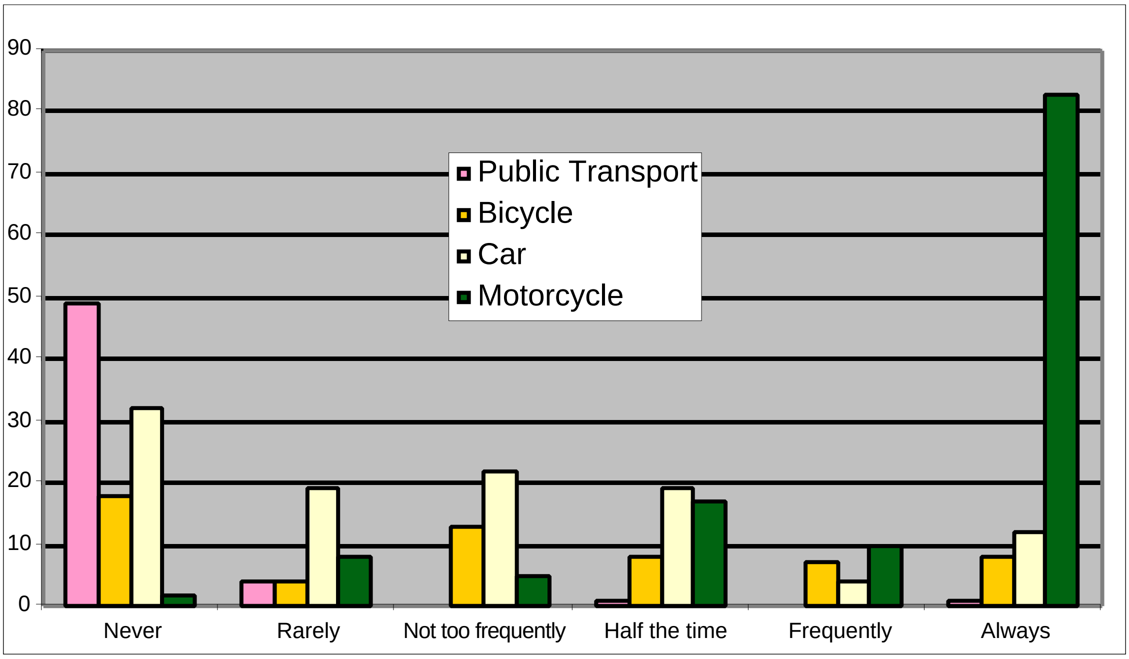

Fig.16 Use of different modes for enjoyment: motorcycle owners

The tolerance of motorcyclists to cold and hot conditions is consistent with this interpretation, while the levels motorcycle usage for the journey to work are only slightly reduced by the wet weather that is the major reason cited for not using their motorcycle.

These findings are particularly useful as these users have a choice of mode or their different forms of travel in any Stated Preference experiment (Hensher, 1994) it is likely that a large alternative specific constant (ie. a substantial weight in favour of the choice of motorcycle as against other available modes) will be associated with the choice of motorcycles for different forms of travel.

Such experiments are now appropriate, now that the basic pattern of choices are clear, it is necessary to determine how much people will pay for different aspects of their choices. This will then allow better evaluations of likely responses to policy changes, and also to improved models of motorcyclist behaviour.

People without a motorcycle appear to regard the bicycle rather positively as a vehicle for enjoyment, although motorcycle riders also look favourably on bicycles for enjoyment.

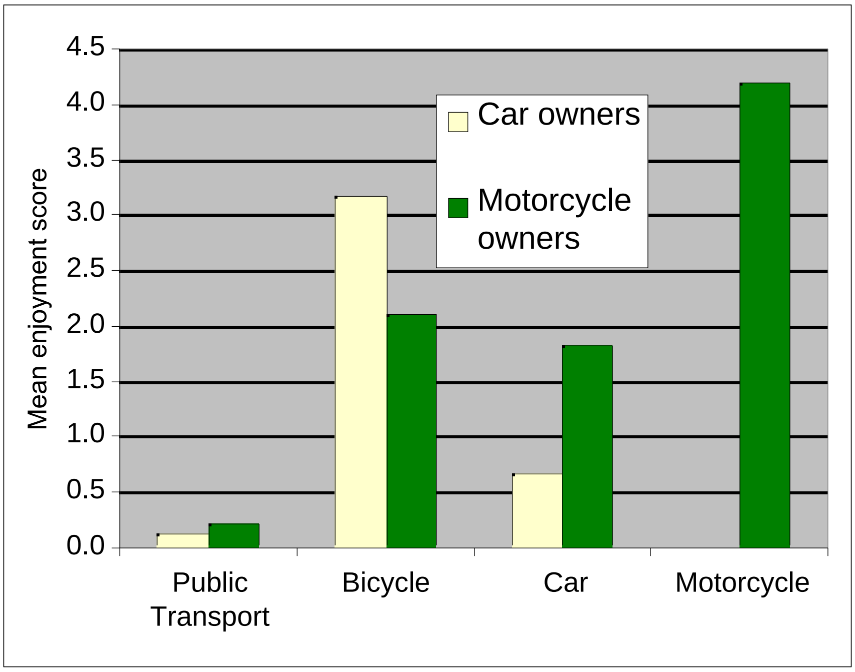

Fig. 17. Non-motorcycle owners: patterns of modal choice for enjoyment

These results are only a few of those that can be derived from the Oxford 2000 survey, but are particularly useful for understanding key mode choice characteristics of motorcyclists. The comments written onto the survey forms by the respondents contain a wide range of views, which help to illuminate motorcyclists concerns (Appendix 14).

In Figures 16 and 18 the vertical axes are the actual number of respondents expressing a view. There are 140 motorcyclists and 32 car owners. Consequently a far higher proportion of car owners than motorcyclists expressed their views. The motorcycle owners surveyed enjoy the process of driving both kinds of powered vehicles more than those owning only cars.

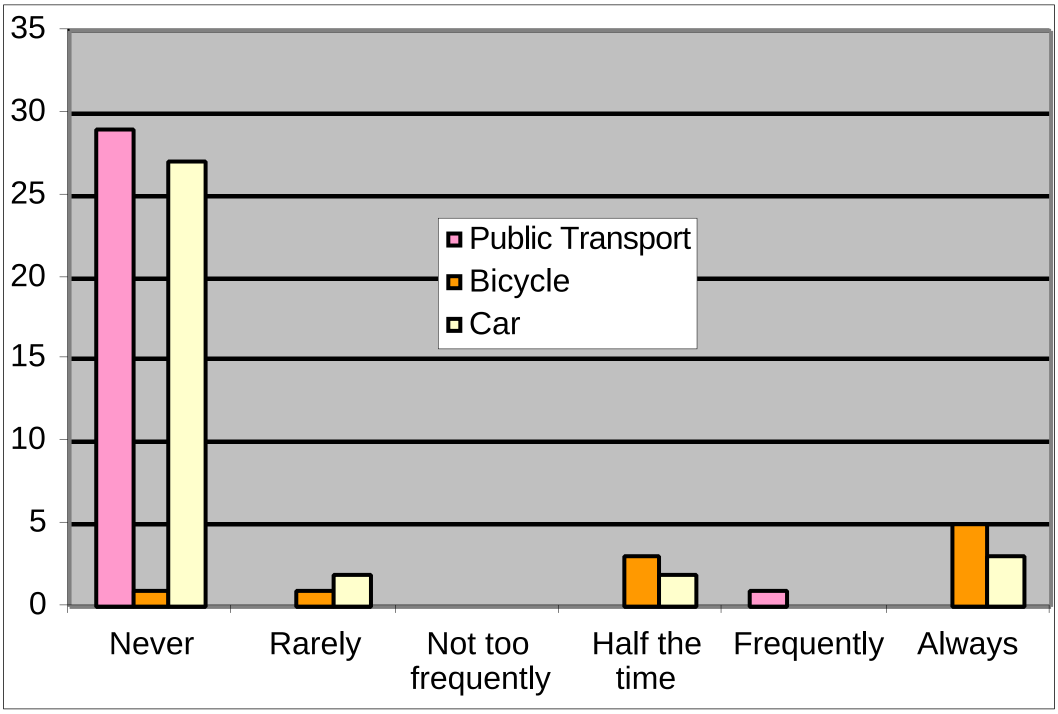

Fig. 18. Non-motorcycle owners: patterns of modal choice for enjoyment

7. Special rider groups

Two special groups of riders were approached to obtain further information about motorcycles as transport for professional riders. These were motorcycle couriers and police riders on a variety of tasks. Data was also obtained from Sydney where motorcycle MICA paramedical emergency vehicles are now in use. Specific features of motorcycle use in congested areas was sought to complement the transport usage of ordinary motorcyclists.

7.1 Courier riders

Gaining access to motorcycle couriers is not straightforward. Couriers have a poor image (Hamer, 1996) in several counties, and Hamer points out that the London motorcycle courier accident rate is 2-5 times that of other motorcyclists. It is possible that their mileages are correspondingly high (in the Oxford 2000 survey this appears to be the case) and more details of courier riders was clearly needed for the present report as they are an important professional rider group. The characteristics of courier riders were therefore of special interest in the present project brief. Direct approaches to courier companies were not encouraging, and the field search method soon found out why. Many couriers may have a base station as far out as Mulgrave but work exclusively from a CBD location, using their radios for job assignments.

The courier companies that employ them also found it difficult to assist due to the time-critical nature of their business. The couriers themselves were one of the most helpful, constructive and cooperative groups encountered in this project.

Field intercepts in the CBD by an experienced motorcyclist (the principal investigator) wearing good quality motorcycle clothing and a university jersey (see the photograph inside the back cover) riding what was regarded by the couriers to be a desirable large motorcycle obtained a good response from couriers in the field by providing clear affiliation with motorcycles and a university association. The VMAC business cards with the motorcycle problem reporting line details were also handed out prior to any request for an interview. The period from 7.30am-9am is appropriate before the load builds up. This also provided an opportunity to get a feel for the approach taken by couriers and to assess and select the courier -issues to pursue.

Almost all couriers approached were happy to help, and completed the forms at once. Later in the day the interest and espoused cooperation was the same, but the return rate was very low. A variation on this intercept approach provided them with a business card to ring the principal investigator in the evening, and two responses were obtained by such a call back. The standard survey forms were fully completed and an ancillary set of courier- specific questions were also completed (Appendix 15).

At the specific invitation of one of the couriers who had called back, a group of couriers were then met on their own turf in the early morning in the CBD, far from their radio base, where they waited in the monring for jobs together with cycle couriers. Several couriers completed a structured interview and some also completed a survey form.

These forms are included in the survey database with all personal and courier-specific excluded, but distinguished by the ‘courier’ mode of collection.

The key questions posed to the Couriers covered

% of activity in the CBD.

For the couriers interviewed this was about 50-60%, with 30% in the adjacent eastern suburbs. Motorcycle types are selected with an eye to the area in which they work most.

Number of stops or deliveries

Typically 40-60 pickups or deliveries a day (ie 20-30 jobs). In wet weather, this is cut by a third or even a half, and pressure to travel faster is strongly resisted. Several were concerned at the behaviour of car drivers who were clearly unaware that drying roads are still treacherous around the city and drove accordingly.

What is different about riding a motorcycle as a courier?

The most-repeated comment was that wear and tear and maintenance was very important, and they allocate significant funds towards maintenance as a result.

The other was a real concern at the poor standard of skill in car drivers, and their lack of sensitivity to slippery road conditions “where they drive as if the roads were dry”: up to three very close misses from other vehicles per day were reported, with a measure of pride in the skill used to avoid the unexpected and unpredictable manoeuvres involved.

Relationships with bicycle couriers?
Generally amicable, and an acknowledgement that (in the CBD area) they could often operate more quickly – but the offhand comments were that it "would probably be different if they obeyed the road rules and traffic signs as we have to'.

Footpath parking
Used very extensively, 95-100% of the time. Few hassles with pedestrians as the majority expressed the view that "the footpath is their turf" and were very careful. One stated that some kerbs were very high and as a result he had gone some distance along the footpath. He had been ticketed for this and regarded this as reasonable. The only problems reported were with one or two pedestrians who were not aware that footpath parking is legal.

Police relationships
A positive attitude was expressed toward the Police as a whole, especially the Divisional van-borne police. The Traffic Operations group motorcycle and car police were not well regarded, as they were seen to have a far less constructive attitude towards couriers.

Tickets and violations
The annual mileage is high for all the couriers interviewed: the number of tickets collected on motorcycles ranged from Nil for several riders, to two for one. The rider with the largest number of tickets (10) had obtained all of them driving his car - and had a clean record on his working vehicle, his motorcycle.

The overall findings were that the couriers interviewed covered high mileages in difficult conditions with surprisingly good accident and violation records for this substantial mileage, and with a generally positive attitude towards the police. They also demonstrated a lively awareness of the need for good maintenance and were prepared to pay for it, and were concerned at the often low standards of skill displayed by car drivers on wet and drying roads.

7.2 Police and emergency services: motorcycle performance in traffic

Motorcycles are used by several groups of professional road users for their fast response and traffic penetration performance. Their experience complements the measures of travel time and cost carried out on ordinary drivers, examples of which are summarised elsewhere in this report.

- *Victoria Police escort work*:. The ability of police motorcycles to filter through heavy traffic ahead of an escorted vehicle is critical to the effective and unobtrusive performance of the task. Police cars would need to use sirens and other warning signals to achieve a similar escort result, which would in many cases be inappropriate due to the effects on the surrounding traffic. The Victoria Police Special Solos Group find motorcycles essential for their escort tasks.

- *Victoria Police traffic work*: The Region 1 Traffic Tasking Unit of the Victoria Police advised that the ability of motorcycles to safely filter swiftly through traffic enabled fast response to events in heavy traffic conditions, and that access to difficult locations such as freeways provided by their ability to get through gridlocked or highly congested conditions to major accident sites had been proven, and was relied upon as police cars and ambulances simply could not get through in many such cases.

- *NSW State Ambulance Operations Centre motorcycle MICA fleet.* The initial fleet of three machines has proved their worth, and are continuously deployed in Sydney CBD during daylight hours. They provide very substantial improvements in response times, and in heavily congested areas. An indicative illustration was given by a 10-15 minute (and very variable) MICA car access time from the Redfern HQ to Circular Quay as against 6-7 minutes (with little variation) by the motorcycle MICA. The motorcycle MICAs are also excellent in heavy crowds and are deployed at night for major events. Additional machines are now being added to the initial fleet.

The experience of these professional motorcycle drivers complements the motorcycle courier reports. Motorcycles have substantial benefits in traffic performance in congested areas and, as other vehicular traffic is often stationary or moving very slowly, are reliably adding traffic capacity to the road system as they can safely perform at reasonable motor vehicle speeds when the capacity for other vehicles has been exhausted.

These professional, public health and commercial service aspects suggest that a reassessment of recent regulations that could debar lane splitting, as these regulations (intended for general vehicle application) may be having an adverse effect on overall community costs.

The very substantial gains in MICA response times available (with the large increases in survival rates of the patients that come with this) indicate that this should be assessed. The safety record of lane splitting has not been well established in the professional safety literature, other than the positive findings of the Hurt report (Hurt, Ouellet, & Thom, 1981a; Hurt, Ouellet, & Thom, 1981b).

8. Costing for the balanced evaluation of motorcycle usage

8.1 The nature of evaluation

There are many different ways of evaluating motorcycle usage. Safety and accident costs provide the most commonly used approach to date. A popular approach is to use safety incidence (ie just the number of crashes observed). Another evaluation standpoint is to consider the priorities for enforcement of safety-related offences as perceived by the police. A 1990 study examined this with the Victorian Police, and rated the importance held by the responding policeman and the ratings that were perceived to be the official Force priority (Gunn & MacLean, 1990). These two ratings are shown in Fig. 19, in order of overall priority.

Priorities are set both by the community pressure to act in a given area and the costs of doing so. Evaluation is needed to work out what should be done and how cost-effective it is. Only then can priorities be set consistently. In practice a mix of economic and political factors are used in evaluation, and motorcycle transport is no different.

Evaluation requires a similar distinction to be drawn between what is measured and how it is assessed, and may include economic, social and environmental factors.

Consequently the use of the word 'evaluation' often needs clarification, as it can mean very different things to different people. When measures are taken strictly for safety purposes, what matters most are the numbers and types of crashes involved. For regulatory purposes this is often enough. However, if something has to be built, then these accidents have to be given a dollar value to see if the investment is justified.

Economic evaluation in transport requires values to be given to user operating costs, travel time, crash costs, and the costs of pollutants produced. There are arguments about the basis on which each of these costs are worked out, and as a result standard values are agreed to use in project evaluations in transport. The values associated with motorcycles are not generally known or determined, and often the benefits and costs are specifically excluded from transport evaluations.

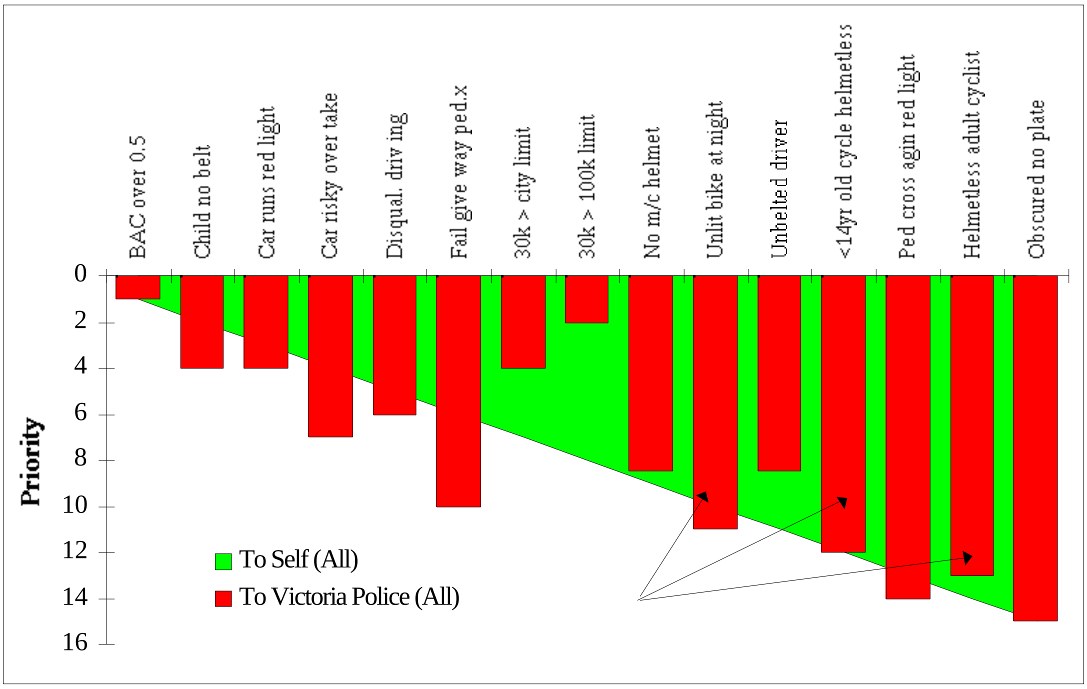

Fig. 19 Costings or priorities? Police views (Gunn & MacLean, 1990)

As crash data is usually the only form of data available, evaluations of the effects on (and of) motorcycles are usually ignored. As motorcycles usually comprise only around 1% of the traffic flow this process is broadly appropriate for major transport project evaluations.

However, when measures that specifically affect motorcycles are being considered, this also means that the user cost, travel time, emission and other factors are neither available to be used or even considered for inclusion. This situation is shared by the other two vulnerable road user modes (pedestrians and cyclists) and is becoming a matter of concern across many countries. A few papers have considered the full economic evaluation of these modes (Litman, 1999; Wigan, 1994; Wigan, 1995), but the process has not yet led to standard evaluation parameters for economists and engineers to use.

Until these become available, and modeling and evaluation processes are set up to include them, motorcycles will by default be evaluated on the basis of safety data alone.

8.3 Operating and accident costs

The present project has systematically searched for the relevant sources and data to build up such economic parameters for evaluation of motorcycles in transport and traffic, and there are a series of examples provided which include some of the results. Appendix 16 covers the operating and ownership costs of motorcycles of different sizes, which can be compared with the costs for cars on the same basis in Appendix 17.

Data has been extracted from a variety of sources to address the operating costs of motorcycles. However in most cases motorcycles are such a small fraction of these expenditures that the statistical significance is very limited. Appendix 18 is one of the key building blocks required to cost emissions by motorcycles. The extensive tables in Appendix 18 are based on measurements of a limited number of motorcycles, and should be taken as a self-consistent set of values rather than as representative of any specific motorcycle fleet on road.

Appendices 19 and 20 are the best available motorcycle-specific safety costings available (Andreassen, 1991). The DCA codes used in Appendices 19 and 20 provide a clear view of the different types of accident referred to. The most recent updated visual version of these DCA codes is given as Appendix 20 to illustrate the value of accident and costing analysis by type of accident. It is critically important to examine the values quoted for accident costs by mode, as these are often expressed on a per - accident basis (when several vehicles may be involved).

This is especially important when dealing with vulnerable modes such as motorcycles where substantial additional costs may be attributed on the per-accident basis, leading to misleading conclusions if the appropriate corrections are overlooked when examining motorcycle measures.

Nothing has yet been done in Australia on motorcycle operating, time valuation or user costs. Although some information on motorcycle operating costs can be found in the Family/Expenditure and Household Expenditure surveys, but have very high standard errors, and we have chosen not to include them here.

As motorcycles can travel through traffic faster than the other vehicles in the traffic stream, the operating and pollution costs are over estimated by assuming that they are equivalent to cars, and their travel time benefits are under-estimated. While including these factors will not have much effect on overall major projects, they can have a substantial impact on the evaluation of regulations and provisions specifically affecting motorcycles.

The UK has a National project appraisal system implemented in a computer model COBA, but the instructions in the official government guide are:

> Motorcycles usually form a very small proportion of the traffic flow, even in urban areas, and COBA ignores them for economic appraisal purposes. For consistency, they should also be ignored in the traffic appraisal, unless there is a good reason for doing otherwise (Anon, Undated-b)

None of these economic parameters are straightforward to determine. The remainder of this section now considers several of the different evaluation components in greater detail.

Litman (1999) recently reviewed user operating costs for a wide range of modes for North American purposes. These are expressed in the following diagram in US Dollars, and the variations between vehicles as well as the trends with vehicle mileage are useful to review. The absolute values are subject to differences between US fuel pricing and insurance practices as well as taxation factors. Litman (Figure 19) finds that motorcycles cost their owners less in terms of out of pocket costs and travel time than public transport, bicycles or telecommuting, however much or little they are used. This is significant, as motorcycles can offer the full range of a car and can handle most of the transport tasks required by individuals including many of the disabled who cannot use some forms of public transport or a bicycle. The front cover of this report includes such a person, driving a motorcycle and sidecar.

The most complete form of evaluation must therefore include not only economic and environmental factors, but also accessibility and mobility and social disadvantage and equity. This is precisely the direction in which several countries are now moving, and all of the vulnerable road user modes are taking on a greater significance when all these factors are included.

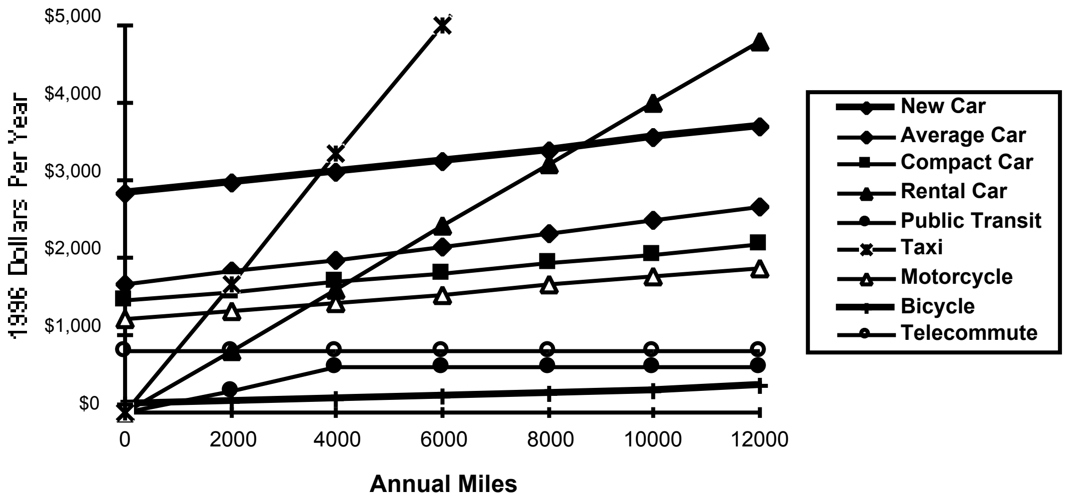

Fig. 20 VTPI Estimated User Expenses for Various Modes[10] (Litman, 1999)

[10] Based on estimates in this chapter; $50 monthly transit pass; $1.25 per mile average taxi fares; $0.40 per mile average rental car charges; "New Car" from *Your Driving Costs*, AAA.

The motoring organisations in some countries issue operating cost guidelines for new vehicles of all types, usually qualified for second hand vehicles as the depreciation rates vary widely for different vehicle groups. The UK AA (Automobile Association) still issues costings for motorcycles of different sizes, and for both petrol and diesel-engined cars (UK: Automobile Association, 1999). The data sheets for 1999 for petrol engined cars and for new motorcycles, mopeds and scooters form Appendices 16 and 17. Comparing the values for cars and motorcycles of different sizes shows that the costs of some motorcycles can be higher than for some cars.

In addition to the very much higher cost of fuel, it should be born in mind that the average car size in the UK is far smaller than in Australia so the overlap in costs between the two modes is significant. The inclusion of helmets in the ‘user costs’ for motorcycles illustrates some of the overheads that should be included in any complete costing of motorcycle ownership. The effects of depreciation is important as most motorcycles are not new, adjusting this row will have a big effect on the overall user cost. However, the cost seen by motorcycle users is only part of the story. Accident costs affect both the individual and the community.

Accident costs may be derived in a variety of ways, each appropriate to the purpose for which they are intended to be used. The Bureau of Transport Economics regularly produces overall costings of the total impact of road accidents on the community, but it is not correct to simply divide these by the number of people or crashes involved as the numbers of vehicles and people involved in accidents vary considerably. Differentiating the costs by type of accident and by type of vehicle is necessary to be able to make proper use the most appropriate evaluation costs.

8.4 Environmental costs

Environmental costing is still a very difficult process. It is possible to determine the amount of different pollutants emitted when vehicles are driven in particular standard ways (driving cycles), but evaluating the relative weight or impact cost of each different pollutant is not straightforward.

Table 6 Unit costs of different types of airborne motor vehicle pollution

Synthesised estimates of unit costs of environmental damage from airborne pollutants 1996$/kg)				
Sector	Nox&NMVOCs	CO	SOx	Particulates
Major Urban				
Average	0.07	0.002	0.01	12.5
Likely range	0.01-0.70	0.0-0.02	0.0-.45	3-18
Other				
Average	0.02	0	0	0
Likely range	0.0-0.23			

(BTCE, 1996)

The best available specifically-Australian guidance is Table X.1 on p460 of the BTCE Report on greenhouse gases and transport (BTCE, 1996). These values have been built up using a wide variety of sources, and are appropriate for the comparatively low levels of pollution in Australia. The key groups are Oxides of Sulphur (SOx), Carbon

Monoxide (CO), Oxides of Nitrogen (NOx) and Non Volatile Methane Organic Compounds (NMVOCs).

These values are difficult to estimate, and harder to put in a form suitable for use with transport planning models. However there is now a body of material around the world that will allow this to be done more consistently. It will be necessary for transport and traffic analysts to know more about the vehicles on the road and how many, of what age are travelling how far.

Table 6 shows that particulates are by far the most costly to the community in terms of $/kg produced. As the quantities emitted are extremely low for most motorcycle engines (diesel engines are comparatively heavy emitters) this means that particulates produced by motorcycles are in most cases neither important nor costly.

The relative importance of the other pollutants (in terms of unit cost) are shown in Fig. 21. Note that in rural areas the costs of CO and SOx are close to zero. The unit costs of pollutants still requires a measure of the production of each pollutant in terms of grams/km before the total impact can be assessed.

The production of pollutants is strongly dependent on the age of the vehicle, and also on the state of tune of the engine and exhaust system. The values quoted are various sources for the total production of pollutants by different types of vehicle are based on the following steps:

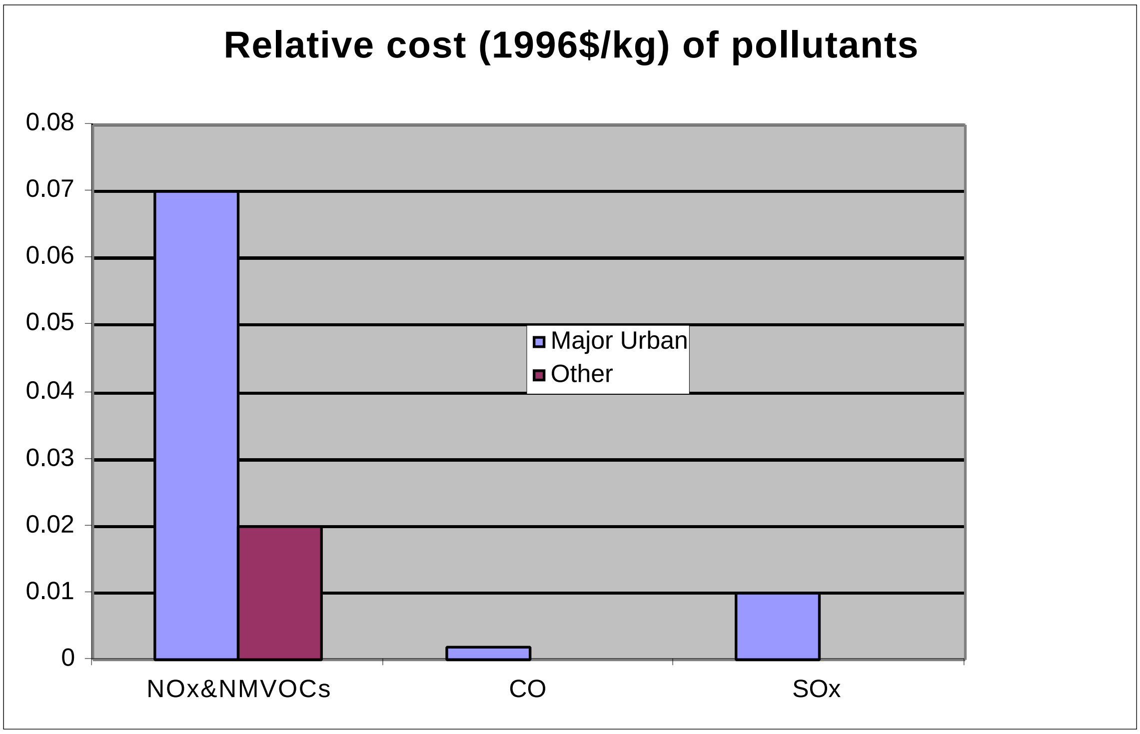

Fig. 21 Relative costs of non-particulate motor vehicle pollutants

• Knowledge of the g/km emitted by a motorcycle of a given age

This requires knowledge of mileage done by motorcycles of different ages, and of the mix of two and four stroke engines of each age as each produces a different mix of gases. The emission factors for Californian vehicles (note, these are in many cases specially produced solely for California) are given as Appendix 18 as produced by the CARB models (CARB, 2000) for this purpose[11].

- An assumption that this motorcycle is running at the same speed as other traffic, and has the same number of stops

This assumption comes from the standard mix of speeds, stops and start that is used to define a 'driving cycle'. It is assumed that the driving cycle for a motorcycle is the same as that for a car in a given set of traffic conditions. This is frequently not the case, although motorcycle pollutant levels could be raised simply by banning filtering through traffic and thereby increasing the numbers of stops and lowering the average running speed to match the rest of the vehicular traffic.

This is sufficient to estimate the amount of exhaust gases produced. Unless the local concentration of these gases near the road is required, this is sufficient to calculate the total amount of pollutants produced. The unit cost of the impact of each type of pollutant can then be applied to obtain the net cost of the emissions.

In policy terms the European Union (EU) position is typified by this extract from the recent Austrian Government environmental policy report (Anon, Undated-a). The European Union has far higher levels of pollution than Australia, but several of the factors covered are relevant – and some of the major differences are highlighted after this quotation..

> "Mopeds and small motorcycles are powered almost exclusively by 2-stroke engines. Without catalytic converters, these engines have very high hydrocarbon emissions compared with 4-strokes. Currently, the limits adopted in Austria in 1988 for motorised bicycles cannot be fulfilled without catalytic converters. These devices would permit an over 90% drop in specific HC and CO emissions. The NOx emissions of this vehicle class, which are negligible, would remain unchanged. The emission-reducing measures were responsible for an average fuel consumption drop of nearly 15%. Since fuel prices are a secondary factor for mopeds, further reductions in consumption cannot be achieved without additional official regulations. In 1990, new limits were introduced for motorcycles as well. These were set separately for 2- and 4-stroke engines in order to account for the different characteristics of the two engine types. Most motorcycles up to around 250 cc are 2-strokes and can only fulfill current HC limits with catalytic converters; this class of machines therefore behaves much like mopeds. The current limits for 4-stroke motorcycles can be achieved relatively easily even without converters. An emissions technology similar to that employed in small cars is being installed by a few manufacturers on a voluntary basis. This increases sticker prices. Also, relatively small vehicle size and high

[11] The computer runs reproduced in Appendix 18 were produced for this report by Chuck Purvis, from the Metropolitan Planning Organisation for the Bay Area of San Francisco.

> performance makes it difficult to place the converter far enough away from the engine".(Anon, Undated-a)

It is important to note that the statement made about small motorcycles does not apply to the Australian motorcycle fleet, where there are large numbers of four stroke small machines and very few mopeds at all. As an indication of the future, the direct injection and other advanced two stroke technologies (ACEM Pollution Research Group, 1998) (typified by those of the advanced Australian Orbital Engine Company) will provide significant improvements to two stroke emissions for engines of all relevant sizes.

9. PTW Cost and impact balance framework

A planning balance sheet is one way to ensure that all the factors involved in evaluating motorcycle and other PTW factors are included for evaluations, and that all relevant costs and benefits are included. Such a balance sheet would include all relevant parameters. A summary of the available values and how to estimate values for those that have not been possible to measure is the next stage. There is far better agreement on the factors to be included in such a balance sheet than there are on the values to be attributed to each individual factor. Consequently any current balance sheet can comprise no more that a checklist of evaluation factors, and the background to the estimation of appropriate parameters discussed in various places in the present report as each evaluation component is addressed.

More factors are included than usually form part of an economic appraisal for most traffic and transport projects or proposals, but as motorcycles have systematic differences (as well as similarities) to other powered vehicles, the discussion is necessarily fairly detailed. The resources on which to base this section have been drawn from across the world as well as from Australia.

Currently the working values used in road transport are defined in a series of reports from Austroads. The most recent being (Thoresen & Rosalion, 2000). Each factor has a measure of disagreement on the makeup and application of particular values, but the Austroads values are broadly used for comparable evaluations.

There are some PTW-specific factors that do not appear directly in the Austroads tables. These include induced exposure and other still not widely used factors, in addition to the factors discussed in the present report. The factors discussed in this report are those commonly accepted as appropriate for transport appraisal, but once these values have been suitably updated for PTW applications, there are additional factors to be brought to account when Vulnerable Road Users are being assessed in a mixed traffic stream (Wigan, 1994).

There are problems in choosing specific values. Tables 8 and 9 (Thoresen & Rosalion, 2000), show the fine levels of detail used to discriminate between different types of trucks - which make up a small part of the overall vehicle fleet. The reason is that freight vehicles play a very large role in determining road structure, construction and maintenance costs. The disparities between light scooters and heavy motorcycles are even greater than from light to very large freight vehicles. No values for motorcycles are included in these official values and as they are a small part of the traffic flow this can be done without significantly affecting overall transport assessments.

The valuations of time are based on the resource costs (ie the resources net of taxation) and do not reflect the market costs perceived by the road users. This is a typical issue that can make it difficult to appreciate how economic evaluations relate to the prices as seen by road users.

Table 7. Claims (non-work) accepted by TAC in 1992: costs of claims as at 1994

Age	Pedestrian	Motorcyclist	Cyclist	Driver	Passenger	Train/Tram	Total
Female av. Claim	$12,495	$8,538	$5,688	$5,238	$4,846	$3,084	$5,805
Female no. claims	673	106	108	3115	2979	79	7060
Male av. Claim	$14,638	$13,222	$7,349	$8,670	$7,349	$7,215	$9,550
Males no. claims	767	1057	406	3054	1772	31	7087

The valuations of accidents also require careful interpretation to appreciate exactly what is included and why. The use of partial figures, from, say Transport Accident Commission in Victoria (see Table 7 and Figures 22 and 23 below) are visually persuasive but are not necessarily the best guide for evaluations of road and traffic works. Figure 22 shows the costs of no-fault non-work road crash claims to the Traffic Accident Commission in 1992. To obtain this cost, as much of the expense to TAC occurs as an income stream to the victims, requires a cut off date for the costs so far attributed to the claims accepted in 1992. The figures shown correspond to a cutoff date of 1994 for the accumulating regular payments made to the injured under the TAC Acts.

Table 8. Estimated accident costs fatality Injury and property damage accidents. Resource prices at 30 June 1998

	Rural			Metro		
	Fatal	***Injury***	***Damage***	***Fatal***	***Injury***	***Damage***
NSW	$1,115,159	$98,722	$15,866	$933,225	$62,755	$17,319
Vic	$1,064,269	$98,473	$16,174	$940,707	$72,642	$17,319
Qld	$1,051,430	$96,514	$15,866	$958,783	$69,177	$17,319
SA	$1,116,560	$84,119	$15,866	$949,345	$46,645	$17,319
WA	$1,074,762	$107,615	$15,547	$956,906	$59,594	$17,119
Tas	$1,204,716	$108,178	$15,844	$924,311	$58,688	$17,392
NT	$1,187,163	$136,461	$16,035	$853,755	$73,669	$17,633
ACT				$962,537	$66,085	$17,319
Australia	***$1,102,092***	***$99,527***	***$16,326***	***$951,894***	***$64,523***	***$17,823***

(Thoresen & Rosalion, 2000)

These costs must also be placed in perspective of the distribution of claims made for different modes to TAC. The effect of gender is marked in both diagrams. Females claims cost roughly half as much as males by all modes (although there are other factors in payment policies that will affect this, as females overall earn less than males in the workplace). Females also place fewer claims than males for all modes but the heavily used car driver and passenger modes.

Figures 22 and 23 assist in addressing the question: what happens if more females ride motorcycles? What happens if more people walk? Ironically switching to walking is the highest cost option of all.

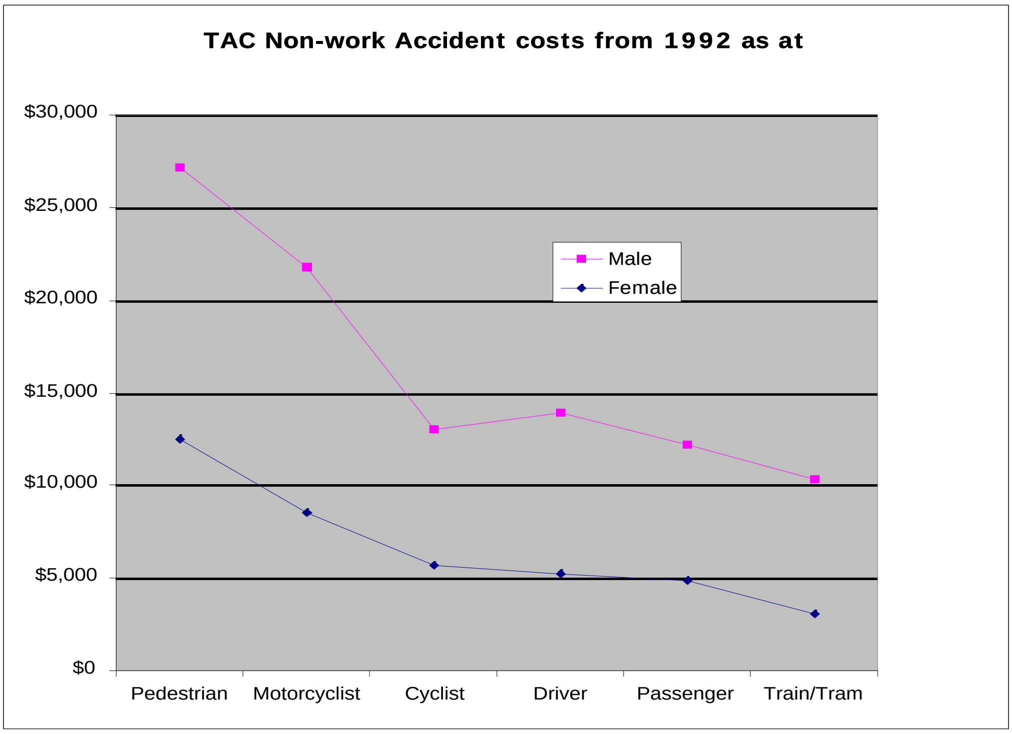

Fig. 22 Victorian Transport Accident Commission claim costs by mode for 1992

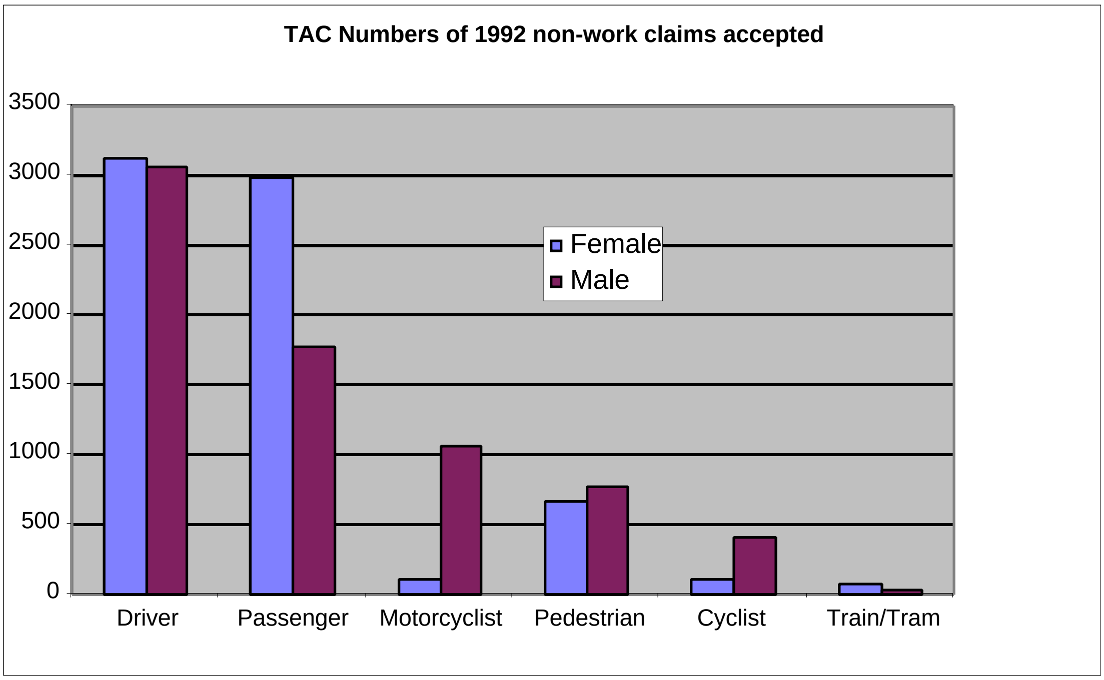

Fig. 23 Number of claims by mode accepted by the Victorian TAC in 1992

Even switching from car to motorcycle has no great effect, if the switch is from a male driving a car to a female driving a motorcycle. The average claim levels are the same. Such mode switches are entirely possible if motorcycles and cars are added to a two-job household, and such switches between the options available in multiple vehicle households are rarely considered in purely safety evaluations.

Similarly, a motorcycling household may purchase a scooter (there are two examples in the survey database) – and the female may then take to travelling by scooter to work. The assumption that this will increase social costs does not appear to be entirely correct when such options and actions are considered in a transport context.

Even so, such values as the TAC accounting costs for claim payments are solely accounting values and include wage compensation caps and other distorting factors. TAC claims costs could therefore contain a bias against road users with lower than average incomes. Motorcycles have in the past been in that group, and the strong emphasis on 18-25 year olds in motorcycle accidents includes a very large student population.

For these and many other reasons, TAC claims values do **not** reflect the values people place on avoiding fatal or serious injury (Andreassen, T.R.L.Thoresen, & Wigan, 1988). Such 'willingness to pay' values are now commonly used in many countries for road project evaluations.

Table 9. Estimated value of travel time resource prices at 30 June 1998 Occupants and Freight payload $/vehicle/hr

Vehicle type	**Rural**		**Urban**		**Freight travel time**	
	Occupancy rate	**Value per occupant**	**Occupancy rate**	**Value per occupant**	**Urban**	**Rural**
Cars						
Private	1.7	$7.61	1.6	$7.61		
Business	1.3	$24.36	1.4	$24.36		
Trucks						
Rigid						
Light 2axle 4 tyre	1.3	$15.41	1.3	$15.41	$0.91	$0.46
Medium	1.2	$15.70	1.3	$15.70	$2.47	$1.25
Heavy	1.0	$16.12	1.0	$16.12	$8.45	$4.29
Articulated						
4 axle	1.0	$16.99	1.0	$16.99	$18.20	$9.24
5 axle	1.0	$16.99	1.0	$16.99	$16.90	$8.58
6 axle	1.0	$16.99	1.0	$16.99	$25.03	$12.71
Combination						
B-Double	1.0	$16.97	1.0	-	$36.22	$18.39
Double Road Train	1.0	$17.68	1.0	-		$24.58
Triple Road Train	1.0	$18.11	1.0	-		$36.22

(Thoresen & Rosalion, 2000)

There is also a real and significant equity issue for public sector investments – particularly in transport if the valuation placed on all persons lives were **not** to be the at same rate. This is clearly evident for fatal accidents, but applies equally well to the valuation of travel time and other components in the transport evaluation mix. The current UK Integrated Transport policy requires all Local Transport Plans to provide a basis for assessing the equity and access and social disadvantage aspects of transport measures, safety being only one of a range of such factors.

Vulnerable road users also present special features in terms of safety evaluation (Wigan, 1994). Motorcycles and scooters share many of these features of the other two Vulnerable Road User types (pedestrians and cyclists).

All aspects of vehicle operating costs also need to be looked at from different points of view for evaluation purposes, and values appropriate for an overall costing of - say – safety to the community are not the appropriate values to use for specific project appraisal purposes. The values developed by ARRB for different types of motorcycle accident are given in Appendix 19 and 20 in 1991 dollars (Andreassen, 1991) and form part of a systematic program to develop such tailored crash costs.

The codes for different accident types are the DCA Codes used in accident reporting, and allow a wide range of configurations of accident and vehicle events to be summarised concisely. These codes, developed by Andreassen, are now a working standard in Australia and a useful summary (including details of the codes and accident record forms) can be found in the manual for the Crashstats CDRom (VicRoads, 1996) and in Andreassen (1994). However these have recently been revised and have been reproduced by permission as Appendix 21. However, the 1991 report costings use the earlier DCA coding scheme reproduced in the Crashstats manual.

The Transport Accident Commission costs reflect only a part of the costs of an accident, but do provide a basis for viewing the some of the direct medical costs.

This broader framework raises questions about the validity of the implied assumptions of cost reduction by regulation and reduction of exposure as a key safety policy for vulnerable road users. Bicycles now benefit from a more progressive and balanced safety/encouragement/education/and infrastructure-provision policy balance at state and national level and are generally regarded as a less significant safety issue and rarely accorded similarly balanced treatment (see for example a formal response received from a State transport authority, reproduced as Appendix 22).

Clearly motorcycles, scooters and mopeds need to be assessed in a similar manner to bicycles, and ideally as part of a full Vulnerable Road User Transport Strategy covering pedestrians, bicycles, power assisted bicycles, mopeds, scooters and motorcycles. It is significant that there is no Australian National Motorcycle Transport Policy, simply a Safety Round Table.

The UK has recognised that motorcycles and mopeds need a broader framework and has begun to set up a framework to address this (DETR, 1998)(p47). There is some uncertainty over the balance of costs and benefits for large and small motorcycles in green transport plans, and a recognition that it is necessary to obtain more information. An Advisory Committee has been set up by DETR to further this process. If Australia is to move into balanced and sustainable transport policies, as is becoming widely accepted, then such policies and the wider range of objectives exemplified by the UK Integrated Transport Policy will be an essential tool.

9.1 Differential speeds of motorcycles and car in the same traffic stream

For evaluation purposes it is necessary to take a more detailed view of vehicle and travel operating costs than is usual for transportation. The motorcycle family of vehicles has fewer stops, fewer slow speed periods and faster travel speeds than the overall average traffic flow. It is therefore not appropriate to lump in motorcycles of any kind with the average car fleet measures of transport performance for evaluation, especially in cities. In a given level of traffic congestion, motorcycles will be travelling faster, with fewer stops and with shorter periods of inefficient idling. Consequently the findings of the study below provide some guidance as to how this might be taken into account.

Table 10. PTW fuel consumption trails reported by ACEM

City	Type of vehicle	Duration of journey (min)	Fuel Cons-umption (l/100km)	Average speed (km/h)	Idling time as per cent of journey time
Paris	Passenger car 1,1 litres	189	9.0	21.7	37
	Scooter SV125	133	3.71	30,0	23
Rome	Passenger car 1,4 litres	118	16.0	14.6	Not recorded
	Moped SI	66	3.04	26,2	18
	Motorcycle 125 NSR	54	5.21	27	24
Munich	Passenger car 2,5 litres	250	12,0	28,3	Not recorded
	Motorcycle K75 RT	209	5.45	33.6	15.4

Source: EU Motor Vehicle Emission Group quoted in ACEM (2000)

These results correspond to those from other small-scale sources (see Appendix 24, for example), and add the critical aspect of idle time. There are a wide range of small-scale trials comparing mopeds or motorcycles and cars travelling through urban and rural areas. ACEM also quotes such cases.

It is clear that work is needed to define appropriate driving cycles for measuring motorcycle, moped and scooter fuel and emission performance as the conditions that they encounter at a given level of congestion are quite different to the cars there at the same time. This needs to be taken into account when assessing the amount of exhaust pollution produced.

10. Broad transport context for a consistent PTW policy and areas for positive contributions

Most of the information generally available for motorcycle and scooter assessment has been drawn from accident and crash records. There is a comparatively restricted coverage of the transport patterns of use, and few analyses of the mode choice characteristics.
This has materially hampered the development of a sound and informed framework for balanced PTW assessment. PTWs include a very wide range of vehicles that are in many cases not even superficially similar. Large motorcycles, sports and cruiser designs, commuter motorcycles, scooters, and mopeds all have different operating characteristics, and areas in which they operate and tend to have different types of owners and users.

PTWs need to be considered in a balanced manner and as alternatives to the car, public transport and nonmotorised transport. PTWs also need to be considered as users of road space (where they have excellent efficiency in some situations), and as users of parking space (where cars demand substantial areas in city centers) as well as emission sources. The evaluation of their use needs to encompass both the objective costs and benefits (operating costs, travel speed in congested areas etc, safety factors) and the values of time and any mode-specific factor for choosing PTWs.

There are a range of situations where powered two wheeled vehicles have significant advantages, but most require a positive attitude of government and regulators to enable the community to secure and retain these benefits.

Typical examples are

- Road space allocation
- Parking space and access
- Advanced stopline access
- Lane usage
- Bus lane access

All of these are currently controlled by regulation. In accord with vulnerable road user policies for pedestrians and bicycles, PTW should have similar regulatory and legislative support to ensure that the safety of each type of user is secured more effectively while the special advantages of PTWs are better realised for the community.

These potential benefits can be secured by a similar package of measures to bicycles, including selective dedicated facilities to protect these vulnerable road users, regulatory adjustments to take full advantage of the special features of powered two wheelers, education of both the vulnerable roads users themselves and the other road users that affect them.

The outcomes are improved road safety, higher levels of capacity realised from the existing road system, lower fuel consumption and emissions, and more efficient use of space otherwise tied up in car parking space.

The methods required to achieve this include administrative and research support, special facility and regulatory provisions and funding support for field trials and facilities. All of these are already accepted and committed for other vulnerable road users (the VicRoads series of Cycle Notes provide such a series of examples).

11. Motorcycles and Traffic Capacity[12]

Mopeds are closely similar to bicycles in size, and motorcycles and scooter vary from a similar size (for small 50cc scooters) to considerably larger for bigger motorcycles.

This physical size permits up to eight powered two wheelers to fit into a single parking space laid out for a car, although 4-6 is a more realistic number when larger machines are included. This significant advantage in space utilisation is important, as car parking space is a major consumer of urban road and related areas.

On the road, with normal lane widths, motorcycles (as a shorthand for the powered two wheeler group) can ride safely to the right of the lane delineation line, and have an escape route between the lines of vehicles. Filtering between stationary lines of traffic is also possible, and is an advantage heavily used by Police and emergency services in almost all countries. This practice has been found to be safe for motorcycles in California.(Hurt et al., 1981a; Hurt et al., 1981b).

The objective information on the traffic and transport performance of motorcycles is, once again, sparse. Areas which need attention include the traffic issues of allocating, managing and using:

- Roadspace
- Kerb space
- Parking space

The use of roadspace by vehicles is normally expressed in terms of Passenger Car Equivalents (pcu). A car has a pcu value of unity.

The pcu value for a vehicle indicates the number of cars that would have the same effect on the capacity and performance of the traffic stream. These values vary, depending on the situation. The values for free running on an uncongested freeway are quite different to those found in a congested traffic signal controlled intersection. There are few such values available for bicycles, moped, scooters or motorcycles (Van Laarhoven, 1985).

A value of 0.6 pcu for a motorcycle has been quoted in Australia, but is based directly or indirectly on work at the UK Transport and Road Research Laboratory (Holroyd, 1963), which in turn drew on field work in the late 1940's. This single value did not allow for any differentiation by vehicle or road type, or for freeway, urban or intersection conditions. The levels of congestion and the characteristics of the vehicle from even as recent as 1963 are no longer relevant to post-2000 conditions and vehicle flows and characteristics.

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[12] This section is drawn largely from a paper submitted to TRB for the 2001 Annual Meeting (Wigan, Unpublished)

PCUs can be estimated in several ways, and both regression and headway methods can be used, and produce comparable results (Kimber, McDonald, & Hounsell, 1985).

The limited motorcycle data available for countries comparable to (Branston, 1975; Branston, 1977) reported values for the UK as follows :

> “the smallest headways are associated with motorcycles on the M4 measurement during capacity flow conditions” (Branston, 1977)(p6).

11.1 Free running motorcycle pcu values

Pcu equivalents can be estimated in a number of ways, but will vary depending on the conditions under which they are measured. Other measures of capacity are often used, but pcu has the benefit of being a straightforward relationship on the relative capacity impacts of vehicles of different types in different situations.

Table 11. Free running pcu values for motorcycles in the UK

Slow lane Sample Vehicle	Number	Mean headway	Standard Error	Fast Lane Sample Number	Mean Headway	Standard Error
Car	807	1.70	.041	1851	1.433	0.02
Van	47	2.05	0.23	52	1.707	0.11
Bus/coach	10	2.22	0.20	12	2.737	0.65
NonArtic Truck	119	3.34	0.27	19	3.005	0.48
Artic Truck	42	4.89	0.57	2	3.415	1.29
Motorcycle	7	1.57	0.51	8	0.797	0.09

(Branston, 1977)

> "Motorcycles (have) lateral freedom of movement which enabled them to pass the reference line alongside a vehicle in the same lane. Under such circumstances the effect of their presence on other vehicle types, and vice versa, is difficult to assess." (Branston, 1977)(p7)

The best available figure for Motorcycle pcu in free running motorway conditions is currently 0.5 +or- *0.1*

11.2 Motorcycle pcu values at intersections

In a later paper (Branston & Van Zuylen, 1978) PCU measurements were made at saturated intersections in Barnet in North London using both asynchronous and synchronous methods at saturated intersections (the latter includes a bias correction).

The enforced traffic streaming by motorcycles (presumably taking gaps between the lines of vehicles or moderation of erratic car movements) may be the factors that lead to an enhancement of intersection capacity and more than compensated for the road space used. (The equivalent PCU value for bicycles was estimated to be around 0.6).

The best available figure for Motorcycle pcu value at signalised and congested intersections is currently 0.0 + or - *0.01*

Clearly any switch from car to motorcycle – or indeed from bicycle to motorcycle - will have a real and positive effect on scarce road and intersection capacity, and a very significant one in congested conditions, where one additional car contributes far more than it gains by continuing to travel on such a road.

Table 12. Saturated intersection PCU Equivalences for Motorcycles in the UK

	Asynchronous measurements			**Synchronous measurements**		
Straight on	**PCU**	**SE**	**No. of vehicles**	**PCU**	**SE**	**No. of vehicles**
Car	1		688	1		1460
Van	*1.14*	*0.09*	*51*	*1.28*	*0.14*	*30*
Bus	1.79	0.15	22	1.61	0.21	10
Truck	1.74	0.16	17	1.59	0.29	14
Motorcycle	0.04	0.15	23	-0.08	0.17	14
Left turning values (in UK and Australia this does **not** require a turn across facing traffic)						
Car	0.89	0.08	65	0.89	0.10	46

(Branston & Van Zuylen, 1978)

11.3 Advanced stoplines

The ability of motorcycles to penetrate traffic safely and effectively has led to attention being paid to gaining further road capacity by providing advanced stoplines at signal controlled intersections specifically for motorcycles. Advanced stoplines for pedal bicycles have been installed in several countries, including Australia. They have been installed for a range of objectives, from enhanced safety of bicycles to a designed limitation of motor vehicle traffic flow. One hundred advanced stoplines installed along several bicycle routes in Edinburgh are being monitored over a year. A before and after survey of the levels of bicycle demand and bicycle and pedestrian accidents will be used to evaluate their performance.

Controlled studies of the capacity effects and compliance of motorcycles and other powered two wheelers would be useful to complement this work. Data is also needed on the operational compatibility of different vulnerable users at advanced stoplines Such work could lead to a considered and balanced policy including motorcycle, scooter or moped access. The evidence from recent work on intersection capacity suggests that this would lead to increases in intersection capacity, especially at saturated intersections.

Work on motorcycle, bicycle and moped capacity effects is more common in developing nations such as India, Indonesia and China, where most of the current work is being done (Chandra, Kumar, & Sikdar, 1995; Ramanayya, 1988; Srinivas, 1996). Work in Indonesia by Leeds University (Powell, 1997) has shown that the users of advanced stoplines (official or unofficial) - the so-called ‘Q-fliers’ who leave from the front of the traffic queue in the first 6 seconds of the green time - have a pcu of zero, if permitted to filter to the front of the stationary queues of vehicles at these intersections.

Powell reports observing up to 40 motorcycles at the front of an intersection approach, with an effective pcu equivalent of zero. Advanced stoplines in conjunction with filtering or lane access through the traffic offers both a significant addition to intersection capacity in congested conditions and faster travel times for vulnerable road users.

The best available figure for motorcycle pcu value when using advanced stoplines is currently: 0.00

11.4 Motorcycle capacity measurements in developing countries

Some caution should be applied when interpreting other pcu values obtained in countries such as China and Indonesia who have a high percentage of powered two vehicles in the traffic stream. These vehicles often also carry heavy passenger and luggage loads and a large proportion have only small capacity engines. These factors will tend to increase the effective pcu for motorcycles measured in these countries, and produce values larger than in Australia, Europe or North America. The experiments required to determine this have not yet been done.

For congested signal-controlled intersections in Indonesia, the Indonesian Highway Capacity Manual values (heavy vehicles 1.3, Motorcycles 0.2 and nonmotorised vehicles 0.5) were based on extensive video surveys in 15 cities. Lower saturation flows were found than in Western nations (due to differences in the vehicles, drivers and traffic mixes), and in movements across opposing flows the motorcycle pcu found was 0.4, and nonmotorised vehicles as high as 1.0 (Baang & Palgunadi, 1994).

Similarly, for free running urban road sections, the Indonesian Highway Capacity Manual values (heavy vehicle 1.2, motorcycles 0.25 and nonmotorised 0.8) were based on video logging surveys of 35 road sections in two cities. Free running speeds were 5-15 km/h slower than in western countries and capacity slightly higher (Marler, Harahap, & Novara, 1994).

11.5 Access to transit, high occupancy vehicle and bus lanes

The use of transit lanes is an excellent example where the management of road space on a consistent policy basis would be very effective. In Victoria motorcycles are permitted to use the high-occupancy lane (the outermost or 'fast' lane) on the Eastern Freeway into the CBD, and no reports of problems have been sighted. However the signage for the use of the emergency stopping lane on the near side of the carriageway permits both buses and taxis to use this 'lane' in peak hours, but debars motorcycles.

No trials have been located that assessed the compatibility and overall effectiveness of motorcycles using this lane. One of the interviews for this project raised the case of a strip, about 1m wide left as a result on realignments and remarking of lanes on the Monash Freeway that would appear to be ideal for safe motorcycle use. Apparently motorcycles have been debarred from using this area.

The recent advent of the Australian Road Rules on 1 December 1999 has created a need to address this issue, as the lane filtering through stationary vehicles that offers a safe additional road capacity benefit through motorcycle movements has now been restricted to movements only on the outside of a vehicle and within a lane. This effect has not yet been reviewed as part of the continuing updating and refinement of the National road rules.

The safety record of such filtering appears to have been very good. No examples have yet been located where such filtering has been the cause of an incident. The continued use of this additional road capacity would appear to be largely debarred from police, emergency vehicles, motorcycle MICA (emergency paramedic) and ordinary riders alike. This unintended side effect of the initial release of the Australian Road Rules needs to be reassessed. This is an issue that needs to be raised in the first round reviews of the Australian Road Rules, as the safety impacts do not appear to outweigh the capacity gains for the community and the critical access gains for emergency and medical services.

11.6 Road space management

The findings of these various studies strongly suggest that the capacity benefits of motorcycles in Western nations has not yet been realised. A road space management policy covering all modes of road usage now needs to be worked out to balance the marginal costs of capacity and infrastructure against safety, environment and user cost factors. Other areas where the interactions of capacity allocation and consequences have not yet been properly appraised include the effects of narrowing lanes (which reduced traffic filtering by police emergency and private motorcycles).

One of the reasons for such lane narrowing is the introduction of bicycle lanes. This indicates that a review of capacity and safety impacts of such road space allocation would be highly desirable. Motorcycles and bicycles are both high vulnerability modes, and need positive treatment to ensure that the benefits from such modes are fully realised. Studies of congested areas in Western nations are also beginning to show that the effect of including bicycles and motorcycles can lead to congestion where there was none when only cars and larger vehicles were included in the model (Sharples, 1993).

Consequently, in addition to working on the inclusion of vulnerable road users in transport and traffic models, some of factors that need to be worked through include:

- The observed bicycle utilisation of pedestrian footway and road crossing space in congested areas
- Traffic movement volumes of vulnerable road users (bicycles and motorcycles) and their estimation
- Access regulation and management for bus, transit and high occupancy vehicle lanes
- Low utilisation of advanced stoplines due to limited takeup by bicycles
- Which subsets of bicycles and motorcycles should have access to which parts of the road reserve and for what purposes.

This should include 200w electrical and internal combustion-engined powered bicycles , mopeds, very light scooters etc: all of which have overlapping performance envelopes, as well as cost benefit assessments of the priorities for road space between the two major vulnerable road users (bicycles and motorcycles). A practical perspective on road utilisation levels at peak hours (when capacity issues are most critical) is illustrated in Fig. 24, where the levels of travel for the journey to work are comparable for the two modes across all NSW.

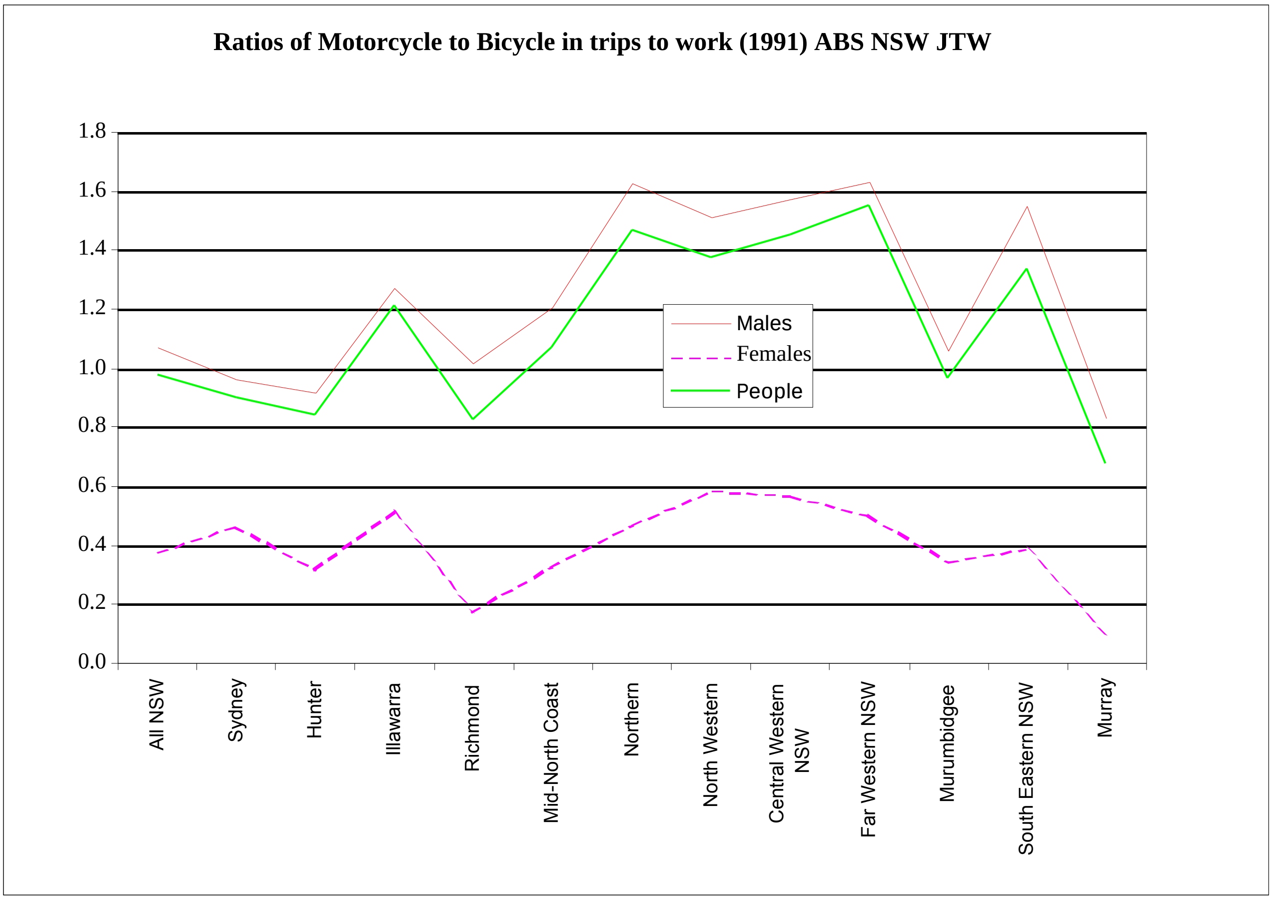

Fig. 24 Ratios of motorcycle to bicycles in travel to work: city and rural NSW

Both vulnerable road user modes require a balance of safety, regulation, enforcement, training, education and positive engineering provisions. Currently the balance of specific investment in positive infrastructure provision currently strongly favours bicycles and that in enforcement regulation and training emphasises motorcycles. It is clear that joint vulnerable road user policy assessment of these balances would be both desirable and cost-effective and could lead to adjustments in the regulation and provision of road space allocation and access for all modes using the road.

Furthermore, in areas of real congestion the current omission of modeling of bicycles and motorcycles in capacity, marginal cost analysis, and system performance analysis needs to be corrected to obtain accurate cost/benefit results covering all road users and the full costing of road and intersection capacity.

11.7 Lifestyle factors

Lifestyle needs have an influence on transport choice and opportunities in a number of ways. The outer suburbs of Melbourne are difficult to serve with public transport at a high level of service due to their low densities. The patterns of movement between home and workplaces have become sharply less focussed on the CBD and the radial capacity that the large fixed public transport infrastructure that Melbourne has in place.

The increasingly dispersed (and time flexible) demands of both home to workplace travel and travel for other purposes have made the task of public transport increasingly difficult, as concentrated corridors of demand at defined times have faded in importance. The peak demand period is no longer concentrated into two morning and afternoon peaks, and a longer and more diffused peak in the afternoon is making multiple use of scheduling of school and public services with the same fleet increasingly difficult for smaller operators. The responses have been to deliver smaller buses, develop hubs for interchange and a slowly increasing range of specialised services such as Nightrider for the very late entertainment traveler.

The performance envelope of motorcycles, mopeds and scooters has been shown in several ways in this report to be comparable to cars, and over a far longer range of distances and weather conditions than all but the most dedicated and committed bicycle users.

The regulatory barriers to the use of even light scooters are substantial in Victoria, which has a high driving age and restrictive regulations for mopeds by world standards. The pressure on mobility is substantial, and the trend to multiple cars in outlying areas in households of low income was established several decades ago.

Now, with the rise in congestion and traffic levels, as well as the rise in two worker and part time households, there is an opportunity to expand the options available for mobility by a carefully judged package of measures assisting powered two wheelers in the same way that the other major vulnerable road uses (bicycles) have already benefited from.

To realise such a package will require social and environmental as well as economic and traffic factors to be developed and integrated as a model for regulatory, traffic engineering and transport policy measures.

Previous Victorian transport strategies such as Transporting Melbourne (Department of Infrastructure, 1996) substantially ignored motorcycles (Green, 1997). Only specialised reports on the road safety component have included anything substantive on motorcycles, scooters or mopeds.

It would be to the benefit of all if a formal integrated transport policy were to be developed in which all these factors – and all of the vulnerable modes – could be effectively fitted and appropriate support be committed to realise the overall gains that are available.

The present report provides some of the basic materials required for the vulnerable powered road user components to be developed for such a policy package.

12. Conclusions

There are a number of transport and traffic situations where motorcycles, scooters and mopeds (PTWs) offer or already provide realisable advantages

12.1 Information resources

The consultation processes with Local Government has demonstrated that the available material to guide provisions for PTWs has been very sparse. The recent Austroads Guide to Traffic Engineering Practice – Motorcycle Safety, Part 15 was quoted as a useful safety and traffic engineering resource by several (Austroads, 1999), but was the sole resource quoted. The recent issue of a series of Motorcycle Notes by VicRoads (VicRoads, 1999; VicRoads, 2000a; VicRoads, 2000b; VicRoads, 2000c; VicRoads, 2000e; VicRoads, 2001) will help to address this limited access to workable guidance in selected areas.

This has materially hampered the development of a sound and informed framework for balanced PTW (powered two wheeler) assessments.

There are no professionally developed teaching units on motorcycle, moped and scooter issues which could be included in University, professional, commercial or technical short courses or degree programs. While many of the traffic, transport and economic evaluation issues are covered broadly in general units, there is a demonstrated need for a more focussed resource that brings the transport, traffic engineering, safety, social, economic and environmental materials together in a unified and usable form.

There would be advantages in making this information and teaching resource one that covered all three of the vulnerable road users (pedestrians, bicycles and motorcycles) in a unified manner as there are substantial common factors as well as crucial differences. Both would need to be highlighted: the combined bicycle/pedestrian course developed by the US Federal Highways Administration (FHWA, 2000) illustrates both the strength of this approach to providing resources and guidance in an accessible form for a broadly technical audience - and also emphasises the need to include all three vulnerable modes to make an effective unit that would both appeal to and inform planning, safety, transport and environmental communities involved.

The importance of this combined group in road safety terms alone would make this a valuable resource, and given the effectiveness that Local Government in particular show when provided with appropriate materials and presumably training access) this would be a cost effective action.

12.2 Target areas for PTW measures

A number of areas have been identified in this report where motorcycles, mopeds and scooters offer realisable advantages.

• More efficient use of road space

- Reassessments of existing dedicated lane utilisation, including transit, bus and cycle lanes, and assessments of compatibility and joint use regulation possibilities
- Assessments and trials of advanced stoplines
- Better accessibility

- Enhanced police, emergency services and medical access, requiring adjustments to the current Australian Road Rules to be re-established or maintained
- Extension of existing motorcycle parking rights and facilities on and off the roadway will enhance accessibility or professional and ordinary motorcycle, moped and scooter users

• Emission and pollution gains

- Switches from current cars to current motorcycles (or simply greater use of motorcycles with cars by people with both cars and motorcycles) offer significant gains in fuel consumption as well as reductions in emission, information on in-use motorcycle and scooter fleets an emission characteristics and evaluation criteria are needed to secure these gains.
- Improved car driver access to small modern scooters etc, can also enhance such gains

• Reduced parking space provision on and off street

- Costings of space overheads of each mode mix for different trip purposes: large portions of central cities are dedicated to on and off road car parking space. The effectiveness of altering this large commitment - even at the margin - offers gains in several different areas including road capacity.

• Improved mobility

- Specific valuation of the utilisation of time saved by using a motorcycle or scooter and recognising their superior performance in travel speed, operating costs, parking space and emission characteristics in addition to differential safety costs in economic evaluations could expand the access and mobility of appropriate groups in the community.

12.3 Specific areas that justify early attention include (with application examples):

• Economic and environmental evaluation

- Motorcycle courier performance for business
- Better focused and differentiated crash, user cost, and time cost valuations
- Environmental benefits including full life emission/energy use

• Positive capacity management measures

- Assessments of filtering through traffic

- Road space utilisation and allocation policy

    - As part of a joint Vulnerable Road User policy
    - Use of advanced stoplines
    - Dedicated lanes

- Enhanced accessibility

    - The activity patterns and costs of people using motorcycles
    - Shopping, medical and personal services access by older people (30+)

There are numerous examples of specific steps that could be taken up, and a short list of some of these are given as Appendix 24 (ACEM, 2000). However, although there are many clearly under-assessed and under-used potential areas of motorcycle contribution, there are four things lacking:

- An integrated Vulnerable Road User Strategy with broader evaluation criteria than solely safety

- A sound set of economic, social and environmental evaluation factors to assess such policies

- Adequate monitoring information on powered and vulnerable two wheelers as a whole, ie data to correct the current unbalanced over-reliance on crash statistics.

- A coherent information and instructional resource covering the different aspects of all vulnerable road users with instructional support

These shortfalls demonstrate that powered two wheelers are currently inadequately integrated into the transport policy process as a whole. The present report is to assist in this process by bringing together existing and fresh information on motorcycles, mopeds and scooters in this broader context.

References

ACEM. (2000). *Smart wheels for city streets: powered two wheelers a practical alternative* (Report). Brussels: ACEM.(59p).

ACEM. (Undated). *Position Paper on the End of Life Vehicles Directive* . Brussels: ACEM.

ACEM Pollution Research Group. (1998). *Motorcycle pollution research programme on motorcycles* (Report). Brussels: ACEM.(71p).

Adena, M. A., & Montesin, H. J. (1988). *Day to day travel in Australia 1984-5* (Report CR69). Canberra: Instat Australia for the Federal Office of Road Safety.

Anderson, P. R., Montesin, H. J., & Adena, M. A. (1989). *Road fatality rates in Australia 1984-5* (Report CR70). Canberra: Office of Road Safety.

Andreassen, D. C. (1991). *Trucks, Semi-Trailers and Motorcycles: accident costs for project planning and appraisal* (Report ARR 232). Vermont: Australian Road Research Board.

Andreassen, D. C. (1994). *Model guideline for road accident data and accident types version 2.1* (Technical Manual ATM29). Vermont: Australian Road Research Board.

Andreassen, D. C., Thoresen, T.R.L., & Wigan, M. R. (1988). Review and requirements of costing and valuation of road accidents. *Australian Road Research, 18*(2), 110-111.

Anon. (Undated-a). *Austrian National Environment Plan*. (http://www-vie.unep.net/service/cedar-website/data/nup/nup-english/nup343.html)

Anon. (Undated-b). *Design Manual for Roads and Bridges (DMRB)* (http://www.highways.gov.uk/): DETR UK. (http://www.official-documents.co.uk/ document/ ha/ dmrb/index.htm).

Arup Transportation Planning. (1995). *The 1994 crash exposure survey* (Report). Melbourne: Arup Transportation Planning for VicRoads.

Australian Bureau of Statistics. (1996). *ABS Survey of motor vehicle use* (Preliminary). Canberra: Australian Bureau of Statistics.

Austroads. (1999). *Guide to Traffic Engineering Practice: Motorcycle safety*. (Vol. 15): Austroads.

Baang, K. L., & Palgunadi. (1994). Capacity and Driver Behaviour in Indonesian Signalised Intersections. *Proceedings Of The Second International Symposium On Highway Capacity, 90*(1), 71.

Bell, M. C., & Dolphin, R. W. (1990). *Bicycles and motorcycles. Urban road usage* (TRRL Contractor Report). Crowthorne: Transport and Road Research Laboratory.

Branston, D. (1975). *The effect of different vehicle types on capacity* (Report). Montreal: Centre de Recherche sur les Transport, Universite de Montreal.

Branston, D. (1977). Some Factors Affecting the Capacity of a Motorway. *Traffic Eng Control, 18*(6), p304-307.

Branston, D., & Van Zuylen, H. (1978). The Estimation of Saturation Flow, Effective Green Time and Passenger Car Equivalents At Traffic Signals By Multiple Linear Regression. *Transp Res, 12*(1), p47-53.

BTCE. (1996). *Transport and greenhouse: Costs and options for reducing emissions* (Report 94). Canberra: AGPS.(541p).

CARB. (2000). *OnRoad MVEI Models: MVEI7G Software Documentation* (Report in 6 Volumes http://www.arb.ca.gov/msei/mvei/mvdocs.htm): California Air Resources Board.

Cambridge Systematics, & Bicycle Federation of America. (1999). *Guidebook on Methods to Estimate Non-Motorized Travel* (FHWA-RD-98-165). Washington, DC.: U.S. Department of Transportation Federal Highway Administration.

Chandra, S., Kumar, V., & Sikdar, P. K. (1995). Dynamic Pcu and Estimation of Capacity of Urban Roads. *Indian Highways, 23*(4), p17-28.

Department of Infrastructure. (1996). *Transporting Melbourne: A strategic framework for an integrated transport system in Melbourne* (Report). Melbourne: Department of Infrastructure.

DETR. (1998). *A new deal for transport: better for everyone. The governments' white paper on the future of transport* (CM 3950). London: HMSO for the Department of Transport Environment and the Regions.

Diamantopoulou, K., Brumen, I., Dyte, D., & Cameron, M. (1995). *Analysis of Trends in Motorcycle Crashes in Victoria* (Report CR84). Melbourne: Monash University Accident Research Centre.

Federal Office of Road Safety. (1999). *Road fatalities Australia: 1998 Statistical summary* . Canberra: Federal Office of Road Safety.

FHWA. (2000). *Draft FHWA course on bicycle and pedestrian transportation: CDRom Student workbook* (Draft), [CDRom]. Federal Highways Administration Washington DC USA.

Galambos, S., & Haworth, N. (1994). *Survey of motorcycle rider characteristics* (Unpublished Report). Melbourne: Monash University Accident Research Centre.

Green, R. (1997). *Transporting Melbourne: Motorcycling's role* (Submission to the Victorian Department of Infrastructure in response to 'Transporting Melbourne'). Melbourne: Motorcycle Riders Assocation of Australia.

Greenhouse Computing. (1999). *Motorcycle accidents in Victoria* (Unpublished Report). Melbourne: Greenhouse Computing for Vicroads Road Safety Department.

Gunn, K., & MacLean, S. (1990). *Summary report on a quantitative study: Police attitudes to traffic law enforcement* . Melbourne: AGB: McNair for VicRoads.

Hamer, M. (1996). Messengers of death. *New Scientist, 10*(5), 14-15.

Haworth, N., Smith, R., Brumen, I., & Pronk, N. (1997). *Case-control study of motorcycle crashes* (Report CR 174). Canberra: Monash Accident Research Centre for the Federal Office of Road Safety.

Hensher, D. A. (1994). Stated preference analysis of travel choices: the state of practice. *Transportation, 21*(2), 107-133.

Holroyd, E. M. (1963). The effect of motorcycles and pedal cycles on saturation flow at traffic signals. *Roads and Road Construction, 41*, 315-316.

Hurt, H. H., Ouellet, J. V., & Thom, D. R. (1981a). *Motorcycle Accident Cause Factors and Identification of Counter Measures. Volume 1: Technical Report. Final Report* (Report DOT-HS-805-862). Washington DC: University of Southern California, Traffic Safety Center, University Park, Los Angeles for NHTSA.

Hurt, H. H. J., Ouellet, J. V., & Thom, D. R. (1981b). *Motorcycle Accident Cause Factors and Identification of Countermeasures. Volume II: Appendix/Supplemental Data* (DOT-HS-805-863). Washington DC: University of Southern California, Traffic Safety Center, University Park, Los Angeles for NHTSA.

Instat Australia. (1988). *Review of the Australian day-to-day travel survey data base 1984-5* (Report CR68). Canberra: Instat Australia for the Federal Office of Road Safety.

Kimber, R., McDonald, M., & Hounsell, N. (1985). Passenger car units in saturation flows: Concept, Definition, Derivation. *Transportation Research. Part B: Methodological, 61*.

Litman, T. (1999). *Transportation cost analysis; techniques, estimates and implications* . Victoria Canada: VUTPI.(235p).

Marler, N. W., Harahap, G., & Novara, E. (1994). Speed-flow relationship and side friction on Indonesian urban highways. *Proceedings Of The Second International Symposium On Highway Capacity, 56*(2), 447.

Melbourne City Council. (1998). *Motorcycle parking: Questionnaire June 1998 summary of results* (Report P:\7018\00\013514.doc). Melbourne: Melbourne City Council.

Powell, M. (1997). Modelling the behaviour of motorcycles at traffic signals. *Traffic Engineering And Control, 38*(10), p521-528.

Ramanayya, T. V. (1988). Highway capacity under mixed traffic conditions. *Traffic Engineering And Control, 29*(5), p284-287.

Research International Australia. (1988). *Final report: Motorcycle exposure and accident risk study* . Melbourne: Road Traffic Authority.

Rheinberg, F. (1991). Flow-experience when motorcycling: a study of a special human condition. *Proceedings of the International Motorcycle Safety Conference, 7, 349.*

Schulz, U., Gresch, H., & Kerwien, H. (1991). Motorbiking: motives and emotions. *Proceedings of the International Motorcycle Safety Conference, 7, 465.*

Schwartz, W., & Porter, C. (1999). *Bicycle and pedestrian data: Sources, needs and gaps* (BTS-00-02). Washington DC: Cambridge Systematics for US Department of Transportation Bureau of Transportation Statistics. (77p).

Sharples, R. (1993). Modelling cyclists in Saturn. *Traffic Engineering And Control, 34*(10), p472-475.

Simons, P. C., Farndon, D. F., Kloeden, C. N., & McLean, A. J. (1999). *Gorge Road motorcycle safety audit and research project* (Report). Adelaide: BC Tonkin and Associates and Adelaide Road Accident Research Unit for Transport SA.

Socialdata Australia. (1987). *A database for the evaluation of road user risk in Australia* (Report CR51). Canberra: Socialdata Australia for the Federal Office of Road Safety.

Srinivas, D. (1996). Energy-environment linkage of urban transport sector in India. *Indian Highways, 24*(8), p27-37.

Thoresen, T., & Rosalion, N. (2000). *Road user costs for use in the economic evaluation of road expenditures: unit values as at 30 June 1997 and 1998* (Publication AP491). Sydney: Austroads.

Tilley, A. (1998). *A study of motorcycle, moped and scooter use in Sandwell* (http://www.sandwellmbc.broadnet.co.uk/). Sandwell West Midlands UK: Sandwell Metropolitian Council.

Transport Research Centre. (1999). *The VATS Process: 1998 Release 2*. Melbourne: RMIT.

Travers Morgan. (1982). *Small motorcycle study: Stage 1 Overview*. Adelaide: Director General of Transport South Australia.

UK: Automobile Association. (1999). *Motoring costs* (http://www.theaa.co.uk/motoringandtravel/motorcosts). UK: Automobile Association.

UK: Department of Engineering Services. (1999). *Motorcycling in Stoke-on-Trent: Survey results and report* . Stoke-on-Trent: City of Stoke-on-Trent.

UK: Motorcycle Industry Council. (1999). *Powered two wheelers: The SMART choice in local Transport Plans: the Motorcycle Industry Association's policy resource kit for powered two wheelers* (Report). Coventry: Motorcycle Industry Council.

Van Laarhoven, A. J. M. (1985). Generalized models for the number of passages and encounters in mixed traffic flows. *Verkeerskunde, 36*(9), 402-405.

VicRoads. (1996). *Crashstats: Road crash statistics Victoria 1991-1995*, [CDRom]. Swinburne University of Technology for VicRoads.

VicRoads. (1999). *Motorcycle Advisory Council Workshop* (Motorcycle Note 1 VicRoads Publication 330). Melbourne: VicRoads.

VicRoads. (2000a). *Consultation for motorcycle measures* (Motorcycle Note 2 VicRoads Publication 382). Melbourne: VicRoads.

VicRoads. (2000b). *Designing for motorcycle clearances* (Motorcycle Note 4). Melbourne: VicRoads.

VicRoads. (2000c). *Loose surfaces and motorcycles* (Motorcycle Note 3 VicRoads Publication 478). Melbourne: VicRoads.

VicRoads. (2000d). *Road safety strategy for Victoria 2000-2005* (Discussion Paper). Melbourne: Victorian Roads Corporation.

VicRoads. (2000e). *Road surface friction standards* (Motorcycle Note 5). Melbourne: VicRoads.

VicRoads. (2001). *Designing for the unexpected* (Motorcycle Note 6). Melbourne: VicRoads.

Volmuller, J. (1978). *Traffic engineering design of bicycle facilities.* Paper presented at the 13th Interational Study Week - Traffic engineering and safety, Montreux Switzerland.

Wigan, M. R. (1979). *Mopeds: legal and technical requirements for Australia* (Research Report ARR 95). Vermont, Victoria: Australian Road Research Board.

Wigan, M. R. (1984). Bicycle ownership use and exposure participation and activity patterns in Melbourne, Australia. *Transportation Research A, 18*(5/6), 379-398

Wigan, M. R. (1987). *Australian personal travel characteristics*. (Special Report SR 38). Vermont: Australian Road Research Board.(256p).

Wigan, M. R. (1994). *Taking Non-Motorised transport seriously: measurement and evaluation.* Paper presented at the 19th Australian Transport Research Forum, Lorne, Victoria.

Wigan, M. R. (1995). Walking as a transport mode. *Transportation Research Record*(1487), 7-13.

Wigan, M. R. (Unpublished). *Motorcycles and traffic capacity.* Paper submitted to the Transportation Research Board, Washington DC.

Wigan, M. R., & Carter, A. C. (1980a). *Australian moped users* (Research Report ARR 115). Vermont, Victoria: Australian Road Research Board.

Wigan, M. R., & Carter, A. C. (1980b). *Mopeds and the Australian user profile.* Paper presented at the International Conference on Motorcycle Safety, May 1980, Washington DC.

Wigan, M. R., & Rockliffe, N. R. (1998). *Freight survey requirements for urban areas.* Paper presented at the 19th ARRB Conference, Sydney, NSW.

Wigan, M. R. (1998). *Using geographical information systems to promote vulnerable road user safety education.* Paper presented at the Proceedings of the Conference on Pedestrian Safety, Australian College of Road Safety and Parliament of Victoria, Melbourne, Australia.

Wigan, M. R., & Smith, N. C. (1996). *Creating ANBI: the Australian National Bicycle Information Base.* Paper presented at the Velo Australis "Bicycles; a global solution to local problems": International Bicycle Conference, Fremantle, Western Australia.

OS Report OS6/2000 July 2000 Vol 1 Final Report

Biblographic Reference:

Victorian Roads Corporation (2000) Motorcycle transport: powered two wheelers in Victoria. Vol 1. Final Report. Report for VicRoads on behalf of the Victorian Motorcycle Advisory Council by Oxford Systematics, Heidelberg,Victoria, Australia. VMAC Report 2000-1-1. July (63p)

Abstract

Motorcycles have generally been treated solely from the safety aspects of their usage. This report examines motorcycles as transport, and their characteristics in terms of terms of mode choice, multiple vehicle ownership, traffic flow and capacity impacts, environmental and economic assessment. The limited data from across the world shows clear deficiencies on professional coverage on almost all aspects other than safety factors. Australian and new Victorian survey data was analysed to place motorcycles, scooters and mopeds in a transport and traffic context. Key findings are 1. A vulnerable road user policy is needed, covering pedestrians. cyclists and motorcyclists: ie both nonmotorised and motorised vulnerable transport modes together. 2. A road space management policy for all road users on consistent grounds. 3. Improved economic evaluation factors. 4. Integration into transport and traffic models. 5. Instructional resources covering all vulnerable road user modes.

Dr Marcus Wigan, Principal, Oxford Systematics. Dressed as proved to be effective for good survey response
Location: Elizabeth St Melbourne: the oldest motorcycle precinct in the world. *Photo by Damien Codognotto*