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Research is recommended to obtain basic information on the nature and geographic distribution of accidents, and the potential for town planning countermeasures. Other specific studies are suggested. A bibliography is included, and several more detailed background reports are referred to.

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A REVIEW OF LITERATURE AND PRACTICE

R.E. BRINDLE, Principal Research Scientist, ustralian Road Research Board.

TOWN PLANNING AND ROAD SAFETY - A REVIEW OF LITERATURE AND PRACTICE

AUSTRALIAN ROAD RESEARCH BOARD

The Australian Road Research Board is the focal point of road research in Australia. It regularly undertakes and arranges road and road transport research over a comprehensive range of subjects. The results of that research are disseminated to appropriate organisations and to the scientists, engineers and associated specialists involved with the design, location, construction, upkeep and use of roads. The need for a national research centre was realised by NAASRA, the National Association of Australian State Road Authorities, who founded the Board in 1960. In 1965 ARRB was registered as a non-profit making company financed by Australia's Federal and State Government Road Authorities. Each member authority is represented by its permanent head on ARRB's Board of Directors, whose policies are administered by the Executive Director.

All research is controlled from the Australian Road Research Centre at Vermont in Victoria, but, since its inception, the Board has sponsored research conducted at universities and other centres. The 1981-1982 overall program of the Board was budgeted at \$3.8m. The Board also relies on advice from its technical committees in Road Technology, Road User Behaviour, Road Transport and Local Government and its overseeing Steering Committee.

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EXECUTIVE SUMMARY

This Study aimed to find out what was being promoted as good town planning practice for road safety, what was actually being done, what is the scope for improvement, and what research is required (p.1). Detailed discussions and findings are contained in several background reports (Appendix A).

A summary of Australian local government practice revealed that over 90 per cent of municipalities have had direct experience with at least some planning-for-safety measures, although safety was often not an explicit motive (p.11). Australian practice reflects reasonably high level of awareness of what is commonly accepted as good practice (Chapter 3).

Since the principal interest of the Study was in the effectiveness of the various recommended practices, particular attention was paid to any reports of measurement or evaluation of effects. A critical assessment of the effectiveness and feasibility of planning ideas as road safety measures was also made (Chapter 4).

The findings on specific measures covered by typical planning guidelines are summarised in Chapter 5 (especially Tables 16, 17, 18 and 20).

The following general conclusions were reached:

- (a) Examples of most of the more effective measures are common in Australia, but effective practice cannot be described as universal.
- (b) Some of the commonly accepted guidelines do not wholly accord with the conclusions on effective practice, and should be carefully considered before being further promoted. For example, the conventional interpretation of 'road hierarchy' accepts dual access and traffic carrying functions for nearly all roads. These functions are in conflict. Promotion of a hierarchical road system which accepts or ignores this conflict seems to be counter-productive in safety terms.
- (c) Some potentially effective practices appear not to be covered by current guidelines, nor reflected in common practice. For example, safety benefits would apparently follow from frontage management (access control, wider frontages, greater building set-backs, etc.) on a wider range of roads above the local access street, and not just major arterials.
- (d) Local area planning appears to present the greatest opportunities for effectively applying planning-forsafety measures. A significant minority of urban casualties occurs on local streets, and it is there that designers and planners have greatest influence on the physical environment.
- (e) Most of the potentially effective practices are the responsibility of, or under the influence of, local authorities. Some observations on why good practice is less extensive than might be preferred are made (p.35-36).
- (f) There is a paucity of research and monitoring to support current practice. At the very least this means that we lack basic information to evaluate alternative plans. The safety benefits of most specific planning measures cannot currently be quantified.

Twenty-five possible themes for further investigation were identified during the course of the Study (Appendix B). These have been consolidated into recommended study areas on the basis of feasibility and likely benefits of planning activity in the area concerned.

On that basis, support seems to be strongly indicated for studies on local area traffic management and street replanning in older areas, and to neighbourhood planning generally. Improvements in town planning aspects of networks and major road management seem to be next in potential value. Pedestrian and cycle aspects are particularly predicated in all areas.

However, before specific major studies can be recommended in particular areas, it is necessary to obtain basic information on the distribution of urban accidents and the feasibility and rationale of planning as a road safety tool. Two studies in these areas are recommended.

Subsequent studies of most immediate interest are likely to be those in areas of current practice about which some doubts are raised in the Report, e.g. a comparison of T and Cross intersections (p.40, 47-49); an examination of the real value of comprehensive planning (p.37-38); a closer look at the differences in accident experience between developments from different eras, and their causes (p.32); development of alternative interpretations of the meaning of road hierarchy to avoid some of the problems found in current practice (p.39, 47); and the value of Radburn layouts compared with alternative forms of local layout (p.38, 50).

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GLOSSARY

In this Report, the following terms take the given particular meaning:

ACTIVITY CENTRES	areas or locations at which there is a concentration of trip ends and within which there is considerable pedestrian activity; mostly retail in function, but including social, educational, entertainment and other focal points.
AUSTRALIAN GUIDELINES	document issued in Australia under the title 'Road Safety Guidelines for Town Planning' (Department of Transport 1978).
DISTRIBUTOR ROAD	any road serving to distribute traffic over an urban area; whence:
	primary distributor — synonymous with major route;
	district distributor — a road distributing traffic at a district level;
	local distributor — a road distributing traffic within a local area (often synonymous with 'collector' in other contexts).
EVALUATION	assessment of the degree of success and worth of a (planning) measure.
GUIDELINES	a general term used to cover the body of literature and planning thought about recommended planning practices for road safety.
LOCAL AREA	a term used loosely to cover areas bounded by major routes — therefore including 'local roads', and embracing other area labels such as 'precinct', 'neignbourhood', etc.
MAJOR ROUTES/ROADS/NETWORKS	those roads/networks serving to distribute traffic in an urban region, generally comprising those roads commonly defined as arterials and sub-arterials.
MONITORING	observation and measurement of the performance of a (planning) measure.
PLANNED COMMUNITY	a community which has been comprehensively planned and developed by, or under the control of, a single authority or organisation.
ROAD HIERARCHY	a systematic grading of roads according to increasing or decreasing importance of their traffic-carrying function.
SCAFT GUIDELINES	document issued in Sweden as a basis for planning of housing areas and the supporting road system, for safety objectives. The primary emphasis was on segregation of different forms of movement within housing areas (Swedish National Board of Urban Planning 1968).
SERVICE ROAD	a subsidiary carriageway constructed between the principal carriageway and the property line, connected only at selected points with the principal carriageway.
TOWN PLANNING	the control of changes in the urban physical environment, and the way it operates, to achieve desired social, economic, gesthetic and other goals.
URBAN FORM	the general pattern or shape of an urban area.
URBAN STRUCTURE	the way in which centres and major land uses, together with the supporting transport and other networks, are arranged in an urban area.

ABBREVIATION

ADT	Average Daily Traffic
ARRB	Australian Road Research Board
DoE	Department of the Environment (U.K.)
DoT	Department of Transport (Australia)
LATM	Local Area Traffic Management
LGA	Local government authority or area (depending on context)
MMBW	Melbourne and Metropolitan Board of Works
NAASRA	National Association of Australian State Road Authorities
NCDC	National Capital Development Commission
OECD	Organisation for Economic Co-operation and Development
PEC	Planning and Environment Commission (N.S.W.)
ORS	Office of Road Safety (of the Department of Transport)
RoSTA	Road Safety and Traffic Authority (Vic.)
TCPB	Town and Country Planning Board (Vic.)
TRRL	Transport and Road Research Laboratory (U.K.)

Chapter 1

INTRODUCTION TO THE STUDY

'Any town so planned that its citizens are killed and injured in vast numbers is obviously an iil-planned town' (Tripp 1942).

BACKGROUND

Long before the motor car was dreamed of, planned communities were devised as a means of improving the health and welfare of citizens (Howard 1946; Foster 1981). The above quotation from Sir Harry Alker Tripp, dating back 40 years, reflects the longheld confidence that town planning, by setting and controlling the physical arrangement of urban areas, can reduce not only road accidents but also many of society's other problems.

There has been a resurgence of interest in the role of planning theory and controls in creating potentially safer physical environments, at least in those parts of the world where public intervention in the development and operation of the land use/traffic system is accepted.

Work commenced at Chalmers University in Sweden in 1961 to investigate the links between physical planning and road safety. This led in 1968 to the issuing of the Scaft Guidelines (Swedish National Board of Urban Planning 1968), which were concerned primarily with criteria for road planning, particularly in residential areas. These principles were becoming known in Australia at the start of the 1970s and helped to reinforce the long-held view that 'good planning' did indeed create safe cities.

Town planning and road safety was one of the topics in the 1971 national review of road safety issues sponsored by the Department of Transport, Australia (DoT) (Loder and Bayly 1973). Interest in the subject was sustained by the Office of Road Safety (ORS), leading eventually to their *Road Safety Guidelines for Town Planning* (Department of Transport 1978). Subsequent interest has been directed towards guidelines for safer residential areas (Murray 1983).

It became evident as a result of this sustained interest that the practices promoted in the 'planning and road safety' area deserved close examination, and the extent and results of their application should be recorded as part of that examination. The Office of Road Safety then invited the Australian Road Research Board (ARRB) to participate in a Study, for which the following objectives were defined.

(a) 'To collect and evaluate in one volume a review of the practical urban planning activities and associated research in relation to road safety ... It will be essentially a state-of-the-art review with a critical assessment of the value, in safety terms, of the proposed and current practices.'

- (b) To identify gaps in research into the potential road safety benefits of various planning practices, at both the regional and local scales, with particular reference to evaluation needs, in order to establish future research priorities.
- (c) 'To generate study proposals, with specified objectives, resource requirements and likely benefits.'
- (d) 'To determine the extent that safety-oriented planning practices have been adopted, and to identify those factors militating against their adoption.'
- (e) 'To identify the scope for improvement in both development and redevelopment of urban areas and localities in relation to road safety, on the basis of information gathered in the course of the Study.'

This report records the findings of the Study, and some of the investigations and deliberations which lie behind them. Supplementary information and discussion may be found in ARRB's background reports issued during the course of the Study, which are referred to throughout this report and summarised in Appendix A.

The very familiarity of many of the principles contained in 'Road Safety Guidelines for Town Planning' (which will be referred to as the 'Australian Guidelines' throughout the rest of this report) led some practitioners to denigrate the value of the publication, on the grounds that they were already an established and proven part of good practice. Nevertheless, this Study has shown the subject to be far from clear-cut; the principles are neither universally applied, nor are they all demonstrably beneficial. This is not the same as saying they are *not* beneficial, only that — so far at least — many of the familiar principles have not adequately been scrutinised, although some seem at best to be ineffective or inefficient measures.

At the other extreme of the spectrum was the sceptical view that we are unable to identify the real causes of accidents; therefore, inferences which might be drawn about the effects of particular planning measures or physical environments are (according to this view) invalid.

Another view accepts the proposition that the kinds of changes made through planning actions may correspond with changes in accidents (even if they do not 'cause' them); nevertheless, according to this view, the long and complex chains of causes and

effects makes it impossible (or at least impractical) to predict confidently the effects of a particular planning measure in a particular environment.

Such questioning of the basic premise of 'planning for safety' (that behaviour and physical conditions can be manipulated by planning action to reduce road accidents) was not envisaged in the Study objectives, and created the need to pay particular attention to the *effectiveness* of planning measures.

Evidence of effectiveness was thus specifically sought in the Study. Once a change or redirection is proposed in the urban land use/traffic system, a knowledge of the consequences is demanded. Not only must there be confidence that the proposed action will produce the result aimed for, but also its other likely consequences must be anticipated. Improved road safety is an example of a specific motive for planning actions, whose actual effects need to be scrutinised to see if they achieve what they are popularly believed to achieve, and at what cost.

In summary, and to anticipate the rest of this report, the Study confirmed that the subject was neither worthless nor exhausted. It did transpire that rather more scepticism was warranted than the objectives suggested. This is not to question either the premises of the Study or the theory of the guidelines. Rather, it suggested a need for close attention to assessing the observed or likely safety impacts of recommended planning measures, for whatever reasons those measures may be principally warranted.

THE LITERATURE ON PLANNING AND ROAD SAFETY

Although more than 400 sources were cited in the Study reports (see Bibliography), substantial references on this subject are few in number. From the modern (post-World War II) literature, only four English-language sources are known to present and/or substantiate planning guidelines for road safety across a broad range of planning activities. These are:

- The Scaft Guidelines (Swedish National Board of Urban Planning 1968)
- The Australian Guidelines (Department of Transport 1978)
- Conclusions based on a state-of-the-art review by Cameron (1977 a and b) in South Africa
- Recommendations on practice put forward by Harper (1972) based on his earlier work.

These sources were used as benchmarks for the examination of the basis, application and validity of the various recommended practices. They are not entirely independent, being woven in with each other and several other sources. *Fig.* 1 shows the citation links between these sources (i.e. who cites whom); the importance of the Swedish work via Harper to the Australian Guidelines is readily evident.

THE SCAFT GUIDELINES

The Scaft Guidelines (Swedish National Board of Urban Planning 1968) were issued as a basis for the planning of housing and the road system in Sweden. The Guidelines were drawn up by a working group at the Institute of Urban Planning, Chalmers University of Technology, at Goteborg, and grew out of the work which had been taking place there since 1961. The workers recognised that the practical economic and safety consequences needed assessing, and that was the objective of a series of investigations and 'competitions' through the 1970s.

The Scaft Guidelines contain 41 principles, with supplementary comments and illustrations. The primary emphasis is on reducing the possibility for conflict by segregating vehicular from non-vehicular movement, and access traffic from the traffic distribution system. A characteristic of the Scaft Guidelines is the clear distinction between minor roads and all levels of traffic distributor, which have no abutting access or parking.



Fig. 1 — Citation links between some of the key sources (Note: Source at the head of the arrow cited the source at the tail of the arrow.)

Although the existence of the Guidelines was not noted in the 1971 Australian review (Loder and Bayly 1973), no known copies being accessible in Australia at that time, reference to it was made subsequently by the investigators when supplying bibliographical assistance to the then Department of Shipping and Transport. By the time Harper (1972) addressed planning aspects at the National Road Safety Symposium (which, like the 1971 National Review, was part of the work of the Expert Group on Road Safety (1972)), the nature of the Scaft Guidelines had become more widely known in Australia.

Gunnarsson (1982) reports that the Scaft Guidelines and the standards derived from them served to good effect as a tool for urban and traffic plans during the 1970s. They have since been replaced by new standards, based mainly on the same principles.

THE AUSTRALIAN GUIDELINES

By 1974, the availability of these broad-ranging reviews and guidelines, and a considerable amount of specific information on particular measures, was recognised (McKinna 1976). But it was felt by the Australian Department of Transport that the information was not being put to maximum use. Based on material drafted by P.G. Pak-Poy and Associates (1974), the Guidelines were foreshadowed by McKinna (1976) and eventually appeared in 1978 (Department of Transport 1978).

The Australian Guidelines comprise 31 recommendations (including seven related to existing street systems). The publication describes itself as being similar to the Scaft Guidelines, yet there are clear differences between the two both in content and effect. Even allowing for differences between Sweden and Australia, the two sets of Guidelines would create distinctly different physical results if fully applied. The essential differences relate to the two key characteristics of the Scaft Guidelines which have already been identified:

- (a) The critical emphasis placed on segregated movement systems compared with the permissive tone of the Australian Guideline 20 : 'Pedestrian/cycle routes should be included ...'
- (b) The kind of road hierarchy which would result; the Australian Guidelines represent a refinement of the status quo, in which roads serving a mixture of substantial traffic and access functions ('non-descript roads', Tripp (1942) called them) are not only tolerated — they are an inevitable result of the practice reflected in the Guidelines.

There are equally distinct differences between the two in their effect. The Scaft Guidelines have more readily been applied, partly because of the stronger influence on application held by the sponsoring bodies, and partly because of the more prescriptive (standards-oriented) nature of the Swedish document. The National Board of Urban Planning is responsible for drawing up regulations which guide municipalities and consultants on planning methods and environmental standards. Their collaborators, the National Road Administration, is the central authority responsible for planning and construction of Sweden's nighway system. By comparison, the Australian Guide ines are purely advisory, their sponsors having no direct influence over application. The attitude of the implementing authorities and professionals to the Guidelines is therefore important.

SOUTH AFRICAN REVIEW

The Australian Guidelines admitted to an emphasis on 'traffic engineering and road design research and principles, no attempt having been made to produce a comprehensive manual on urban planning'. The review work in South Africa reported by Cameron (1977a and b) was restricted even further, to the influence of the layout of the road network on road safety. However, many of the topics covered by Cameron correspond to the scope of the Australian Guidelines. Since they are supported by extensive review material and lead to specific principles and application guidelines, these topics provide a useful alternative source in the present Study.

THE REST OF THE LITERATURE (Brindle 1982a)

Over 400 other literature sources were found to contain material which was in some way relevant to the Study. Most of these made only incidental reference to safety, or concerned applications of the various planning techniques for other than safety reasons. An impression was quickly formed as the literature grew, which remained throughout the Study: this is a subject on which there is much opinion, less real action, and little proof or demonstrated justification.

The dates of these publications reflect the increase in interest in aspects of this topic in recent years; over 60 per cent of them were published in 1977 or later, and over one-third after 1979, which was originally the nominal review year. Thus, even during the course of the Study, the body of literature increased significantly.

About half of the material related to urban networks and local area traffic management, with nearly one-quarter of the sources in each of these two categories. Only 40 per cent referred to applications, studies or data, the rest being guidelines, policies or general discussion. Of the sources on applications, the largest single group (39 per cent) referred to local area traffic management.

THE QUESTIONNAIRE SURVEY

In addition to the literature review, direct contact was made with government and other bodies, both in Australia and overseas (Brindle 1982a). Australian local government authorities (LGAs) were initially sent a questionnaire whose objectives were:

- (a) to establish the extent to which local authorities have implemented or approved those planning activities likely to have road safety benefits (defined in 16 categories):
- (b) to find out how many of these were in fact motivated by road safety objectives;
- (c) to determine whether any form of monitoring and evaluation of these actions had taken place;

- (d) to obtain information from these authorities on the extent to which various local street management techniques have been applied (only changes in a planning or area-wide context were relevant); and
- (e) to identify those local authorities worthy of more detailed follow-up.

The questionnaire was sent in 1978-79 to 352 local government authorities who met one of the following conditions:

- (a) were part of a metropolitan statistical district;
- (b) were part of a provincial city;
- (c) were any small city, town or borough council; or
- (d) were any rural shire containing a township having more than 5000 population. (In some cases, smaller towns were accepted.)

After reminders, 273 returns (78 per cent) were received and were used as the basis for the discussion on Australian practice which is summarised in Chapter 3.

OTHER CONTACTS

The questionnaire aimed to find out what has been done and experienced at the local government level. It could reasonably be expected that local government authorities would be aware of virtually all 'on the ground' applications of the sorts of measures with which this study is concerned.

It was recognised, however, that local government may not be the sole or major source of information on such things as:

- (a) data collection, analyses and assessments by outside bodies (State Traffic Authorities, Universities and so on);
- (b) works and reviews carried out by public development corporations, regional planning bodies and so on; and
- (C) procedures, planning approaches and assessments related to works by government instrumentalities.

There was also a need to communicate directly with government and research bodies overseas. Therefore, a general request for information was sent to 24 overseas bodies, 32 Australian federal and state bodies, and 10 Australian tertiary institutions (Brindle 1982a).

The Australian respondents were those considered to be possibly active in implementation, research, approval or data collection, excluding the State Road Authorities with whom separate contact had been established. Overseas bodies were identified from their recurrence in the literature or from reports of relevant research and documents listed in various international compilations. Participants in relevant OECD programs were also contacted.

The overall impressions from these responses were as follows.

- (a) Australian housing and development authorities are quite active in the areas which are the subject of this study, and attempt to apply positively their understanding of the state-of-the-art in planning for road safety.
- (b) Among Australian authorities only the National Capital Development Commission (NCDC) is in the position to systematically collect and analyse data specifically to draw general conclusions about the safety consequences of planning actions.
- (c) Consequently, subjective views abound.
- (d) No University or College reports current or past research on the subject, although one reported that it was contemplating work on pedestrian safety and subdivisional design.
- (e) Overseas sources produced several examples of assessment of effectiveness.

BACKGROUND REPORTS

This report is a consolidation of extracts from several background reports produced during the course of the Study.

These are listed, with abstracts, in Appendix A and can be referred to for more detailed discussion and information.

In addition, several papers were produced which are listed under the author's name in the Bibliography.

Chapter 2

THE SCOPE OF THE PRINCIPLES AND GUIDELINES

OUTLINE

Before the application and effectiveness of 'safetyoriented planning practices' can be discussed, the nature of those practices must first be established. This Chapter will summarise the guidelines and principles found in the basic sources described in Chapter 1, supplemented by comments on their planning basis and their place within what could be loosely described as the body of planning thought.

At this stage, no indication of approval or doubt about any of the guidelines and principles is intended. Appropriate comments on that subject follow in subsequent Chapters.

Throughout this discussion, the term 'guidelines' will be used as a general term to cover the body of literature and planning thought specific to the subject of recommended planning practices for road safety, including the basic sources introduced in Chapter 1. If any specific source is intended then it will be identified (e.g. 'the Australian Guidelines', referring to Department of Transport 1978).

The guidelines will be outlined under four general headings, which correspond to the scope of the separate background reports (urban form and structure, major routes and networks, centres, and local areas).

THE SCOPE OF THE GUIDELINES AND RECOMMENDED PRACTICES

GUIDELINES FOR URBAN FORM AND STRUCTURE

If accidents occur in the traffic system as a result of the numbers and concentrations of moving vehicles, then it would follow that there would be fewer collisions if the amount of travel could be reduced, and its distribution could be manipulated to reduce conflicts. 'After all,' Harper (1972) says, 'if people are not on the road they cannot be involved in traffic accidents.' Cameron (1977a) similarly states that minimisation of total travel distance is 'obviously one means of reducing accidents.'

Thus runs the logic of planning to reduce total car travel, which is a keystone of the various guidelines for road safety. Two themes are readily identified:

- (a) Manipulation of the urban form (general shape of the urban area) and urban structure (location of major land uses, particularly residential and employment zones) to reduce trip lengths.
- (b) Transport policy and modal planning to reduce the proportion of travel by car.

The efficiency of alternative urban structures, with trip length as the criterion, has been a major concern of both transport and land use planners for a long time, and there is an abundance of literature on the analysis of urban trip lengths arising from different urban structures (Hemmens 1967; Ogden 1970).

The Australian Guidelines include as an objective 'the reduction of the need for motor car traffic'. This evolved from a collection of local sources (Blunden 1972; Andrews 1972; Harper 1972) which spoke optimistically of the contribution that the organisation of land uses could make to the reduction of road accidents, and the use of transport modelling to that end.

Attempts to reduce the proportion of travel by car are based on the better safety performance of public transport. Achieving such an objective through urban planning requires not only that available public transport be used but also that the link between urban form and structure on the one hand and public transport feasibility on the other be clearly established.

The close similarity between discussions on the effects of travel planning on road accidents and on energy conservation is noted, especially since most of the pertinent literature relates to the latter subject.

GUIDELINES FOR MAJOR ROUTES AND NETWORKS

The common understanding of what constitutes good network planning practice, as reflected in the various guidelines, relates to:

- the establishment of a hierarchical road system, principally distinguishing major traffic routes from local streets;
- (b) the different planning and design principles which apply at each level in the hierarchy;
- permissable and prohibited connections between different levels in the road hierarchy;
- (d) the number and form of intersections on the major network, particularly concerning the preference for T-junctions over unsignalised cross-intersections;

- the location of traffic generating (attracting) land uses.
- (f) restrictions on the degree and type of access to different levels of road; and
- (g) the provision of routes and networks for nonmotorised travel in a town.

Road Hierarchy Guidelines

The importance of a 'functional hierarchy of roads', both as good road planning and for safety reasons, is one of the most deeply entrenched principles in the area covered by this review.

The establishment of a road hierarchy, being evidently a 'sensible' activity, has seemed not to need an empirical basis. Indeed, the subject by its nature does not lend itself to empirical appraisal and the rationale for hierarchically-defined road classes seems rather to be conceptual. However, implications that hierarchical distinctions promote certain accident patterns may be drawn from some studies of the distribution of accidents and travel on different classes of road (some of which are usefully summarised by Cameron (1977a); see also Brindle (1978; 1979b for a somewhat different picture). In particular, the low accident rate found on most freeways (for example, Nielsen (1972)) is commonly cited as a justification for including more freeways in road programs (Expert Group on Road Safety 1972) and, by inference, as an example of the benefits of hierarchical road networks. However, a discussion of road hierarchy implies more than just road geometry, although different standards of geometry typically are an important consequence of an hierarchical classification.

It is noted that the guidelines vary in the degree to which they specify the practical meaning of 'road hierarchy'. Whereas the Scaft guidelines tied road class names to design and operational characteristics, there is a tendency in other sources for a 'road hierarchy' to be seen as an end in itself, with little practical assistance for application. In fact, there are different concepts of 'road hierarchy'. Apart from obvious differences in the ways in which road classes can be defined, a hierarchy may (for instance) be based on concepts of urban structure or on some sort of theory of movement.

Although the common intent of typical guidelines is to clarify each road's functions and, by inference, to reduce conflicts between different functions, they differ in the way in which this is intended to be achieved. In Chapter 4, the relevance of these different interpretations of road functions to the likely effect of road hierarchies on accidents is highlighted.

Guidelines for Intersections on Major Roads

Typical guidelines refer to intersections along the higher-order roads in a number of ways:

- Minimisation of the number (and therefore controlling the spacing) of intersections, including those between major and minor roads (OECD 1971; Harper 1972; Cameron 1977a).
- Preference for T-junctions over cross intersections if the intersection is uncontrolled (Expert Group on Road Safety 1972; Department of Transport 1978; Harper 1972).
- Controlling the connections between roads of different levels in the hierarchy.

Guidelines for Abutting Development

Guidetines commonly specify controls on the location of land uses relative to elements in the road network, and the forms of access to properties abutting different levels in the road hierarchy. They reflect a widely-understood need to locate traffic generating and other incompatible land uses away from local streets while at the same time protecting the quality of traffic service on the arterial system. These considerations are an obvious extension of the concept that design should reflect role in the hierarchy.

Access control and control over the location of traffic generators, while familiar to practitioners, are most commonly encountered in the context of protection of traffic service (Marks 1971), but it is also recognised that 'the control of road frontage development can also reduce accidents' (Expert Group on Road Safety 1972). This implies that access control along future arterial roads on the urban fringe should also be anticipated (Harper 1970).

The rationale behind the guidelines covering abutting development and access control is that conflict between major traffic streams and the traffic activity generated by abutting land should be minimised. The safety benefits do not accrue solely to the passing traffic; in fact, the marginal difference in accident rate per unit travel from the addition of each access point is negligible (although, cumulatively, the effect of many access points may be significant). This fact is often used to justify permitting one new access point to a major road. But the relative risks for users of the site between direct access and access via, say, a controlled local street outlet are significant. Access control thus potentially achieves smoother flow for the major traffic stream and greater safety for users of adjacent land.

Guidelines for Segregated Networks Beyond the Neighbourhood

This report embraces urban planning provisions for pedestrians and cyclists but does not attempt to cover the much wider subjects of pedestrian and cycle planning. The distinction is important. Those projects not forming a specific *network* for nonmotorised travel are generally excluded, as are those matters not directly concerning the land reservation or land use control requirements of pedestrians or cyclists. Thus, segregated path systems (but not isolated projects) at the town and neighbourhood level are clearly included, as are 'pedestrianised' shopping areas. Matters related to design and traffic engineering are excluded.

The separation of cyclists and pedestrians from at least the major traffic routes is a key feature of the guidelines (Swedish National Board of Urban Planning 1968), although the emphasis in safety-oriented planning tends to be placed on local rather than district or town-wide application (Department of Transport 1978; Cameron 1977a).

The principle of segregated networks for cyclists, either combined with or separate from pedestrians, is virtually unchallenged in European literature. Opinion is far from unanimous, however; for example official North American bicycle literature tends to concentrate more on the practical problems of catering for cyclists within existing street networks.

Many commentators argue for cycle planning in particular to be treated as an aspect of total transport planning, being a legitimate mode of movement. Daecher (1977), for example, submits that a utility view of bicycles would influence the kind of planning which would follow: specifically, a transportation rather than solely recreational view of cycling would, she suggests, support the need for bikeways.

GUIDELINES FOR CENTRES

In the planner's jargon, 'activity centres' are areas or extensive sites which generate a concentration of trip ends and within which there is considerable pedestrian activity. Most activity centres are principally retail in function, but the term and the planning principle that pertain to it equally well apply to airports, university and college grounds, and major recreation complexes, for example. Furthermore, although current practice displays a preoccupation with city centres ('downtown' or the Central Business District), application of the principles to suburban centres potentially rates higher in priority, at least on safety criteria.

Centres present two kinds of problem which have generated two bodies of literature:

- (a) pedestrian movement and security within centres; and
- (b) vehicular circulation and access conflicts.

These in turn suggest the scope which a discussion of traffic safety at centres should cover (*Table 1*). Centre safety must be seen to be more than a pedestrian problem, and guidelines should aim at more than pedestrian-vehicle segregation. The solutions both for pedestrian and non-pedestrian collisions may be found in the general strategy of segregating all centre circulation (vehicular and pedestrian) from non-centre traffic. The concept, if not the practice, is far from new:

' The traffic artery must be a traffic artery and the shopping street a shopping street. Traffic routes are not the place for shopping centres' (Tripp 1942).

While Alker Tripp saw the problem almost entirely in terms of pedestrians, and spoke of 'place-segregation' and 'time-segregation' of pedestrians and vehicles, he nevertheless urged remedial actions aimed at separating the centre from the principle source of danger:

' If the shop premises cannot be moved because the shopping interests are too deeply entrenched, then the through traffic must be drawn away to other conduits.'

However, safety is rarely a predominant or even implicit objective of centre planning or replanning, especially when directed at the pedestrian environment. As Brambilla and Longo (1976) observe: 'The major goal of almost every North American pedestrianization effort has been the revitalization of declining downtown retail economy.' European programs tend to emphasise the creation or restoration of pedestrian amenity (OECD 1974), although 32 German civic authorities surveyed by Kuhnemann and Witherspoon (1974) cited traffic engineering and economic objectives more than twice as often as environmental objectives.

Planning for pedestrians in retail centres is often conceived in terms of reduction of stress and physical disturbance, creation of a relaxed atmosphere, and so on (Thompson 1974). Almost invariably this involves some degree of segregation of pedestrians and motor vehicles; Stanley (1977) describes pedestrian segregation as 'normal practice' during the past twenty years in new towns or redeveloped centres. In existing centres this has usually involved partial or total removal of motor vehicles to create some form of 'mail'.

Literature on malls and other forms of pedestrianisation (OECD 1974; TCPB 1977a; Tuohey 1978) amply covers techniques and examples, but tends to place an emphasis on the reactive process of segregation and the detailed design implications, rather than on active planning for pedestrians. Interestingly, while the occasional references to safety in the context of centre planning or replanning almost always concern pedestrian safety, there is in fact very little information to justify concentration on

TABLE 1

Topic	Action						
	New Centres	Existing Centres					
Centre/arterial road interface	Avoid arterial frontages	Re-shape centre away from					
	Treat entrances/exits as major	arterial					
	intersections	Redirect arterial traffic					
Control, reduction or protection of	Avoid ribbon development	As above					
pedestrian crossing movements	Develop only on one side of	Kerbside fencing					
	arterial	Grade separated crossings					
		'Parking mall' (slow route)					
Separation of vehicular and	'Car-free' centres	Mall conversion					
pedestrian circulation systems	(peripheral parking)	Pedestrian zones or qystems					
Needs of special vehicles	Transit mall						
(buses, deliveries,	Selective permitted use						
emergency venicles, etc.)	Reserved routes and standing areas						

FRAMEWORK FOR DISCUSSION OF TRAFFIC SAFETY GUIDELINES AT CENTRES

pedestrian protection through segregation rather than on other aspects of centre safety. Bennett (1974) notes that:

Helping the pedestrian in urban areas' has become more and more acceptable politically. At present, however, attention seems concentrated on city and suburban centres. These are very important places, but only a small proportion of pedestrian accidents occur in those short lengths of street which it is practicable to pedestrianise."

GUIDELINES FOR LOCAL AREA PLANNING

So far, guidelines for broad-scale urban planning, major networks and centres have been outlined. This heading concerns the balance of the urban area, much of which is not homogeneous but is predominantly residential. By implication, 'local roads' in this discussion are all those urban roads not previously covered in the earlier discussion on the highly-connective traffic distribution system covering the urban area.

Planning practices have traditionally had a strong residential area planning flavour. Both new and existing residential areas form the major portion of the urban area, and provide practising planners with extensive and relatively frequent opportunities for application of planning techniques.

The Study revealed that concentration of planning interest on local areas for road safety motives is well-founded: up to one-third of all urban casualties and higher proportions of pedestrian, cycle and child casualties typically occur on streets which are 'local' in character and function, and these may be reduced by appropriate local planning measures. Safety and other problems associated with traffic in local areas arise from interactions:

- within the traffic stream,
- between traffic and other road users, and
- between traffic and adjacent activities (or land uses).

The general objective of the Australian and other guidelines relating to local streets in both new and existing areas, is to reduce conflict (or at least its consequences). Three types of strategy are implied:

- (a) Minimisation of conflict within the traffic stream by separating local traffic from arterial traffic, by clarifying the local network to avoid or at least reduce conflicting movements, especially at intersections, and by minimising conflict with pedestrians, cyclists and crossing or merging traffic.
- (b) Segregation of vehicular from non-vehicular traffic.
- (c) Moderation of vehicle behaviour so that it is more compatible with other uses of the street space.

Essentially, (a) and (b) focus on simplifying components of road use by keeping them apart as much as possible, and (c) focusses on integration. Implicit in all three are elements of orderliness and simplicity in the traffic system. These various functional characteristics can be specifically expressed in road safety terms. However, in various forms, the strategies can be traced through the historical development of local planning ideas, in which road safety has been at best an incidental objective. The evolution of planning ideas demonstrates that the origins of current residential area planning, and even elements of the safety guidelines, were not all essentially directed at maximising road safety.

Most of today's accepted 'safe' residential area planning practices arose from observations on the performance of various types of layout and planning concepts, rather than from deliberate development of safe practices from first principles. Much of what is generally accepted as desirable from a safety point of view is seen largely (and originally evolved) as good planning and design practice in the broad sense. The definition of areal units (e.g. neighbourhoods in new area planning, and precincts in the management of existing areas), the recognition of a functional distinction between arterial roads and roads within localities, the provision of full or partial separation of motorised from non-motorised traffic, and even the extensive use of culs-de-sac illustrate basic elements of the safety principles which are far from recent concepts (Fig. 2).

The segregation and integration approaches give rise to quite different guidelines, as the comparison of the Australian and Scaft Guidelines in Chapter 1 showed. Absolute segregation of vehicular and non-vehicular movement is the keystone of guidelines following the Scaft model. On the other hand, guidelines originating from traffic engineering approaches (particularly those based on U.S. studies) tend to emphasise vehicle occupant safety through traffic network design. There is also a widespread recognition in the Australian Guidelines and other expressions of currently-accepted good practice that the form of the road network should act to exclude traffic from local areas if it has no purpose there. In most cases, these various objectives are reflected in guidelines which relate to the planning and design of the networks themselves rather than the total design of the locality.

Local area planning guidelines cover the following aspects:

- Network planning and street function internal road hierarchy; connectivity; network clarity.
- Road design speed restraint; sight distance.
- Minor intersections T-junctions favoured.
- Pedestrian and cycle provisions paths linking local activities: connection with town-wide path system.
- Management of existing local areas control over changes in land use; correction of network deficiencies; elimination of cross intersections; areawide traffic management.
- Locality planning creation of neighbourhoods or precincts; location of land uses to minimise traffic and its impacts.



Fig. 2 — A stylised mapping of the evolution of some of the basic elements of the safety guidelines for planning localities

Chapter 3

REPORTED APPLICATIONS AND INVESTIGATIONS

INTRODUCTION

This Chapter brings together reported Australian practice in the areas covered by the guidelines discussed in Chapter 2, with comments on overseas practice. Since the principal interest of the Study was in the effectiveness of the various recommended practices, particular attention was paid to the observations, if any, which were reported in each case. The survey of local government authorities conducted as part of the Study specifically sought information on whether or not planning measures were being applied explicitly for safety motives, and on the extent of monitoring and evaluation which had subsequently taken place.

OVERVIEW OF RESPONSES TO THE SURVEY OF LOCAL GOVERNMENT PRACTICES

AGGREGATE RESPONSES

The details of the LGA responses, as they relate to specific planning activities, are discussed in the background Reports. In aggregate, the responses presented a broad picture which enabled those respondents apparently worthy of follow-up to be identified, and gave an initial picture of the scope covered by planning activity in local government.

Tables 2 and 3 summarise the extent to which practice was reported in each of the listed planning areas for the whole of Australia. Of the 273 responses, 257 (94 per cent) reported that they had applied one or more of the actions listed. Conversely, only 16 reported no relevant action.

SAFETY MOTIVATION

Table 4 summarises the proportions of LGAs who reported explicit safety motivation for the actions noted in Table 3. (The percentages in Table 4 are based on totals in the corresponding cells in Table 3). Note that the construction of the survey did not permit this information to be directly obtained for area-wide changes to existing local streets, and this item is omitted from Table 4.

MONITORING AND/OR EVALUATION

The balance of the questionnaire sought to identify those authorities who had attempted to monitor the safety results of any of their planning actions, or who had evaluated such actions in safety terms. The positive responses in any single planning category were very few *Table 5* summarises the numbers of respondents in each State who reported that they had monitored or evaluated any one or more planning actions.

FOLLOW-UP ON SPECIFIC ITEMS

This apparently promising group of respondents formed the basis of subsequent follow-up, the purpose of which was to obtain specific information on the evaluation and monitoring techniques, and the results observed by the respondent. Authorities which had reported evaluation or monitoring in one or more of the listed planning areas (including areawide programs of street improvement) were asked if they had actual data and calculations, or if the monitoring and evaluation was subjective. Table 6 summarises the results of this follow-up. Of 71 local authorities which originally indicated that they had some form of data on or had object vely evaluated any of the items on the survey form (other than local area traffic management) none were able to produce actual data.

This simple observation is a significant and important finding. It does not mean, however, that no data exist on the effectiveness of Australian practice in the area covered by the survey. As a specific enquiry in the to low-up, data were also sought from all local authorities which had indicated area-wide (i.e. other than isolated) application of physical changes to the connectivity of local street networks, a subject already weil documented and known to the Office of Road Salety (DoT 197)8). Table 7 lists the results. of 57 authorities reporting application of the above items on an area-wide basis (an interesting ligure in itself), six were able to produce data to test the effectiveness of some of these measures. Severa. others reported that accident data would be available retrospectively if required, which could be compared with implementation costs. Since the time of the Survey, the quantity of local government information in this area has grown even further

PLANNED COMMUNITIES

In this discussion, the term 'planned community' is used to describe new or substantially expanded urban communities which are comprehensively planned

SURVEY OF LOCAL GOVERNMENT AUTHORITIES - NUMBER OF RESPONDENTS BY REPORTED ACTIVITY

	Reporting one or more listed actions*	Reporting none of listed actions	Total
New South Wales	68	5	73
Victoria	87	4	91
Queensiand	21	2	23
South Australia	37	0	37
Western Australia	30	2	32
Tasmania	14	3	17
Total	257	16	273

Notes:

i.e. any of the 16 planning actions listed in the survey form (Brindle 1982a), or area-wide application of local street management techniques. See list in Table 3.

TABLE 3

NUMBER AND PERCENTAGE OF RESPONDING L.G.A.'S WHO REPORTED IMPLEMENTATION OF SPECIFIED ACTIONS IN THEIR MUNICIPALITIES AUSTRALIA 1978-79

	No. and °o of LGA's who reported implementation of stated action							
	Metro Non-metr (n = 139) (n = 134		metro 134)	ro Total I) (n = 273)				
				۰,		2 ₀		
STRATEGIC PLANNING								
Pian to minimise travel	43	31	29	22	72	26		
Road hierarchy	65	47	51	38	116	43		
Reduced car travel	16	12	7	5	23	8		
Any one or more of these	76	55	55	41	131	48		
LOCAL PLANNING								
Location siting and access	66	47	44	33	110	40		
ACTIVITY CENTRES								
'Traffic free' centres	62	45	27	20	89	33		
Pedestrian-vehicle separation	42	30	21	16	63	23		
Off-street parking	81	58	59	44	140	51		
Rearrange shopping strip	16	12	10	8	26	10		
Priority access (P.T., goods)	30	22	14	10	44	16		
Any one or more of these	111	80	80	60	191	70		
PEDESTRIAN/CYCLE								
Provision of routes/network	46	33	29	22	75	27		
NEW LOCAL STREET NETWORKS								
Access and connectivity	57	41	35	26	92	34		
Avoidance of cross roads	84	60	90	67	174	64		
Slow-speed designs	54	39	52	39	106	39		
Salety-based width criteria	65	47	70	52	135	49		
Any one or more of these	113	81	102	76	215	79		
EXISTING LOCAL STREET NETWORKS								
Intersection visibility	92	66	64	48	156	57		
Control roadside hazards	50	36	30	22	80	29		
Area-wide changes	46	33	11	8	57	21		
Any one or more of these	112	81	78	57	190	70		

NUMBER AND PERCENTAGE OF RESPONDING L.G.A.'S WHO REPORTED IMPLEMENTATION OF SPECIFIED ACTIONS IN THEIR MUNICIPALITIES EXPLICITLY FOR SAFETY MOTIVES — AUSTRALIA

	No. and ::* of LGA's who reported safety motives for implementation of stated action					
	Ме	tro	Non-	metro	То	itai
STRATEGIC PLANNING						
Plan to minimise travel	7	16	4	14	11	15
Road hierarchy	13	20	11	22	24	21
Reduced car travel (P.T.)	2	13	2	29	4	17
LOCAL PLANNING						
Location, siting and access	12	18	6	14	18	16
ACTIVITY CENTRES						
'Traffic free' centres	9	15	6	22	15	17
Pedestrian - vehicle separation	15	36	4	19	19	30
Off-street parking	22	27	14	24	36	26
Rearrange shopping strip	4	25	2	20	6	23
Priority access (P.T., goods)	10	33	8	57	18	41
PEDESTRIAN/CYCLE						
Provision of routes/network	30	65	20	69	50	67
NEW LOCAL STREET NETWORKS						
Access and connectivity	21	37	19	54	40	43
Avoidance of cross roads	66	79	74	82	140	80
Slow-speed designs	26	48	29	56	55	52
Salety-based width criteria	36	55	35	50	71	53
EXISTING LOCAL STREET NETWORKS						
Intersection visibility	80	87	60	94	140	90
Control roadside hazards	42	84	22	73	64	80

Note:

* i.e. the percentage of those LGA's who report implementation of the stated action -- from Table 3.

TABLE 5

NUMBERS OF LGA'S IN EACH STATE REPORTING MONITORING OR EVALUATION OF ONE OR MORE PLANNING ACTIONS* ON SAFETY GROUNDS, 1978-79

	Number reporting monitoring and/or evaluation				
	Metro	Non-metro	Total		
New South Wales	8 (34)†	9 (39)	17 (73)		
Victoria	12 (47)	10 (44)	22 (91)		
Queensiand	1 (4)	4 (19)	5 (23)		
South Australia	10 (25)	2 (12)	12 (57)		
Western Australia	10 (22)	4 (10)	14 (32)		
Tasmania	1 (7)	0 (10)	1 (17)		
Total Australia	42 (139)	29 (134)	71 (273)		

Notes:

· Listed in Table 4.

t Numbers in parentheses are total number of LGAs who responded in each category, e.g. of the 47 metropolitan respondents to the survey in Victoria, 12 reported monitoring or evaluation.

RESULTS OF FOLLOW-UP ENQUIRIES ON MONITORING AND/OR EVALUATION OF PLANNING MEASURES* UP TO 1978-79

		Number			Result of Follow-up		
	Total LGAs Responding	Reporting Monitoring and/or Evaluation *:	No Data	Some Data	No Reply	Not Contacted	
New South Wales	73	17	7	-	3	7	
Victoria	91	22	8	-	8	8	
Queensland	23	5	-	-	4	۱	
South Australia	57	12	5	-	4	3	
Western Australia	32	14	6	-	4	4	
Taamama	17	1				1	
Total Australia	273	71	26	-	21	24	

Note:

* Listed in Table 4.

+ From Table 5.

TABLE 7

RESULTS OF FOLLOW-UP ENQUIRIES ON MONITORING AND/OR EVALUATION OF PHYSICAL CHANGES TO EXISTING LOCAL STREET NETWORKS* UP TO 1978-79

	AL		Result of	Follow-up	
	Reporting Application*	No Data	Some Data	No Reply	Not Contected
New South Wales	14	6	0	1	7
Victoria	13	1	3	3	6
Queensland	1	C	a	1	0
South Australia	13	8	2	2	3
Western Australia	15	7	1	4	3
Tasmania	tt	0	0	· 0	1
Total Australia	57	20	6	11	20

Notes:

local street management techniques applied as part of an area-wide scheme.

and developed by, or under the control of, a single authority or organisation. Of particular interest are the planning opportunities which such control presents, and the unique physical conditions which may result. The degree to which planned communities do in fact create conditions which are different from elsewhere varies considerably. Privately-developed new communities are inclined to place less emphasis on the 'public good', especially when this is not reflected in the price which home buyers are prepared to pay. Depending on the nature and strength of control exerted by supervising authorities, private development may also be expected to place less emphasis on the major movement networks than on local networks and neighbourhood design.

Since planned community construction, public or private, permits coordination and integration of the land use and traffic systems, it provides opportunities for the application of all of the guidelines discussed in the review of Town Planning and Road Safety. That in itself creates a problem for the pr since the consequences of specific types of development or control then become difficult to segregate.

The original British Garden Cities (Letchworth 1903; Welwyn 1919), which evolved from the socially-oriented concepts of the 19th Century industrial utopian visionaries (Rowntree, Owen, Salt, Cadbury, Lever, Buckingham and others) and the writings of Ebeneezer Howard (1946), themselves inspired planned communities in the U.S. and Europe.

Between 1946 and 1952, 14 'Mark 1' New Towns were commenced in the U.K. More than 30 New Towns were eventually designated, currently housing over two million people.

As the show-places of the state-of-the-planner's-art (or, more precisely, its several different states), planned communities not unexpectedly display most of the guidelines in combination. Perhaps the emphasis should be reversed: in a very real sense, the new towns have helped to shape the guidelines which act as models for planning practice.

This is not to say that the planning principles demonstrated in planned communities have been similar in all places at all times. For example, the Mark I British New Towns refined a land use/road model which first emerged before World War II. Subsequent New Towns displayed an evolution of planning ideas and community tastes, especially with respect to increasing car ownership, which created quite different urban areas.

For example, while a hierarchical segregation of traffic movements, and provision of separate pathways for pedestrians and cyclists, are features of most U.K. New Towns, there are many degrees of achievement of these features and many ways in detail of putting the guidelines into practice.

in continental Europe, there are many examples of large scale planned communities, especially in Holland, Germany and France, most of which are contiguous with or satellite to existing large urban areas.

Few are clearly separate from existing urban areas, in the earlier British style, but there are many examples of comprehensively planned urban fringe communities. Most of the European new communities, like the British, result solely or primarily from government enterprise.

Scandinavian countries, with their tradition of social action and good design, provide many examples of planned neighbourhoods and centres in which the road safety guidelines find application, e.g. the suburbs and domitory satellites of Stockholm (Vallingby, Arsta, Forsta, Grindthorpe) and the famous town of Tapiola, Helsinki, which was the work of a non-profit welfare and housing organisation.

In Eastern and Southern Europe there are several examples of new towns created as part of a program of regional economic development by the State.

Planned communities are found in many other parts of the world, including Japan, South Africa and Latin America. However, of greatest potential interest to Australia (because of the level of car usage and the predominance of private enterprise planners) are planned communities in the U.S.

The U.S. Government, through the U.S. Housing Corporation, had made funds available during World War I for new town experiments, but these funds terminated at the end of the war. Foster (1981) notes that 'American planners had a keen interest in Garden City experiments during the 1920s'. In the absence of government activity, 'a handful of larger corporations continued their first tentative trials in town planning'.

These early trials proved to be abortive, achieving at best only partial development before major revision or being swamped by suburban growth. Virtually all existing U.S. planned communities are suburbs of, or peripheral to, existing cities. With few exceptions, they are predominantly dormitory in function and many have little or no employment.

AUSTRALIAN PLANNED COMMUNITIES

Ripples of the Garden City and Garden Suburbs movements were felt in Australia (e.g. the 1919 South Australian Garden Suburb Act which enabled Colonel Light Gardens — formerly Mitcham Garden Suburb to be laid out), and there were echoes of the earlier attempts by the enlightened industrialists (e.g. H.V. McKay's 1905 model housing venture for workers at his Sunshine (Vic.) plant, and the housing estate provided by the Cadbury company around its Hobart factory).

But, of existing urban areas, only Canberra and Elizabeth, about 30 km north of Adelaide (and now part of the contiguous suburbs), could claim direct descendancy from the Garden City-New Towns philosophy, although some housing ventures (such as the Kwinana 'new town' commenced in 1952) attempted to apply the neighbourhood principle, with varying degrees of success. The change of government in 1972, and the subsequent creation of the Cities Commission, marked the first attempt at a national program of new town and growth centre development with an emphasis on selective rather than dispersed decentralisation.

Much of the resultant planning remains unfulfilled Of the 17 centres nominated by the Cities Commission, a few (such as Bathurst-Orange, Albury-Wodonga and Macarthur) got to the stage of having a functioning development control organisation with staff. The Macarthur area, while not quite a new town in the conventional sense, is nevertheless the most actively developing, comprehensively planned and controlled urban area outside Canberra.

In Albury/Wodonga, where the plans generally present an alternative to normal Australian urban development, some construction has been completed but neither of the two planned 'new town extensions of the city have yet taken on a coherent character. Bathurst-Orange, like Geelong, is actively promoting development but has not produced its 'Newcity' (Wright 1977). Perth's northern and northwestern regions are experiencing rapid growth and producing noteworthy land use-traffic planning from a combination of private enterprise and public control The other urban areas have generally continued to expand in a conventional manner.

Note should also be made of private enterprise 'new towns'. Australia has a long tradition of 'planned' (in the sense of deliberately laid out) towns for shortterm purposes, e.g. outback weapons research establishments, and also of transitory townships in mining areas. But many of the provisions made by mining companies in the 1960s and 1970s to house employees illustrate planning ideas of the time. These towns represent a substantial proportion of new urban area creation during a time when there was much talk but relatively little progress on the Growth Centres concept. The new mining towns of the Pilbara, for example, have provided accommodation for more than 30 000 people in total (Government) of Western Australia 1976; Taylor 1969). Each houses generally less than 5000 and thus tends to take on the nature of a remote neighbourhood. Thus, they add little to the present discussion, but do provide interesting illustrations of local planning ideas.

To summarise: only Canberra's component townships offer illustrations of planning ideas combined in a new town context over a relatively long period up to the present time. Elizabeth illustrates application of new town planning ideas current 30-40 years ago, and Macarthur may provide illustrations of current planning concepts under the control of a single development body. Other Australian new towns and growth centres do not, for the present at least, provide examples of land use/network planning above the neighbourhood level under a single development control body.

Canberra

Canberra's comprehensive planning and development, especially since the creation of the National Capital Development Commission (NCDC) in 1958, not only demonstrates many of the planning principles discussed in this report but also provided much of the experience and expertise utilised in the 1970s when there was a temporary upsurge in planning interest in Australia. Canberra's sequential development over the last 25 years reflects changing philosophies and emphases in town planning. Consequently, some planning and design ideas were implemented in one part of Canberra and not in another.

Up to 1958 Walter Burley Griffin's plan for Canberra remained remarkably intact. While the physical end-product of Griffin's plan has strong aesthetic appeal, both in plan form and as seen on the ground, those parts of Canberra today which are based on the Griffin plan represent a different, older branch of planning evolution to that which led to the British New Towns and in the U.S. to the neighbourhood layout for Radburn, New Jersey, in 1928.

In practical terms, this meant that Griffin's plan, and those elements of Canberra today which conform to it, did not consciously embody the principles of neighbourhood, road hierarchy and concern for protected movement systems which were characteristic of the new town planning ideas which were evolving at that time.

Thus, a study of the possible effects of 'new town planning in Canberra on traffic accidents necessitates the separation of North and South Canberra, which embraces the Griffin design, from observations on the later towns of Woden-Weston Creek, Belconnen and Tuggeranong (*Fig. 3*), in which for the first time Canberra saw application of the neighbournood planning unit (at least initially), a hierarchy of roads defined by degree of access, and specific provisions for pedestrians.

Westerman (1975) notes that, while the three existing Canberra new towns were planned within short intervals of each other and thus have similarities, there has been a continuing development of new concepts which is reflected in their structure.

Common through all the post-1960 development in Canberra is a strong hierarchy of roads. The planning and design implications of the hierarchical definitions do not appear to have varied significantly between the successive stages of development since 1960.

However, the three Canberra new towns do differ in their treatment of pathway networks. While pedestrian links within neighbourhoods were a feature of the earliest suburbs within Woden onwards, a stronger concept of pedestrian (and, later,



Fig. 3 — The Canberra Structure Plen, as adopted in the mid-1970s (under revision in 1984) (Source: NCDC 1977)

bicycle) routes extending between as well as within neighbourhoods was later applied in Belconnen, focussing particularly on the Belconnen Town Centre and the group centres.

Tuggeranong represents a significant step forward in 'off-road movement' planning. A specific design philosophy for non-motorised travel, and its influence on town structure, emerged (NCDC 1977a). The neighbourhoods and hierarchy of activity centres seen in earlier planning were replaced by 'territorial units' and an 'activity spine'. Thus, Canberra provides opportunities in case studies of the effects of hierarchical road planning, of different forms of town structure, and different degrees of segregated route planning, although it will be some time yet before some of the more detailed analyses can be made. Tuggeranong is still only partially developed (the population in 1983 being about 40 000 with a target of 90 000), and Belconnen, approaching full development, will need some time for normal patterns of usage to be established.

URBAN FORM AND STRUCTURE PLANNING PRACTICE

The review of international practice noted an interest by analysts in the effects of urban structure on trip making since the early days of urban modelling in the 1950s and 1960s. Studies have tended to be theoretical rather than practical (Hemmens 1967; Latham 1978; Ogden 1970; Rice 1977; Voorhees, Barnes and Coleman 1962; Bassett 1977; Jamieson, MacKay and Latchford 1967; Loder and Bayly 1978a; Sharp, Brotchie and Roy 1981; Black and Katakos 1981).

In practice, the reduction of travel is a common structure planning objective. Structure planning to induce more travel by public transport is also, but less frequently, a stated goal. However, only in Sweden were these objectives pursued for road safety motives. There are no reports of measured trip making consequences of particular urban patterns following plan adoption.

In Australian practice, the reasons for travel minimisation through urban planning have tended to be stated as generalised goals (conserve energy, reduce traffic noise and air pollution, reduce congestion, etc.), which rarely include road safety. In virtually all theoretical and practical discussions, a preoccupation with homeplace-workplace relationships is noted.

As observed in overseas cases, strategic planning reports for Australian cities typically contain some reference to the relationship between urban structure and trip making, but have lacked formal analyses of this relationship. Any effect it might have on the adopted structure is intuitive. In some cases major planning studies omit any reference to minimising travel or trip lengths.

There has been a handful of analyses of the trip making consequences of various land use and activity location strategies (for Canberra and other cities). These include the analysis of work trips in Tuggeranong by Morison, Gordon and Bell (1970) and the demonstration of the use of the TRANSTEP package by Nairn and Partners (1978). TRANSTEP was also used for this purpose in Albury-Wodonga (De Leuw, Cather 1974).

There is, however, no reported case of subsequent analysis of trip making in those places where such considerations influenced the planning decision. Verbal enquiries during the course of the study were similarly negative.

Elizabeth (S.A.) presents an example of an established satellite town whose travel characteristics could be compared with observations elsewhere. Thomas (1977), for example, confirmed that the New Towns which were satellites of London are more self-contained with respect to employment than comparable towns around London, but argued that the benefits of this self-containment are comparatively small because the towns themselves are small compared with the rest of the London region. Forster (1974) presented data on Elizabeth's worker/job balance in various employment categories. In 1966, despite the objectives, 50 per cent of jobs in the town were held by outsiders, 53 per cent of the resident workforce travelled elsewhere to work. Presumably Elizabeth's proximity to the Adelaide metropolitan area was at least partly responsible.

LOCAL GOVERNMENT RESPONSES ON PLANNING URBAN FORM AND STRUCTURE

Of the 72 local authorities who reported that their areas were subject to a planning strategy which located activities such that total travel was reduced (*Table 3*), only 13 claimed that the motivation was for safety reasons and only 11 claimed that the effects had been monitored and/or evaluated. Follow-up enquiries yielded very little firm data to substantiate this response. In fact, only two local authorities were able to verify that an appraisal had taken place (Sale, Vic. and Woodville, S.A.). Both of these in fact referred to arrangement of activities at the local, rather than regional, scale.

Similarly, of the 23 who reported attempts to implement a transport plan aimed at reducing car travel, only four suggested a safety motive and six claimed some monitoring and/or evaluation. None of these produced data relevant

In summary, it is concluded that, while the effectiveness of regional structure planning to reduce total travel and planning to reduce car travel in particular are both widely accepted, little or no attempt has been made anywhere to validate such beliefs or to assess the trip making consequences of such policies. Certainly there is no known reported assessment of the effects of planning at this scale on road accidents.

MAJOR ROAD HIERARCHY PRACTICE

The establishment of a functional hierarchy of traffic routes is reflected in design guidelines, codes of practice and regulations in many countries, the specification of consistent design standards for different types of road (particularly the higher-order roads) in particular being an almost universal practice. Indirectly, safety objectives have influenced these standards.

However, this review exposed no cases where the accident consequences of a hierarchical basis for road definitions, design standards or management practices had been quantified. Furthermore, only in Sweden (Swedish National Board of Urban Planning 1968) has a code promoted hierarchical functional classes specifically for safety reasons.

In Australia, the practical application of road hierarchy concepts above the local street level seems to be limited to 'new town' type of development (e.g. Canberra and Albury-Wodonga) and traffic management in existing networks.

The promotion of functionally-based road designations as a basis for traffic management and other aspects of operation in existing networks has increased in recent years in Australia, since an agreed road classification must first be established in a local area traffic management program, so that each road's acceptable functions and the nature of traffic control over it can be specified (Brindle 1979c).

This was the intent of Melbourne's Hierarchy of Roads Study (MMBW 1980), which noted that the need for the designation of a five-level road hierarchy

for metropolitan Melbourne arose from factors such as the detriment caused by through traffic in local streets, the importance of road goods movement, and the coordination of all components of road transport. Safety was not listed, although its inclusion as an aspect of amenity is implied in the discussion. Tables included in the report suggest ideas on transport and land use management measures on the higher orders of road, noting that safety could be one of three purposes of the measure (the other two being movement and amenity). It is too early yet to judge the extent to which the recommended road designations will affect accident experience.

A similar intent was behind discussions encouraged by the Traffic Authority of New South Wales, which led to their publication 'Functional Classification of Roads' (Traffic Authority 1980a). The report, according to its foreword, was prepared 'for the guidance of councils, consultants and other authorities in the preparation of road hierarchy plans based on the functional classification of roads and will assist the councils in their planning for traffic and environment.' An increase in activity by councils in Sydney to that end is expected over the next few years.

The designation of road hierarchies at the municipal or subregional level for traffic management and other purposes is far from a recent activity. Belmont (W.A.), Woodville (S.A.), Hawthorn (Vic.), and Caulfield (Vic.) provide examples going back ten years or more. Only Woodville (S.A.) has any documentation of the accident consequences of the action which followed, which relate to local street traffic management. Richardson (1983) describes a noteworthy recent example in Stirling (W.A.).

LOCAL GOVERNMENT RESPONSES ON MAJOR ROAD HIERARCHY PLANNING

It was noted in *Table 3* that over 40 per cent of responding LGAs at the time of the survey had some form of specified road hierarchy. This response must be interpreted somewhat cautiously. Although the emphasis was on application to new development, affirmative responses were sometimes obtained from established urban municipalities such as Brunswick and South Melbourne (Vic.), Waverley (N.S.W.), and Henley and Grange (S.A.). This indicates that many of the responses refer not to new road hierarchies, but to specification of hierarchical labels to existing networks which the previous discussion noted was the predominant area of application of hierarchical road concept with respect to the major road network.

Under the present heading, the conclusion that can be drawn from the Survey response is that, while belief in the value of establishing a road hierarchy is widespread and many local authorities operate some form of hierarchical road classification for design or traffic management or both, fewer than a quarter of the cases where road hierarchies apply are recognised to have had safety motives, and only one municipality has produced any data on accident effects. This one case (Woodville S.A.) stands out as a pioneer of area-wide local traffic management in Australia, and it is in that context that its application of a road hierarchy (basically a simple distinction between arterial and residential streets) must be evaluated (Vreugdenhil 1972 and 1976).

PLANNING PRACTICE AFFECTING INTERSECTIONS ON MAJOR ROADS

The widely accepted principle that uncontrolled cross intersections should be avoided on the arterial network has long had formal sanction (Ministry of Transport 1966). Application of the principle — and related guidelines governing the spacing of major and minor intersections on the major network — is widespread, especially in new towns and other cases where considerable control can be exerted on the whole road network. The high quality of road planning and intersection treatment found in new towns around the world makes it difficult to isolate the specific benefits of particular aspects of the planning, such as the nature and spacing of intersections.

Rules governing the location and spacing of intersections on the more important roads are commonplace (e.g. the minimum recommended distance between intersections on arterial streets in OECD (1971) is 250 m with greater distances being urged for 'high performance networks'). This guideline was confirmed by rare analytical work in South Africa (Del Mistro and Fieldwick 1981).

In a related study, Del Mistro (1980) developed a model for the optimum number of access points to residential areas in order to minimise accidents.

Given that the preference for T-junctions over cross roads is so deeply entrenched, the limited number of reported comparative assessments, and the lack of detail in those cases that are reported, is perhaps surprising. Retrospective analyses of accidents at samples of existing intersections on arterial roads are summarised by Cameron (1977a), with varying results. Rarely are accident rates quoted in terms of the numbers of vehicles using the intersection, but three studies that do so produce the interesting and consistent results shown in *Table 8*.

In Australia, the NAASRA Urban Guide (NAASRA 1972) illustrates the widespread recognition of the influence of intersection type and spacing on accidents and traffic flow. The Guide calls for avoidance of unsignalised cross intersections on major urban roads, and spacing of intersections at a minimum of 350 to 550 m. The desirability of connecting local street systems to the major road network through a limited number of local distributors (or collectors) is also recognised.

Table 9 presents information on the frequency of intersections on a selection of major roads (i.e. primary or district distributors, commonly also called 'arterials and subarterials'). The areas chosen are all of recent vintage, being developed in the past two decades, with the exceptions of the route in Elizabeth S.A. (which is interesting as a reflection of what was regarded as the best of Anglo-Australian town planning practice of the 1950s), and Northbourne Avenue in Canberra.

Three observations can be made from Table 9. Firstly, the ideals of hierarchical road planning would prohibit access streets from connecting directly with major routes. Of the chosen sites, only Mill Park in Melbourne, two of the Canberra locations and the two Perth examples met this requirement. (There are many other examples elsewhere in Australia.)

MAJOR/MINOR INTERSECTION ACCIDENTS/10 MILLION VEHICLES ENTERING

	Indiana (cited by Cameron 1977a)	Victoria (Harper 1 966)	Finland (Kivela and Lyly 1980)
T-junction	1.8-2.6	mean = 2.8	mean == 2.3
Cross-intersection	1.7-6.8	mean = 4.7	mean = 4.5

TABLE 9

INTERSECTION SPACINGS ON A SELECTION OF MAJOR (PRIMARY OR DISTRICT DISTRIBUTOR) ROADS

				Ni.	mber of ctions with					64	
Road and Locality	Length Studied	Other Ma	ior Aputes	Loce/	Distrib.	Access	Screets*	Density	of Minor *	Aver Interac Specie	age ection ng (m)
	hand	+	T	+	7	+	τ	+	7	Me/or	All
MELBOURNE											
Plenty Road, Mill Park*	2.0	0	1	o	t	0	0	0	1.0	1000	500
Burwood Highway/Stud Road. Wantima	3.6	2	0	3	1	2	3	1.4	1.1	1800	330
Burwood Highway, Vermont South	2.5	1	1	1	2	1	10	0.8	4.8	1250	160
SYDNEY											
Elizabeth Drive, Bonnyrigg/Ashcroft	4.6	2	3	1	5	0	8	0.2	2.8	920	240
BRISBANE											
Inala Avenue, Inala	3.7	1	1	1	4	1	17	0.5	5.7	1850	150
ADELAIDE											
Philip Highway/Yorktown Road. Elizabeth	5.4	3	2	1	6	t	30	0.4	6.7	1080	130
Main South Road, Noarlunga	3.4	3	2	0	4	0	10	٥	4.1	680	180
PERTH Marrison Avenue, Baldon/Padbury	59	4	o	o	13	0	٥	٥	2.2	1480	350
Beach Road, Gimawheen	5.5	3	1	0	6	ō	ō	0	1.1	1380	550
ACT		-									
Southern Cross Drive, Beiconnen	5.0	2	2	1	12	o	D	0.2	2.4	1250	290
Northbourne Avenue, North Canberra	5.0	õ	4	1	2	1	3	0.4	1.0	1250	450
Yamba Drive, Woden	5.0	2	1	0	8	o	o	· 0	1.6	1670	450

Notes:

* Development currently on one side only; calculations are adjusted accordingly.

* "Minor' means local distributors ('collectors') and access streets.

Includes only connections to main carriageway, including service road entries and exits.

Secondly, cross intersections formed by access streets and local distributors on major routes are by no means uncommon (although they would be very much rarer than major/minor T-junctions). In many cases, where the major route has a dual carriageway, the absence of a median break turns a cross-intersection on paper into two unrelated T-junctions on the ground.

Thirdly, there is a very wide range of intersection densities (or spacings), due mainly to wide variations in the numbers of minor roads intersecting the major route. In most cases on the fringes of existing cities, the major road network is largely constrained by the existing rural road pattern and/or the pattern formed by the boundaries of broadacre landholdings. Sometimes de facto major routes (in the district distributor class) emerge through usage and subsequent extension into neighbouring suburbs. More rarely the State, regional or local authorities set down a basic major road pattern prior to further subdivision. Perhaps the best and most extensive example of this practice outside Canberra, and an illustration of its consequences for intersection spacing, is in the newer northern suburbs of Perth. On more than 11 km of major route noted in *Table 9*, other major routes generally formed simple cross intersections at regular intervals somewhat less than 1.5 km.

The range of average spacings of major/major intersections is not great, given the different ways in which the major road pattern comes about. Most fall in the range 1000 to 1800 m. (The extremely regular road framework in Noarlunga (S.A.) creates square development cells with sides about 1100 m long. The lower average spacing in *Table 9* arises partly from addit onal T-junctions created on one section of the Main South Road where it turns diagonality across the grid road pattern) However, the density of minor intersections with the major routes covers a much greater spread, from one to two per kilometre (typified by the 'model' developments in Mill Park, Victoria and the new areas in the northern suburbs of Perth noted in *Table 9*) to more than seven per kilometre in the Elizabeth (S.A.) example. A value of two to three local street connections per kilometre could be regarded as conforming to commonly accepted best practice. Several of the examples in *Table 9* conform to that criterion, and many more examples could be found throughout Australian cities.

Similarly, while overall intersection spacing in about half of the cases listed is lower than conventional highway design rules of thumb (about 300 m), the Scaft guidelines (300 to 600 m, depending on road status), the NAASRA (1972) guidelines (350 to 550 m minor 'major urban roads') and other sources (e.g. 250 m in OECD 1971), nevertheless the remaining cases illustrate that average intersection spacings of 350 m or more along major routes in new Australian suburbs are not at all uncommon.

LOCAL GOVERNMENT RESPONSES ON MAJOR ROAD INTERSECTIONS

The local government survey did not explicitly raise this question, except in relation to the more common matter of road networks inside subdivisions.

Neither the local government survey nor the general review of Australian practice revealed any reported attempt to evaluate the safety effectiveness or the cost and other implications of the intersection planning practices described in this section.

PLANNING PRACTICE AFFECTING ABUTTING DEVELOPMENT

Planning guidelines governing the safety impact of abutting development concern the nature of both the land use and its interface with the road system.

Control over the location of land uses (and hence the type and intensity of uses abutting different levels of road) is an integral part of zoning and development control, and is exercised to varying degrees in those countries where such planning controls exist.

South African data showed a significantly higher accident rate for retailing and commercial frontages than for residential and other land uses (Del Mistro and Fieldwick 1981). There is a relatively small body of information on the effects of frequency and type of access points on accidents (McMonagle 1952; Box 1970; Uckotter 1974; McGuirk and Satterley 1976), which provides little practical guidance other than confirm a positive relationship between access frequency and accidents. This may not be causal.

To some degree, access restraint is observed widely throughout the world but precise measures of the methods used, and their results, are not reported. Marks (1971) gives a comprehensive description of the rationale and techniques of access management, but without specific examples or reports on degree of application. Thomas (1979) discusses the legal implications of different forms of access limitations, indicating (if extent of litigation is any guide) that application of the techniques in the U.S. is extensive.

The techniques are of three broad types: land use control, access management and access planning. Land use control covers the restriction of types and intensities of development abutting traffic routes. through the use of zoning and/or permit procedures. Access management seeks to minimise disruptions to the traffic stream caused by traffic seeking access to adjacent land (using frontage roads, median break location and other controls over turns, and control over the number and frequency of points of access). Access planning refers to the minimisation of access points to a road by providing access on another boundary, especially when subdivision takes place. Individual lots may then back or side onto the main route boundary but gain their vehicular access from a local street. Bradford, Gelling and Beauchamp (1980) note that land use control tends to be used in countries, such as the U.K., where planning legislation and practice is stronger. In countries such as the U.S. (and, they add, Australia) where planning powers are weaker, the responsibility for access conditions falls more heavily on the highway authority which tends to utilise the techniques of access management, i.e. road design and traffic engineering.

In Australia, Canberra stands out as a notable example of control of points of access to higher-order roads. Site abuttals and locations of connections with lower-order road have been tightly controlled in all the post-1960 development in Canberra.

All Australian States have provision for some form of access control, at least on specific kinds of road. Most of these powers exist to authorise the construction and operation of freeways. Bradford *et al.* (1980) regard the Victorian situation as superior to that in any other State, and cite it as a model. The Road Construction Authority (RCA) may limit access to any declared RCA road. Local councils may declare a road to be limited access, and may subsequently deny further points of access if alternative access can be made available. The Victorian Town and Country Planning Act provides for access control to be included in planning schemes, giving local authorities similar control on all roads to that exercised by the RCA on the declared road system.

Victoria also has in operation an approved Statement of Planning Policy No.5 (Highway Areas), which potentially strengthens the case for abutting land planning and access planning for greater safety. The policies include:

Any new use or development of land in the vicinity of an existing or proposed highway shall be so planned and regulated as to avoid detriment of the levels of service, safety and amenity desirable for that highway in both the short and long term.' (Town and Country Planning Board 1973).

Whether or not as a result of the Statement of Planning Policy No.5, it is true that many examples of the techniques of land use/road regulation urged in the various guidelines can be found in Victoria. In particular, the use of tree reserves between main roads and rear or side property boundaries ('back-up lot subdivision') is becoming increasingly common. These reserves, commonly of the order of 15-18 m wide, lie outside the road reservation. They avoid the need for service roads parallel to the main road and direct vehicular access from the subdivision to the local distributor outlets. For traffic control purposes the width is immaterial. Access control through planning of adjacent land is extensively employed in the City of Knox (Vic.), which took the initiative at the start of the 1970's when such treatments were unusual in suburban development. Other extensive examples can be found in Perth, W.A., (Shire of Wannaroo and along the Leach Highway south of the Swan River, for example) and elsewhere.

No information on the relative safety performance of these types of frontages is available. Abutting tree reserves are part of access planning, where traffic movements from adjacent land are organised within the development and interact with main road traffic at controlled points. Far more common in Australia is the practice of access management by the use of road design and traffic engineering measures within the road reserve. Most familiar are service (frontage) roads and medians, which (especially the latter) perform a number of functions but also act to limit the number of points at which traffic can enter or turn across the major traffic stream. Attitudes towards service roads, and design practices, vary from State to State. Although design matters are beyond the scope of this study, they do affect the acceptability of service roads. It has been argued that, even if the general practice favours back-up residential development, there will always be the need for service road frontages for highwayoriented uses such as fast food stores, display homes, caravan yards and hotels. It is anticipated that service roads will continue to be a feature of expanding Australian cities.

Apart from new town scale of development, decisions on the location of major land uses relative to the road system generally concern traffic generation aspects. The best available compendium of traffic generation data associated with land uses in Australia (perhaps among the most thorough in the world) is that collected and published by the Traffic Authority of N.S.W. (1980b). The safety value of traffic generation analyses is recognised by the Authority; the first sentence in its Policy and Standards for Traffic Generating Development (Traffic Authority of N.S.W. 1978) states:

A safe environment and an efficient road system require compatibility between development and vehicular and pedestrian traffic.

The policy draws attention to the safety problems caused by vehicle movements at driveways of traffic-generating development, even at isolated locations, on both urban and rural roads.

While it does not specifically indicate that certain activities may not abut higher-order roads, the policy does strongly prescribe the conditions under which access from one to the other should be provided. This, with the Victorian Statement of Planning Policy No.5 suggestion that even the location of a major generator may be controlled if it could prove detrimental to the major route, illustrates that the principles of access control (from land use control and access planning to the design and traffic engineering aspects of access management) are well known in Australia. The subject has also been a matter of concern in other States. The South Australian Department of Housing, Urban and Regional Affairs, for example, prepared an unpublished discussion paper in 1979 on the control of development adjoining arterial roads which suggested more compact commercial/retail development (to reduce turning movements), and 'co-ordination' of parking facilities. It envisaged that development guidelines needed to be established. These would cover traffic impact, forms of access and access design.

Because of the inevitable real constraints, practice often falls short of principle, but there are nevertheless many examples of application. No attempts at assessment of the safety benefits of these applications — in general or in particular — came to light during the review.

LOCAL GOVERNMENT RESPONSES ON ABUTTING DEVELOPMENT PLANNING

Table 3 noted that 47.5 per cent of metropolitan respondent local authorities and 32.8 per cent of nonmetropolitan respondents located 'proposed land uses specifically with regard to their traffic generation characteristics, the nature of their catchment, their access requirements, and the appropriate level of access control for the roads they are to front on to'.

Of the total of 108 local authorities who reported this type of planning control, only 18 (17 per cent) acknowledged that they had explicit safety reasons for doing so. Only 11 (10 per cent) claimed any monitoring or evaluation, and of these none of those contacted offered any data or further information. Planning and management of access to major traffic routes is clearly another example of widespread application of techniques whose value is seen to be self-evident.

PLANNING PRACTICE CREATING SEGREGATED TOWN-WIDE NETWORKS

Significant segregated pedestrian and cycle systems beyond the neighbourhood level are found in several European towns and cities, mostly constructed as part of new development (e.g. Stevenage, Peterborough, Bracknell, Harlow and Milton Keynes in the U.K., Le Vaudreuille in France, Vasteras in Sweden, Bijlmermeer on the fringe of Amsterdam in Holland; see Kjellin (1976); Statens Planverk (1975); Trevelyan (1976); Efrat (1979); Potter (1979); Hudson (1978).

Fully or partially segregated pedestrian/cycle facilities introduced into existing urban areas tend to be single routes or route sections. There are many examples in Europe, North America and Japan, in particular, reported by Potter (1979), Quenault and Morgan (1979), Hudson (1978), Muhlrad (1978b), Japan Bicycle Road Development Association (1977), Christchurch City Council (1979 and 1980), Jennings (1979), and Ramsay and Stevenson (1976).

As in the U.S. and elsewhere, Australia has examples of state-of-the-art reviews (Hawley 1975), bicycle master plans or strategies (e.g. Pike and Conquest 1976, for Melbourne; its critique and extension by Parker 1977; Geelong Bikeplan Study 1977; Pak-Poy 1980 for Ballarat), guidelines and what could be termed 'statements of intent' (e.g. Cycleways Advisory Committee 1975 for Perth; Planning and Environment Commission 1976 for N.S.W.; Bicycle Track Committee 1980 for South Australia), and many proposals for individual lengths of bicycle route and partial networks, some having a high degree of segregation (e.g. Cycleways Advisory Committee 1975). Some of these proposals have already been implemented (e.g. in Melbourne, Adelaide and Geelong) although only Canberra has what could be described as a segregated network for both cyclists and pedestrians (Fig. 4).

Metropolitan Melbourne, which is part-way through a comprehensive bicycle planning program, was estimated early in 1981 to have about 40 km of segregated paths and 10 km of bike lanes (i.e. onroad). Geelong was now implementing its worldrenowned bicycle strategy (Geelong Bikeplan 1977) and is estimated to have 30 km of paths and 10 km of lanes in 1983. Only Canberra, with about 90 km of segregated paths, has more segregated route facilities for cyclists than the two Victorian cities. Canberra provides examples of new path systems in existing urban areas (albeit unusually spacious ones), and planning for major bicycle routes in new development. The planning theory for these routes and their relationship to urban features is highly developed (Bestor 1969), as illustrated by the 'multitrail' concept for Tuggeranong, A.C.T., which is built up from provisions for segregated movement in residential areas.

There has been no published (nor, as far as can be ascertained, unpublished) assessment of the accident benefits of Canberra's bicycle network. Canberra's accident data system is, however, orderly and accessible, and could readily yield data on occurrence and location of reported cycle accidents. In the absence of detailed accident studies which might shed specific light on the value of extensive pedestrian and cycle networks in Canberra, gross data must be referred to. These show that, while the A.C.T. has a significantly lower road death rate than the national average and, over the three years from 1975 to 1977, had a pedestrian death rate only 33



Fig. 4 — Canberra's cycleways (August 1983)

per cent of the national average, its cycle death and injury rates were higher than the national average. No obvious conclusions can justifiably be drawn from this, particularly since no account is taken of differences in usage and exposure.

LOCAL GOVERNMENT RESPONSES ON SEGREGATED NETWORK PLANNING

Of the 75 local government authorities who reported provision of segregated pedestrian or cycle paths beyond the neighbourhood level by 1978-79, 47 had explicit safety motives for the schemes. Of the 13 of these who originally indicated that they had monitored and evaluated their schemes, none in fact were able to produce specific information in response to follow-up. While the costs and physical details of projects are obtainable, their nett effects on accidents are impossible to assess without specific monitoring programs. Respondents tended to reply that their 'evaluation' had been subjective, or that the paths they had installed were too short or isolated to produce any measurable benefit so far (and hence strictly do not meet the requirement for this study that they form a network or system).

PLANNING PRACTICE IN CENTRES

NEW CENTRES

Traffic and design arrangements for new centres (either in new towns or new suburban centres in established cities) are not widely reported in the literature, at least with respect to actual safety experience in and around the centres. New centres, at all scales, today typically demonstrate the principles of site access management, some degree of pedestrian-vehicle separation, and traffic management, which appear in one form or another in the framework for discussing traffic safety guidelines (*Table 1*). Often this is primarily for climate control for the benefit of shoppers, or to satisfy marketing objectives of centre planning.

The range of provisions found in the different U.K. New Towns illustrates the wide variations in the extent of application of the principles in centres in new communities (Pain 1969; Owen 1972; Tetlow and Goss 1965; Bor 1974; Stanley 1977; Riddell 1977; Cumbernauld Development Corporation 1967).

In the more familiar instance of new centres within, or on the fringes of, existing cities there are of course many examples all over the world. It would be both tedious and unnecessary to attempt a comprehensive listing of examples. In type, they range from little more than tidy versions of older centres, with frontage and/or parking separated from the adjacent traffic route, through 'off-street' centres with shops and facilities grouped beside or around parking areas, to 'under one roof' centres with peripheral parking. The latter type covers a wide range of centre sizes, from the local centre (typically comprising a supermarket, variety and/or homewares store, and supporting food and other shops) to the regional centre of 100 000 m² gross retail floor area or more.

Such developments incorporate several of the guidelines, in broad terms; they avoid direct frontages to abutting roads, the number and location of access points are controlled, and thus the two-sided ribbon development character of older centres is avoided. Guidelines for planning and designing the access points to these centres are well-established, the American procedures (Institute of Transportation Engineers 1975) in particular demonstrating the treatment of points of access as major (often signalised) intersections.

EXISTING CENTRES

Pedestrian-vehicle segregation is a key feature of most modern conversions of existing centres, and inadequate separation of circulating traffic from noncentre traffic is often the real problem which remains unsolved.

Vertical segregation is extremely expensive, and is relatively uncommon in existing centres, apart from individual grade-separated crossing facilities and elevated plazas which are numerous but do not fall within this study. The system of linked elevated walkways in Minneapolis (the 'Skyway'; see Hegland and Podolske 1977) and the Birmingham (U.K.) 'Bullring' are illustrations. However, by far the most common technique of segregation in existing centres is the restriction or removal of traffic from selected streets to form malls or precincts (Fig. 5). The literature on this subject is abundant, and reveals that most reported European and North American pedestrianisation examples are located in city or town centres. (TCPB 1977a; Brambilla and Longo 1976; Brambilla; Longo and Dzurinko 1976; OECD 1975; Public Technology Inc. 1977; Kuhnemann and Witherspoon 1974; Ramsay and Stevenson 1976: Uhlig 1979; Daiby 1973; Roberts 1981; Westbrook 1974; Levinson 1974; Tuohey 1978 and others).

Very few of the sources present accident data before and after mall conversion of a street, and what data there are tend to be sketchy. More convincing is the data available on area-wide vehicle exclusion and suppression schemes (Spielberg 1977, Wickstrom 1975, Lindqvist 1977, OECD 1979a).

Many cities allow trams or buses to operate in pedestrian streets without apparent safety problems (Carstens 1974, Eburah 1976, Turner and Giannopoulis 1974, Parker and Eburah 1973, Mackay 1977, Tuohey 1978, Muhlrad 1978a, Roberts 1981). These so-called 'transit malls' are commonly regarded as a good compromise between pedestrian and public transport requirements.

AUSTRALIAN PRACTICE

Safety is only one aspect of the traffic and other problems of existing centres, which have received considerable attention. Planning proposals to attempt to induce a centre into a better shape (especially to adapt centres straddling traffic routes), or to redirect non-centre traffic onto a bypass route, are numerous (generally in inaccessible Council or consultant reports). But relatively few of these proposals reach implementation and none are known to involve safety appraisals.

'Pedestrianisation' of parts of shopping and civic centres is relatively familiar in Australia, and is reasonably well-documented, at least in a descriptive sense. As elsewhere in the world, the most extensive and best known examples are found in city centres (*Fig. 6*). *Table 10*, which lists a selection of



Fig. 5 - New Brighton Mail, Christchurch, N.Z.



Fig. 6 — A typical central area mail (Hay Street, Perth, W.A.)

PEDESTRIAN SCHEMES IN AUSTRALIAN CENTRES

		Place	Description	Cost	Sources
N.S.W.	Sydney	Martin Place	Interrupted mall, extending five city blocks. (Early 1970s)	_	RAPIJ (1981a) TCPB (1977a)
		Other pedestrian areas	Parts of Sydney's pedestrian strategy	-	As above
	Bankstown	Bankstown Plaza	Pedestrianisation of old Town Centre at railway 475m (1978/79)	\$1 million	O'Toole (1981) Memo (1979) Bankstown (1977)
	Lane Cove	Plaza	Pedestrianisation of shopping street (1977)	-	RAPIJ (198†a)
	Bondi	Oxford Mall	Closure of major thoroughfare through centre (1979)	\$670 000	RAPIJ (1981a)
	Maniy	Corso Plaza	Pedestrianisation of shopping street (1977)	\$370 00 0	RAPIJ (1981a)
	Newcastle	Hunter Mall	Pedestrianisation of main street (1970)	-	Atkins (1971)
	Amidale	Beardy St	Pedestrianisation of main street (1974)	\$65 700*	RAPIJ (1981b) TCPB (1977a)
Vic.	Melbourne	Bourke St	Transit mall (trams) extending one city block (1979)	-	_
	Footscray	Nicholson St	Interrupted mail, two blocks (1971)	\$500 000	TCPB (1977a.b)
	Oakleigh	Eaton St	Closure of minor street in centre (1977)		-
	Stawell	Mall	Pedestrianisation of main street (1978)	\$521 000	RAPIJ (1981a) Howells (1978)
	Swan Hill	Campbell St	Parking mall, four blocks in town centre (1978)	\$1.2 million	Ellis (1979)
	Ballarat	Bridge St	Pedestrianisation of narrow section of main street (1980)	\$790 000	Nuttall (1981)
Qid	Townsville	Flinders Mall	Pedestrian street (two blocks) with emergency 'clearway' (1979)	\$1.6 million	RAPIJ (1981c)
	Gold Coast	Cavill Ave	Pedestrian street in town centre (197?)	_	_
S.A.	Adelaide	Rundle St	Mall in city centre (1976)	\$1.2 million	Llewellyn-Smith (1981) TCPB (1977b) Madigan (1977)
W.A .	Perth	Hay St	Mall in city centre (1970)	-	RAPIJ (1981a) TCPB (1977a)
	Fremantie	High St	Pedestrianisation of one block with local traffic management (197?)	-	_
Tas.	Launceston	Brisbane St	Pedestrianisation of one block in city centre (1975)	-	TCPB (1977a)
		The Quadrant	Pedestrianisation of minor street in city centre (1978)	\$280 000	Duffy (1981) Burrows (1979)
	Hobart	Elizabeth St	Mail in city centre (197?)	_	—
	Devonport	Mall	Mall in city centre (197?)	-	-
A.C. T.	Canberra	Civic Plaza	Extending system of pedestrianised streets and spaces (1971-79)	\$1 million approx.	_

Note:

* Excluding donated materials and labour.

Australian pedestrianisation schemes noted in the literature, notes 22 urban areas and municipalities in which examples may be found. Little is known of the forty or so other examples of horizontal or vertical segregation claimed to exist in Australia (*Table 3*). However, neither the survey nor the literature review exposed any specific comments on safety benefits of pedestrian-oriented facilities in existing centres. Costs of mall schemes in excess of \$1m are not uncommon, yet very little mention is made in the literature of any attempt to justify these sums on *any* grounds, much less safety (Neither is there any known discussion of the safety aspects of other kinds of activity centres such as stadiums, campuses, or airports.)

LOCAL GOVERNMENT RESPONSES ON CENTRE PLANNING

The Local Government survey sought information on five aspects of activity centre planning:

- the extent of development of new 'traffic free' centres;
- (b) pedestrian-vehicle separation in existing centres.
- (c) off-street parking specifically to remove kerbside parking on arterials;
- (d) rearrangement of existing linear centres; and
- (e) provision of special access for goods, public transport and other specific vehicles.

Table 3 showed that 80 per cent of the 139 responding metropolitan LGAs reported experience with at least one of these measures. The most common is the provision of off-street parking to enable shopping street traffic to be reduced. Although in 27 per cent of the cases this was claimed to be for safety reasons, and about three quarters of that group claimed to have carried out some kind of assessment, follow-up produced no factual data on which to base a judgement about the potential safety benefits of Australian practice with respect to parking provisions in existing centres.

The second most commonly reported measure of the five was the construction of new 'off-street', or so-called 'traffic free' centres (*Fig.* 7). Sixty-two metropolitan and 27 non-metropolitan municipalities (45 and 20 per cent of their respective samples) reported that they had such centres within their areas. Clearly, Australia has many examples of these 'off-street' centres, at all scales.

There are indications that a larger proportion of retail and other activity is occurring at these planned centres; Alexander and Dawson (1979), for example, report substantial real decline in capital city central area retail sales and retail employment from 1968-69 to 1973-74, while middle and outer suburban figures increased by up to 50 per cent or more. Assuming that the shift and growth is being diverted largely to planned centres whose attributes reflect the safety guidelines, and assuming that these attributes do indeed correspond to greater safety, then it could be concluded that accidents related to shopping activity are lower than they might have been. There is, unfortunately, no available analysis to confirm or deny this.

None of the nine LGAs reporting assessment of these centres was able to produce specific data. The literature review revealed that, while the retailing



Fig. 7 - Inside a typical 'traffic-free' centre (Belconnen, A.C.T.)

aspects of such centres are reasonably widely documented, there is little reporting of their physical aspects and no discussion of their accident characteristics (much less their safety benefits) was encountered. Enquiries of retail analysts and developers revealed no specific concern for safety in centre development proposals, either on their part or that of local authorities. Exploratory analyses of several Australian cases conducted as part of the Study showed that the small number of casualties in the chosen centres had not changed significantly as a result of traffic diversion from one section of street (Brindle 1983*d*).

PLANNING PRACTICE IN LOCAL AREAS

OVERVIEW

There is a large quantity of literature on local area planning, design and management. The overall impression from this literature is that, as in other topics within the scope of this study, there are very few instances where the consequences of particular planning actions are recorded and even fewer where recorded consequences include safety effects.

Practice under this heading will be summarised in three sections:

- planning of local areas neighbourhoods, networks, paths and land uses;
- local street planning functions, geometry and intersections; and
- local area traffic management and street changes.

PLANNING OF LOCAL AREAS

Leaving aside the question of street design and the detailed architectural treatment of the land, houses and roads, local area planning concerns the form and structure of the locality. The form is influenced by the size and shape of the area, what defines its boundaries, what mixture and density of land uses it contains, what are its natural features, and so on. The structure is defined by the internal road and pathway networks, major easements and open spaces, the distribution of land uses and the nature and location of local activity centres (schools, halls, shops, medical facilities, etc.).

Neighbourhood

In practice, the network is the principal means by which neighbourhoods are defined, i.e. the neighbourhood is more a traffic precinct than an area having a coherency defined by its use and linkages. The effects of the two (networks and neighbourhoods) are therefore almost impossible to segregate.

New urban areas almost universally embody some form of neighbourhood or locality definition. As with most of the elements of form and structure of local areas, examples are so numerous and familiar not to warrant particular reference.

In Australia, local planning practice offers examples across the full range from unstructured urban extension to strictly defined neighbourhoods in the

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classic mould. Elizabeth, S.A., with its similarities to the Mark I U.K. New Towns, contains formal development units hung around the local distributor road system. Pumpurs (1980) notes the evolution of development units in Canberra from the 'classical' neighbourhoods of Woden-Weston Creek, through the defined but less cohesive neighbourhoods of Belconnen (NCDC 1977c), to the planned 'territorial units' of Tuggeranong (NCDC 1977b). The dissociation of the territorial unit from the neighbourhood's traffic precinct basis is evident (NCDC 1975a).

Insulation from non-local traffic, the concept of simple catchments around local facilities, and the sense of belonging to an identifiable community were essential characteristics of the original neighbourhood. The exposure of practical and theoretical unrealities in the second and third of these (e.g. Keller 1968; Voorhees 1981 a and references; Gans 1968) still leaves the insulation from extraneous movement as a basis for defining local areas.

In safety terms, much of Australia's modern suburban development satisfies at least the traffic aspect of neighbourhood planning, even if internal movement patterns are not generally well-anticipated or catered for. However, even in modern development, there are many examples of localities whose internal road pattern attracts non-local traffic, thus infringing even the relatively simple traffic requirement of neighbourhood planning. This brings us to the question of the internal road network as a component of the structure.

Street Networks

The adoption of a hierarchical internal road pattern is very common (Bestor 1969; OECD 1979b), and again it should not be necessary to cite examples. Both in Australia and overseas, however, there appears to have been little attention paid, at least in extensive suburban areas, to the design of the local street system as a network which has to satisfy specific requirer ents. While many planned localities conform to one c. another of the local distribution categories identified by McCluskey (1979) (*Fig. 8*), vast areas of suburbia have no consciously-defined network structure.

Rules for the design of the local networks are not uncommon (particularly in the U.K. County housing codes, but also in Australia e.g. Pawsey 1976) but it is doubtful that as many as one third of Australian local government authorities do in fact require local networks to conform to specific criteria covering connectivity, catchment and external connections, as *Table 3* suggested. Once again, Canberra provides extensive examples of network structures of different types, the elements in which conform to clearly stated functional rules (NCDC 1975a).

Local Pathway Systems

Segregated pathway systems in new development range from conventional alternative routes (e.g. Stevenage (Stanley 1977) and the French new towns (Muhirad 1976)) to variations of the Radburn concepts of dual access systems (e.g. parts of Cumbernauld, U.K., and many other places). The Scaft guidelines are in effect an extension of the Radburn concept into multi-storey residential development, and have been widely applied in Sweden (Gunnarsson 1974; Gunnarsson *et al.* 1972 and 1973).



Fig. 8 — Residential access street network types, according to McCluskey (1979)

However, few developments claiming to be in the style of Radburn contain all the essential elements of the original (Tetlow and Goss 1965; Potter 1981; Birch 1980):

- (a) hierarchical distinction between local and main roads;
- (b) the development of 'superblocks' defined by the main roads, onto which all circulating traffic is directed;
- (c) the provision of schools, playgrounds and shops at the local level according to Perry's neighbourhood concept which was developed and applied during the same period;
- (d) exclusive use of culs-de-sac for vehicular access to houses within the superblock (derived from Parker and Unwin's earlier layouts in the U.K.); and
- (e) a separate footway system through public open space linking all dwellings in the neighbourhood with the schools and other local activities, providing each dwelling effectively with separate 'frontages' for foot and vehicular access.

In Australia, examples of segregated pathways in local areas are widespread in both publicly and privately developed areas. Extensive Radburn-type development is less common, the best examples being found in Canberra (NCDC 1975b) (*Fig. 9*). Experience with relatively early (i.e mid-1960s) Australian examples (e.g. Fountain Gate at Narre Warren (Vic.), which was reported initially to have met buyer resistance and have maintenance problems) perhaps contributed to professional and developer reluctance for some time to promote widespread use of the Radburn design concept. Crestwood, W.A., is a Radburn-style layout by Paul Ritter which was commenced in the middle-1970s. Gehl (1979) quotes Stein himself as saying that Crestwood is not only a perfect Radburn plan, but it is also the only entirely correct Radburn plan which has ever been built. The description seems excessively complimentary. Crestwood has house frontages on distributors and continuous loop roads (Fig. 10), and the roadways are no less generous than in many conventional streets. Nevertheless, it serves as a noteworthy and rare example of traffic segregation outside Canberra, and its accident characteristics should be monitored.

In recent years, the cluster housing concept has been applied in Australia. Groups of cluster courts can create some of the characteristics of Radburn designs, but the vehicular access ways in cluster developments are not essentially pedestrian-free (on the contrary, they are designed as mixed-function areas), neither is an extensive pedestrian/cycle pathway system through the shared open space an essential part of the cluster design concept.

Table 3 noted that 33 per cent of metropolitan LGAs and 22 per cent of non-metropolitan LGAs (27 per cent of all urban) contacted in the Survey reported the provision of pedestrian and/or cycle



Fig. 9 — Radburn layout at Rivett (A.C.T.) (Source: N.C.D.C. plan)



Fig. 10 --- Radburn layout in Crestwood, Perth, W.A.

routes or networks. Of the total of 75 LGAs which this comprises, it is presumed that many referred to pathway systems in local areas, although most of the case material supplied by the respondents referred to segregation from arterial movements rather than local systems.

Land Uses And Local Activity Centres

Homogeneity of land use in local areas has been a keystone of conventional planning practice for most of this century. There has, however, been considerable variety in the types and locations of activity centres permitted within local areas. The original 'neighbourhood', as Perry saw it, had a primary school centrally placed within its unique catchment but its shops were on the periphery (preferably at or near an arterial intersection). By the time the neighbourhood appeared as the basis of the British New Towns, local activity centres were located within the neighbourhood rather than on its periphery.

The neighbourhood facilities in Canberra at first followed the U.K. model. However, it became evident that the 'unique catchment' concept was not wholly valid, and many users of local facilities were coming from outside the neighbourhood. At the same time, the prevalence of vehicular access to local facilities was known to create problems. The solution proposed for Milton Keynes (Liewellyn Davies 1970; Bor 1974) was to place local activities, not internally, but midblock on the boundaries between adjacent neighbourhoods (Fig. 11). Similar considerations led to the activity centres in Tuggeranong being located in an 'activity spine' (NCDC 1977b) rather than on local collectors and distributors as in Belconnen and earlier developments. Apart from the question of traffic access, the location of local activities is also important with respect to local pedestrian and cycle planning. In general, the pathway system in the Canberra 'new towns' leads to most of the schools and shops.

In typical Australian suburban development, there is less consistent consideration given to the location of schools and other local activities. The provision of fully or partially segregated pathway systems to schools and some other attractors is not uncommon (*Fig. 12*), but neither is it universal practice.



- Shops
- Middle school
- First school
- Secondary school
- A Social information centres
- : Bus stops
- Local employment



Fig. 12 — Pedestrian path connecting to primary school across cul-de-sac heads at Endeavour Hills, Berwick (Vic.)

LOCAL STREET PLANNING AND DESIGN

The Street As Part Of The Housing

Although not directly an aspect of planning practice, the concept of the access street as a physical, social and emotional part of the house and its surrounds is critical, both to the physical design of the neighbourhood and to the design and operating philosophy for the local street system.

The interaction between households and traffic was discussed by Appleyard (1981a), and Gehl (1980) conducted formal analyses of the use of the street and abutting spaces. Gehl's studies of the 'interface' area between private and public territories in streets included work in Melbourne (Gehl 1977). Non-traffic perspectives of local streets have received attention from such writers as Nassau (1976), who considered streets from the point of view of the householder, and Colman (1978), who placed street design in the context of house siting and planning. This holistic view of street design underlies much of the innovative residential development found in Australia. The best illustrations are found in Canberra, in some public housing projects, and in private developments where the developer has control over all aspects of the housing and street design.

Street Functions And Geometry

The growing emphasis on local streets as multi-functional spaces within housing areas opens the way for variations from traditional design practices. Official deliberation on road functions in Australia has so far been directed towards network planning and local area traffic management (MMBW 1981; RoSTA 1981). However, a recognition of the immediately-local functions served by access streets (Brindle 1979b) is basic to the 'reduced' (i.e. smaller dimension and lower speed) design standards contained in the highly respected British guidelines (DoE 1977) and the various U.K. County design standards for streets in housing areas which have followed. Examples of such designs in the U.K. are found in Telford (Stevenson 1979), Halton Brow, Runcorn, and Ballock Eastfield, Cumbernauld (Riddell 1977).

In Australia, the state of present practice is typified in the planning study for major urban expansion east of Melbourne (Yuncken Freeman 1975?). The N.S.W. recommendations (PEC 1978) are considered variously as daring or conservative (*Table* 11). As in the U.K. and elsewhere, there have been arguments for 'lower' standards (Rockliffe and Paterson 1976; Thomas 1976). Armour (1982) found some suggestion that speed and width were directly related, although considerably more research appears to be required.

Table 3 earlier noted that nearly one-half of responding LGAs in the local government survey reported the adoption of street widths which were based on expected probabilities of vehicles meeting, and on the separation of parked vehicles from moving vehicles. This response is suspect. The question of probability of meeting is still under debate (Eyles 1979) and very few examples of separately-delineated areas for parking are known in new street design, one of which is at Sale (Vic.).

Respondents were also asked to indicate if they could produce examples of planning and design standards which encourage slow speed operation and/or create driveway type street environments. An unexpectedly high 39 per cent responded affirmatively, much seeming to depend on the definition of 'slow speed'. No cases of new street designs inducing speeds as low as those in the Dutch woonerven (below 30 km/h) are known, but Duek-Cohen's (1976) 'slow-way' proposals have attracted wide interest and Ames and Smithers (1983) report a partial application in Fairfield, N.S.W. Most Australian attempts at slow-street design have been in the context of local area traffic management.

Local Street Intersections

Overseas, avoidance of local cross intersections is common practice, although Bestor (1969) acknowledges that, especially in small subdivisions within existing rectilinear development, grid-type street patterns may still have been created in recent years. In Australia, avoidance of cross roads in the design of new street networks is so widespread that continued emphasis on the merits of T-junctions over cross roads seems to be unnecessary; more LGAs (63 per cent) reported avoidance of cross roads in the local government survey than any other planning measure.

Local Area Traffic Management (LATM)

A large proportion of the Study's attention was directed towards the control of traffic and street changes in existing residential areas (Brindle 1983e). The continuing evolution of ideas in Holland, Denmark, Germany, the U.S. and elsewhere was noted. Overseas practice in this area is so extensive and changing so rapidly that it would be neither practical nor appropriate to cover it in this report. Reference to the background reports and other literature is recommended (OECD 1979b; Bendixson 1978; Bendixson and Simkowitz 1979; Appleyard 1981a; Institute of Transportation Engineers 1981; Smith and Appleyard 1980).

Table 3 noted that about one in five of LGAs responding to the local government survey reported area wide programs to change local street systems or traffic conditions up to 1979-80. Despite recent interest in techniques aimed at modifying driver

TABLE 11 A SELECTION OF PROPOSED AND PERMISSIBLE RESIDENTIAL STREET ROADWAY WIDTHS

Roadway widths (m)

Source	Minor Cul-de-sac or Short Loop	Longer Access Streets	Local Road (Some Distributor Function)	Local Distributor/ Collector*
NSW (PEC 1978)	6	8	8	11
Proposed for Perth (Colman 1978)	5	6	6	9
Propased by Vreugdenhil (1972)	5.5 to	6.7	7.3	
NSW Housing Commission (Quoted by Colman 1978)	6-8	6	8	11
Canberra (NCDC 1975a)	6	6.7	7.5	7.5
Revised Essex Standards (Conform to DoE 1977)	4.8-5.5	5.5-6.0	6.0-6.75	7.3
Commonwealth Bureau of Roads (unpublished)	5-7†	5-7†	5-71	7.3-9.0†
Albury (Trestrail 1978)	8	6	10	11-13

Notes:

Definitions inconsistent — widths may not be comparable.

Higher figure allows for kerbside parking.

behaviour (speed control devices, etc.), most experience has been with street closures located at intersections (71 per cent of metropolitan LGAs and 57 per cent of all respondents) and with minor street roundabouts (35 per cent of metropolitan respondents and 27 per cent of all respondents).

Experience with a wide variety of planning and engineering techniques in local streets has increased considerably in recent years. At the time of the survey, only about one-third of the LGAs reporting installing LATM treatments said that they had done so in the context of an area-wide plan.

Compared with other States, Victoria has a wider spread of experience with LATM treatments. Many Victorian municipalities have conducted, or commissioned, area traffic studies, Of particular note are those studies conducted for (or in co-operation with) the former Road Safety and Traffic Authority (RoSTA), now the Road Traffic Authority (RoSTA 1979 and 1980b; Loder and Bayly 1981 *a*, *b*, and *c* for example).

Individual LGA interest has also been high elsewhere, particularly in N.S.W., S.A. and W.A., and guidelines or other forms of official encouragement of LATM are being developed in the first two of these as well as in Victoria. The overall impression from this extensive Australian experience, however, is that safety is not often an explicit motive.

REPORTED ACCIDENT RESULTS OF LOCAL PLANNING

The widespread interest in local planning and traffic management for safety reasons has led to rather more specific mention of accident consequences in the literature on these subjects than in other areas covered by this Study. As the following discussion shows, however, such data reinforce the general value of local planning without always clearly verifying the effectiveness of specific actions.

Planning of New Local Areas and Networks

A number of sources cite comparative data for areas of different layout type as evidence of the safety benefits of one type of layout over another. The most common data consists of pooled accident records comparing different eras of development (e.g. Lindstrom, Gunnarsson and Lindgren 1969; Gunnarsson 1974; Road Traffic Board 1972).

The relative accident histories of different parts of Canberra have been the subject of NCDC investigations, particularly in the late 1960s. Summaries of data for 1969 are reported by Andrews (1972) and for 1975 by Department of Transport (1978). The Commission concluded on the basis of their data that neighbourhood design has helped substantially in increasing safety in the suburban environment, and that modern (i.e. post-1960) designs were superior to the Burley Griffin layouts. *Table 12* summarises the data from the two sources. However, it should not be taken too readily at face value in this form, for several reasons including:

- (a) bias against the older areas, with greater vehicle density and non-resident travel;
- (b) the unexplained narrowing of the gap between the older and newer areas between 1969 and 1975;
- (c) the hidden variability in the data (there is greater overlap between the rates for older and newer areas than the grouped rates suggest); and
- (d) the lack of control over differences between areas to allow valid conclusions on the effects of specific planning measures to be drawn.

Thus, while such data strongly suggest that different planning styles and/or eras of development do indeed correspond to different accident rates, the analyses carried out so far are not detailed enough to warrant either the conclusion that 'new' designs are all superior to the 'old', or that one particular aspect

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TABLE 12

ACCIDENT RATES FOR AREAS IN CANBERRA 1969 AND 1975

	Thousand Population		
	1969 (Andrews 1972)	1975 (Department of Transport 1978)	
'OLD DESIGN'			
Tumer/O'Connor/Lyneham	21.3	19.5	
Braddon/Reid/Campbell/Russell	30.9	34.8	
Kingston/Griffith/Narrabundah/Red Hill	35.7	27.2	
Yarralumla/Deakin/Forrest/Barton	28.8*	42.8	
TOTAL 'OLD DESIGN'	29.2	30.1	
'NEW DESIGN'			
Hughes/Garran	11.4	14.3	
Curtin/Lyons	13.1	29.6	
Chifley/Pearce/Torrens	7.1	10.1	
Aranda/Cook/Macquarie	9.1	24.0	
TOTAL 'NEW DESIGN'	10.2	19.2	

Note:

The author calculates this figure as 39.4 from the original data. The figure quoted here is that published by Andrews. of the design (e.g. variations in the road network) is the explanation for any differences.

Such examinations have on occasions produced some unexpected results; a U.K. study found that between-the-wars suburbs in four towns had lower accident rates than both more recent and older suburbs (TRRL 1977). This subject clearly bears closer examination.

There is strong evidence that, at least under some circumstances, the *form of the local network* has a fundamental influence on an area's accident character. Data have been presented on three aspects of form;

- (a) the relative accident performance of culs-desac;
- (b) the significance of mixed-function local distributors; and
- (c) the method of local traffic distribution.

Bennett (1974) observed that collector (local distributor) roads 'almost invariably attract higher accident rates', and noted the relative salety of culsde-sac (*Table 13*). This, said Bennett,

'underlines the importance, for the safety of a street, of its position in the system. What matters in the design of an estate is the *strategy*, that is to say, the general layout of the streets, their function and their interrelationships. The details are much less important.'

This view was confirmed by Gunnarsson (1974), who found that the form of traffic distribution in a neighbourhood had a strong influence on accident rate.

With regard to the layout of the local roads themselves, no accident data were encountered in the review which supported or negated different local road design approaches. European appraisals (OECD 1977c) noted that the effect of meandering road pavements was yet to be proved, and that, while different parking provisions are clearly an element in safety for pedestrians (particularly children), research is needed.

As a final comment, a U.K. finding should be noted. In a study of 17 residential areas, the accident rate per dwelling was found to increase as the residential area became larger. The relationship was geometric, annual accidents per area being proportional to the square root of the cube of the number of dwellings (TRRL 1977).

TABLE 13

ACCIDENTS RATES FOR LOCAL STREETS —U.K.

	Accident/10 000 Population of Relevant Group		
	Cul-de-sac	All Streets	
Child pedestrians	4.0	23.6	
Adult pedestrians	0.2	2.6	
All pedestrians	1.3	8.5	
All non-pedestrians	0.4	8.5	
All groups	1.7	17.0	

Source: Bennett (1974).

LGA Survey Responses On Local Planning Actions

The Survey sought information on the location of land uses within the context of local development control, the design of the local network, the degree of avoidance of cross-roads, and geometric standards. When pressed, no local authority could produce data on any of these matters.

Safety Effects of Local Area Traffic Management

Attention to the safety effects of LATM focusses on two aspects: the safety impacts of individual treatments, and the effects of area-wide programs. By definition, the effects of individual devices fall outside the ambit of this study, at least with regard to their use as spot safety improvements. However, since the question of the safety (or lack of it) of the devices used within an area-wide LATM program is often an issue, some mention should be made of data which is to hand.

The most comprehensive safety appraisal of LATM treatments appears to be that conducted in Newcastle (U.K.) under a TRRL project (Silcock and Walker 1982). Fifty-three techniques and devices were evaluated against a number of criteria, including their safety effects. The general conclusion was that

a combination of conventional low-cost engineering techniques, applied on an area-wide basis, can offer improved road safety in residential areas.'

Other published assessments support the view that the techniques used in LATM would not produce a decline in safety at the sites where they are installed (Smith and Appleyard 1980 and 1981). Daley (1981) reports a significant (47 per cent) reduction in accidents at local cross intersections after the installation of roundabouts. Generally, the published material reflects the difficulty experienced in reaching statistically valid conclusions at sites where the numbers of incidents are low, and assumed proxies for accidents (such as observed reductions in speed, as in Loder and Bayly 1981a) are often resorted to.

There is somewhat more information on the accident effects of area-wide schemes. Specific or incidental data on the effects of LATM programs in the U.K., U.S., Sweden, Germany and South Australia was reviewed. Despite the obvious international interest in their performance, the special mixed-traffic zones ('woonerven') in Holland had not been evaluated up to the end of 1982; the results of evaluation studies in two test areas (Rijswijk and Eindhoven) were expected in 1983 (Royal Dutch Touring Club 1980). Guttenberg (1981) notes some of the non-empirical consequences (e.g. objections to the changing of historical streetscapes and the creation of standardised treatments), and said that it was still not clear whether or not the concept was widely accepted.

Brownfield (1980) reports on preliminary Greater London Council findings at 19 'environmental areas' where LATM measures (principally street closures) had been installed in the period 1972 to 1977. A significant variation between sites was observed, both within the areas and on their periphery. The total number of internal accidents decreased at 13 sites and increased at 6, with a significant (1 per cent level) decrease of 31.2 per cent over all. Internal pedestrian accidents decreased at 10 sites and increased at 7, with a non-significant overall decrease of 24 per cent. Most of the reduction was in nonserious accidents, which had the effect of increasing the severity rate by 39 per cent. On the peripheral roads, there was an overall reduction (not significant). Brownfield concluded that LATM can significantly reduce accidents, and displaced traffic does not necessarily cause an overall increase in accidents on peripheral roads. However, in view of the wide spread of results, it was noted that care in scheme design is essential.

The American case reported by Bagby (1980), involving a number of street diverters and closures in a neighbourhood of Grand Rapids, III., during the 1950s, also produced accident reductions: from 43 accidents (undefined) in 1951-53 to two accidents in 1955-57. Bagby, whose principal interest was in property values, notes that the reduction in accidents alone justifies such a program. Smith and Appleyard (1980) report the accident effects of LATM applications in two neighbourhoods in Berkeley, California. Total accidents within the two areas declined from 41 in a three-month before period to 18 in a comparable three-month period two years later. The brevity of these before-and-after periods may downgrade the value of these data, but it is noteworthy that the apparently significant decline in local accidents is largely attributable to a sharp decrease in right-angle collisions, presumably as a result of the intersection changes. The data revealed an interesting pattern in local street accidents, particularly low numbers of pedestrian and cycle accidents.

In Vasteras, a distict of Gothenburg (Sweden), street replanning in about 1968 to provide pedestrian protected zones (by means not specified) led to a 32 per cent reduction in injury accidents and a 41 per cent reduction in total accidents (Gunnarsson 1974). The 9.5 km² area, housing 8000 people and containing 700 jobs, experienced a 69 per cent reduction in total accidents and 43 per cent reduction in injury accidents internally, which was partially offset by a 25 per cent increase in total accidents and 28 per cent increase in injury accidents on surrounding streets. A Danish report (Denmark-Justitsministeriet 1978) observes that the reduction in accidents resulting from Swedish programs of 'traffic reorganisation' seems mainly to arise from reductions in property damage accidents, while injury accidents remain relatively constant (compare with the similar observation from the GLC study noted previously). As a result, the claim is made that 'traffic reorganisations along the SCAFT guidelines fail to solve the problems of fragile road users, and that remedies to these drawbacks are under investigation.

In Germany, accidents within the test areas in North Rhine-Westphalia were reported to have 'halved' (private communication). The only published data encountered in the review (from the limited German sources available in Australia) show that, while injuries rose 1 per cent in 1978 compared with 1976-77 in urban areas generally in the region, they fell by 44 per cent in treated zones (*Table 14*). All accidents fell by 11 per cent in the test areas compared with a 10 per cent increase overall. Of the techniques used in this German program, changes to the street network (closures) and changes to carriageways (i.e. constrictions and the introduction of meandering pavements with alternating angle parking) were found to produce the greatest reduction in accidents. In TABLE 14

_	Accident Numbers Compared With Index of 100 for Average of 1976/77		
	All Accidents	Injury Accidents	
All inner urban areas	110	101	
Street network changes	71	53	
Changes to carriageway	104	56	
Both	77	36	
All treated 'residential zones'	89	56	

Source: Pfundt (1980).

combination, such measures reduced injury accidents by 64 per cent. Pfundt (1980) notes that the greatest reduction was in serious accidents to children.

Although evaluation has received emphasis in trial programs in Victoria since 1980, results are not yet available. There are no known systematic reports of accident changes from any of the many Australian LATM programs. However, some incidental information on South Australian examples can be quoted. The Woodville (S.A.) schemes were described in terms of elimination of through traffic (Department of Transport 1978), and observed accident reductions were attributed to this. In the first area to be treated (Woodville South in 1971), internal accidents reduced by 48 per cent. Within a second area (Flinders Park) the reduction was 33 per cent. It was reported that the perimeter road rate was unchanged.

In Unley, the first two months of experience produced a 60 per cent reduction in accidents internally and a 36 per cent reduction on peripheral roads (Road Traffic Board 1975). Absolute numbers of accidents were not given. Perhaps more meaningfully, after 12 months experience there had been 56 per cent fewer injury accidents and 42 per cent fewer total accidents internally than were expected. Peripheral road accidents were slightly higher than expected but injury accidents were 32 per cent less (both observations not significant at 5 per cent level). Within Burnside, internal accidents over one year decreased from 50 to 29. Meanwhile, peripheral road accidents between major intersection also dropped (from 145 to 127). The major intersection rate remained about the same (Cairney and Brebner 1980). Cairney and Brebner noted that 61 per cent of Unley respondents spontaneously mentioned improved safety or a reduction in noise following road closures there, a belief which is borne out by the data. Bibbo and Rose (1980) found that the accident reduction in Unley was significant at the 1 per cent level.

In summary, while the nature of the areas concerned and the treatments employed in them vary widely, it could be concluded that LATM programs in existing local street networks would generally be expected to produce significant improvements to local safety, in terms both of injury and damage accidents. In particular, child safety should greatly improve. The reports to hand suggest that, even where substantial diversion of traffic back on to arterials occurs, accidents on peripheral roads have not generally increased in the cases which have been reported.

However, since this is an area of intense current interest and activity, the need and opportunities for careful study of the consequences of local area traffic management programs are very strongly indicated.

FACTORS INHIBITING THE ADOPTION OF SAFETY-ORIENTED PLANNING PRACTICES

It is apparent that many of the practices promoted by the Guidelines, or thought for other reasons to be likely to improve road safety, are not fully implemented. Many in fact are represented by only a few examples in Australia. Some possible reasons for this are as follows.

- (a) In practice, general statements of planning intent, which the Guidelines typify, do not always give sufficient guidance to what should actually be done. The planner is left with a range of possible ways of apparently satisfying the principle, not all of which are productive (e.g. 'A hierarchical street network should be provided').
- (b) Despite a widespread feeling that the principles are well-known, there is in fact a widespread lack of awareness among planners and decision makers of the areas in which planning can make substantial contributions to safety and the particular measures by which this can be done (e.g. local safety through particular techniques of street planning).
- (c) Planners and decision makers are sceptical about the real value of many of the principles, especially those which require substantial costs in effort and resources to carry through (e.g. local area traffic management).
- (d) Many of the measures are costly, whether or not their benefits are substantial and evident, and this leads to caution on other grounds. For example, given the apparent attractiveness of bicycle provisions for several reasons apart from safety, the limited nature of the works which had actually been carried out in Australia to the end of 1980 was a little surprising. Investigation showed that the high cost of separate lanes or paths was a principle inhibition, but in addition there is uncertainty about (for instance) the effect of current laws affecting cycle usage and precedence when cyclists or pedestrians conflict with vehicles. There is also a reluctance to commit the large sums involved without more reliable estimates of future use than are currently available. These problems of implementation deserve some attention if there is to be greater effort in cycle and pedestrian planning.
- (e) Existing communities are often not aware of a problem, and therefore are unwilling to pay for local measures.

- (f) Some measures are not readily marketable to the community because of the future costs that they involve (e.g. the inconvenience created by local area traffic management), or the inate unattractiveness which some of them have (e.g. some of the devices used in local area traffic management).
- (g) Conservativeness of planners and the community at large inhibits the introduction of new ideas; all change brings a reaction of some sort.
- (h) Responsibility for planning control is dispersed among several bodies at different levels of Government. This not only inhibits the adoption of common objectives and planning procedures, but also divides responsibility and concern.
- (i) For this and other reasons, planning constraints which influence safety are often unknowingly imposed on a development before it gets to the actual design stage where safety factors might receive practical (but less effective) attention.
- (j) There are different legal powers and constraints in each State, e.g. covering the vehicular use of verges (for parking), the treatment in law of bicycles, and subdivision and planning procedures.
- (k) The legal powers required to introduce some of the measures (e.g. the introduction of supplementary traffic distributors as a requirement of a subdivision) are unclear and are generally untested. Often, this leads to an assumed lack of power on the part of the local authority.
- There is often a misunderstanding of what is 'safe', e.g. a wide street with high visibility is commonly thought, by practitioners and laymen, to be safer (Martin 1983).
- (m) Many planners, trained in the social/behavioural/environment schools, understandably tend to react against the rather mechanistic end-results of many of the accepted Guidelines, which they see as having a heavy engineering orientation.

In summary, the planner may have insufficient specific guidance and proof that the techniques are effective, the community may be largely unconvinced that there is a problem which planning action in some areas can reduce, or by the time most developments get to the point where safety could receive attention. legal and physical constraints already limit the range of measures which could be applied. There is in any case a strong suggestion that in some areas of planning, such as residential area layouts, the framework imposed at the initial network planning stage is more influential on safety than is subsequent control imposed over design elements (see Chapter 4).

Dr John Grant concluded from a brief investigation of local government activity in this area conducted as part of the Study (Grant and Brindle 1979) that:

- (a) Local government generally covers a smaller area than the functional traffic region. As a result, they are unable to significantly control flows of traffic into or through the municipality.
- (b) Control over the various means which might be adopted to promoted road safety is widely dispersed. Agencies such as the State traffic, highways and utility services authorities, as well as

private residential or commercial developers all nave legislated or defacto powers over components of the road system or the major origins and destinations of traffic. As a result, the real power of local government is limited in practice to a relatively narrow band of potential measures. Even so, as the foregoing discussion has noted, these could be exploited more effectively

(c) Because of the complex nature of traffic and road safety problems, the limited knowledge about them and the complex administrative structure and system in the road traffic planning area, local government's capacity to deal with safety problems varies widely. That capacity depends upon the resources (manpower, finance) devoted to these problems.

Grant detected an inclination by local government to see itself as a 'major focus of power over safety and the key to remedial action'. Certainly, safety (or the perceived lack of it) has potentially high local political repercussions.

Consequently, Grant observed, the goal of a 'safe environment' is held by all local authorities, either explicitly or implicitly. This results in a situation where safety issues pervade all actions which may influence the level of safety of individuals on local roads. At the same time it is also evident that safety is only one of many competing goals in planning of any local environment. Except in a small number of cases, safety does not emerge as the sole criterion for action. Commonly, it is only of many criteria applied to the evaluation of a set of alternatives, the others being cost, administrative and political feasibility, the impact on traffic flow, amenity, convenience and a 'balance between these and other goals. Safety considerations are, moreover, used to

eliminate some alternatives, and all of those acceptable on this basis are then more closely examined. The criterion of safety is, therefore, said to be the first to be used in a 'mixed-scanning' approach. This, then, raises the fundamental question of whether the standard of safety which is used to eliminate some alternative courses of action is sufficiently high, and whether local authorities actually have enough information on the likely safety effects of the requirements and standards they impose.

Grant's discussions suggested that local authorities see road safety problems in one-off, sitespecific terms and think of appropriate spot remedies rather than preventative action through planning. As a result, he observed that most municipalities see their own set of traffic and safety problems as unique from all others, and that 'standard' solutions are inappropriate without adaptation based upon detailed local knowledge of the physical, social and political environment. As a result, while there is often considerable acquaintance with the literature on traffic safety, its relevance to local detailed problems is perceived to be of limited value.

Much of the literature on planning and road safety, being 'solution' oriented, tends to encourage this view by local authorities. Many of the particular measures taken elsewhere may not prove acceptable, for various reasons. Yet, as this study has found, much of the effective planning action concerns 'method' (i.e. principles) rather than 'solution'. The extent to which these principles are more translatable from place to place than are specific solutions needs to be explored. However, it seems highly likely that many local authorities are preoccupied with superficial variations in planning practices having at best a marginal effect on safety, while being apparently unaware of the importance of the more basic principles over which they have some control.



Chapter 4

ASSESSMENT OF EFFECTIVENESS AND FEASIBILITY OF PLANNING MEASURES

INTRODUCTION

The purpose of this Chapter is to summarise the findings of the Study about the evidence of effectiveness of the various planning measures so far discussed. Basic sources are cited in the following; a fuller discussion is contained in the various background reports.

NEW TOWNS AND OTHER PLANNED COMMUNITIES

Three points can be made about the safety consequences of the kind of land use/traffic systems which comprehensive planning and development control has made possible:

- (a) The very small amount of data available does not convincingly demonstrate a safety advantage in planned towns.
- (b) If there is indeed a superior safety record in planned new towns, it is certainly not possible to say, on the basis of present information, which of the planned components has most effect on safety, or whether it is the concept of unified planning and control of the new town per se which creates the improved traffic safety conditions.
- (c) Safety gains are not the only measures of satisfaction of new town residents.

ACCIDENT RATE COMPARISONS

Standard data sources have proven to be not particularly useful in allowing a comparison of planned towns with other urban areas, and the selected data and papers on this theme contain only superficial comparisons.

United Kingdom sources have for some years claimed a safety advantage for new towns in general, and towns with segregated road and pathway systems like Cumbernauld in particular (Cumbernauld Development Corporation 1967; Potter 1978; Riddell 1977; Stanley 1977; Cameron 1977a). Accident rates are typically quoted in terms of population, and occasionally in terms of vehicle-kilometres of travel. This data should not be accepted too readily at face value; there is, after all, no established theory that relates accident rate strongly to population or vehicle-kilometres of travel. A brief but revealing presentation by Raymond and Hodgkinson (1979) sounds a cautionary note. A random sample of 100 urban areas, stratified by population, was selected from the 412 then existing in England, Scotland and Wales. For each, the values of 18 independent variables were tabulated (covering town population, area, traffic measures, social parameters, housing and planning parameters, and so on). Forty-five different measures of accidents were defined as the dependent variables.

A multiple regression analysis on the data revealed that population level accounted for just over 32 per cent of the variation in the data matrix. While population was thus shown to be an important input variable, it was a poor predictor on its own.

Application of the 'best fit' multi-variable model showed that, although new towns tended to be below the norm in most instances, they appeared to behave less favourably than would be expected relative to other areas. Cumbernauld, for example, had a lower than expected level of deaths and severe casualties but was worse than the norm on many of the measures (such as child pedestrian casualties).

In Australia, many of the physical features acknowledged to contribute to a safe traffic environment are found in Canberra. Present data do not permit an adequate assessment of Canberra's performance compared with other cities. However, superficial comparisons of aggregated data hint at some possibly valid conclusions. For example, Canberra's severity ratio (deaths per casualty accident) and road deaths per unit population appear to be lower than expected. Pedestrian casualties form a much lower percentage of total casualties than other cities, but cycle casualties form a higher percentage than average. This may be due to the greater use of cycles as a travel mode, or merely to statistical observations due to the relatively small numbers involved.

Unpublished data for Canberra also are reported to suggest that Canberra's primary road system has a very low accident rate. Thus, in a number of respects relevant to the safety consequences of new town network planning, planning in Canberra seems to be demonstrating safety advantages. However, available data do not allow the point to be made more strongly than that, and Canberra's accident data storage and retrieval system should be utilised to look more closely at the accident characteristics of the different planning styles reflected in different parts of the city.

It seems fair to conclude that the general case supporting a safety advantage in new towns is 'not proven'. Furthermore, while there is every reason to expect that a thorough analysis of new town accident data would reveal a consistently better than average safety performance, that in itself would not necessarily constitute an argument in support of the specific planning measures evident in new towns. This leads to the second point.

THE ROLE OF THE PLANNED COMPONENTS

This report covers a wide range of physical planning measures, all of which may be components of a given planned town and any or all of which may have a strong influence on a town's safety performance. Aggregate data for each town do not permit valid conclusions to be drawn about the safety benefits of one particular attribute of the town's physical environment. Any safety advantage that Canberra may be found to have on closer analysis, for example, could perhaps be attributed to the rather unusual socioeconomic mix of its population. If such an analysis were possible, it may even transpire that, for a city of its size and socio-economic mix, Canberra has a higher than average accident rate. What conclusions could then be drawn about its physical environment? It is doubtful in fact that any valid conclusions could be drawn at the city scale from separating the physical characteristics of the city from the social and other characteristics of its residents, and even less from identifying one component of the physical environment.

To foreshadow later discussion on local planning, for instance, Bennett (1974; 1979b) suggests that the apparently good safety records of Cumbernauld and other new towns, especially in respect of child pedestrian accidents, is not due 'so much to the dual access (Radburn) principle as to the fact that most of the houses are on culs-de-sac or similar streets and that most of the distributors are free from frontage development.' This appears to cast doubt on conclusion of the Cumbernauld Development Corporation (1967) that 'planning for pedestrian and vehicles as separate entities has a return in the reduction in personal injury accidents', especially if the observation by Raymond and Hodgkinson (1976) (that Cumbernauld's child pedestrian casualty rate was in fact three times higher than expected) holds true.

SAFETY NOT THE ONLY MEASURE OF SATISFACTION

Planning and urban decision making are not singleobjective matters. The point is made strongly by Potter (1978) and Hillman and Potter (1975) in relation to pedestrian planning. Potter accepts the safety record of Cumbernauld's Radburn planning at face value, but traces the evolution of Cumbernauld from its original compact concept to its eventual lower-density form. It was a theme of new town planning in the 1960s:

With lower density structures walking became less of an important design element and more of a by-product of estate layout in all of these plans the Radburn concept of pedestrian/vehicle segregation remained, but the 'pedestrian freedom of Cumbernauld took on a very different meaning in Runcorn and Milton Keynes. (Potter 1978)

Hillman and Potter (1975) see a consistent failure in the car-oriented new towns to cater for pedestrian access (as distinct from pedestrian segregation) beyond the neighbourhood level. In his later paper, Potter (1978) observed that: 'Providing pleasant pedestrian routes may result in impressive accident statistics, but it does nothing to guarantee the range of facilities available to the pedestrian. Too often a Radburn layout became a blind to hide the fact that this was little more than a lip service to the needs of pedestrians in modern new town design'.

Lovemark (1972) in particular has drawn attention to the non-use by pedestrians of facilities provided for them, noting that 'people choose up to 30 per cent longer distances in a vehicular traffic system than a shorter, separated pedestrian system.' Potter clearly shows the design implications of this behavioural characteristic, and also emphasises the distinction between a pedestrian-oriented town and one which merely has segregated facilities but which involves great inconvenience for walking or cycling beyond the neighbourhood.

The degree to which towns meet these planning and design requirements varies widely, whether or not they have segregated facilities. Clearly, the satisfaction of all pedestrian and cyclist requirements — convenience, amenity and minimum effort as well as safety — is a criterion few, if any, new towns have yet achieved.

STRUCTURE PLANNING TO REDUCE EXPOSURE

Despite its frequent appearance in the stated objectives of urban structure planning studies, the validity of reducing travel by carefully arranging urban activities at the regional scale is not well established in practice, neither is the reduction of car travel by promotion of public transport use through regional organisation.

Aggregated data studies have been quoted to argue that vehicle travel is not necessarily less in smaller or more compact cities (Zahavi 1978; Kneebone and Wilkins 1977), although it is possible that disaggregated data comparisons may highlight substantial areas of difference (Wigan and Morris 1979).

Although certain city structures would allow a city to continue operating efficiently (albeit with a smaller range of choice of destination) if a strong constraint was imposed on travel, current experience has been that without such a constraint the citizens do not automically choose to reduce their travel.

Neither satellite towns nor system cities seem to be safety-oriented planning concepts. Although greatly increased travel costs would probably induce greater acceptance of closer destinations, neither satellite town or multi-town (e.g. Canberra) arrangements are intrinsically more efficient than any other urban complex having a balanced distribution of residences, employment and other opportunities. On the contrary, the separation of the urban units is always likely to increase total travel within an urban region as long as the costs of travel remain low (Forster 1974; Thomas 1977).

The relationship between urban structure and public transport use is even less well-established. although the presumption of such a relationship forms the basis of views popularly held by planners and laymen alike. Furthermore, the preoccupation with home-to-work linkages in those few cases where such views have influenced strategic planning begs the question of the accident-reduction effects of reductions in peak hour car usage. Being a relatively 'low risk' journey, reduction of the car trip between home and work (either by shortening its length or by inducing a mode transfer) is likely to produce only marginal changes in road casualties. On the contrary, if off-peak discretionary car travel increases as a consequence (as the 'travel time budget' school would hold), one could expect a nett increase in casualties.

There is insufficient information and understanding to indicate the potential value of decreasing car usage through transport or land use planning. This may be a research area worth considering.

At the heart of this topic is our present inability to model the travel consequences of different forms and structures in real cities. Because strategic planning is necessarily large-scale, policy-oriented and operates over a long time scale, transference of observations from elsewhere provides little insight into the consequences of policies in a particular place. Modelling is therefore essential, but here a practical problem arises. The present state of land use-travel modelling is such that, while disaggregated data studies are leading to a greater understanding of travel behaviour, adequate descriptive disaggregate models are still some way off. The aggregated models which have been around for some time have achieved some success in describing system conditions but are generally recognised to be of questionable validity when applied to forecasting the effects of policy and other variables which are substantially different to those operating at present. Common objections are the use of constant trips rates or trip lengths, the limited range of variables used, and the absence of behavioural logic. Nevertheless, the literature available on the subject relates to the application of these aggregated data models, with or without a pseudo-behavioural element. The value of these analyses to practical policy making must therefore be regarded as limited.

This overview tends to lead to the conclusion that too little is known about the response of urban systems to changes in their components to permit firm conclusion to be made about travel responses to urban structure. Zahavi (1978) argues for greater study of how cities behave before radical policy decisions are made on urban structure for travel objectives. Attaining the secondary objectives through manipulating urban form and structure (reducing energy consumption, pollution or accidents, for example), and certainly being able to predict confidently what gains could be made in these areas, seems to be beyond present knowledge. Further research on this subject will bring indirect benefits to the study of urban planning for road safety motives.

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ROAD HIERARCHIES

A concept of road hierarchy arising from classical planning considerations leads naturally to an understanding of the difference between two basic types of road : traffic routes and access streets. Tripp (1942) clearly demonstrated how this kind of two-class hierarchy followed logically from the 'residential precinct' concept. The distinction was adopted by Buchanan (1963), who wrote that 'there are only two classes of road — distributors designed for movement, and access roads to serve the buildings'. Hart (1976) recalls that in fact the idea predated both Buchanan and Tripp, being identified by Sir Raymond Unwin before World War One.

More familiar to Australian traffic engineers and road planners is the 'tributary-within-grid' concept of road types based on a 'hierarchy of movement' (Marks 1971). The movement and land service functions of roads are seen as being describable by continuous functions across the range of road types, and each type of road corresponds to a combination of particular 'values' of these functions.

When discussing the safety effects of hierarchical road planning, we must therefore distinguish between these two types of definition.

Even assuming that a hierarchical distinction between road types can be achieved in all urban areas (and there is some argument about that (see Wegman 1979), it is evident that the concept of road hierarchy and the labelling of roads in a network cannot in themselves produce safety benefits. What matters are the design and operational consequences which follow. Here there is a problem. Conventional road classification practice, if acted upon, can produce safety benefits through two achievements:

- (a) reduction of conflicts and interruptions in arterial traffic flow, for example by defining priorities at minor/major intersections, and
- (b) segregation of non-local from local traffic within residential areas.

But the 'balance' between traffic and other functions of roads which the conventional view of road classification depicts is often in practice a *conflict*, especially on that large group of intermediate roads which serve a substantial traffic movement function as well as accommodating housing and other sensitive abutting uses (Brindle 1979b). This is discussed further under the heading Local Area Planning, later in this Chapter.

The conventional approach to defining road classes therefore tends to create a broad range of roads intermediate between major traffic routes and minor streets on which there is a conflict of access and movement functions, leading to lower levels of safety and amenity than are desirable. This in fact is the kind of 'road hierarchy' which Australian local authorities have generally adopted.

If, on the other hand, road hierarchy consideration lead to a clear distinction between traffic routes and access streets then improved safety could be expected. This is a matter of importance in local planning and will be returned to later. With respect to the major network, a reduction of conflict between traffic and other functions leads naturally to a consideration of access to abutting land uses under a later heading in this Chapter. The low accident rates per unit travel on freeways are explained best in terms of access control and geometric design, rather than as evidence of the safety benefits of 'hierarchical road planning per se.

INTERSECTIONS ON MAJOR ROADS

The Guidelines cover the spacing and type of intersections along the more important roads. It is difficult to reach positive conclusions about the effectiveness of such controls since there are little data available. 'Good planning practice' without a strong empirical base seems to provide its own justification.

In outline, the rule-of-thumb minimum distance of 250 m between intersections along arterial streets (OECD 1971) received empirical support from a South African study (Del Mistro and Fieldwick 1981). Evidence on intersection types (essentially a comparison of T and cross) is inconsistent, and clouded by the fact that traffic volumes and turning movements are usually not quoted and the form of priority control is not described.

Considerable caution would therefore appear to be warranted when interpreting comparative intersection accident rates. Notwithstanding this, the available evidence in fact questions, under some conditions at least, the validity of the argument that 'T-junctions are safer than cross intersections because they have fewer conflict points', with its inevitable diagrams illustrating the relative conflicts (e.g. Department of Transport 1978). In addition to Harper's (1966) data, two other sources can be quoted to test the implied relationship between conflict points and accidents, and to show that the influence of other variables, especially traffic flows, may be substantial.

Firstly, David and Norman (1975) analysed accident rates and conditions at 558 U.S. intersections at which two or more accidents had been reported in a two and a half year period. Holding everything else constant, David and Norman's data suggest that not only are the rates for cross-intersections *not* more than twice those for comparable T-intersections, but also they cannot in fact be said to be consistently higher than the rates for T-intersections.

The second source is the South African work reported by Del Mistro (1979a), who reached the conclusions summarised in *Fig.* 13 and *Table* 15. The broad conclusion is that, the higher the approach volume, the more likely a cross-intersection is to be safer than T-junctions serving the same traffic. This last condition is important, since conclusions based on intersection conversion may not be valid when applied to planning new networks. Further caution is justified by Del Mistro's inclusion of signalised intersections in his sample (nine out of the 61 three-way intersections), suggesting that, in the absence of more information, *Fig.* 13 could be interpreted to mean merely that signalised cross intersections are safer, where they can be warranted by volumes. Furthermore, while he measured and cited turning volumes, Del Mistro did not discuss the effects of different proportions of turning traffic.

Nevertheless, being one of the more thorough analyses of this question. Del Mistro's work is interesting since it suggests that, on typical urban subarterials or arterials carrying (say) 8000 vehicles per day, the safety superiority of T-junctions with minor streets becomes questionable for minor street volumes much above 400 vehicles per day — a very low figure.

Furthermore, it is interesting to note that, under the broad ranges of traffic volumes commonly found on Australian local distributors (1000-3000 vehicles/day) and some of the more important routes (4000-12 000 vehicles/day), Del Mistro's results support Harper's (1966) reservations about a dogmatic prohibition of minor/major cross intersections.

This is an area of some controversy, however, even though the common preference for T-junctions is backed by very little published evidence. On major and minor roads, further study seems appropriate to establish whether or not the ranges of conditions under which either T- or cross-intersections are clearly preferable can be defined for Australian traffic.

The foregoing discussion is not inconsistent with observations that conversion of minor/major intersections along a length of major route into T-junctions improves accident experience. In most cases, the primary effect of such action is to reduce the number of small-volume connections to the major road, and combine them at local distributor outlets which still operate in the region in which T-junctions are preferred. The intersection spacing rather than type may well be the primary influence on accident improvement in such cases. The data are too inconsistent and site specific to enable conclusions to be drawn about general practice. In particular, great care must be exercised when extrapolating the results of changes to existing networks to the specification of design and planning principles for new urban areas. Furthermore, none of the foregoing discussion necessarily contradicts the well-documented experience that conversion of rural cross intersections to staggered T-junctions improves safety.

CONTROL OF ABUTTING DEVELOPMENT

Relatively few attempts have been made to establish a relationship between the nature of abutting urban land use and access, and accidents. Most of the reported data comes from the U.S. (e.g. McMonagle 1952; Box 1970; Uckotter 1974; McGuirk and Satterly 1976).

This work generally indicates the accident susceptibility of direct driveway access points, particularly to commercial frontages. South African data (Del Mistro and Fieldwick 1981) also found a measurably higher non-intersection accident rate for retailing and commercial frontages.



by the square root of the sum of the approach volumes on the minor legs

Fig. 13 — Boundaries of relative safety for T and Cross Intersections (South African data) (Source: Del Mistro 1979a)

TABLE 15

EXPECTED IMPROVEMENT IN ACCIDENTS RESULTING FROM INTERSECTION CONVERSION

Volume index Range ^(a)	Conversion	Expected % Reduction in Accidents
VP = 0 to 1 000 000	Crosses to Tees	50%
VR - 0 to 1000		
VP - 1 000 000 to 3 300 000 VR - 1000 to 1800	Crosses to Tees	30%
VP = 3 300 000 to 23 000 000	Tees to or From Crosses	No change
VR = 1800 to 4800		
VP = 23 000 000 to 70 000 000		
VR = 4800 to 26 000	Tees to Crosses	30%

Source: Del Mistro (1979b)

Note:

(a) VP = Product of the sum of the approach volumes (ADT) on the major and minor legs.

 e.g. Major road ADT
 = 3000
 Minor road approach volumes (ADT)
 = 600 and 500
 VP = 3000 x (600 + 500)
 = 3 300 000

 VR = Square root of the sum of the approach volumes on the major legs multiplied by the square root of the sum of the approach volumes on the minor legs.

 e.g.
 VR = √3000 x √1100
 = 1817

The Study concluded that the safety benefits of access planning and management warrant quantification, as do the various costs involved in obtaining them. Current practice illustrates the range of administrative and physical means available and readily demonstrates the feasibility of access control as a safety measure, if not its economic worth.

It should be added that, rather than 'access control', the term 'functional separation' could well be used, to emphasise that the conflict between the land access and traffic-carrying functions of the road is often at the root of the safety and operational problems (Brindle 1979b). A service road or roadside tree plantation is as much a means of removing arterial traffic from a site frontage as it is of restraining access to the major traffic stream.

The difference in emphasis highlights the question which arises from the discussion in this section: do the safety benefits of the guidelines under this heading accrue from the planning measures aimed at functional separation, or from the traffic engineering techniques of access management? Present knowledge does not justify a preference for back-up development over service road frontages, either residential or non-residential. If there are extra costs involved in back-up development then presumably the safety and other benefits compared with conventional service road development would need to be established.

Two problems are associated with Australian access control practice:

- (a) The measures for access control have not been universally applied. Not all recently-developed urban arterial frontages are controlled. This applies particularly to arterial roads under municipal rather than State Highway Authority control.
- (b) By far the majority of arterial road frontages were developed before the benefits of access control were realised. Very few of the techniques of access control applicable in newer areas can be applied to existing development. If the frontage cannot be controlled, the responsible authorities can only exert influence on the number and type of vehicle movements across the boundary — for instance, by using traffic generation analyses to control the types and intensities of land use abutting arterial roads (particularly through the process of planning permits for redevelopment), and by the use of medians to control turns at site entrances.

In both cases, the legal rights of access attached to properties and the extent of powers vested in public authorities are sometimes believed — rightly or wrongly — to constrain the full application of 'functional separation'. It seems clear that this is an area requiring investigation of the legal issues and possibilities, perhaps resulting in changes to powers and rights concerning abuttals to arterial roads.

This Study has raised the question of the location of major traffic generators (or, more accurately, 'attractors') and its possible effects on accidents. Part of this question obviously relates to access control, but existing controls over the size and location of these developments suggest a wider issue: the safety impact of attracted traffic on those roads feeding the site. There has been no known study of the pros and cons of different types of location (relative to the traffic system) of different types and sizes of development. It could probably be of assistance to planning bodies to have such information, if it can be established.

Finally, although most of the discussion in this section has concerned arterial roads, the study has emphasised the need for concern about functional separation on other elements of the major road system, and indeed into the minor road system. The strong probability that conflict between the traffic ('road') function and access ('street') function of local distributors, especially, contributes to neighbourhood insecurity has been discussed in reports and papers produced during the conduct of the study (Brindle 1978, 1979a, b, d'). This matter is pursued further in the discussion on local planning in this report.

At this point we are left with the question of the extent to which control of access to less-important elements of the major road system (subarterials or district distributors) can be justified. It is not possible to state, on the basis of available information, to what extent access control is applied at each level of the road hierarchy in Australia. But observation suggests that attempts at functional separation on the lower order arterials or district distributors is rare outside Canberra, even in newly-developed suburbs. Whether or not the application of access control techniques to these types of road would produce safety benefits is conjectural. There is a strong *suspicion* that this is so, however, and research would appear to be warranted.

SEGREGATED NETWORKS

The literature reviewed in the course of the Study did not establish a case justifying extensive town-wide segregated networks on safety grounds. The question is not whether segregated networks for pedestrians and cyclists would reduce casualties because full segregation clearly would — but whether full segregation is both feasible and cost effective. Feasibility must take into account the ubiquity of pedestrians and cyclists, and cost effectiveness must acknowledge the present extent and distribution of casualties, the cost of segregated facilities, and the extent to which the facilities being promoted meet the real needs.

THE UBIQUITY OF PEDESTRIANS AND CYCLISTS

The concept of segregated networks — at both regional and local levels — is based on the presumption that independent movement systems can be c: ated which will eliminate all bike/vehicle or pedestrian/vehicle conflict. Even in planned new towns this has not proven to be so. Inability to solve all pedestrian safety problems by relying on segregation was one of the earliest conclusions of this Study (Brindle 1978), and the same argument was put by the Geelong Bikeplan Study Steering Committee (1977) in relation to bicycle segregation.

Special pedestrian/cycle facilities, especially isolated routes, do little for overall safety since the very freedom of non-motorised movement means that the pedestrian and cyclist can and will still travel on or adjacent to roadways for the majority of the time. Enforced segregation, such as in several states of the U.S. where it is illegal to cycle on a carriageway if a parallel segregated facility is provided, is observed to produce hostile defiance. (The same law applies in parts of Australia but seems to be largely unknown and ignored.) Perhaps most importantly, there is concern that expenditure of funds on short lengths of segregated route tends to divert attention from more appropriate on-road and black-spot treatments.

EXTENT AND DISTRIBUTION OF CASUALTIES

Annual pedestrian deaths in Australia are currently under 700 and cyclist deaths are of the order of 100 per annum. Approximately 10 per cent could be assumed to be non-urban (Jarvis 1978a) and a further 30 per cent could be taken to occur within residential precincts (i.e. not on important roads).

Therefore fully-segregated pathway networks catering for all pedestrian and cycle movement above the neighbourhood level in all Australian urban areas would have a maximum theoretical benefit of about 400 pedestrian and 60 cycle deaths per annum on current figures.

The realistic targets would of course be well below these figures, if allowances are made for inevitable conflicts at those road crossings which are not grade separated and driveway-related conflicts at property frontages. Most existing and proposed cycle paths in established urban areas retain at least some at-grade intersections with motor traffic, for obvious cost reasons. On the argument that special provisions to remove such intersection conflicts are spot engineering treatments rather than attributable to the segregated path as a whole, it is concluded that the sort of segregated networks theoretically possible in existing urban areas have a target of about 20-30 cyclist and something less than 200 pedestrian lives per annum, on present rates, excluding those savings due to intersection treatments.

COST OF SEGREGATED FACILITIES

The Geelong Bikeplan (1977) report estimated the cost of separate paths at \$11 000/km sealed and \$7000/km unsealed. This presumably excludes costs of grade separated crossings and land acquisition. Actual costs of facilities constructed in Knox (Vic.) in 1981 were \$20 000/km. The projects funded under the U.S. Bikeway Demonstration Project, described by Jennings (1979), reflected a bicycle path cost up to \$60 000/km. The Geelong Bikeplan estimated the costs of lower-key bicycle provisions on existing roads (grate replacement, line marking, parking restrictions, signs, etc.) at up to \$2000/km (1977 values) plus monitoring and maintenance costs. Many design and site variables will of course affect the costs which apply from place to place, but these rates can give indicative values.

To construct a bicycle path system having the same route density as the existing arterial/ subarterial network in Australian urban areas,

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with at-grade intersections with all traffic roads, would probably cost more than \$200m (for 11 000 km) plus land costs.

MEETING THE REAL NEEDS

Cyclists in the U.S. and Australia express concern that the commitment of large sums of money to separated facilities diverts attention from those matters which cause most safety problems to them. The Geelong Bikeplan (1977) report identifies difficult intersections and poor road surface as being typical problem issues. Forester (1977) further claims that '90 per cent of cyclist injuries do not involve motor traffic.' Data from a survey in Sydney generally support both of these observations (Trauma Prevention Unit 1980). The further evidence of cycle casualty under-reporting (Bull and Roberts 1973; Triggs *et al.* 1981), especially where motor vehicles are not involved, suggests that bicycle accident discussions should not rely solely on official accident files.

Clearly, 'bicycle safety' and 'reducing bicycle/vehicle conflict' are two different objectives. How far one supports the other requires considerable further study. However, there are strong indications that some familiar forms of bicycle facilities attack only a minor proportion of cyclist injuries. An attempt should be made to clarify the potential safety benefits of various forms of bicycle facility by closer and more comprehensive examination of data on bicycle casualties.

It was concluded, with regard to cyclists, that:

- (a) Segregated cycle routes should reduce nonlocal accidents, where they are installed, to an extent dependent on the prior accident situation on the road sections being substituted and on the manner in which intersections and crossings are treated.
- (b) The type and extent of segregation which can realistically be achieved in Australian urban areas would not greatly improve overall cyclist safety.
- (c) There may be cheaper and more effective means of achieving the same safety results, e.g. through improved conspicuity and cyclist protection (helmets). Most mid-block cycle safety problems related to vehicles can be overcome by greatly improved cycle conspicuity, adequate vehicle-cycle clearance, and by road surface improvements.
- (d) Most of the safety advantages of fully segregated bicycle facilities would then be gained from the fact that individual vehicle-cycle conflict points are grade separated or signal-protected, not because the path network itself is segregated.

PEDESTRIANS

Much of the discussion on cyclists applies to pedestrian facilities. Most urban main roads in Australia, of course, already have 'segregated' pedestrian facilities — the parallel sidewalk or footpath. The problems that arise at crossing points are the subject of traffic engineering rather than urban planning, except where (as in the case of independent bike paths) the pedestrian movement is accommodated on a special network of paths segregated not only horizontally but, at crossing points, either vertically or in time from traffic routes. Except where (as in new towns) the primary road network has a high degree of access control, prevention of pedestrian passage along and across most major routes would be virtually impossible to achieve. Almost certainly, Canberra's comparatively low pedestrian casualty rate (which arises largely from its very low percentage of casualties on the higher-order roads) results from its control over abutting access and the location of pedestrian-generating activities away from major traffic routes. Whether independent facilities in arising cities would attract sufficient numbers of pedestrians away from arterial routes to achieve noticeable safety benefits is doubtful, especially since a high percentage of midblock pedestrian casualties on arterials and subarterials appears to be associated not with travel but with movement within linear shopping centres.

Within neighbourhoods, different considerations apply. At this point, some doubt is expressed about both the effectiveness and feasibility of large-scale planning of segregated pedestrian facilities. As in the case of bicycle facilities, most of the benefit appears to be gained from the protection of pedestrians at individual crossing points (grade separation or lights) rather than as a result of segregated routes.

CENTRES

A discussion of the value of the application of the centre planning guidelines must focus on two principle points:

- (a) The extent of the need, as reflected in actual accident experience within activity centres.
- (b) The effectiveness of the various measures as reflected by available data.

Because they contain concentrations of activity (both vehicular and pedestrian), the central areas of cities and towns usually experience greater concentrations of collisions and injuries per unit area. However, the potential for improvement in city streets and strip centres is usually not great perhaps up to two or three casualties per year even in the busiest streets. Thus, in general, 'effectiveness' of measures aimed at individual lengths of street within centres is inevitably difficult to demonstrate statistically. In safety terms, the wider the area of action the stronger the evidence becomes; pedestrian-only or pedestrian-dominated zones seem more beneficial in safety terms than relatively short lengths of vehicle-free street, and the redirection of non-essential traffic in town centres by means of 'zone and collar' schemes (Nottingham, Gothenburg, Geneva and elsewhere) appears likely to be able to achieve substantial reductions in numbers rather than just proportions of casualties.

The reasons for this are not just statistical. Areawide traffic management and pedestrian-oriented zones are more likely to arise from an awareness of area rather than street problems, and are also more likely to be based on comprehensive planning with area effects in mind. The limited items of data available on past experience suggest that the smaller the area or street length within which pedestrianisation is applied, the less effectively will pedestrian-vehicle segregation be applied and the less apparent will its safety benefits be.

'Effectiveness' of the activity centre planning measures discussed here is also made difficult by the incompleteness of information about the changed or relative patterns of accidents.

There are two problems:

- (a) the data are not reported over a comprehensive enough area; and
- (b) many actual collisions and incidents contributing to a general lack of security may remain undetected or unaccounted.

The first of these is the familiar problem of displaced accidents. Obviously pedestrian security is increased at the location where vehicle numbers are reduced or eliminated altogether. In those few cases where accident data have been reported, it was noted earlier that it is not uncommon for accident trends on alternative routes to be included. Even this kind of data has the usual problems associated with before-and-after studies. Accident trends in a control area, which provide some reference points for assessment of effectiveness, are rarely quoted. Most often, when safety is mentioned in connection with centres, it appears to refer to pedestrian safety within the shopping area itself. There appears to be little or no understanding of the effects of displaced traffic, or its extent, and the changes in accident type and number which it may lead to.

The second of the above points hints at a possible underestimation of the extent of insecurity in many existing centres which could therefore warrant some action, and in the environs of many newer centres which incorporate aspects of the safety guidelines (i.e. the value of the planning measures may be understated in converted centres and overstated in new ones). This is due to a number of factors.

Pedestrian 'security' is not necessarily (a) measurable (or at least adequately reflected) by small-magnitude numbers of pedestrian casualties in centres. Conversion of a street to a mall potentially does more than reduce pedestrian casualties in the street - it could be expected to reduce the level of what could be called 'pedestrian/vehicle tension'. On the other hand, many newer off-street centres provide very badly for pedestrians once they leave the vehicle-free shopping area (Fig. 14). It was observed early in the course of the Study that if safety was really a consideration in new shopping centre planning then 'there would be better planning for pedestrians at the doorways of 'car free' shopping centres, which almost invariably open onto major circulatory roads, and in the car parks of such centres' (Brindle 1978). If anything, present design philosophy tends to favour traffic bustle at the centre doorways, to draw intending shoppers past the entrances before they park, and to emphasise the contrast with the traffic-free environment inside.



Fig. 14 — Danger at the door of a 'traffic-free' centre (Eastland, Vic.)

- (b) While all casualties presumably are reported, whether in strip centres or in car parks attached to newer centres, there is a possibility that injuries which occur in car parks and access ways are not all finding their way into accident records. Wigglesworth (1977) noted that about: 3 per cent of Australian vehicle-related fatalities over the decade to 1974 were 'off-road' and did not appear in the official statistics on 'Road Traffic Accidents Involving Casualties'. What proportion of these occurred in vehicle areas associated with activity centres is unknown as is the number of injuries in the same category.
- (c) Many minor property damage accidents occur in car parks and access ways. The proportion of these which are reported is unknown, even in those States where damage above a certain value must be reported (e.g. W.A. and N.S.W.). Perhaps Canberra's accident database holds the greatest potential for examining these accidents in parking areas. The removal of through traffic streams from the circulating and parking traffic associated with an existing strip centre must reduce the occurrence of these minor collisions and should therefore be considered as a contributory reason for change. On the other hand, the costs of vehicle damage in the car parks of newer centres are an unaccounted debit against whatever safety gains such centres may create.

Movement and accident patterns in centres have not been studied closely enough to identify the likely effectiveness of countermeasures, which should arise from a consideration of two broad categories of activity centre conflicts:

(a) External — interference with and by through (or passing) traffic, requiring management of the arterial/centre interface. (b) Internal — conflicts between different forms of movement associated with the functioning of the centre, requiring attention to be paid to the access and circulation systems.

While it is still open to analysis and contradiction, it appears reasonable to suppose that a strip centre with little or no through traffic performs much better than one which straddles a major traffic route. If this is so, then the question arises as to the extent of the further benefit obtainable by turning the centre away from the road altogether. It becomes important to know the extent to which the internal conflicts (for example, between cars circulating within the centre, or between pedestrians and cars seeking access to the centre) contribute to accident numbers. Perhaps an off-street newer centre with poor access and internal circulation performs less satisfactorily than a strip centre with good circulation planning. The data available do not permit firm conclusions to be drawn. It seems doubtful that accident experience in most existing strip centres could by itself establish a clear warrant for major reorganisation of the centre.

LOCAL AREA PLANNING

Once again, the assessment of the value of this area of planning focuses on two points:

- (a) the potential for significant improvements, and
- (b) the effectiveness of the various measures.

That local areas should receive greater road safety attention is strongly indicated by the available accident data (Brindle 1983e). Whether or not the level of accidents experienced within a locality is amenable to reduction through planning activity was a key question which the Study focussed on. Andrews (1972) suggests that planning can reduce accident rates down to a certain base level, below which further improvement is unlikely by the nature of the traffic system — a concept promoted by the late Reuben Smeed — and further, that recentlydeveloped areas in Canberra have already reached that ideal through modern planning practices.

Whether or not this idea is accepted (and the author sees no convincing evidence for it), there is still clear scope for investigating the reasons for different rates between types of areas, and assessing the effectiveness or otherwise of local planning actions. Both in new areas and management of existing areas, these actions fall into four broad groups:

- (a) the definition of discrete land units, which may be conceived as functional units, but in any case are to be protected from extraneous traffic;
- (b) the road network serving the locality;
- (c) non-vehicular routes; and
- (d) inducement of appropriate road user behaviour.

There is at least superficial evidence that familiar planning activity directed at one or other of these areas can produce safety benefits. However, the obvious conclusions may not always be the correct ones. For example, Bennett (1979a) notes that dualaccess, segregated-traffic Radburn layouts have 'gratifyingly low' child pedestrian accident rates. This, he says, may be due simply to the fact that most of the houses are on culs-de-sac or similar low-connectivity, low-speed roads and that most of the distributors are free from frontage development. Bennett saw no difference in safety between Radburn culsde-sac and conventional ones; in fact, it seemed to him that they provide a safe environment 'irrespectively of how they are designed'.

Another example can be found with 'traffic precincts' or 'environmental areas'. Some data have been found which suggests that reduction of extraneous traffic corresponds to a reduction in local accidents. Is the accident rate still the same, however, and is the reduction in accidents merely a result of a reduction in volume? If the rate itself is dropping, is that because internal intersections have been changed? For his part, Bennett (1974) argued that 'the fact that a residential estate is free from through traffic is no guarantee at all that it will be safe for child pedestrians'. He also warned that the creation of 'environmental areas' by establishing a strong distinction between arterial and local roads in existing networks cannot be expected to reduce accidents in all cases (Bennett 1979b).

The exclusion of through traffic is, of course, a key characteristic of neighbourhood planning. These observations seem to suggest that it is, at the most, a necessary but not sufficient condition for local safety. In practice, new 'neighbourhoods' rarely conform to the model; typical private developments in Australia demonstrate a widely-varying degree of care given to the location of local attractors (schools, shops, etc.) and access patterns to them. On the other hand, an attempt to satisfy the road network objective — to deter non-local traffic — is-evident in most (but not all) modern estate planning. The fact that these attempts are not always successful suggest that there are inadequacies in the planning tools.

Action that follows within the neighbourhood can aim either at segregating motor vehicle from other movement, or at modifying road user behaviour to reduce the risk and consequences of conflict. It still has not been positively established what behavioural factors are the critical ones, and whether or not manipulation of the physical characteristics of neighbourhood streets is an efficient way to modify them. However, there is a strong consensus of opinion that measures aimed at reducing speed in local streets are indeed a positive means of increasing safety, despite the limited data revealed by this Study. For example, Linde (1981), from ADAC (the German Automobile Club), said: 'we believe that traffic restraints can only be implemented successfully if the primary consideration is the safety of children' indicating that restraint of driver behaviour and accident reduction are related.

But merely introducing traffic engineering devices in an attempt to reduce speed may not be enough, specially if maximum community support is hoped for. The OECD Road Research Group on safety in residential areas noted that (OECD 1979b):

⁶ There seems general agreement that the hard landscape should be altered in appearance so that it resembles those areas customarily associated with pedestrians rather than vehicular activity' (OECD 1979b).

Adopting this general objective, the simple (and common) step of placing speed control devices in existing streets, leaving the streets otherwise in their former condition, would seem to be insufficient. For instance, tests by the Australian Road Research Board have helped to identify effective and safe designs for speed control humps (Jarvis 1980a), but on their own they would not create an appearance of 'pedestrian rather than vehicular activity'. Indeed, it appears that road humps are most suitable if employed as part of comprehensive programs of street changes aimed at doing just that. Some doubt must be expressed about the wisdom of installing road humps in the inviting expanses of the typical Australian street, and expecting them to solve, on their own, a problem which is created by the design of the street itself.

The question of speed restraint raises different kinds of problems in the design of new residential streets. Virtually all control over the safety characteristics of Australian subdivisions is exercised in terms of the detailed design of the internal road network. Common standards typically specify that highway design concepts of alignment, reaction time and sight distance, based on a design speed, be observed in street design, although the relevance of highway-based reaction time or stopping distance data to residential street design has not been demonstrated.

It is also widely held that failure to require a 'design speed' of 60 km/h or more would create an unsafe situation for which the municipal engineer would bear legal responsibility (Brindle 1979*d*), but the validity of this belief is open to question. Modal or 85th percentile actual speeds are likely to exceed the design speed in any case; the exact relationship (if there is one) are not known. Nor are there any data which reliably correlates accident rates with design speed, nor indeed with those geometric design parameters, such as width and alignment characteristics, over which local authorities typically exert such strong control.

Bennett, who has extensively and systematically studied accidents in residential areas, concludes simply that 'traditional standard designs are just not good enough' (Bennett 1979b), even though the current U.K. guidelines (DoE 1977) already promote geometric design criteria (e.g. single lane carriageways in access streets) which would be considered revolutionary in many parts of Australia. Bennett describes observations on roads and access ways which appear to break all the current 'rules' yet which seem to work, and expresses the hope that:

These results will encourage designers to persevere with experiments for shared surfaces for vehicles and pedestrians at the traffic level of the access cul-de-sac. At that level, in the author's opinion, such innovations do not necessarily reduce accidents, as some people claim, but they are certainly quite acceptable, and their real rationale lies in the creation of an environment which is not dominated by the car and where perhaps 'perceived' safety is enhanced'.

The importance of clarifying a hierarchical relationship within the local street system is a feature of the planning guidelines. However, having in mind the problem of the local distributor which has been noted in this report, it appears that the planner must be aware of the practical implications of a local road hierarchy. The following observations arise from an appraisal of the conventional approach to hierarchical road planning made during the course of this Study (Brindle 1978 and 1979b).

It was noted earlier in this Chapter that, in common Australian practice, the movement of traffic between arterials and lowest order access streets is theoretically achieved through a graded hierarchy of roads, with the access function gradually gaining prominence as the traffic function decreases down the scale of road types. Within this concept, the local distributors (or 'collectors' - the most important roads within a residential cell) are seen as providing a balance between movement and non-movement street functions (Fig. 15a). But an inspection of real streets reveals that the access requirements along quite important roads are not substantially less than those along minor access streets. Access frequency is not a direct proxy for 'street' function as perceived by users and residents; clearly the occupants of properties along arterials and sub-arterials have different expectations about the nature of the space in front of their homes compared with residents in a cul-de-sac, even if access density is much the same. Perhaps this does reflect some sort of compromise between the traffic and access functions of these higher-order roads, although the nature of frontages to them deserves attention.

The situation is not as clear-cut on the local distributors. An investigation of the way in which local distributor residents perceive their street would be instructive, because it appears that there is a *conflict*, not a balance, between traffic functions and nontraffic functions of this level of street (*Figs 15b* and *16*). Rising status in the hierarchy corresponds





(a) The traditional concept of a graded road hierarchy





Fig. 15 — A possible explanation of the traffic and safety problem on local distributors

generally to greater volume, length, width and speed. Thus, it is not surprising that a correlation is observed between these characteristics and accident rates (Bennett and Marland 1978). But that alone would not explain the apparently higher rate on local distributors than on arterials (*Fig. 17*; see Brindle 1983e). The conflict of functions on the local distributors may itself be largely to blame (Brindle 1979b).

These considerations tend to support those concepts of road hierarchy which reflect a sharp and substantial distinction between roads forming part of the urban traffic network and those penetrating residential areas; for example the Victorian guide (Loder and Bayly 1980a). Because the spacing of existing primary routes is generally larger than desirable for the creation of suitable residential cells (or precincts), this approach to network hierarchy necessitates the creation of new routes which supplement the existing road framework (*Fig. 18*). Many practical objections could be expected, yet the concept appears highly desirable.

If the nature of local distribution is not modified in this way, then the degree of conflict between functions which appears to give rise to the observed accident problems can be reduced either by reducing the 'street' function of the distributor (by minimising the number of house frontages) or by changing driver behaviour. Without modification in one of these ways, the adoption of a conventional hierarchical local street pattern is not likely after all to be a safety measure, and may in fact be counter-productive.

The other important aspect of the local network is the familiar question of T-junctions versus crossroads. Despite the questioning which this report has



Fig. 16 - Approximate characteristics by cumulative road length



Functional Road Class

Fig. 17 — Apparent form of the road class-accident rate relationship

placed on the adequacy of some of the data used to support the case for T-junctions, the present widespread practice of prohibiting cross-roads within residential areas is probably supportable and, in view of the small effort and cost usually involved, can be regarded as good general practice. However, in particular instances a rigid ban on cross-roads can be too restrictive. For example, it was argued (p.??) that a lot depends on the proportion of turning vehicles. Two short access streets forming a cross-road on a local distributor are not likely to generate many movements across the distributor and it would seem to be immaterial whether they are placed apart or together.

The rule may also prevent the cross-intersection of two higher-order local roads which may be desirable for bus network or other reasons. Interestingly, many Australian intersections between two local distributors fall into the 'indeterminate' zone in *Fig. 13*, which was derived from South African data. Similar relationships would have to be developed from



Fig. 18 — Alternative ways of subdividing 176 ha on the tringe of a town

Australian data if the safety effectiveness of this common rule is to be tested. In any event, there is a compromise available: if all intersections of local distributors (T or cross) contained properly planned and designed roundabouts, the problem is likely to be avoided.

The data available seem to indicate that towns and districts with an emphasis on pedestrian/vehicle segregation, by the use of protected pathways, incidental spaces for pedestrians, areas for children away from traffic and so on, are likely to have lower pedestrian accident rates. But, as Gunnarsson (1974) points out, there can still be wide variations in casualty rates as a result of different approaches to the design of the built environment and the street networks. Furthermore, residential areas featuring traffic segregation are likely not to be fully 'safe' because

In particular, while several studies (particularly at towns in very densely populated, deprived areas) have /vehicle reflected benefits, there is generally little or no ys, incichildren at least as a single measure (Brindle 1978). The nature of play makes it inevitable that it should take place over all accessible places in the peighbour-

especially children.

place over all accessible places in the neighbourhood, and not only in play areas (Churchman 1976). Observations not only on play but also on pedestrian behaviour generally suggest that 'segregation of road and footpath networks in the vicinity of the home is unlikely to be fully effective' (Noble 1977). An

absolute segregation cannot be achieved down to

the very lowest level of activity. This is partly a

design problem, but it is largely an unavoidable con-

sequence of the ubiquity of the pedestrian,

Australian study illustrates the point. Earlier reference was made to Crestwood, in Perth, W.A., 'the only entirely correct Radburn plan'. Yet it was observed (Gehl 1978 and 1979) that 41 per cent of foot and cycle movement on a weekday in Crestwood (22 per cent on a Sunday) occurred along the roadways, as did 33 per cent of weekday (26 per cent of Sunday) 'hanging around' by children and 68 per cent of weekday (73 per cent of Sunday) adult activity (other than movement).

Gehl (1979) concluded that the expense of rear access ways to all dwellings was not warranted, the observations in Crestwood confirming Danish observations. He saw greater promise in the Danish 'Paragraph 40' provisions for mixed-function streets, and even greater advantages in restricting all traffic movement and parking to the fringes of residential groups. Experience with Radburn-type development has led to other reservations about the concept. Alden Christie, an architect who grew up in Radburn, questioned the fundamental elements of the Radburn layout - the common spaces and the dual-access frontages: 'The automobile has been made such a dominant feature that life is more oriented towards the peripheral access road ... than towards the common' (Stern 1981).

The apparently strong demand in Australia for parking for residents and visitors close to each dwelling suggests that any comprehensive approach to residential planning and pedestrian safety must be based on the assumption that vehicles are a part of the pedestrian's environment right up to the house doorway. Kraay and Wegman (1977) raise several other questions about Scaft-style segregation, even in the European context: the high costs, the physical difficulties in most practical cases, and the difficulty of 'harmonising' the different networks for pedestrians, cyclists, mopeds and motor vehicles.

In view of the many functions of residential streets, some writers even question the desirability of segregation, even if it were physically and financially feasible (OECD 1977*c*; Kraay 1976). Perhaps there is even a suggestion that the proximity of vehicles is somehow good for other users of the streets: Provided the traffic volumes are light and the road layout is suitable, the advantages of mixing the various functions lie in economy, in the development of neighbourly contacts and in the opportunities children get for 'socialisation' through early 'playtime' traffic education in the immediate vicinity of the home' (Topp 1975).

Therefore, while noting the improvements in pedestrian safety that the established planning guidelines seem to produce, it is necessary to ask:

- (a) Are the safety benefits merely incidental to other benefits which segregation-oriented physical planning brings?
- (b) Is local safety affected more by the management of mixed traffic areas than by traffic segregation?
- (c) Are there forms of local area design which create inherently safer mixed traffic (i.e. 'ordinary') streets?
- (d) Does the Australian attitude to the motor vehicle, and the 'rights' of residential area penetration which are presumed to attach to it, permit the employment of the high degrees of segregation observed elsewhere (for example, with respect to remote garaging)?

In other words: are the high degrees of vehicle/pedestrian segregation reflected in, say, the Scaft Guidelines and some U.K. practice actually necessary to bring about higher levels of safety in residential areas? Or can present suburbs and design practices be adapted to produce similar results with less cost, inconvenience and change in lifestyle? The conclusion drawn from this assessment, based admittedly on general case study information rather than controlled studies, is that the way traffic behaves within the locality is all-important. In particular, slow-moving vehicles present little threat, no matter what form the design of the locality takes. An affirmative answer to the second of these two questions is therefore strongly indicated. However, it is not possible to be specific about which of the many planning and design strategies are most effective.

Chapter 5 SUMMARY AND CONCLUSIONS

INTRODUCTION

The purpose of this Chapter is to note briefly the principle conclusions of the review, commenting particularly on the extent of application and the degree of substantiation of the various practices, and current implications for practitioners. Areas where further research could be profitable are amplified and given proposed priorities in Appendix B.

PLANNING URBAN FORM AND STRUCTURE

The two basic planning strategies discussed under this heading were:

- (a) reduction of car usage by the organisation of land uses at the regional level, i.e. the control of urban form and major structure; and
- (b) reduction of car usage by reorganising land uses in order to induce greater use of alternative modes.

Table 16 summarises the findings and conclusions of the Study with respect to these two planning strategies. Neither is recommended as a plausible and practical safety strategy. Structure planning (and modal planning) ought to influence directly the total amount of car travel, and indirectly the number of road casualties. In practice, there appears to be no validation of this, and certainly no reported quantification of vehicle travel as a function of deliberate land use disposition.

It is stressed, however, that this does not mean that lower car usage would not lead to fewer casualties. All other things remaining constant, that would obviously be the case. The city of the future could conceivably have a much greater proportion of travel by group transit (trams, buses, light rail, etc.). Presumably a lower road casualty rate would occur. But urban organisation to reduce trip lengths has its own costs, many of which (unlike the rather remote costs of road accidents) would be confronted every day by the urban dweller. This is potentially a very large question, going far beyond the scope of the present study.

Neither does the conclusion mean that the various guidelines under this heading are necessarily

TABLE 16

SUMMARY OF FINDINGS AND CONCLUSIONS: STRATEGIC PLANNING AND ROAD SAFETY

	Reduced travel and hence car usage by land use organisation at the regional level	Reduced car usage by inducing mode change through land use organisation at the regional level
Basis	Non-empirical theory is widespread. Many potentially-relevant theoretical investigations in other fields.	Very little known. Probably based on reverse observations on transport/land use compatibility.
Adoption as a salety objective	Common generally-stated objective in metropolitan studies.	Rare, although implied in some planning statements (e.g. Canberra, Albury/Wodonga).
Reported overseas applications	Few actual attempts reported overseas (e.g. Milton Keynes, U.K.).	None known.
Reported Australian applications	By implication, in plans now being implemented for some cities (e.g. Sydney, Albury/Wodonga).	None known.
Reported effectiveness as a safety measure	No information. Doubtful effectiveness on its own.	No information. Doubtful effectiveness on its own.
Practicality	Doubtful.	Doubtful.
Assessment as safety measure	Theoretically plausible, especially if directed at non-work travel (which is unlikely). Essentially a long-term effect which is hard to implement, control and anticipate.	Not really plausible on present knowledge.

erroneous. It is simply that a long string of effects, not all controllable, intervene between the establishment of a strategic plan on paper and the achievement of a low road accident rate in the physical city that results. Planning analysis is not sufficiently refined to enable us to anticipate such an effect from such a beginning, even if the analysis was to influence the decision taken.

ROAD NETWORK PLANNING

The common understanding of what constitutes good network planning practice, as reflected in the various guidelines, relates to:

- (a) The establishment of a hierarchical road system, principally distinguishing major traffic routes from local streets.
- (b) The different planning and design principles which apply at each level in the hierarchy.
- (c) Permissable and prohibited connections between different levels in the road hierarchy.
- (d) The number and form of intersections on the major network, particularly concerning the preference for T-junctions over unsignalised cross-intersections.
- (e) The location of traffic generating (attracting) land uses.
- (f) Restrictions on degree and type of access to different levels of road.
- (g) The provision of routes and networks for nonmotorised travel in a town.

The study findings in the application of planning methods in these areas are summarised in *Table 17*. These guidelines are based, in the main, on general experience backed by specified or implied concepts of what constitutes 'good practice'. Of the planning actions themselves, only the avoidance of uncontrolled cross-roads on major routes appears to be consistently applied, principally for road safety purposes. Other actions commonly have implicit safety motives.

In Australia, there is certainly a widespread awareness of the general principles covered under this heading, but (apart from the avoidance of uncontrolled cross-roads) actual examples are not commonly found. Canberra provides the best Australian example of widespread and consistent application of hierarchical road planning principles and the design requirements which follow. Canberra also has the only extensive cycle network incorporating substantial lengths of protected path, although networks are growing in other cities.

The empirical basis of all these actions is weak, and there appear to be no substantial reports of their accident consequences, with the exception of some reports of general levels of cycle accidents in places where cycle network planning is active. Without data on usage, and hence exposure, such cycle accident figures are not particularly instructive; cyclists form a higher proportion than average of total casualties in the A.C.T. and Victoria, for instance. This perhaps should be taken as an indication of the degree of cycling in those two places rather than necessarily as a sign of abnormally bad conditions for cyclists.

In summary, specific conclusions were as follows.

ROAD HIERARCHY

A road hierarchy will usually be defined principally for traffic management and geometric design reasons. In themselves the various hierarchical labels mean nothing; they become important when they are the basis for subsequent actions. In safety terms, the concept of road hierarchy will probably be counterproductive if it is used to promote the conventional mixed-function concept of road types. Safety would be positively enhanced if the hierarchical definitions are used to minimise conflicts between the various functions which roads have to serve. While elements of the principles relating to road hierarchy are widely evident, the concepts are probably fully practicable only in a totally controlled urban system. Only Canberra approaches this situation.

INTERSECTIONS ON MAJOR (TRAFFIC) ROUTES

Principles governing outlets to higher-order roads are already widely established, although not necessarily logically based on safety or any other criteria. Empirical evidence for any effect which intersection spacing may have is limited to one known source, and may warrant amplification. The familiar preference for T-junctions along traffic routes is probably valid but may be ineffective over a wide range of common approach volume combinations. Some of the evidence suggests that cross-roads may even be preferred under some conditions (at the lower end of minor road volume). This at least indicates that there may be occasions when other planning requirements need not be compromised in order to avoid creating a major/minor road cross intersection. Control over both the spacing and form of intersections is practicable without excessive planning powers, although there appears to be a need to exert such control along secondary and sub-arterials as well as primary arterials

TRAFFIC GENERATORS

Criteria for the location of major traffic generators (attractors) on safety grounds are not well established. If such criteria could be defined, they could complement the present controls on the location of major land uses.

ACCESS RESTRAINT

The acceptable type and degree of access to a particular road is a consequence of the road's place in the hierarchy. There are strong indications that access characteristics influence safety on all traffic routes (including secondary and sub-arterials), which need to be explored. Access planning, involving the limitation of frontage access rights, raises legal, equity and cost questions which need to be resolved.

TABLE 17

SUMMARY OF FINDINGS AND CONCLUSIONS: ASPECTS OF NETWORK PLANNING

	Road Hierarchy — Design Principles: Connections Between Levels	Intersections on Major Routes — Limits to Frequency (spacing)
Basis	Based largely on planning and traffic engineering concepts.	Based largely on expenience. Recent South Altrican empirical work tends to provide support.
Adoption as a safety objective	Commonly-held general principle, especially in relation to design standards, but rarely explicitly for safety.	Found in codes and guidelines. Salety motive often implicit.
Reported oversees applications	Number of cases actually conforming to models is likely to be small.	Few specific reports, but probably many examples.
Reported Australian applications	Many planning and design codes. Implied in a small number of known planning and traffic management studies (e.g. Albury/Wodongs, A.C.T., Netbourne's Hierarchy of Roads Study).	Many areas conform to desirable minimum spacings, but even in newer areas examples of infringement probably predominate.
Reported effectiveness as a safety measure	No information.	Some supporting data on existing routes.
Practicality	Probably fully practicable only in a totally controlled urban environment.	Possible within present development control procedures.
Assessment as a safety measure	Important as a basis for subsequent decisions, but probably counterproductive if the convertional mixed-function concept of road types is promoted.	Probable effectiveness and ease of implementation make this measure worth examining.
	Avoidance of Uncontrolled Cross- Intersections on Major Routes	Restraint of Access to Arterials and Other Primary Routes
3asis	Planning 'common sense' supported by (sometimes popular misconception of) the few available studies.	The known salety benefits of fully-access- controlled roads, and a little data on accidents as a function of access density.
doption as a safety objective	Common.	Implied in design codes for major roads, but rarely with regard to safety of abutting activities.
Reported oversees applications	Widespread	Common to varying degrees, but very little published information. Many arterial/subarterial and most distributor frontages are not controlled.
Reported Australian applications	Virtually universal. Parely documented.	As above. Most consistent examples in A.C.T. Many service road trontages elsewhere. Other techniques seen in (e.g.) Melbourne and Perth.
Reported effectiveness as a safety reasure	Evidence mixed. Results seem to depend on combinations of approach and turning volumes.	No reports known.
Insclicality	Practicable and accepted.	Legal, cost and equity questions need resolving. Available precedents suggest that application could be wider. Existing frontages are a problem.
Assessment as a safety measure	Probably generally valid, but may be ineffective or even counter productive under some combinations of approach volume.	Almost certainly beneficial for safety, traffic service and amenity reasons. Cost- effectiveness needs verifying.
	Control Over the Location of Traffic- Generating Development	Segregated Cycle/Pedestrian Networks
Danis	Insuitive. No specific history or studies known.	Accepted as good planning practice. Very little substantive information on effects and benefits.
Adoption as a salety objective	Implicit in some policies but not widely accepted as a safety measure. Stated as a principle in N.S.W. guidelines.	Generally accepted principle. Safety commonly explicitly stated to support projects.
Reported overseas applications	Widespread, for traffic service reasons.	Individual projects widespreed but networks less common, U.K. New Towns, Sweden, The Netherlands, Japan and elsewhere.
Reported Australian applications	As above. Safety as a consequence of increased traffic is a common ground for planning decisions and appeals.	Only Canberra has a substantial network which is largely segregated. Semi-protected networks are evolving elsewhere (Melbourne, Geelong, Adelaide, etc.)
Reported effectiveness as a salety measure	None known.	Some reports of accident reduction overseas, but not attributable to any particular sepect of the network on available data.
Practicality	Practicable — a feature of current practice but not specifically for safety reasons.	Costly, Difficult to achieve in existing urban areas. Not all cycle/pedestrian facilities are acceptable to the intended users.
Assessment as a safety measure	Effectiveness uncertain. Data required. Site access probably most important.	Effective, but the principal source of benefit needs to be identified. Cost effectiveness needs examination. Increase in cycle usage may lead to overall increase in cycle usage.

SEGREGATED CYCLE/PEDESTRIAN NETWORKS

Although a cyclist or pedestrian is undoubtedly safer on a fully-segregated path than on a conventional road, it does not follow that the expenditure required is justifiable on safety grounds. The most cost-effective aspects of pedestrian and cycle provisions need to be identified to see if less costly programmes would achieve the same safety benefits. The dilemma presented by cycle planning is that it may generate greater cycle usage. Whether or not protected facilities can be provided fast enough and comprehensively enough to satisfy this growth, there would still be an increase in cycling on the normal road system. If reduction of cycle casualties was the aim, then this would cause some concern. However, an increase in cycling clearly has benefits both to the cyclist and the community against which any increase in casualties must be set. This also acts as a reminder that merely providing cycle or pedestrian facilities which are safer for the users is not enough if the user must surrender time, speed or convenience in order to use it.

PLANNED NEW COMMUNITIES

There are numerous examples of totally planned and managed urban areas around the world. Some of these at least embody planning principles which are expected to produce improved safety, especially in relation to the road hierarchy (corresponding to some sort of definition of protected localities) and provisions for non-vehicular movement. The available data, however, do not permit unequivocal statements to be made about the degree of 'proof' which planned towns provide for these principles, for two reasons:

- (a) the data do not consistently demonstrate a better level of road safety in planned towns than eisewhere; and
- (b) if and where they do suggest a better-thanaverage safety record, the elements in the whole package of planning principles to which this may be attributed are not clearly identifiable.

Finally, the impracticality of accommodating more than a very small proportion of national urban growth in totally planned communities suggests that their safety gains, if any, would not be significant in national terms. This, however, does not invalidate attempts to create safer conditions for residents of specific planned towns.

PLANNING IN CENTRES

Table 1 outlined the topics under this heading and actions which arise from them. Although actions are widely reflected in practice, the principles discussed under this heading are rarely as formally specified as in the Australian Guidelines. For the purposes of this summary, activity centre planning measures will be grouped into:

- (a) Avoidance of ribbon development : re-shaping of centres and construction of new centres away from main road frontages.
- (b) 'Car-free' centres : new centres with peripheral parking.
- (c) Pedestrian streets and areas : conversion of existing centres.
- (d) Provision for special vehicles : transit malls, and other special provisions for public transport and goods vehicles.

The study findings in these four areas are summarised in *Table 18.* The overall impression is that present design and planning practices in activity centres are based on a general concept of 'good design practice'. Very little is actually known about the way in which centres function, in a movement sense. In Australia, new substantial activity centres would rarely be located astride through traffic routes, although the tendency towards 'off-street' centre development can create two or more foci in the one area which may generate movement between them, thus increasing exposure to accidents. The areawide safety effects of modern centre development are rarely mentioned, reflecting a general paucity of information on traffic impacts as a whole.

There are over 20 significant examples of pedestrian malls in existing Australian centres. No specific comments on the safety benefits of these schemes have been encountered in the review. In fact, although costs in excess of \$1m are not uncommon, there has been very little recorded justification of the schemes on *any* grounds.

On safety grounds alone, ignoring all the other far more influential factors in a pedestrian mall proposal, the closure of a shopping street to through traffic can rarely be shown to be cost effective. Not only are costs typically high, the numbers of accidents in the streets concerned are typically small. The potential gain is therefore not great, and it is difficult to establish statistical significance for any changes. This, of course, is not a negative finding. Conversion of a strip centre may not be a significant safety measure, but it would be reassuring to know that when a mall is introduced for whatever other reasons, the displaced traffic does not necessarily create safety problems elsewhere.

Furthermore, pedestrian 'security' is not necessarily measurable (or at least adequately reflected) by small-magnitude numbers of pedestrian casualties in centres. Conversion of a street to a mall potentially does more than reduce pedestrian casualties in the street — it could be expected to reduce the level of what could be called 'pedestrian/vehicle tension'.

On the other hand, many newer off-street centres provide very badly for pedestrians once they leave the vehicle-free shopping area. The ad hoc nature of the design of the private traffic areas surrounding these newer centres, and lack of clarity in the application of traffic law there, also are causes for concern.

SUMMARY OF FINDINGS AND CONCLUSIONS: ASPECTS OF CENTRE PLANNING

	Avoidance of Ribbon Development (New and Modified Centres)	New 'Car-free' Centres
Basis	Intuitive good practice, found to produce more pleasant centres, and supported by sparse data on accidents as a function of frontage development.	Retail planning concept
Adoption as a safety objective	Not known, but probably widely used. Specified in Australian guidelines.	Probably implied in most new proposals, but not reported.
Reported overseas applications	Probably many, but not documented.	Many
Reported Australian applications	Many new non-ribbon centres. Examples of modified centres (back-zoning) not known.	Many
Reported effectiveness as a safety measure	None known.	Not widely documented. Some evidence of benefit, but needs substantiation.
Practicality	Not regarded as widely applicable for existing centres (where bypassing is generally more feasible). Can be a practicable constraint on new centres or expansion of existing centres.	Slowing of retail growth may retard this kind of centre in some places. Otherwise common practice, although some of the desirable site design guidelines may be unattractive to developers.
Assessment as a safety measure	A nett decrease would be expected, although the potential benefit is relatively small and lew existing centres could be modified.	Apart from the car parks and circulatory roads, conditions for pedestrians are generally better Site layout guidelines are needed.
	Pedestrian Streets and Areas	Provisions for Special Vehicles
Basis	Improvement of pedestrian conditions by vehicle segregation and/or restraint	Orderly access and circulation
Adoption as a safety objective	Safety not a dominant motive.	Not known.

Reported overseas applications	Many.	Apart from numerous transit mails, provisions to goods and public transport vehicles tend to be site-specific and unreported.
Reported Australian applications	Many, but tend to be city centre rather than suburban.	Transit malls rare. Other provisions vary widely but are undocumented.
Reported effectiveness as a safety measure	Surprisingly lew reports. Benefits hard to demonstrate. Area-wide schemes particularly tend to show significant accident reductions.	European reports on transit reports on transit mails are encouraging. No known reports of effects of other provisions.
Practicality	Present examples demonstrate practicality and potential wider applicatioon. Costly.	Depends on site. Usually possible to make provision in design alternatives.
Assessment as a safety measure	Improved perceived safety and reduced 'stress' support other reasons for implementation, but not expected to be cost-effective for safety reasons alone. Displaced traffic could cause safety problems elsewhere if care is not taken.	Probably not a significant safety factor. Transit and other vehicular use of pedestrian streets increases risk but probably not significantly.

The high cost of new centres, or the conversion of existing centres, could not be justified on safety grounds alone. Increased safety would almost always be regarded as a supplementary benefit of actions taken for retailing, civic or other reasons.

PLANNING IN LOCAL AREAS

PRINCIPLES AND GUIDELINES

This discussion has noted that accidents on non-arterial streets comprise a substantial minority of urban road accidents. These accidents tend not to be concentrated at black spots; rather, they are systemwide and appear to relate more to random events arising from the usage of the street system than directly to the physical nature of a particular site. Those roads serving to distribute traffic in the locality, as well as acting as access streets to abutting dwellings, appear to experience accident frequencies greater than would be explained by traffic volumes alone. Their accident rate per unit traffic volume in fact seems to be higher than that for other road types above or below them in the hierarchy. However, the data are limited and somewhat contradictory, and more information on the locations and conditions of local street accidents is required.

Local street casualty accidents characteristically involve a higher proportion of non-vehicle occupants — especially children — than elsewhere on the road system. Local planning strategies for road safety must therefore consider the special problems of vulnerable road users as well as the needs of vehicle occupants. The strategies can be divided into four main groups:

- (a) Minimising of conflicts within the traffic stream by detering non-local (through) traffic.
- (b) Minimising of conflicts within the traffic stream by attending to the nature of the local network, including the form of traffic distribution and the nature of the intersections.
- (c) Reduction of conflicts between vehicles and other road users by segregating their networks.
- (d) Modifying driver behaviour so that vehicular movement in the street is compatible with other users of the street space (i.e. to create an 'environment of care').

The common guidelines and current 'good local planning practice' mostly evolved from planning thought dating back more than 50 years: the definition of identifiable areal units, concepts of local networks and street functions, and segregated movement networks. The guidelines specifically relate to network planning and street function, planning aspects of road design, intersections, local pedestrian and cycle systems, and the management or modification of streets in existing local areas. The links between these kinds of actions and the four strategies listed earlier are suggested by *Table 19*.

APPLICATIONS AND RESULTS

There is a large body of literature on the application of the above kinds of measures. The overall impression gained from these sources is that the consequences are rarely documented. The multitude of possible combinations of planning actions makes comparisons between cases difficult, but the following conclusions have been reached and are summarised in *Table 20*.

Areal Units and Location of Key Land Uses

The deliberate definition of some form of areal unit is common practice, usually in relation to the road network whose more important elements are used to define the boundaries of the local areas. In Australia, Elizabeth (S.A.) and Canberra contain examples in the classic mould, and there are numerous public and private housing area examples. Doubts about some aspects of the classic neighbourhood concept (the catchment and identification aspects in particular) do not negate the validity of the idea of the neighbourhood as an area insulated from through traffic.

Within defined local areas, homogenous land uses are the norm. A return to mixed employment/housing areas has apparently not been encouraged, at least in Australia, so the possible travel and traffic effects remain untested. There are different models by which local centres and facilities are distributed (e.g. within neighbourhoods, on the edges, or arranged along spines). Again, no data are available on travel and traffic effects. Observed accident characteristics of different types of local area have been attributed to the form of the local networks rather than to other aspects of local planning.

Local Street Networks

It is common practice to adopt some form of internal road hierarchy, but little attention is paid to the system aspects of the local network. Different concepts of traffic distribution could be formalised and consciously applied, but rarely are. Quantitative or other attempts to consider street connectivity in network design are rare, and have not been discussed in the context of improved safety.

Role in the hierarchy commonly defines a street's design standards, which are often specified in codes adopted by the local authority. The concept of the street space as a physical, social and emotional part of the house and its surrounds is critical, both to the physical design of the neighbourhood and to the design and operating philosophy of the local street system. This suggests an alternative approach to street design to that based on traffic needs, but there are few examples in practice. A consideration of the various needs and functions of streets encourages attempts to define less rigid street design standards. Although attitudes are changing, there is still strong technical resistance to changing present standards, and practical examples of street designs likely to make new impacts on safety are still relatively rare.

TABLE 19	9
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LINKS BETWEEN ACTIONS AND STRATEGIES

Actions	Strategy			
	Separate Local From Non/Local Traffic	Clarify Network; Simplify Vehicle/Vehicle Conflicts	Segregate: Minimise Vehicle/ Non-Vehicle Conflicts	Create Environment of Care
NEIGHBOURHOOD PLANNING	•		•	•
Connectivity/continuity	•	•		•
Hierarchy/functions	•	-	•	•
Geometry, parking		•		
Form of distribution Intersections		•		•
PEDESTRIAN/CYCLE SYSTEM Including Radburn			•	
STREET/TRAFFIC MANAGEMENT	•	•	•	+

TABLE 20 SUMMARY OF FINDINGS AND CONCLUSIONS: ASPECTS OF LOCAL PLANNING

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	Neighbourhood — Definition, Location and Type of Land Use	Networks: (a) Functional Street Hierarchy. Street Uses, Design	
Basis	'Traditional' practice. Principles debated.	Conventional view, perhaps derived from traffic engineering, Debated.	
Adoption as a safety objective	Implied. More explicit in the context of precincts' for LATM.	Common. Stated in Australian Guidelines.	
Reported overseas applications	Many varieties and cases	Nidespread practice, not specifically related to safety.	
Reported Australian applications	As above.	As above.	
Reported effectiveness as a safety measure	No known reports.	No known reports.	
Practicality	Attempted definition of neighbourhood is Required changes in designer and common practice but is usually dependent on attitudes may inhibit adoption of s conditions external to the development.		
Assessment as a safety measure	Probably valid to continue present practice. Size of locality appears to be important and relates to network aspects. Smaller units desirable.	Safety is enhanced if conflicts between functions are reduced, rather than increased (as conventional practice implicitly accepts).	
	Networks: (b) Characteristics (Connectivity, etc.; Form of Distribution)	Networks: (c) Local Intersections	
Basis	Not currently formalised. Some intuitive reliance on traffic diversion concepts.	Past investigations taken to support preference for T over cross intersections.	
Adoption as a safety objective	Only in terms of eliminating through traffic by evolding direct routes.	Common.	
Reported overseas applications	Only in general, non-quantitative terms.	Common.	
Reported Australian applications	As above.	Virtually universal.	
Reported effectiveness as a safety measure	Not specifically reported.	Very little recent data of substance. Some doubt has been cast on need for total ban of cross intersections under all conditions.	
Practicality	Considerable scope within present practice. Requires changes in skills, more information.	Retention of present practice presents few costs or difficulties. Could be relaxed in specific cases, without difficulty.	
Assessment as a safety measure	Possibly highly effective. Network characteristics appear to be vital and need investigation.	Widespread use of T junctions in local areas probably a major local safety factor. Practice should remain, but roundabouts at cross intersections of important local roads may be preferred to staggered T movements.	
	Provision of Segregated Local Pedestrian/Cycle Paths	Modification to Existing Local Networks — LATM and Street Management	
Basis	Based on the assumption that segregation avoids conflict.	General intent is to create conditions similar to those enjoyed in newer areas.	
Adoption as a safety objective	Security and amenity are usual motives of segregated design.	Salety a common but not universal objective overseas. Less commonly stated in Australia. Amenity predominates.	
Reported overseas applications	Many small examples. Extensive schemes less common. Sweden, U.K. New Towns.	Many.	
Reported Australian applications	As above. Canberra, private and public developments elsewhere.	Many, especially involving individual devices or streets. Area-wide schemes less common, but increasing.	
Reported effectiveness as a safety measure	Not consistently reported. Benefits are suggested from available data, but effects on other planning criteria may be more important.	Accident benefits of area-wide schemes, and behavioural effects of some devices, seem to be consistently demonstrated.	
Practicality	Physically practical, if costs not a problem. Difficult in existing areas.	Political issue. Perceived benefits not always seem to exceed perceived costs. Safety benefits tend to be too vaguely understood.	
Assessment as a safety measure	Costs have been queried commercially, and cost-effectiveness on safety grounds is also doubtful.	Modification of driver behaviour clearly understood, network effects less so. Both aspects have potential benefits.	

With respect to local intersections, the avoidance of cross-roads is already conventional practice. However, a rigid ban on cross-roads may be excessive; the safety gains are dubious under some combinations of volumes.

Overall, the nature of the local network does seem to contribute to accident rates. This has been inferred from data on housing areas from different eras, but so far the relevance of each of the possible contributing factors has not been able to be clearly identified. Action aimed at the local distributor (either its elimination from the network, or alternatively tight management of its frontages) appears to be potentially beneficial. A road hierarchy will usually be defined principally for traffic management and geometric design reasons. Safety will be positively enhanced if the hierarchical definitions are used to minimise conflicts between the various functions which roads have to serve.

Local Pedestrian and Cycle systems

There are many existing examples of a wide range of segregated pathway types, but few examples of true Radburn-style development. Consequently, the pathway systems often tend to be superficial additions to areas served by conventional street systems, rather than continuous separate networks around which the area is structured. There are no reports of the safety characteristics of localities as a result of pathway provision. Doubt is cast on the cost-effectiveness of Radburn-type layouts.

Local Area Traffic Management (LATM) and Street Modifications

The literature on LATM is formidable. Information has been selected on treatments in Holland, Germany. Denmark and the U.S. to illustrate the types and extent of schemes. In Australia there is extensive, and growing, experience with LATM devices, but application of an area-wide approach (both to problem analysis and to installation) is far less common. The current Victorian procedures illustrate an appropriate level of guidance and control, which leaves room for considerable local initiative. The effectiveness of some individual treatments (e.g. roundabouts, road humps and slow-points), with respect either to accidents or speeds, has been demonstrated. Data on the area effects of LATM from various sources verify that significant accident reductions may be expected without commensurate increases in casualties on the boundary roads.

Conclusion

On the basis of this discussion, it can be concluded that there is at least superficial evidence that planning directed at one of the five areas (neighbourhood planning, local networks, non-vehicle routes, street modifications and local area traffic management) can produce safety benefits. Cause-and-effect relationships cannot yet be assumed and the critical behavioural factors have not yet been positively identified. Nevertheless, there is a general consensus that designs and modifications aimed at reducing speeds are a legitimate and effective means of adapting driver behaviour, thus contributing to an environment of care in which the rights and needs of other street users are respected. This requires more than isolated devices; innovative design and comprehensive changes are predicated, both to existing streets and to present network layout concepts.

SOME IMPLICATIONS FOR PRACTITIONERS

Out of the foregoing material, a number of practical suggestions and cautions emerges which are summarised below.

GENERAL PLANNING

- Convincing evidence of the safety benefits of planned communities is difficult to find. Planners should not complacently accept current practices.
- Reliance on urban organisation to reduce trip lengths and/or car usage is not an effective safety strategy, particularly in the short term.
- The organisation of urban activities to reduce movement conflicts and confusion is probably feasible, especially at the district and local levels. However, there are no rules by which this can be done;.
- The safety impacts of proposed land uses need to be considered, including the pattern of traffic distribution in the area which results.

ROAD NETWORKS

- The adoption of a hierarchical road system may not be conducive to greater safety. What is important is how the hierarchy is defined and what then follows.
- Safety will be enhanced if a hierarchical distinction is drawn between traffic routes (arterials and distributors) and the local network. Conventional practice does this in two ways:
- reduction of conflicts and interruptions in arterial traffic flow, for example by defining priorities at minor/major intersections; and
- (b) exclusion of non-local traffic from neighbourhood streets.
- However, commonly-adopted definitions of road function are based on questionable concepts, are difficult to apply consistently in practice, and tend to perpetuate some of the problems experienced in older networks. In particular, modern subdivision requirements often encourage the creation of residential roads on which traffic speeds and volumes are high. Inside residential localities, such roads should be avoided. Traffic distributors on the edges of localities should have minimal direct frontages.
- The following steps have been suggested for identifying road classes in existing urban networks:
- The first and most important step is to agree on which roads are not, under any circumstances, to be regarded as being available for 'through' traffic.
- (b) Those arterials or distributors whose character is, or will be, local but which also serve important network functions (i.e. the 'limited arterials') are identified.

- (c) A basis for selecting those streets within localities which are to provide links between arterials/distributors must be devised. These are the 'collectors', or perhaps better described as 'connectors' in most existing urban areas.
- The number of 'special cases' should be kept to a minimum, perhaps by superimposing an 'amenity' or local needs scale on the 'network function' scale.
- In both new area design and in managing older networks, the length of street on which higher traffic volumes and speeds are combined with conventional frontages should be minimised.
- The benefits and techniques of access management on traffic routes are sufficiently well demonstrated to support their use. However, the costs and effort are sometimes hard to justify.
- Data support a wider spacing of intersections along arterials, and therefore the practice of fewer combined outlets from residential ares. However, the effects on the road system within the localities also need to be considered; it is likely that some forms of internal road system feeding fewer outlets could involve higher accident risk.
- Careful thought should be given to intersection type. T-junctions are not always clearly a better choice than cross-roads. Staggered T-junctions have their own sorts of problems, and the evidence does not support closely staggered T-junctions. A cross-intersection is clearly preferred if signalisation is likely. In residential networks a designed roundabout in a cross-intersection is preferable to the more usual practice of staggering local distributor T-junctions.

RESIDENTIAL AREAS

- Safety should be considered when the residential area is being planned. Strict control over street geometry and prohibition of cross-intersections will not overcome safety problems which are inherent in the network itself.
- Residential areas should not be so large that local roads have to carry high volumes of traffic. In large development units (i.e. areas not broken into smaller units by defined arterials and sub-arterials), it is harder to keep out unwanted non-local traffic, to distribute traffic locally without creating the troublesome mixed-function local distributor, and to keep all neighbourhood roads 'local' in character.
- This implies that a traffic generation analysis should be carried out on all new residential estate proposals. As a rule of thumb, a square kilometre of conventional residential development could generate of the order of 10000 vehicle movements each day. The problems that could arise should this volume be concentrated on a handful of local roads are apparent. Given reasonably uniform traffic distribution and wide desirable spacing of local road outlets onto traffic routes, a desirable development unit of not much more than 1 km² is indicated. Areas larger than this will, by implication, require the insertion of recognised higher-order (lower access) roads.

LOCAL STREETS

- Non-local traffic is minimised by making local street routes discontinuous or indirect, i.e. with low connectivity. There are no reliable analytical rules by which this can be done, but awareness of the criterion during design and adequate information on traffic demands will usually be sufficient.
- Excessive speeds in residential areas should be discouraged by avoiding long streets and overgenerous geometrical designs.
- Wide, long, local distributors with conventional house frontages should be avoided in residential areas. They typically have poor safety records.
- If such local distributors are unavoidable, it is desirable to emphasise their traffic function by 'frontage management'. This involves orienting dwellings to side (or rear) streets as much as possible, locating non-residential and space-consuming uses on these local distributors, requiring greater lot widths and house set-backs, and providing wider verges without excessive roadway width.
- The number of residential allotments fronting onto streets with very low connectivity (culs-de-sac and tight loops) should be maximised.
- Sight distance provisions should be analysed in each case rather than applying standard design rules, which often create unnecessarily restrictive requirements.

LOCAL STREET MANAGEMENT

- Physical redesign of existing streets can play an influential role in increasing safety and amenity. Those proposing changes to local street systems should be aware of the potential safety benefits and should draw attention to them when seeking community support for the schemes. The improvement of safety should be a primary, not incidental, goal of such schemes.
- An agreed road classification must first be established, so that each road's acceptable function and the nature of traffic control over it can be specified.
- Street closures, and other forms of network change, are a necessary but not sufficient tool of local street management. The range of measures aimed at modifying driver behaviour is important in achieving an environment of care for pedestrians and cyclists without making substantial changes to local networks.
- It is advisable to act in advance of traffic problems, if possible.

CYCLISTS AND PEDESTRIANS

 Cycle and pedestrian planning should focus firstly on general improvements to their security on the road system, employing appropriate traffic engineering, traffic management and construction and maintenance techniques. Support for segregated cycle and pedestrian facilities is often based on exaggerated perceptions of their benefits.

- At the local level, cyclists and pedestrians would benefit from those local street management schemes which create an 'environment of care'.
- Segregated paths, whatever other advantages and attractions they may have, will rarely prove to be cost effective on safety grounds alone. Preference should be given to route sections bypassing a number of conflict points which otherwise would need traffic engineering or other treatments. Amenity and convenience (e.g. short lengths of path penetrating barriers such as railways or creeks) will common route choice motivations. Ease of location and construction, in the absence of any of these other factors, is a poor reason for bicycle/pedestrian expenditure and would guickly be recognised as tokenism. Routes focussing on schools are obvious first choices. In many smaller urban areas, sealing road shoulders and clearly designating them for cycle use is probably more cost effective than constructing a short length of segregated bike track.
- Radburn types of subdivision layout contain elements conducive to road safety, but so may the

best of conventional layouts. The extra costs of Radburn treatment, which are sometimes substantial, would have to be justified on grounds other than safety.

- If the potential safety benefits of a segregated network are to be fully realised, pedestrian-generating activities should not be located on busy road frontages.

CENTRES

- Safety benefits may be obtained in activity centres by diverting non-foot and vehicular centre traffic away from the areas used by foot and vehicular centre traffic.
- Full mails will rarely be justifiable on safety grounds alone, but reduction of total traffic 'stress' is often a significant gain.
- Various scales of 'off-street' centre can create generally better safety conditions for shoppers. However, conflicts and 'stress' in the car parks and traffic circulation areas need careful attention.