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A History of Traffic Engineering in Australia (1989 - 2015)

Dr Robin Underwood

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The Report is an update of ARRB Special Report No. 42 and covers the period 1989 – 2015. It sets out an up-date of the history of traffic engineering in Australia since 1988. It covers responsibility and organisation for traffic engineering at the National, State and Territory and Local Government levels, the roles of other key National Organisations, Professional Associations, Universities, and Automobile Associations, and provides up-to-date information on road safety, traffic management and the development of intelligent transport systems. It concludes with an overview/reflections on the development of traffic engineering in Australia and a brief look at the future.

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Robin T. Underwood began work in traffic engineering with the then Country Roads Board under H.P. George in 1953, when traffic engineering in Australia was in its infancy. He has spent a lifetime in road and traffic engineering, including road safety, firstly 35 years with the Country Roads Board/ Road Construction Authority (now VicRoads) and then 10 years in academia at Caulfield Institute of Technology/Monash University.

He studied traffic engineering at the Bureau of Highway Traffic, Yale University in 1959-60 as a Sidney Myer Highway Traffic Scholar. His Yale thesis on Speed, Volume and Density Relationships was one of five contributions included in a Yale University Symposium on the Quality and Theory of Traffic Flow in 1961. In 1965 he graduated with the Degree of Master of Engineering in the University of Melbourne for a thesis on Road Traffic Behaviour Studies. In 1971 he undertook a five months study tour of the USA, Canada, Great Britain and Europe as a Winston Churchill Memorial Trust Fellow. In 1987 he was awarded the John Shaw Award by the Australian Road Federation for “a meritorious contribution to roads” and in 1989 was awarded the Webb Prize by the Institution of Civil Engineers (UK) for a paper on The Hume (Melbourne to Sydney) Freeway in the State of Victoria, Australia.

In 1991 he was admitted to the Degree of Doctor of Engineering in the University of Melbourne for a collection of published and unpublished writings submitted in a thesis on Road Planning, Design and Operations. He is a Life Fellow of the Institute of Transportation Engineers, a Fellow of the Institution of Engineers, Australia and a Fellow of the Planning Institute of Australia.

He has served on both national and international committees dealing with road and traffic engineering, including road safety, and has written extensively on these topics, including books on Traffic Management – An Introduction, The Geometric Design of Roads, Road Engineering Practice and Road Safety – Strategies and Solutions.

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SUMMARY

Following on from ARRB Special Report No. 42, this current Report sets out an update of the history of traffic engineering in Australia since 1988. As background to this report, a brief summary of the position in Australia up to 1988 is given in Chapter 2.

In Australia, responsibility for traffic engineering and related activities is shared by the Commonwealth, States and Territories and Local Governments. Chapter 3 summarises these responsibilities and describes the changes in organisation at the three levels of government since 1988.

Chapter 4 summarises the important role and some of the relevant activities, of key National organisations, namely NAASRA/Austroads, the Australian Road Research Board and the Standards Association of Australia since 1988.

Chapter 5 outlines the traffic engineering related role and significant activities, of selected professional organisations including the Institution of Engineers, Australia, the Australian Section (and since 1996 the Australia and New Zealand Section) of the Institute of Transportation Engineers, the Australian College of Road Safety (which in 2003 expanded its membership to include new Zealand and changed its name to the Australasian College of Road Safety), and the Australian Institute of Traffic Planning and Management.

Over the years, many Australian Universities have made significant contributions to the theory, practice and application of traffic engineering by teaching, research, consultancy, professional society, and community activities. Chapter 6 summarises the contributions of six selected Universities to indicate the wide variety of their contributions. Their selection should not be taken as in any way diminishing the contributions of other Universities.

The roles of the Australian Automobile Association and of the various State and Territory Associations are outlined in Chapter 7.

Chapter 8 summarises various aspects of road safety including an overview of road safety, National, State, Territory and Local Government strategies, road safety audits, the Decade of Action for Road Safety 2011 – 2020, the Australasian New Car Assessment Program (ANCAP), the Australian Road Assessment Program (AusRAP) and an overview of Road Safety Management.

Since 1988 traffic management principles and practices have continued to evolve. Chapter 9 outlines developments relating to traffic management centres, speed management, road rail level crossings, local area traffic management and safety provision for heavy vehicles.

Chapter 10 discusses intelligent transport systems, including background, traveller information systems, smart roads, managed freeways (motorways), improved safety at road rail level crossings and the introduction of automated vehicles.

The Report concludes with Chapter 11 providing an overview/reflections on the development of traffic engineering in Australia since the inception of the motor car in about 1900, and a brief look at the future.

1 INTRODUCTION

Traffic engineering is the measurement and study of both stationary and moving traffic, the determination of its characteristics, and the application of the knowledge so gained to provide for the safe, orderly and efficient movement of persons and goods, and to protect and, where possible, enhance the quality of the local environment on and adjacent to traffic facilities. It is concerned with the interrelationships between all components of the road, the characteristics and performance of all vehicles, the behaviour, characteristics, performance and realistic expectations of all road users (including bicyclists and pedestrians), and speed management.

Motor cars first appeared on Australian roads in about 1900, and road laws as they are known today began to evolve soon after. The first State Road Authority was formed in 1913, and by the end of the 1920s all other States had followed suit. In general, the state authorities assumed responsibility for primary (or arterial) roads, while responsibility for local roads remained with local government. For some years, traffic control was largely a police matter.

By the mid to late 1930s the principles of traffic engineering, including the need to consider the road, the vehicle and the driver as an integrated system, were being promoted (Sherrard 1936, 1938), but the term 'traffic engineering' was not yet being used in Australia.

Immediately after the Second World War, there was a long period of significant population growth, including immigration, large-scale development, and a substantial increase in motor vehicle ownership and use. Several technical papers appeared, and they all emphasised the need to collect, analyse and understand traffic data as an essential base for road planning, design and operation. In 1947, the first engineering position in Australia containing the word 'traffic' was created.

During the 1950s traffic engineering grew rapidly in Australia, and by the end of the decade it was firmly established and recognised throughout the nation. During the 1960s, the 1970s and the 1980s there were significant developments in the theory and practice of traffic engineering and it became widely practised throughout the nation. The Australian Road Research Board's Special Report No. 42 (Underwood, 1989) reviewed the history of traffic engineering in Australia up to 1988. Papers by McLean (1988) and Rahmann (1988) are also directly relevant to the history of traffic engineering up to 1988. A brief summary of the material in Special Report No. 42 is included in Section 2 of this report as background to the history since 1988.

The current report provides an update of the history of traffic engineering in Australia since 1988. It describes responsibility and organisation for traffic engineering at the national, state and territory and local government levels, the roles of other national organisations, professional associations, universities, and automobile associations, and provides up-to-date information on road safety, traffic management and the development of intelligent transport systems. It concludes with an overview/reflections on the development of traffic engineering in Australia and a brief look at the future.

2 BACKGROUND

2.1 The Period Before 1950

Traffic engineering as a recognised separate branch of civil engineering had its beginnings in the United States of America in the early 1920s. In 1924, the cities of Pittsburgh and Seattle, and the Ohio State Highways Department, appointed ‘traffic engineers’. From then on traffic engineering grew rapidly in the USA, and in 1930 the Institute of Traffic Engineers was formed.

In the mid to late 1930s several papers on aspects of traffic engineering appeared in Australian literature, although the term traffic engineering was not being used. Sherrard (1936, 1938) wrote about the need to consider the road, the vehicle, the driver and traffic rules as an integrated system, and on the control of traffic, and its relationship with land use. Rodan (1939) wrote on the possible development of the science of traffic flow. Irvine (1939) reported on overseas developments in matters such as road accidents, design standards, guard fencing and signing. Toyer (1940) discussed on developments in centreline marking, lane lines, traffic signals, intersection design and parking meters.

Significant papers by Sherrard (1946), Darwin (1946, 1950), George (1946) and Spowart (1947) appeared soon after the end of the Second World War. They all emphasised the need to collect, analyse and understand traffic data and characteristics as a basis for road planning and management.

In 1947, the first engineering position in Australia containing the word ‘traffic’ was created when the Victorian Country Roads Board (now VicRoads) appointed HP George as Traffic and Location Engineer. He relinquished the position in 1949 (and it then lapsed), but returned to it in early 1953.

Incidentally, the first Australian to undertake graduate study in traffic engineering was AH Munro, who attended the Bureau of Street Traffic at Harvard University in the USA in 1932-33. On his return to Australia, he was appointed City Engineer to the then City of Footscray. The Bureau of Street Traffic commenced operation at Harvard University in 1923. It transferred to Yale University in 1938, where it became the Bureau of Highway Traffic.

2.1.1 Traffic Studies

Some traffic studies had been carried out in Australia for many years. For example, traffic counts were used in Victoria as early as 1913 as one of the factors to be considered when selecting main roads. As another example, in 1926 extensive traffic studies, including traffic counts, origin and destination studies, speed studies and traffic predictions, were carried out as part of the investigations for the Story Bridge in Brisbane.

Systematic manual traffic counting began in New South Wales and Victoria in about 1930, in South Australia in 1949, in Queensland in 1951, in Tasmania in 1967 and in Western Australia in the late 1960s.

2.1.2 Signing and Delineation

As early as 1927, consideration was being given to the standardisation of road signs in Australia. In that year, a bulletin *The Sign Posting of Main Roads* was published by the Main Roads Board of NSW (MRB 1927). That bulletin formed the basis of the first Standards Association of Australia (SAA) Road Signs Code (SAA 1935). The Code was revised and republished in 1946 (SAA1946). The marking of traffic lines commenced in New South Wales and Victoria in about 1930, and the practice progressively spread to all other states. In Australia, broken lines were first used on centrelines to economise on the use of paint in 1941.

Experiments with various types of signs and delineation devices began in Australia as early as the mid-1930s. By the 1950s, a wide variety of road signs and markings, guard fencing and other forms of delineation were being evaluated and implemented.

2.1.3 Traffic Signals

The first automatic traffic signal in Australia was installed at the intersection of Collins and Swanston Streets in Melbourne in 1928. In 1929 two further sets were installed in Melbourne. Sydney's first set of traffic signals was installed in 1933. Tram detector signals and vehicle actuated signals, using pneumatic detectors, were installed in Sydney in the late 1930s. Traffic signal co-ordination was first introduced along Swanston Street, Melbourne, in1944.

The first installations of traffic signals in other state capital cities were in 1936 in Brisbane, in Adelaide in 1937, in Hobart in 1947 and in Perth in 1953.

In 1940, the SAA endorsed the British standard specification for traffic signals, with amendments to suit Australian conditions, as an Australian standard.

2.1.4 Road Safety

Road safety had been of concern for some years. Sherrard (1936) discussed aspects of road safety in his paper. A symposium on road safety was held in Brisbane in 1938, with the main participants being a medically qualified oculist, an electrical engineer, a civil engineer and a statistician.

As a result of actions by the Australian Transport Advisory Council (ATAC) at its first meeting in 1949, an Australia-wide Road Safety Council was set up to consider road safety activities, and two sub-committees were established, one to consider methods of obtaining uniformity in road standards as they relate to transport policy, and one to propose a uniform traffic code.

2.1.5 Traffic Control and Regulation

Road traffic laws relating specifically to motor vehicles were first introduced in Australia in the early 1900s, although the 'keep to the left' rule had been instituted in New South Wales as early as 1820. As the need arose, acts and regulations relating to motor vehicle control, driver licensing and vehicle registration were progressively introduced by the various states. Initially, the police were responsible for the development of traffic rules and regulations and, except in New South Wales, this was the case until the 1950s.

In New South Wales, a Department of Road Transport and Tramways was established in 1930 with responsibility for the licensing and regulation of motor traffic and the formation of traffic rules and regulations. The first engineer appointed by the Department after the 1930 Act to work on what were predominantly traffic engineering functions (but not named as such) was WH Tush. W Peach was appointed in the late 1930s, and he continued in this role until the late 1960s.

2.2 The 1950s

It was during the 1950s that traffic engineering developed quickly, and became recognised as a separate branch of civil engineering throughout Australia.

2.2.1 The Role of the State Road Authorities

The State Road Authorities (SRAs) played a leading role in introducing and developing traffic engineering in Australia. HP George, who had held the position of Traffic and Location Engineer with the Country Roads Board (Victoria) from 1947 to 1949 was reappointed to it in early 1953, and in 1954 RE Johnston was appointed Traffic Services Engineer with the Department of Main Roads (NSW). These two men quickly established traffic engineering units, recruited and trained staff, and introduced the principles and practice of traffic engineering within their organisations. Much of the credit for the early development of traffic engineering in Australia must go to them, although it should be noted that they received strong support from the heads of their organisations, namely DV Darwin and HM Sherrard, who had the foresight to recognise the future importance of traffic engineering and to make appointments within their organisations. In 1955-56 both George and Johnston were sponsored by their organisations to attend the Bureau of Highway Traffic at Yale University in the USA.

The other SRAs made traffic engineering appointments soon after. In 1956, AK Johinke was appointed Traffic Engineer in the Highways Department (SA) and DJ Davies was appointed Traffic

Engineer in the Main Roads Department (WA). E Hogan and JA Watts had part-time responsibility for traffic engineering matters in the Main Roads Department (QLD) and the Department of Main Roads (TAS) respectively from about 1955. These two departments appointed full-time traffic engineers in 1963 (RD Chalk) and in 1970 (JB Lock).

The role of the SRAs in traffic engineering was encouraged by the Conference of State Road Authorities (later the National Association of State Road Authorities and now Austroads), which established a Traffic Engineering Standing Technical Committee in 1955.

2.2.2 The Role of Traffic Management Authorities

In 1952 the NSW Department of Road Transport and Tramways (which had been established in 1930) was abolished, and in the subsequent reorganisation that occurred the Department of Motor Transport, with responsibility for traffic management functions, was established. Early appointments to engineering positions in the Department were RA French and HL Camkin, who both played a significant role in traffic management for many years.

In Victoria, a Traffic Commission, headed by JD Thorpe and JG Westland, was established in 1956, with responsibility for various aspects of traffic control and regulation and road safety. DJ Delaney was appointed its first Chief Engineer in 1960.

In Queensland, a Traffic Commission was legislated for in 1958 although it did not begin operation until 1960, when K Leitch, who had been appointed Traffic Engineer in the Office of Commissioner of Police in 1958, was appointed Traffic Engineer and Executive Officer.

In Tasmania, the Transport Department established a Traffic Division, headed by GE Russell, in 1958. In South Australia, a Road Traffic Board, whose first Executive Engineer was PG Pak-Poy, was established in 1960. In Western Australia responsibility for all traffic management functions remained with the Main Roads Department.

Throughout the 1950s, the police department in each of the states continued to play a significant role in traffic operations and enforcement activities.

2.2.3 The Role of Municipal Councils

In 1954 the Melbourne City Council established a Traffic Division within the City Engineer’s Department, and JM Bayley was appointed to the position of Traffic Engineer. In the same year, Bayley was awarded an International Road Federation Fellowship to study at the Bureau of Highway Traffic at Yale University during the 1954-55 academic year. On his return, he made a major contribution to the acceptance and development of traffic engineering in Australia by widespread application of traffic engineering principles and practices in the Melbourne City Council area and by giving lectures and presenting papers both in Victoria and interstate.

Initiatives of the Melbourne City Council in the 1950s included the introduction of parking meters, the development of off–street parking facilities, introduction of right-turn from the centre of the road, introduction of off-centre lane operation (initially using traffic cones and later using overhead traffic signals), and the extensive use of paint for intersection control and lane marking (there were no lane lines in metropolitan Melbourne prior to 1954).

During the 1950s many municipal councils progressively became involved in traffic engineering activities but, as far as can be ascertained, the only other council to appoint a traffic engineer prior to the 1960s was the Adelaide City Council where G Currie was appointed in 1959.

2.2.4 Study in Traffic Engineering

In about 1954 the Myer Foundation recognised the importance of adequate training in the theory and practice of traffic engineering, and as there were no relevant courses of study in Australia, it decided to award a series of annual scholarships for study at the Yale Bureau of Highway Traffic. Six Australians were awarded scholarships under this scheme between 1955 and 1960.

The Department of Civil Engineering at the University of Melbourne conducted a one- week Summer School in Traffic Engineering in early 1955, the first course in traffic engineering in Australia, with attendees from all over Australia.

In 1955, a Chair of Traffic Engineering was created at the University of New South Wales with financial support from the Australian Automobile Association, and Professor WR Blunden was appointed to it in 1956. He held this position until he retired in 1981. Under Professor Blunden's leadership, the School maintained high standards in teaching and research, gained an international reputation and contributed significantly to the advancement of traffic engineering knowledge and practice.

In 1959 Professor RB Potts, Professor of Mathematics at the University of Adelaide received international recognition for work in traffic flow theory when he and his colleagues at the General Motors Research Laboratories in Michigan were jointly awarded the Lancaster Prize by the Operations Research Society of America for research into traffic flow theory (Gazis, Herman & Potts, 1959).

2.2.5 Other Significant Events

In the late 1950s, some of the automobile associations appointed traffic engineers. In 1957 the RAC (QLD) appointed JI Tindall, in 1958 the RAA (SA) appointed RE Theel, and in 1959 the NRMA (NSW) appointed EA Huxtable. The other states followed with appointments in the 1960s.

2.2.6 Technical Developments

The first automatic traffic counters were purchased by the DMR (NSW) and the CRB (Vic) in 1951-52, and by mid to late 1950s automatic traffic counters were used in all states. Systematic state-wide traffic counting, including the use of permanent traffic count stations at selected locations, was pursued during the 1950s. As a result of data collected at the permanent count stations, detailed information on hourly, daily and seasonal variations became available, and expansion factors, which enabled short-term counts to be expanded to annual average daily traffic volumes, were developed.

During the 1950s many basic traffic studies, such as traffic volume, origin and destination, speed, delay, accidents and parking, were carried out. Specialised traffic studies carried out during the decade included vehicle use, truck loadings and trip length in both rural and urban areas, vehicle operating costs, turning characteristics of trucks and buses, the application of statistical control techniques to traffic analysis, the performance of cars and trucks on grades, traffic behaviour and capacity studies, driver eye height studies and the economics of vehicle axle load limits. Underwood (1956) indicates that the following was by then well accepted:

It is fundamental that the planning, design, construction, maintenance and operation of road facilities be based on the behaviour of all road users and their realistic expectations, and on the performance and geometric characteristics of road vehicles, i.e. in the interests of road safety, road facilities should be fitted to road user and vehicle characteristics – and not the reverse.

Traffic engineering principles were applied to the design and operation of intersections, and channelization and traffic signal systems, including the more sophisticated phasing and vehicle actuated systems, were developed and increasingly applied. Road/railway level crossings received increasing attention, and many were given upgraded protection, including improved signing and marking and sometimes realignment of road approaches, installation of flashing lights or boom barriers and, in some cases, grade separation.

Detailed investigations of road signs, road marking (including beaded lines and road studs) and guard fencing were carried out. Traffic engineering principles were applied to assessing the need for, and evaluating aspects of, the location and design of pedestrian and school crossings (Underwood 1957).

Similarly, aspects of the design of urban divided roads, including the location and spacing of median openings, and the design of turn slots, were examined. The use of narrow medians in Sydney to provide divided road conditions on high volume arterial roads was of particular interest.

2.3 1960 to 1988

During the 1950s traffic engineering in Australia developed rapidly, and by 1960 it was firmly established and recognised as a separate branch of civil engineering throughout the nation. From l960 to 1988 traffic engineering principles and practice continued to evolve.

2.3.1 Traffic Behaviour and Road Capacity Studies

In the early 1960s Australians produced several significant papers dealing with aspects of traffic theory and behaviour, typical examples being Blunden (1962, 1967), Buckley (1968) and Pak-Poy (1962a, 1964).

Studies of the capacity of rural roads commenced in the 1950s (George 1955) and continued into the early 1960s (Underwood 1964). In the period 1967-1970, studies of overtaking behaviour were carried out under the guidance of AJ Miller, who had earlier carried out some theoretical analysis of platooning (bunching) in England. These studies led to a better understanding of bunching and overtaking behaviour on two-lane rural roads (Miller & Pretty 1968, Miller 1969).

In the late 1970s and early 1980s studies were focussed on traffic behaviour and capacity on up-grades and warrants for the provision of climbing lanes. This work was extended to include the case of short sections of additional lanes, not necessarily on up-grades, for overtaking (Hoban 1980, 1982). McLean (1989) contains a comprehensive review of traffic operations on two-lane roads.

2.3.2 Signalised Intersections

The capacity of signalised intersections had been of interest to Australian workers since the early 1960s (Grace & Potts 1962, Pak-Poy 1962b). In 1964, AJ Miller, who had taken up an appointment at the University of New South Wales, began a study of signalised intersections. He initially developed a mathematical model of traffic flow through an intersection, and then undertook a detailed program in a number of Australian cities to determine saturation lane flows and suitable adjustment factors under a variety of conditions. His work culminated in the publication of a guide to the capacity of signalised intersections (Miller 1968).

As traffic signal technology advanced and signals became more sophisticated during the 1970s, the need for substantial updating of Miller's work to match current developing practices, including the use of multiphase designs and modern controllers, became apparent and a comprehensive review, led by R Akcelik, began in 1979. This review led to the issue of a new guide on the capacity and timing analysis of traffic signals in 198l (Akcelik 1981). Because of the complexity of the method of analysis, Akcelik developed a computer software package called the Signalised Intersection Design and Research Aid (SIDRA) (Akcelik 1987).

The geometry on approach roads to signalised intersections was also improved. For example, flaring on the approaches to signalised intersections, and also on the departure side to match, was provided to increase capacity. A slight narrowing of lane widths on the approaches and the provision of separate right-turn lanes also became common.

2.3.3 Roundabouts

Up to about the mid-1970s, roundabouts were used only to a limited extent in Australia. In 1974 CB Horman and HH Turnbull reported on investigations into the design and operation of roundabouts. Until then it had been generally accepted that roundabouts functioned as a weaving operation, but their research clearly indicated that roundabouts of the size normally used in Australia operated by gap acceptance, in that entering traffic was required to give way and to accept gaps in traffic circulating round the central island (Horman & Turnbull 1974). In the mid-1980s, RJ Troutbeck began a program of research into traffic behaviour at, and the design of roundabouts (NAASRA 1986). By the mid to late 1980’s roundabouts were being increasingly used in Australia (Barton 2015).

2.3.4 Traffic Signals

By 1960 traffic signals were in use in all the larger urban areas in Australia. Since then, traffic signal technology has developed rapidly, and by l988 comprehensive and sophisticated signal systems were operating throughout the country. During this period the major development has been the development and implementation of computer- based co-ordinated signal systems along selected arterials and area-wide, early examples of which were systems installed in Sydney in 1963 (French 1965a, 1965b) and in Surfers Paradise in 1969 (Leitch, Dent & Wratten 1970).

In 1975 the Sydney Co-ordinated Adaptive Traffic System (SCATS) commenced (DMR NSW 1983) and was later progressively developed and extended (Sims & Dobson 1979). This basic system, sometimes with modifications, has since been adopted for use in other major cities in Australia (and in some overseas cities).

A SCATS maintenance group was established in 1980 to co-ordinate the documentation, development and implementation of the SCATS system and to deal with any problems that arise in user areas.

2.3.5 Road Safety

By the early 1960s accident recording systems and systematic analysis procedures were being developed to enable examination of accident rates and factors affecting them, accident-prone locations, and the effectiveness of accident countermeasures. Considerable research into basic road user behaviour studies and to the examination of cost effective countermeasures, both at local sites and area-wide was being carried out. This work continued through the 1960s, 1970s and 1980s. Details of this work are discussed in detail in ARRB Special Report No. 42. (Underwood 1989)

2.3.6 Local Traffic Management

Local area (or neighbourhood) traffic management schemes (or traffic calming schemes), designed to control the movement and speed of traffic in residential areas (or in local traffic precincts), to discourage through traffic, to minimise accidents and to improve the level of environmental amenity, have been implemented since the early to mid-1980s, (Brindle 1983, Brindle & Sharp 1983, Tonkin & Associates 1985, Howie & Sullivan 1986).

2.3.7 Other Significant Developments

Other noteworthy developments between 1960 and 1988 include:

- The continuing role of the State Road Authorities.
- The Commonwealth Bureau of Roads, established in 1966, began full operation in 1967 and was amalgamated with the Commonwealth Bureau of Transport Economics in 1977.
- The NAASRA Traffic Engineering Committee continued to meet annually until 1986. It produced a Guide to Traffic Engineering in 1965, which was periodically reviewed and updated over the years.
- The increasing role of traffic management authorities, including the establishment of the Conference of State Traffic Control Authorities in 1974 (disbanded in 1984).
- The establishment of the Australian Committee on Road Devices (ACORD) in 1966 to prepare an Australian Manual of Uniform Traffic Control Devices. ACORD was disbanded in 1977, when it became a reconstituted SAA Road Signs Committee.
- The increasing role of municipal councils in traffic engineering matters.
- Since its inception in 1960 the Australian Road Research Board has actively fostered research, development and dissemination of information in traffic engineering.
- In 1971, an Australian Section of the USA Institute of Traffic Engineers (which became the Institute of Transportation Engineers in 1976) was established.
- In 1988, the Australian College of Road Safety was established.

- The establishment of traffic engineering (or transport) groups in several of the universities and institutes of technology.
- The increasing role of the automobile associations in the active support and promotion of traffic engineering and road safety measures.

3 RESPONSIBILITY AND ORGANISATION FOR TRAFFIC ENGINEERING AND RELATED ACTIVITIES

3.1 Responsibility for Traffic Engineering and Related Activities

In Australia, responsibility for traffic engineering and related activities is shared by the three levels of government. These responsibilities are as follows:

3.1.1 Commonwealth Government

The Commonwealth government responsibilities now include:

- An important role in providing road funding. This role has changed significantly over the years. For instance, at the beginning of the 1990s, the Commonwealth funded, by way of specific purpose payments, works on National Highways, national arterials, State arterials and local roads, but since then its role in road funding has changed considerably (Webb 2004). It now fully funds works on National Highways and provides funds for local roads.
- Administering road safety programs such as a National Black Spot Safety Program for projects on State roads and local roads, and other road safety programs such as the Keys2drive and Seatbelts for Regional School Buses programs.
- Collating and publishing national road safety statistics.
- Co-ordinating the National Road Safety Strategy 2011-2020.
- Developing national standards for driver licensing policy, Australian design rules for motor vehicles and trailers, national vehicle standard rules (which apply to all vehicles), requirements for special classes of vehicles (such as heavy vehicles), and Australian road rules. In general, these rules and requirements have been endorsed by the Australian Transport Council (now the Transport and Infrastructure Council), and have been largely adopted by the states and territories, and enacted under their own legislation.

3.1.2 States and Territories

The states and territories are responsible for:

- Planning, design, construction, maintenance and operation of works on national highways, and road safety programs on state and territory roads, funded by the Commonwealth Government.
- Funding, planning, design, construction, maintenance and operation of state and territory roads, except for local roads.
- Driver licensing and vehicle registration.
- Regulating and enforcing road use and road user behaviour.
- Third-party traffic injury insurance, advertising campaigns and research to reduce the incidence of road trauma.
- Preparation and administering state and territory road safety strategies, consistent with the National Road Safety Strategy.

3.1.3 Local Government

Local government is responsible for:

- Planning, design, construction, maintenance and operation of works on local roads.
- Regulating and enforcing local area traffic management schemes and parking in its area.
- Preparation of local road safety strategies for its local area, consistent with national and state and territory road safety strategies.

3.2 Organisation for Traffic Management and Associated Activities

3.2.1 Commonwealth Government

The Commonwealth Department with primary responsibility for traffic engineering functions, including road safety, has changed over the years as follows (DIRD 2014a):

- from July 1987 to December 1993 – Department of Transport and Communications.
- from December 1993 to March 1996 – Department of Transport.
- from March 1996 to October 1998 – Department of Transport and Regional Development.
- from October 1998 to December 2007 – Department of Transport and Regional Services.
- from December 2007 to September 2010 – Department of Infrastructure, Transport, Regional Development and Local Government.
- from September 2010 to September 2013 – Department of Infrastructure and Transport.
- since September 2013 – Department of Infrastructure and Regional Development (DIRD).

In 1991 the National Road Transport Commission (NRTC), an independent body established by agreements between the national, state and territory governments, and reporting to the Australian Transport Council (ATC), was established to develop policies and practices to make road transport and road use safer and more uniform and efficient. These policies are then normally taken up by the individual states and territories and enacted in their own legislation. In 2003, the NRTC was renamed the National Transport Commission (NTC). The NTC performs the role of an expert advisor to the ATC (the Transport and Infrastructure Council since 2013) (DIRD 20l5b).

The Transport and Infrastructure Council (TIC) brought together Commonwealth, state, territory and New Zealand Ministers with responsibility for transport and infrastructure issues, and the Australian Local Government Association (DIRD 2015b).

In July 1999 the Australian Transport Safety Bureau (ATSB) was established within the Department of Transport and Regional Services. It combined the expertise and resources of the Bureau of Air Safety Investigation, the Federal Office of Road Safety (which had been established within the Department of Transport in December 1977), the Marine Incident Investigation Unit and a new Rail Safety Unit. In July 2009 the ATSB became a separate statutory authority.

In late 2013 the ATSB's responsibilities for road safety research and policy, including administering vehicle safety standards for new vehicles, administering the National Black Spot program and other road safety funding, administering the Keys2drive and Seatbelts for Regional School Buses programs, producing national road safety statistics, and co-ordinating the National Road Safety Strategy 2011-2020, were transferred to a Road Safety Unit within the Department of Infrastructure and Regional Development (DIRD 2015c).

3.2.2 State and Territory Governments

Since 1988 there have been significant changes to the organisation for traffic engineering and associated functions in the states and territories. These are summarised below.

In New South Wales:

- In January 1989 the Department of Main Roads and the Department of Motor Transport were abolished and amalgamated with the Traffic Authority of New South Wales to form the Roads and Traffic Authority of New South Wales (RTA).
- On l November 2011 Roads and Maritime Services was established and the functions, assets, rights and liabilities of the Roads and Traffic Authority and the Maritime Authority of NSW were transferred to the new corporation. Roads and Maritime Services is a multimodal transport agency within a broader transport cluster, known as Transport for NSW (and led by a Director General/Secretary of Transport). Transport for NSW has responsibility for improving customer experience, planning, program administration, policy, regulation, procuring transport services, infrastructure and freight.
- The Centre for Road Safety, also within the transport cluster, leads the development, integration and implementation of state-wide road safety strategies, policies and programs. Its main focus is to reduce the level of road fatalities and serious injuries resulting from crashes in NSW. It also provides leadership on road safety strategy across the transport cluster, local government and the federal government.
- The Transport Management Centre (TMC) monitors and manages the NSW state road network. On 31 August 2010, organisational and functional control of the TMC was relocated from Roads and Traffic Authority to Transport NSW (now Transport for NSW). This allowed the provision of seamless transport management across the entire transport network during peak travel times, major events and unplanned incidents.

In Queensland:

- In April 2009 the Department of Main Roads and Queensland Transport were amalgamated to form the Department of Transport and Main Roads.

In South Australia:

- In 1989 the Department of Transport and the Highways Department were combined to become the Department of Transport.
- In 1993, the Road Transport Agency was created within the Department of Transport.
- In 1997 the Road Transport Agency became Transport SA, an agency within the Department for Transport, Urban Planning and the Arts.
- In 2002 Transport SA became an agency in the Department for Transport and Urban Planning
- In 2005 Transport SA became an agency within the Department for Transport, Energy and Infrastructure.
- In 2011 Transport SA became Transport Services within the Department for Planning, Transport and Infrastructure.
- The Motor Accident Commission is responsible for third-party injury insurance, and for road safety advertising and insurance programs.

In Tasmania:

- In 1988 the Transport Department and the Department of Main Roads were combined to become the Department of Roads and Transport.
- In 1993 the Department of Roads and Transport became the Department of Transport and Works.
- In 1996 the Department of Transport and Works became the Department of Transport.
- In 2004 the Department of Transport became part of the Department of Infrastructure, Energy and Resources.
- In 2014 the Department of Infrastructure, Energy and Resources merged with the Department of Economic Development, Tourism and the Arts to form the Department of State Growth.

In Victoria:

- On l July 1989 the Road Construction Authority and the Road Traffic Authority amalgamated to form the Roads Corporation, which adopted VicRoads as its day-to day operational name.
- In about July 1989 the Traffic Accident Commission, which had been established in 1986 primarily to administer Victoria's compulsory no-fault third-party traffic injury insurance, became actively involved in advertising campaigns and in research to reduce the incidence of road trauma through accident prevention programs.
- The Victorian Road Safety Partnership (VRSP) was first created in the mid-1990s. It then comprised the Transport Accident Commission, VicRoads and Victoria Police. It has since been expanded to also include the Department of Justice and Regulation and the Department of Health and Human Services. The VRSP prepares and implements the Victorian Road Safety Strategy, and involves the community to achieve its objectives.
- In February 2012, a Speed Camera Commissioner was first appointed to independently monitor and review current speed camera operations and to examine complaints by persons concerned by the speed cameras.

In Western Australia:

- In 1993 the Main Roads Department became Main Roads Western Australia.
- In 2009, the Office of Road Safety joined Main Roads Western Australia as a separate unit reporting to the Minister for Road Safety. As the lead agency for road safety in Western Australia, the Office of Road Safety is responsible for developing, co-ordinating, promoting and monitoring the state's road safety strategy. It is responsible for administering the Road Trauma Trust Fund (RTTF) budget on behalf of the Road Safety Council, including managing grants to other agencies for road safety projects approved by the Minister for Road Safety.

In the Australian Capital Territory:

- In 1993 the Transport and Works Division was replaced by ACT Urban Services.
- In 2006 the ACT Urban Services became the Territories and Municipal Services Directorate.

In the Northern Territory:

- In 2001 the Department of Transport and Works became the Department of Infrastructure, Planning and Environment.
- In 2005 the Department of Infrastructure, Planning and Environment became the Department of Planning and Infrastructure.
- In 2009 the Department of Planning and Infrastructure became the Department of Lands and Planning.
- In 2012 the Department of Lands and Planning became the Department of Transport.

3.2.3 Public Private Partnerships

Since the early 1990s, in some states, public private partnerships have become an important way of financing some major road projects – particularly tolled freeways (motorways). In general, a private entity and the state government enter into an agreement in which the entity carries out the design, construction, maintenance, and operation, including all traffic management and road safety activities, for the project, and is granted a franchise for a given number of years during which it recoups its costs from tolls and makes a profit. At the end of the franchise period, full ongoing responsibility for the project reverts to the state.

Public private partnerships operating in Sydney include:

- M2, operated by The Hills Motorway Limited, contract signed in 1994, first opened on 26 May 1997 with a term to 26 May 2046.
- M5 South-West Motorway, operated by Interlink Roads, contract signed 1992, first opened 14 August 1992, with a term to 10 December 2025.
- Westlink M7, operated by WSO Co Pty. Ltd., contract signed in 2003, first opened 16 December 2005, with a term to 14 February 2037.
- Eastern Distributor, operated by Airport Motorway Ltd., contract signed 1997, first opened 16 December 1999, with a term to 23 July 2048.
- Sydney Harbour Tunnel, operated by Sydney Harbour Tunnel Co. Ltd., contract signed 1987, first opened 31 August 1992, with a term to 31 August 2022.
- Cross City Tunnel, operated by Transurban CCT Pty. Ltd., contract signed 2002, first opened 28 August 2005, with a term to 19 December 2035.
- Lane Cove Tunnel (including Military Road E-Ramp), operated by LCT-MRE Pty. Ltd., contract signed 2004, first opened 25 March 2007, with a term to 9 January 2037.

Public private partnerships in Brisbane involving the Department of Transport and Works include:

- Gateway Motorway (Nudgee to Eight Mile Plains), operated by Transurban Queensland.
- Gateway Extension (Eight Mile Plains to the Logan Motorway), operated by Transurban Queensland.
- Logan Motorway, operated by Transurban Queensland.

There are other public private partnerships in Brisbane that involve the Brisbane City Council and Transurban Queensland (the Clem 7 and the Legacy Way tollways), and one untolled that involves the Port of Brisbane.

Public private partnerships operating in Melbourne include:

- Citylink, operated by Transurban, contract signed in 1995, first opened in 2000, with a concession period of just over 34 years.
- Eastlink, operated by ConnectEast, contract signed in 2004, first opened in 2008, with a concession period of 39 years.
- Peninsula Link, operated by Southern Way consortium, contract awarded in 2010, first opened in 2013, and with the government providing quarterly payments for delivery of ongoing services based on key performance indicators.

In September 2014, East West Connect signed a contract for a fourth public private partnership project in Melbourne, the East West Link project, but following a change of government the premier issued an order to stop work on the project and negotiations to terminate it began.

4 THE ROLE OF NATIONAL ORGANISATIONS

4.1 NAASRA/Austroads

In July 1989 NAASRA became Austroads. Austroads is the Association of Australasian road transport and traffic agencies (Austroads 2015a). Its purpose is to improve Australian and New Zealand transport outcomes by providing expert technical input to national road and transport policy development, improving the practices and capabilities of road agencies and promoting operational consistency by road agencies. Its members are the eight Australian state and territory road transport and traffic agencies, the Commonwealth Department of Infrastructure and Regional Development, the Australian Local Government Association and the New Zealand Transport Agency. Some aspects of Austroads work relating to traffic engineering are outlined below.

4.1.1 Support for ARRB Research

At its June 2004 meeting the Austroads Council considered the need to undertake research in key areas to maintain a sustainable core of technical research capacity in Australasia, the identified areas being asset management, bituminous surfacing, pavement technology and road safety engineering. At that meeting the Austroads Council agreed to provide annual funding to ARRB to maintain a minimum level of technical capability in each of the four nominated areas under an Austroads Technical Research Agreement. This Agreement continued until 2010, when it was replaced by a broader Austroads - ARRB Partnership Agreement and an additional area, network operations, was included.

Each year from 2005 to 2010, ARRB Group/Austroads prepared an Austroads Technical Research Agreement – Programs and Achievements report (2005, 2006, 2007, 2008, 2009 and 2010) and since 2011 an Austroads – ARRB Partnership Agreement – Programs and Achievements report (2011, 2012, 2013, 2014). Each report summarised the challenges and outputs for the past year.

Of the identified research areas, network operations and road safety engineering (titled road safety infrastructure in the 2013 and 2014 reports) have a significant traffic engineering content. Those requiring detailed information on the contents of these reports should refer to the original documents. However, in order to give an appreciation of the range of topics covered, a listing of the topics included in the 2014 report under network operations and road safety infrastructure is given in Section 4.2.1 below.

4.1.2 Guide to Traffic Engineering Practice

NAASRA produced its first Guide to Traffic Engineering Practice in 1965. Over the years the guide has been reviewed and updated periodically. In 1988-89, a completely revised and restructured Guide in 12 separate parts was prepared for Austroads by EV Barton, Technical Editor, and various writers. These 12 parts were:

- Part 1. Traffic Flow
- Part 2. Roadway Capacity
- Part 3. Traffic Studies
- Part 4. Road Crashes
- Part 5. Intersections at Grade
- Part 6. Roundabouts
- Part 7. Traffic Signals
- Part 8. Traffic Control Devices

- Part 9. Arterial Road Traffic Management
- Part 10. Local Area Traffic Management
- Part 11. Parking
- Part 12. Roadway Lighting

In the mid-1990s a further three parts were issued, namely Part 13: Pedestrians and Disabled Road Users; Part 14: Bicycles and Part 15: Motor Cyclists. The 15 guides provided a comprehensive coverage of traffic management for practitioners involved in traffic engineering, road design and road safety.

In the early 2000s these guides were further restructured, and *Guide to Traffic Engineering Practice* was replaced by two new sets of guides, namely *Guide to Traffic Management* (in 13 parts) and *Guide to Road Safety* (9 parts).

Of the 15 parts of the Guide to Traffic Engineering Practice:

- Parts 1 to 3 and 8 to 11 were included in the new *Guide to Traffic Management*
- Part 4 was included in the new *Guide to Road Safety*
- Parts 5 to 7 were included partly in the *Guide to Traffic Management* and partly in the *Guide to Road Design*
- Parts 12 to 15 were included partly in the *Guide to Traffic Management* but mainly in the *Guide to Road Design*.

4.1.3 Guide to Traffic Management

The current *Guide to Traffic Management* (2015) comprises 13 parts as follows:

- *Part 1: Introduction to Traffic Management* provides an introduction to the discipline of traffic management and an overview of the structure of the guide (AGTMO 1-09).
- *Part 2: Traffic Theory* provides an introduction to the characteristics of traffic flow and the theories, models and statistical distributions used to describe traffic phenomena (AGTM02-08).
- *Part 3: Traffic Studies and Analysis* provides information and references on the traffic performance of roads and intersections, traffic analysis for mid-block situations and analysis of signalised and unsignalised intersections (AGTM03-l 3).
- *Part 4: Network Management* covers the broad strategies and objectives of managing road networks to provide effective traffic management for all road users (AGTM04-14).
- *Part 5: Road Management* focuses on mid-block traffic management issues that apply to a single length of a road. It covers road space allocation, access management, lane management and speed management (AGTM05-14).
- *Part 6: Intersections, Interchanges and Crossings* is focussed on traffic management at locations where different traffic and road user streams intersect each other. It includes grade separated interchanges, as well as rail crossings and pedestrian and bicycle crossings (AGTM06-13).
- *Part 7: Traffic Management in Activity Centres* covers principles for the planning and traffic management of activity centres and associated transport modes (AGTM07-15).
- *Part 8: Local Area Traffic Management* provides guidance on traffic control measures applied on an area-wide or whole-of-street basis, including the effects such schemes may have on local and arterial roads (AGTM08-08).
- *Part 9: Traffic Operations* covers operational matters such as traffic signals and incident management, and includes the management of transport information and operational management of road space for all road users (AGTM09-14).

- *Part 10: Traffic Control and Communications Devices* provides guidance on the design and use of traffic control and communications devices, including signals, signs, markings and delineation (AGTM10-09).
- *Part 11: Parking* describes the process of determining the demand for, and supply of, parking and provides a parking policy framework (AGTM 11-08).
- *Part 12: Traffic Impacts of Developments* covers the relationship between road level of service and access management, and provides information on the processes for assessing the traffic and transport impacts of land use developments (AGTM12-09).
- *Part 13: Road Environment Safety* covers ways of ensuring a safe road environment within a traffic management context (AGTM13-09).

In addition to this 13-part guide, Austroads has prepared a number of traffic management related reports. A list of these reports is available on https://www.onlinepublications.austroads.com.au/collections.agtm/research-technicalreports>.

4.1.4 Guide to Road Safety

The current Guide to Road Safety (2015) comprises 9 parts as follows:

- *Part 1: Road Safety Overview* provides a discussion of road crash costs and road agencies' duty of care to provide safe travel. The advantages and disadvantages of different ways of measuring road safety are discussed, and these methods are used to illustrate progress in road safety in recent years (AGRSO1-13).
- *Part 2: Road Safety Strategy and Evaluation* is intended as a guide to the process of strategy development and evaluation. It outlines options for strategy development and the value of a 'vision' in driving strategy development. It includes discussion on partnerships and consultation, problem analysis, countermeasure selection, target setting and performance indicators, strategy and action plan development, implementation and monitoring and evaluation (AGRS02-13).
- *Part 3: Speed Limits and Speed Measurement* provides an overview of speed limits and their application as a speed management tool. The use of appropriate speed limits forms an integral part of a safe road system. They are a speed management tool used to improve road safety, while maintaining the efficiency of the road network. There is discussion on the definition of a speed limit, different types of speed limits, how to choose a speed limit and speed signing principles and practice (AGRS03-08).
- *Part 4: Local Government and Community Road Safety* outlines the road safety responsibilities of local government, and discusses the advantages of working closely with the community in meeting these responsibilities. In includes discussion on strategic partnerships and capacity building, developing a road safety strategy, funding a plan and mobilising resources, implementation, case studies, evaluation and review, and communication and reporting (AGRS04-09).
- *Part 5: Road Safety for Rural and Remote Areas*. Road trauma in rural and remote areas is a major national road safety problem and well over half of all fatal crashes occur within these environments. This part of the guide discusses an analysis of crashes in rural and remote areas, risk factors and road safety countermeasures (AGRS05-06)
- *Part 6: Road Safety Audit* includes an explanation of a road safety audit, and discussion on legal issues, the audit process, the audit of road designs, other types of road safety audit, case studies, safety principles, audit tools, notes on the road safety checklist and on master and detailed checklists (AGRS06-09).
- *Part 7: Road Network Crash Risk Assessment and Management* introduces the concept of risk management in the road safety network context. It discusses the principles of risk assessment and risk management, establishing the context, identifying risks, analysing risks, evaluating and prioritising risks, the treatment of risks, monitoring and review, case studies and the Australian level crossing assessment model (AGRS07-06).

- *Part 8: Treatment of Crash Locations* discusses the purpose of treatment guidelines, the road crash situation, the components of the traffic system, taking measures to improve road safety, road crash data, steps in the crash location treatment process, identifying crash locations, diagnosing crash problems, selecting countermeasures, designing a safe remedial treatment, justifying the expenditure, report writing, ranking treatments to include in a works program, implementing the treatment, monitoring treated locations and evaluating treatment programs (AGRS08-09).
- *Part 9: Roadside Hazard Management*. Run-off-road crashes are a major type of road crash that result in death or serious injury. There are many reasons why vehicles leave the roadway and crash. This guide discusses keeping vehicles on the road and providing a forgiving roadside environment (AGRS09-08).

In addition to this 9-part guide, Austroads has prepared a number of road safety related reports. A list of these reports is available on <https://www.onlinepublications.austroads.com.au/collections.agtm/research-technicalreports>.

4.1.5 World Road Association – PIARC

The World Road Association (PIARC) is an international road organisation with 118 member governments. Australia is a national member of PIARC (Permanent International Association of Road Congresses) through the Commonwealth Department of Infrastructure and Regional Development. Colin Jordan, Chief Executive of the Royal Automobile Club of Victoria (RACV), is a past-President of PIARC and is still a member of the Executive Committee.

Austroads International Committee (PIARC) is recognised by the PIARC and the Australian Government as the National Correspondent Organisation for PIARC in Australia and is charged with managing Australia's involvement, and co-ordinating it with that of New Zealand, particularly in regard to PIARC committee activities. New Zealand is a separate national member of PIARC.

The World Road Association is primarily interested in issues of road infrastructure planning, design, construction, maintenance and operation. The work of the association is undertaken by 17 committees that bring together technical experts from around the world. Austroads currently has full or corresponding representatives on 15 of the 17 committees. These representatives are either members or have a close working relationship with an Austroads task force or working group. They provide Austroads with regular progress reports on the work being conducted by their committees.

The committees operate under four strategic themes, namely Management and Performance, Access and Mobility, Safety, and Infrastructure. The committees most relevant to traffic engineering, including road safety, include:

- Strategic Theme 1. Management and Performance. Committee - Risk management.
- Strategic Theme 2. Access and Mobility. Committees – Road Network Operations, Improved Mobility in Urban Areas, and Freight Transport.
- Strategic Theme 3. Safety. Committees – National Road Safety Policies and Programs, Design and Operations of Safer Road Infrastructure and Road Safety Manual Task Force.
- Strategic Theme 4. Infrastructure. Committee – Management of Road Assets.

4.1.6 Intelligent Transport Systems

Austroads is playing a key role in the development and implementation of intelligent transport systems in Australia. See Section 10.

4.2 Australian Road Research Board

The Australian Road Research Board commenced operation in 1960. Since then, there have been changes to its name (to ARRB Transport Research Ltd in 1995 and to ARRB Group Ltd in 2004), to the composition of its board, to its structure and to its mode of operation (including its relations with Austroads). Discussion of these changes is beyond the scope of this Special Report, but are discussed in detail in Sharp et al. (2011).

Since its inception in 1960, ARRB has played a significant role in encouraging and supporting research, and in disseminating research findings in traffic engineering (and indeed in all aspects of road engineering). It has sponsored both internal and external research on a wide variety of traffic engineering topics, and many relevant papers have been presented at its major conferences and in the relevant conference proceedings, in its quarterly journal as well as at specialist symposia and workshops, and in other ARRB publications. Details of all material published by ARRB can be found in its library publications and computerised databases.

Dr MG Lay, the Executive Director of ARRB between 1975 and 1988, provided strong leadership, and placed great emphasis on raising the academic and research standards of the work of ARRB. He led by example, and authored over 750 publications on a wide range of topics, including various aspects of traffic engineering. His books include Source Book for Australian Roads (Lay 1981), History of Australian Roads (Lay 1984), Ways of the World (Lay 1992) and Handbook of Road Technology (Lay 2009), now in its fourth edition. In 2000 ARRB named its library the MG Lay Library to honour his passion for the dissemination of high-quality professional information.

4.2.1 ARRB Research Programs

During the 1990s, research at ARRB included a wide range of topics related to traffic management (engineering) and road safety, including young drivers, speed limits, access management, bicycle safety, safety audits, road surfaces, neighbourhood (local) traffic management, effects of road geometry, speed behaviour on curves, accident costs, brightness of line marking, truck safety, and rail level crossings. Examples identified by Sharp et al. (2001):

- a study of truck crashes (Cairney 1991a, 1991b).
- VLIMITS; an expert system speed zone advisor (Donald 1992).
- consumer views on information technology-based systems for passenger cars (Cairney 1995).
- driver comprehension of formats for presenting traffic information on dynamic signs (Catchpole, Hancock & Cairney 1995).
- studies of signage at transitions between highway speeds and town speeds (Donald 1994 1996).
- an objective assessment of higher open road speed limits (Donald & Cairney 1997).
- traffic management performance: development of a traffic frustration index (Gunatillake, Cairney & Akcelik 2000).
- the behaviour of young drivers (Catchpole, Cairney and McDonald 1994, Green 2000).
- effects of a 40 km/h local area speed limit on traffic behaviour and community expectations (Cairney & Fackrell 1993, Cairney & Swadling 2000).
- on-road tests of bicycle night conspicuity aids (Cairney 1992).
- road user behaviours that contribute to accidents at urban arterial local road intersections (Cairney 1991c).
- studies of the relationship between outcome measures of road performance and road features and condition (McLean 1997).
- an evaluation of VicRoads drive time system (Ramsay, Catchpole & Luk 1997).
- ARRB's contributions in the environmental and road safety areas (Brindle 1995, 1996a).

In 2001 a High Court decision removed immunity from road authorities where an unknown deficiency on the road network may have contributed to the occurrence of a road crash or its severity. The Austroads response to this decision was to increase its investment into risk management through a road safety risk assessment research project (Sharp et al. 2011). This research commenced in 2002, and since 2004 has formed a substantial part of the research program carried out under the

Austroads Technical Research Agreement. Sharp et al. 2011 provide comprehensive details. Based on this research, a number of reports, all relating to road safety, have been produced, namely (Sharp et al. 2011):

- crash risk and geometric design standards (McLean, Veith & Turner 2009)
- crash risk mitigation (Styles et al. 2010).
- best practice in crash database design (Turner & Hore-Lacy 2010)
- treatment life for road safety measures (Turner & Comport 2010)
- review of crashes on unsealed roads (Boschert et al. 2010)
- crash reduction factors (Turner & Roper 2010)
- crash rates databases (Jurewicz & Bennett 2010)
- rural head-on crashes (Tziotis, Styles Turner (2010)
- rural intersection crashes (Tziotis, Turner & Styles 2010)
- rural run-off-road crashes (Tziosis, Pyta & Mabbott 2010)
- road safety and maintenance (Cairney 20l0).

As mentioned in Section 4.1.1, each year from 2005 to 2010, the ARRB Group/Austroads has prepared an Austroads Technical Research Agreement - Programs and Achievements report (2005, 2006, 2007, 2008, 2009 and 2010) and since 2011 an Austroads - ARRB Partnership Agreement - Programs and Achievements report (2011, 2012, 2013, 2014), each report summarising the challenges and outputs for the past year. These reports contain a wealth of information.

Of the identified research areas, network operations and road safety engineering (titled road safety infrastructure in the 2013 and 2014 reports) have a significant traffic engineering content. Those requiring detailed information on the contents of these reports should refer to the original documents. However, in order to give an appreciation of the range of topics covered, a listing of the topics included in the 2014 report (Austroads 2014) under network operations includes:

- Intelligent transport systems architecture and protocols agreed nationally
- harmonisation of traffic system requirements
- network operations for all modes
- network performance measures
- National Cycling Strategy 2011-16 implementation
- standardised information services for users
- update of the Austroads Guide to Traffic Management.

The range of topics included in the 2014 report (Austroads 2014) under road safety infrastructure includes:

achieving safe system speeds on urban arterial roads

- strategic review of the Austroads Guide to Road Safety
- update of the Austroads Guide to Road Safety
- towards harmonisation of best practice speed limits
- improving safety for disadvantaged groups
- crash analysis in Australia and New Zealand
- investigation of rear-end crashes

- investigation of treated black spots that do not achieve expected safety benefits
- safe system in the planning process
- improving the performance of safe system infrastructure
- safe system roads for local government
- development of a detection and advance warning system for at-risk high commercial vehicles on steep descents.

The outputs from the network operations and the road safety infrastructure core areas in 2013-14 are listed in the 2014 report. These include both Austroads and other outputs.

4.2.2 World Road Association (PIARC) Road Safety Manual

In 2012, at PIARC's request, ARRB carried out studies to define the structure and contents of a second edition of the PIARC *Road Safety Manual* under the leadership of a PIARC task force and with the participation of road safety experts from the PIARC Technical Committees on road safety, and the cooperation of the World Bank, the World Health Organisation, the OECD and the African Development Bank. In 2013, ARRB was awarded a contract to write the second edition.

The Manual is to be in three parts and twelve chapters as follows:

Part 1: Introduction.

Chapter 1: Scope of the road safety problem

Chapter 2: Key developments in road safety

Part 2. Road Safety Management

Chapter 3: The road safety management system

Chapter 4: The safety system approach

Chapter 5: Effectiveness management and use of road safety data

Chapter 6: Road safety targets, investment strategies, plans and projects

Part 3. Safe Planning, Design, Operation and Use of the Road Network

Chapter 7: Roles, responsibilities, policy development and programs

Chapter 8: Design for road user characteristics

Chapter 9: Infrastructure safety management

Chapter 10: Assessing potential risks and identifying issues

Chapter 11: Intervention, selection and prioritisation

Chapter 12: Monitoring and evaluation of effectiveness of actions

Technical Appendices.

It is understood that writing of the Manual is nearing completion and that it is currently expected that it will be launched in late 2015 with the title PIARC Road Safety Manual (2nd edition). A Manual for Practitioners and Decision Makers on Implementation of Safe System Infrastructure.

4.3 Standards Association of Australia

The first Standards Association of Australia (SAA) standard relating to traffic engineering was originally published in 1935 (SAA 1935). It was revised and republished in 1946 (SAA 1946) and further reviewed, expanded and again republished in 1960 (SAA 1960). Over the years since then, much work has been done in revising, updating and expanding the coverage of standards. At the end of 2014 relevant standards were the following:

Manual of Uniform Traffic Control Devices. Parts 1 to 17.

AS 1742.1 – 2014	General introduction and index of signs
AS 1742.2 – 2009	Traffic control devices for general use
AS 1742.3 – 2009	Traffic control devices for works on roads
AS 1742.4 – 2008	Speed controls
AS 1742.5 – 1997	Street names and community facility name signs
AS 1742.6 – 2014	Tourist and service signs
AS 1742.7 – 2007	Railway crossings
AS 1742.8	Discontinued. Absorbed into AS 1742.15 – 2007
AS 1742.9	2000 Bicycle facilities
AS 1742.10 – 2009	Pedestrian control protection
AS 1742.11 – 1999	Parking controls
AS 1742.12 – 2000	Bus, transit, tram and truck lanes
AS 1742.13 – 2009	Local area traffic management
AS 1742.14 – 2014	Traffic signals
AS 1742.15 – 2007	Direction signs, information signs and route numbering.

Other relevant Australian standards

AS/NZS 1158.0 – 200	2005 Lighting for roads and public spaces – Introduction
AS/NZS 1158.1.1– 2005	Lighting for roads and public spaces – Vehicular traffic (Category 5) lighting – Performance and design requirements
AS/NZS 1158.1.2 – 2010	Lighting for roads and public spaces – Vehicular traffic (Category 5) lighting – Guide to design, installation, operation and maintenance
AS/NZS 1158.2 – 2005	Lighting for roads and public spaces – Computer procedures for the calculation of light technical parameters for Category V and Category P lighting
AS/NZS 1158.3.1 – 2005	Lighting for roads and public spaces – Pedestrian area (Category P) lighting – Performance and design requirements
AS/NZS 1158.4 – 2009	Lighting for roads and public spaces – Lighting of pedestrian crossings
AS/NZS 1158.5 – 2007	Lighting of roads and public spaces – Tunnels and underpasses
AS/NZS 1158.6 – 2010	Lighting for roads and public spaces – Luminaires
AS 1348 – 2002	Glossary of terms – Roads and traffic engineering
AS 1428.1 – 2009	Design for access and mobility – General requirements for access – New buildings
AS 1428.2 – 1992	Design for access and mobility – Enhanced and additional requirements – Buildings and facilities
AS 1428.3 – 1992	Design for access and mobility – Requirements for children and adolescents with physical disabilities
AS/NZS 1428.4.1 – 2009	Design for access and mobility – Means to assist the orientation of people with vision impairment – Tactile ground surface indicators
AS 1428.5 – 2010	Design for access and mobility – Communication for people who are deaf or hearing-impaired
AS 1743 – 2001	Road signs – Specifications (New version expected in 2015)
AS 1744 – 1975	Forms of letters and numerals for road signs (known as Standard alphabets for road signs) (New version expected in 2015)
AS/NZS 1906.1 – 2007	Retroreflective materials and devices for road traffic control purposes – Retroreflective sheeting
AS/NZS 1906.2 – 2007	Retroreflective materials and devices for road traffic control purposes – Retroreflective devices (non-pavement application)

AS 1906.3 -1992	Retroreflective materials and devices for road traffic control purposes – Raised pavement markers (retroreflective and non-retroreflective)
AS/NZS 1906.4 – 2010	Retroreflective materials and devices for road traffic control purposes – High visibility materials for safety garments.
AS 2144 – 2014	Traffic signal lanterns
AS 2353 – 1999	Pedestrian push-button assemblies
AS/NZS 2890.1 – 2004	Parking facilities – Off-street car parking
AS 2890.2 – 2002	Parking facilities – Off-street commercial vehicle parking
AS 2890.3 – 1993	Parking facilities – Bicycle parking facilities
AS 2890.5 – 1993	Parking facilities – On-street parking
AS/NZS 2890.6 – 2009	Parking facilities – Off-street parking for people with disabilities
AS/NZS 3000 – 2007	Electrical installations (Australian/New Zealand wiring rules)
AS/NZS 3845 – 1999	Road safety barrier systems
AS 4191 - 1994	Portable traffic signal systems
AS 4852.1 – 2009	Variable message signs – Fixed signs
AS 4852.2 – 2009	Variable message signs – Portable signs
AS 5156 – 2010	Electronic speed limit signs
AS /NZS 2276.1 – 2004	Cables for traffic signal installations – Multicore power cables
AS/NZS 2276.2 – 1998	Cables for traffic signal installations – Feeder cables for vehicle detectors
AS/NZS 2276.3 – 2002	Cables for traffic signal installations – Loop cables for vehicle detectors
AS 2339 – 1997	Traffic signal posts and attachments
AS 2578 – 2009	Traffic signal controllers
AS 2700 – 2011	Colour standards for general purposes
AS 2445	Superceded by AS 1906
AS 2342 – 1992	To be incorporated into a new 2015 edition of AS 1743

5 THE ROLE OF PROFESSIONAL ORGANISATIONS

5.1 The Institution of Engineers, Australia

The Institution of Engineers, Australia (sometimes shortened to IEAust, and trading as Engineers Australia) has been actively involved in traffic engineering activities for many years. Early papers relevant to traffic engineering that appeared in the Journal of the Institution during the 1030s included those by Sherrard (1936, 1938), Irvine (1939), Rodan (1939) and Toyer (1940). Papers in the Journal in the mid-1940s included those by Darwin (1946), George (1946), Goodman (1947) and Spowart (1947). Until the advent of the Australian Road Research Board in 1960, the Institution was the main avenue for the presentation and/or publication of authoritative papers on the subject in Australia.

By 1988, the Institution had transport panels (or branches) in all of its divisions except Northern and Tasmania, and this is still the case. Papers relating to various aspects of traffic engineering could be presented to meetings of the transport panels, division meetings and the Institution's annual meeting, and published in the Institution's transport engineering, civil engineering and multidisciplinary engineering journals.

The Institution formed a National Committee on Transportation in 1973, which was renamed a National Committee on Transport in 1983. In 2012, the Institution's Civil College Board amended the status of this national committee to a working group of the Board which was given the task of researching the viability of creating a Transport Technical Committee. As a result, in late 2014, the Council of the Institution approved a proposal to create a Transport Technical Society to be known as Transport Australia. It is intended that this society will act as the home and forum for strategic transport issues of state and national significance. The Society was launched in May 2015 (Civil Engineers Australia 2015).

The technical journal called *Transport Engineering in Australia* first appeared in June 1995 (Vol.1, No.1). *The Civil Engineering Transactions* became the *Australian Journal of Civil Engineering* in 2003 (Vol.1, No.1) and, in the same year, the *Multi-disciplinary Transactions* became the *Australian Journal of Multi-disciplinary Engineering* (Vol.1, No.1).

The Institution produces a monthly magazine, *Engineers Australia*, which is published by Engineers Media, a wholly owned subsidiary of the Institution. Its *Civil Edition* reports on the latest news of interest to engineers and this may include matters relating to traffic engineering.

The Institution awards a Transport Medal, usually biannually, 'to reward and recognise outstanding contributions to transport in Australia'. Past recipients have included Professor WR Blunden (1989), Dr K Davidson (1991), Dr D Scrafton (1993), Dr M Lay (1995), A Sims (1997), K Dobinson (2003), Dr K Ogden (2004), Professor D Hensher (2006), Professor R Troutbeck (2008), Professor G Martin (2010), Professor B Indraratna (2011), and Professor M Taylor (2014).

5.2 The Institute of Transportation Engineers

The Institute of Traffic Engineers was founded in the USA in 1930. Its name was changed to the Institute of Transportation Engineers in 1976. The Australian Section of the Institute was created in 1971 in District 8 which covered the whole of the world outside the USA. In 1996, the Australian Section became the Australia and New Zealand Section (ITEANZ). and currently has about 200 members. In addition, there are many friends of ITEANZ who actively participate in its activities. There are currently over 1000 on its mailing list.

Regular seminars and events are held to keep members and friends informed on topical issues. There is also an annual President's Dinner and an annual Breakfast Meeting – mostly held in Melbourne. Road Safety conferences were held at VicRoads in 1995 and at the City of Darebin in 1999. Following the 1999 Conference, the ITEANZ President, W. Saggers, was invited as an international speaker at the 2000 ITE Annual Meeting held in Nashville, Tennessee.

A joint ITE and Australian Section International Symposium on Road Capacity was held in Sydney in 1994. A joint ITE District 8 and Australian Section Regional Conference on Environmentally Sustainable Transport was held in Melbourne in 1996.

In 2005, the ITE Annual Meeting was held in Melbourne. This was the first ITE Annual Meeting to be held in the southern hemisphere and only the second to be held outside the United States. Two Australians, A O'Brien and Daly were the co-chairs of the Arrangements Committee for this Meeting.

Presidents of the Australian Section and of the Australia New Zealand Section since 1988 have been A O'Brien (1987–88), N English (1989–90), G Giummarra (1991–92), D Bennett (1993–94), J Perone (1995–96), W Young (1997–98), W Saggers (1999–2000), P Daly (2001–02), P Hunkin (2003–06), D Przychodzki (2007–10), H McDonald (2011–12), D Hutchins (2012–14) and N Szwed 2014–15).

Australians who have served as District 8 directors on the International Board of the Institute have been A Fry (1987–1989), P Daly (2004–07), P Coombs (NZ) (2011–14) and D McKenzie (NZ) has been appointed to commence in this position on 1 January 2015. P Daly also represented District 8 on the ITE Co-ordinating Council for 2003–04, which co-ordinates the activities of the various ITE specialty councils.

Two Australians have been elected as honorary members of the Institute, namely E Barton (1998) and A O'Brien (2007). 'Election to honorary membership is the highest recognition of notable and outstanding professional achievement presented by the Institute'. Since the award was first made in 1933, only 80 members worldwide have been recognised in this manner.

The ITEANZ makes annual awards in each of six categories, namely Contribution to the Transport Profession (first awarded in 2004), Outstanding Service to the ITE (first made in 2004), Sustainable Transport (first made in 2013), Emerging Professional (first made in 2007), SIDRA Solutions Postgraduate (first made in 2014) and Student (first made in 2007). Winners of the Contribution to the Transport Profession Award have been A Sims (2004), Dr D Scrafton (2005), Dr K Ogden (2006), Professor G Currie (2007), Dr R Akcelik (2008), S Golding (2009), Dr M Lay (2010), Professor M Taylor (2011), Dr D Bennett (2012), Professor W Young (2013), and Professor D Hensher (2014). Winners of the Outstanding Service to the ITE Award have been J Perone (2004), A O'Brien (2005), L Dondonville (2007), E Barton (2007), R Dunn (2008), W Saggers (2009), P McCoombs (2010), J Carlisle (2011), A Fry (2012), P Daly (2013) and P Hunkin (2014). Prior to the establishment of these awards, certificate of commendation awards were presented to R Brindle and R Akcelik at the 1999 City of Darebin Road Safety Conference in recognition of 'an outstanding contribution to the advancement of the profession'.

Where appropriate, ITEANZ makes submissions to governments or other bodies about matters of concern to it, typical examples being:

- In 2014 a submission to the Victorian Government expressing concern about the high level of window tinting on front side car windows.
- In 2014 a submission to the Australian Department of Infrastructure and Regional Development in relation to a review of the Motor Vehicle Safety Act 1989.
- In 1999 a submission to a government enquiry into an airport transit link. The panel members, and later the Minister of Transport, expressed their appreciation of the objectivity of the ITEANZ submission. The government's subsequent decision reflected the ITE submission closely.

5.3 The Australasian College of Road Safety

The ACRS was established in 1988, initially as the Australian College of Road Safety, as an association for people and organisations working in road safety. In 2003, membership was expanded to include New Zealand and its name became the Australasian College of Road Safety. Membership of the ACRS includes both personal membership and corporate membership, comprising traffic engineers, epidemiologists, road trauma specialists, researchers, psychologists, driver trainers, enforcement agencies, policy makers, transport manufacturing industries, motoring organisations, insurance companies and others who have a stake in road safety. Members have a diverse range of knowledge and experience in various aspects of road safety, ranging from those who are highly specialised in particular areas, through those who are skilled general practitioners, to those with an interest (but no specialised training) in road safety.

The College has a range of activities to promote best practice in all facets of road safety, including conferences and seminars, state and territory chapter programs, workshops, joint conferences with related organisations, submissions to governments on road safety matters, and publication of a quarterly journal. The College holds an annual Australasian Road Safety Research, Policing and Education Conference, the first of which was held in 1990.

ACRS residents since the inception of the College have been E Montgomery (1988-1990), B Connor (1990–92), B Searles (1992–94), H Camkin (1994–96), L Palmer (1996–97), R Taylor (1997–99), P Waugh (1999–2001), Dr S Job (2001–02), Dr R Grzebieta (2002–06), K Fitzgerald (2006–07), Dr R Grzebieta (2007–08) and L McIntosh (2008–current).

The College has released a number of policy statements on various aspects of road safety. The current statements are as follows:

- *Safe Road Users*: Australian road laws, carriage of driver's licence, enforcement, alcohol, other drugs, fatigue, heavy-vehicle fatigue, young drivers, pedestrians, older road users, bicycle helmets, passenger restrictions and injury statistics.
- *Safe Roads and Roadsides*: audits, road safety barrier systems, and rural roads.
- *Safe Speeds*: speed management, 50 km/h general urban speed limit, and hypothecation of fines.
- *Safe Vehicles: air bags, bull-bars, daytime running lights, motorcycles,* roll-over crash worthiness, roll-over propensity, school buses, vehicle inspections, and fleet safety.

All these statements can be read on <http://acrs.org.au/about-us/policies>. During 2015 these policy statements are being reviewed and updated.

In February 2013, The National Health and Medical Research Council and the ACRS jointly hosted a workshop aimed at developing a national road safety research strategy, in line with the National Road Safety Strategy 2011–2020 and the United Nations Decade of Action for Road Safety. A report on the workshop was released in April 2013 and a draft National Road Safety Research Framework was released in June 2013 (NHMRC & ACRS 2013).

As appropriate, the College makes submissions to governments and inquiries, recent ones including:

- 2014: Submission to the Australian Road Safety Community in regard to boosting Australia's productivity and infrastructure standing through road trauma reduction
- 2013: Submission to the Productivity Commission's Inquiry into Public Infrastructure
- 2012: Submission to Safe Work Australia.

These submissions can be read on <http://acrs.org.au/publications/submissions>.

5.4 The Australian Institute of Traffic Planning and Management

The Institute caters for practitioners in traffic and transport planning and management. Members are involved in traffic engineering, planning, environmental sciences, social and behavioural sciences, law enforcement, education, insurance, administration and economics.

Membership is open to those who hold relevant formal academic qualifications and who are practising in traffic planning or management, or those who have had appropriate experience and are actively practising in the field. The Institute was founded in 1966. It currently has over 850 members across Australia and New Zealand. There are five state branches – in New South Wales, Queensland, South Australia, Victoria and Western Australia.

The Institute offers a comprehensive state-based and national events program that is available to members and to the broader traffic planning and management industry. The peak events program is an Annual National Conference. Regular forums and networking activities are held throughout the year in each of the state branches.

National presidents since 1988 have been F Gennaoui (1987–91), R Fleming (1992–93), B Hagan (1994–95), P Cook (1996–97), A Avent (1998–99), J Reid (2000–01), R Hanslip (2002–03), G Mason (2004–05), A Hulse (2006–07), J Bunker (2008–09), P Boube (2010–12), C Woolridge (2013) and J Stephens (2014).

The AITPM makes annual excellence awards in each of three categories, namely Traffic Engineering/Management, Transport Planning, and Transport and Land Use Modelling. An overall winner is selected from the three category winners and is awarded the Janet Brash Memorial Award for the most outstanding nomination across the three categories (AITPM 2014). The Janet Brash Memorial Award was created to honour the memory of Janet Brash, for her vision and leadership as a committee member, as vice-president and president of the Victorian Branch and as National Vice-president. The Janet Brash Memorial Award was first made in 2007. Winners have been C De Gruyter (2007), R Smith (2008), H Davis (2009), H Lansdell (2010), no award in 2011, J. Willbery, R Falconer and J Rawlins (2012), A. Lantzke and R Bruno, P van den Bos and S Beyer (2013) and H Le (2014).

Other awards that have been made since 1998 include an Outstanding Service Award and Scholars' Awards. In 2003 an Outstanding Achievement Award was made to Emeritus Professor WR Blunden.

In 2010 the AITPM, in partnership with Main Roads (WA) and the Institute of Public Works Engineers, Australia, undertook a feasibility study for the development of a Traffic and Transport Diploma. The course structure for the diploma received national recognition in 2013. Options for its implementation are now being considered.

Following a strategic planning day held in 2012, the AITPM produced a Strategic Plan 2013–2017. This document set out the Institute's vision and objectives and provided details of key activities for the next five years, including professional development, information collection and dissemination, industry sustainability leading the future and governance (AITPM, 2013).

6 THE ROLE OF SELECTED UNIVERSITIES

Over the years, many Australian universities have made significant contributions to the theory, practice and application of traffic engineering in Australia by conducting undergraduate, postgraduate and specialised short courses in traffic engineering and related topics, in research and consultancy, in professional society activities and in community involvement. For purposes of this section, six universities, all of which have been judged to have made substantial contributions to traffic engineering, have been selected in order to indicate the wide variety of contributions by universities. However, their selection should not be seen in any way as diminishing the contributions of the other universities.

6.1 The University of New South Wales

The University of New South Wales Injury Risk Management Research Centre (IRMRC) was established in 1999 as an independent research centre within the Faculty of Science in the University of NSW. It had strong collaborative and administrative links to the UNSW Faculties of Engineering and Medicine. Its funding partners were NSW Health, the Roads and Traffic Authority, the Motor Accidents Authority and the University of New South Wales. Its focus was on all injury prevention – not just transport and road safety. Professor R Grzebieta was appointed to the Chair of Road Safety at the IRMRC in 2007.

As a result of a restructuring of the Faculty of Science in 2009/2010 the Transport and Road Safety (TARS) Research Unit, a research group dedicated entirely to road and transport safety research, was established in 2010 within the School of Aviation in the Faculty of Science. The philosophy of the road and transport safety research focus at the TARS is the safe system principle, adopted by the Australian Transport Council in 2004 (ATC 2004). This requires a multi-disciplinary approach to road safety research and policy development, where researchers focus on safer roads, safer vehicles, safer speeds and safer people and their integration into a safe system. TARS research is structured around the essential disciplines needed for an effective transport and road research centre: safety policy and systems, psychology, human factors, engineering and crashworthiness, information technology systems, biomechanics, epidemiology and social sciences.

Professor Grzebieta's Chair of Road Safety ceased in June 2013, and in July 2013 he was reappointed as Professor of Road Safety in the TARS group. Professor A Williamson is the director of TARS.

In November 2014, two TARS researchers, Professor Grzebieta and Ms L Mooren, received special acknowledgement of their outstanding achievements in road safety by the Governor-General, Sir Peter Cosgrove, at the annual awards ceremony organised by the Australasian College of Road Safety.

A list of TARS research reports can be found at <http://tars.unsw.edu.au./publications>.

6.2 Queensland University of Technology

In 1990 Dr R Troutbeck joined the School of Civil Engineering as a senior lecturer with expertise in traffic engineering and road safety. Dr L Ferreira joined soon after as a senior lecturer with expertise in transport modelling and evaluation. Dr Troutbeck became Professor and Head of the School in 1993. Dr J Bunker joined the School in 2000 with expertise in traffic engineering and transport planning. Professor Troutbeck retired from the School in 2005 when it merged to become the School of Urban Development. Professor Ferreira moved to the University of Queensland in 2010. In 2010 the School of Urban Development became the School of Civil Engineering and the Built Environment. In 2011-12 Professor S Washington joined the School of Civil Engineering and Built Environment in a half-time appointment specialising in transport engineering and a half-time appointment with CARRS-Q (Centre for Accident Research and Road Safety – Queensland), while Professor J Bunker was appointed as the School's Transport Group Leader.

In 2010/11 Professor E Chung was appointed to establish the Smart Transport Research Centre (STRC) within the School of Urban Development. The STRC undertakes collaborative research to develop innovative technologies, services, products and policy solutions to combat congestion and to improve multimodal network operations. The Centre uses simulation, modelling and visualisation techniques to develop innovative solutions for better management of motorways and arterial roads. The research aims to provide accurate real-time and predictive traveller information to optimise network efficiency. A list of publications by the Centre can be found on <http://www.strc.com.au/researchpublications>.

The Transport Research Group (TRG) was established in 2012 in the Faculty of Science and Engineering, and has close associations with the Faculty of Health and the QUT Business School. The Group was initially led by Professor E Chung. Since 2012 it has been led by Professor J Bunker. Projects currently underway involve over 30 postgraduate students and has strong industry support, including from the Department of Transport and Main Roads. The Group has established a number of national and international links. The senior researchers associated with the TRG are Professor E Chung, Professor S Washington and Professor J Bunker. The TRG and the STRC have close working links with CARRS-Q.

The CARRS-Q is based in the School of Psychology, Faculty of Health, at the Queensland University of Technology in Brisbane and forms part of the Injury Prevention and Rehabilitation Domain of the Institute of Health and Biomedical Innovation ((IHBJ). The Centre was founded by Professor of Psychology M Sheehan in 1996 as a joint venture initiative of Motor Accident Insurance Commission (MIAC) and Queensland University of Technology (QUT) to undertake research and to deliver education programs to improve road safety and to reduce deaths and injury. Since 1998, Professor B Watson has been the Centre's Director.

The Centre conducts research under six themes. The themes and the theme leaders are as follows:

- Intelligent transport systems (Professor A Rakotonirainy).
- Occupational safety (Professor J Davey).
- Regulation and enforcement (Professor B Watson).
- Road safety infrastructure (Professor S. Washington).
- School and community injury prevention (Dr K Armstrong).
- Vulnerable road users (Professor N Haworth).
- The Centre offers graduate certificate/diploma programs in road safety, both campus based and by distance education, short courses in road safety and postgraduate research programs. It also focuses on outreach to, and engagement with, the community by presenting a variety of seminars, forums, workshops and special events.

In 2000 CARRS-Q and the Royal Automobile Club of Queensland jointly launched the Queensland Road Safety Awards. Since 2006, the awards have been supported by Queensland Transport and Main Roads and, since 2007, also by the Queensland Police Service. The awards recognise excellence in road safety programs implemented through community, school, industry, business, and state and local government initiatives.

The Centre has a state-of-the-art driving simulator, launched in March 2010, which incorporates a complete Holden Commodore vehicle with working controls and instruments. It has been part funded by the Australian Research Council, QUT, University of Queensland, Department of Transport and Main Roads, RACQ, MIAC and General Motors Holden. The simulator brings together researchers from disciplines including optometry, psychology, mathematics and road safety. It provides researchers with the opportunity to study driver behaviour in different driving conditions with a high degree of realism but free of crash risk.

In 2008 the Centre established the Queensland independent Survey Panel in Road Safety consisting of a random sample of households to assist in its research into preventing accidents and injury and to improving road safety.

For detailed information about CARRS-Q see the web site <http://wwvv.carrsq.qut.edu.au>.

6.3 University of Adelaide

There has been a traffic engineering and road safety presence at the University of Adelaide since the early 1960s. In 1963–64 the ARRB sponsored an in-depth investigation of traffic accidents in Adelaide (Robertson, McLean & Ryan 1966), initially in the Pathology Department. In the early 1960s, Professor Potts, Professor of Mathematics, pursued research into traffic flow at intersections (Grace & Potts 1962, Dunne & Potts 1964, Gazis & Potts 1966). In 1973 the Road Accident Research Unit (RARU) was established. In 2002 the RARU became the Centre for Automotive Safety Research (CASR). Professor J McLean was Director of RARU from 1973 to 2002, and Professor M Lydon has been Director of CASR since 2002.

CASR is focussed on conducting multidisciplinary research to understand how road crashes and the resulting injuries are caused, proposing and evaluating ways to prevent crashes and injuries, and providing independent professional advice on road safety matters to government and non-government organisations in Australia and overseas.

CASR's research investigations include (University of Adelaide 2010):

- The relationship between travelling speed and crash risk in urban and rural areas.
- In-depth crash investigations leading to a better understanding of crashes and injury mechanisms.
- Research tracking of new drivers which has demonstrated the rapid increase in driver competency in the first year of driving.
- Older driver research with a particular focus on the issue of self-regulation of driving behaviour.
- Research into vehicle design for pedestrian protection.
- Design, building and operating a pedestrian impact laboratory.
- In co-operation with the Royal Adelaide Hospital research has shown that pre-existing medical conditions play a far more significant role as contributors to crashes than previously thought.

CASR has entered into a long-term collaboration with INRETS (a French research laboratory) to work on pedestrian collision research using computer simulation of typical crashes. The researchers are interested in the ways that pedestrian simulation can be harnessed as part of the reconstruction of real pedestrian injury to provide some idea of the forces experienced by the pedestrian in the crash.

The CASR Impact Laboratory (Centre for Automotive Safety Research 2010) is a purpose-built facility used for conducting pedestrian subsystem testing. The laboratory is the official testing facility for the pedestrian component of the Australasian New Car Assessment Program (ANCAP), and is the only facility of its kind in Australia. It is equipped to assess the danger posed by the front of a vehicle to a pedestrian. The tests do not use full-scale crash test dummies as is done with studies on occupant protection. Instead, subsystems that represent separately the head, upper arm, and lower leg of a pedestrian are launched at the stationary vehicle.

CASR develops new road safety professionals, including supporting postgraduate research students, and is actively involved in providing road safety research training for countries in the region. It also plays a major role in promoting road safety in the South Australian community.

A complete list of CASR Research Reports can be found at <http://casr.adelaide.edu.au/publications/list>.

6.4 University of South Australia

A Unit for the Analysis of Transport Systems (UATS) at the University of South Australia was introduced in 1991 when Professor M Taylor joined the University as Professor and Head of Civil Engineering. In December 1994 the UATS became an entity in its own right, titled the Transport Systems Centre (TSC) and Professor Taylor was appointed its director. He remained as director until mid-2008 when the Centre merged with three other research centres, namely the Agricultural Machinery Research and Development Centre (AMRDC), the Centre for Industrial and Applied Mathematics (CIAM) and the Sustainable Energy Centre (SEC), to form a multidisciplinary research institute called the Institute for Sustainable Systems and Technologies (ISST). Professor Taylor was appointed the Director of ISST in late 2008. The transport and traffic engineering work of the TSC continued under the ISST umbrella, with the Centre as a recognisable unit within the ISST. Dr R Zito became the Director of TSC when Professor Taylor was appointed the director of ISST. In 2010 the ISST was renamed the Barbara Hardy Institute (BHI).

Professor Taylor retired in July 2012, and shortly afterwards the TSC left the BHI to operate as part of the School of Natural and Built Environment, reflecting the change in emphasis and research direction of the Institute after his retirement. In July 2014, Professor Zito was appointed as the foundation Professor of Civil Engineering at Flinders University, and a number of TSC researchers moved to Flinders University with him. As a result, the TSC now no longer exists at the University of South Australia. However, it is being reborn at Flinders University as the Flinders Centre for Transport Systems Engineering.

Traffic engineering activities at the TSC have included road safety engineering, especially road safety audit. In 1995, the TSC developed a training and accreditation course in road safety audit for Transport, South Australia, and continued to run and deliver this program up to 2014 (this task is now being handed over to CASR). Other activities have included traffic modelling, fuel data analysis tools in traffic engineering design, application of GPS and GIS in traffic studies and traffic analysis, methods and tools for extracting historical traffic volume and system performance from urban traffic control systems (such as SCATS), and intelligent transport systems.

6.5 Monash University

Monash University has been involved in transport studies since 1969 when a Transport Group was established within the Department of Civil Engineering under the leadership of Dr K Ogden. Since 1988, leaders of the Group have been W Young and G Rose (who operated as a partnership for parts or all of the years between 1998 and 2012) and M Sarvi (since 2013). Since its inception, this group has been engaged in fundamental, applied and industry-relevant research and education, covering topics such as land use/traffic interaction, freight movement, road safety, local area traffic management, parking policy and design, public transport, carpooling, traffic management and related matters. It runs undergraduate and graduate programs, a distance education program and short courses and workshops. Staff of the Transport Group are actively involved in consulting and in professional society activities. In addition, they have made substantial contributions to the literature, for example see Ogden (1992, 1994, 1996), Ogden and Bennett (editors) (1979, 1981, 1984, 1989), Ogden and Taylor (editors) (1996), Taylor and Young (1988) and Young (1991).

The books edited by Ogden and Bennett and by Ogden and Taylor presented a comprehensive up-to-date source of information on traffic engineering in Australia. They were written for the practising traffic engineer or traffic professional and had particular appeal to students because they deliberately emphasised the fundamentals and theoretical underpinnings of the subject matter. Ogden and Taylor (1996) contained a chapter headed *Traffic Engineering Folklore* by Taylor, Bennett and Ogden (1996), which sets out a summary of quick and easy approximations to traffic-related problems, design and management. Its content is based on the responses to an Australia-wide survey of existing folklore set out in an Appendix by Bennett (1989) in Ogden and Bennett (1989). The authors comment that the folklore should be used as a guide – but the appropriate standards and manuals should be referred to for final details.

The Institute of Transport Studies (ITS), an Australian Research Council Key Centre of Excellence of Teaching and Research in Transport Management, was established in 1995 as a joint venture between the Monash University Transport Group and The University of Sydney Institute of Transport

Studies (which had been established in 1991) within the Graduate School of Business. It operates as a two-node centre, the ITS-Monash node and the ITS-Sydney node. In 1998 ITS-Sydney relocated to the Faculty of Economics (now the University of Sydney Business School) and in 2005 it was renamed the Institute of Transport and Logistics Studies. The Key Centre continues to have integrated nodes at Monash University (ITS-Monash) and at the University of Sydney (ITLS-Sydney). The system-wide director of the Key Centre is Professor David Hensher, who is also director of the ITLS-Sydney node (University of Sydney 2013).

Leaders of the ITS-Monash node have been W Young and G Rose (who operated as a partnership for parts or all of the years between 1998 and 2012) and M Sarvi (since 2013). The Institute's aims are to progress transport knowledge and practice to contribute to prosperity and sustainability of industry and the wider community. Its areas of interest generally parallel those of the Transport Group. Monash University (2015) provides more details of the ITS-Monash Node and highlights its activities in research, education, industry and society engagement.

The Institute of Transport Studies (Monash) Ogden Transport Lecture is a free annual public lecture initiated in 2001 to recognise the key role which Ken Ogden played in the formation and development of the transport program at Monash University. The lecture reflects the commitment of ITS (Monash) to progress transport knowledge and practice through its activities which span education, research, community and professional services. For details of the lecturers since 2001 and their topics, see <http://eng.monash.edu.au/civil/research/centres/its/ogden-transp-lecture.html>.

The Monash University Accident Research Centre (MUARC) was established in l987. Professor P Vulcan was the founding director and he held the position until 1998. Directors who followed him were K Tingeall (1999 to 2002), I Johnston (2002 to 2007), R McClure (2008 to 2014) and M Stevenson (since 2014). MUARC's research, consultancy and training is conducted across six priority areas, namely behavioural science for transport safety; global engagement; human factors in transport systems in-depth crash investigations and transport regulation; statistical analysis and transport data systems and traffic engineering and vehicle safety. A listing of reports and papers prepared by MUARC staff can be found at Monash University (2014).

In 2009, MUARC established an ongoing research partnership with Western Australia's Curtin University. The Curtain – Monash Accident Research Centre (C-MUARC), which is supported by the government of Western Australia, provides research expertise specific to that state's needs (see Section 6.6 below).

In 2012 MUARC, in partnership with the University of Adelaide's Centre for Automotive Safety Research and the Melbourne Business School, launched an innovative Road Safety Management Leadership Program designed to develop and nurture leaders tasked with achieving improvements in road safety performance over the coming decades.

6.6 Curtin University

The Curtin – Monash Accident Research Centre (C-MARC) is a road safety research centre that was established in 2009 with support from the government of Western Australia and in partnership with the Monash University Accident Research Centre to conduct research into the causes of road trauma in Western Australia, to identify new and evaluate, existing safety measures, and the prevention of injuries. The director of the Centre is Professor L Meuleners. The Centre has an active multidisciplinary research program carried out by scientists at either Curtin or Monash universities. Key disciplines include engineering, injury prevention, human factors, economics, public health, occupational safety, education and marketing, legal and regulation, enforcement, and technology.

A listing of research reports emanating from the Centre can be found at Curtin University (2014).

Also at Curtin University is the Curtin University Sustainable Policy (CUSP) Institute headed by Professor P Newman since 2008. Professor Newman's research interest is in sustainable cities with a focus on transport and land use, and while much of his work is more specifically related to sustainability rather than traffic engineering, some of it is particularly relevant, for instance the book *Sustainability and cities – overcoming automobile dependence* (Newman & Kenworthy 1999).

7 THE ROLE OF THE AUTOMOBILE ASSOCIATIONS

Over the years the automobile associations have actively promoted and given strong support to many traffic engineering and road safety initiatives, and have been represented on state and national committees associated with these types of activities. They have examined various traffic operations and safety problems and, where appropriate, have made recommendations to the relevant authorities on suitable corrective actions.

7.1 The Australian Automobile Association

The Australian Automobile Association (AAA) is the peak organisation representing Australia's motoring clubs, with a combined membership of 7 million Australians. It aims to represent and advance the interests of the constituent motoring clubs and their members to the Australian Government and other national and international bodies (AAA 2015a).

7.1.1 Budget Submissions

The AAA makes regular prebudget submissions to the government on behalf of itself and its constituent motoring clubs, typical of which is the 2015–2016 prebudget submission. This submission listed seven key priorities, of which five had direct relevance to traffic engineering, including road safety, namely (AAA 2015c):

- Stronger investment in infrastructure
- New approaches to road funding
- Increased focus on road safety
- Promotion of consumer awareness about safer vehicles
- Support for safer vehicles in the Asia-Pacific region.

Detailed discussion on each of these items is provided in AAA (2015c).

7.1.2 Australian Road Assessment Program (AusRAP)

AusRAP is a program ran by the Australian Automobile Association and the state and territory motoring clubs, with financial support from the federal government. AusRAP is part of the International Road Assessment Program (iRAP) to improve the safety of roads. AusRAP 's objectives are to (AAA, 2013):

- reduce deaths and injuries on Australia's roads by systematically assessing risk and
- identifying safety shortcomings that can be addressed with practical road improvement measures
- put risk assessment at the heart of strategic decisions on road improvements, crash protection and standards of road management.

The AAA began working towards the introduction of an AusRAP, similar to the EuroRAP in the early 1990s and, as the first step, it released a report on the national highways system (AAA 2002). This report linked fatal road crashes to specific sections of the national highways.

Metcalfe and Smith (2005) presented a progress report on the methodology and early results of the application of two AusRAP protocols (or measures), namely risk mapping, which assesses historical crash rates, and the road protection score, which assesses the inherent safety of roads. The paper firstly outlined some of the forces driving the development of AusRAP, including community perceptions about road safety and the scale of the problem in Australia. It then discussed the methodology used for the first AusRAP protocol, risk mapping, using results from Queensland as an illustration. Finally, it discussed early work on developing the second protocol, the road protection score.

Since then development work has proceeded and AusRAP now has four protocols for assessing the safety of roads, namely (AAA, 2013):

- Risk mapping - a measure of the real-life performance of a road network based on crashes that have actually occurred. These crashes are the result of factors related to driver behaviour, the vehicle and the safety of the road infrastructure.
- Performance Tracking - comparing two risk maps over time.
- Star ratings – measuring the inherent safety of a roads infrastructure, i.e. the degree to which built-in safety measures prevent crashes from occurring and reduce the severity of those crashes that do occur. Each road is assigned a star rating to indicate how safe the road is.
- Safer road investment plans – allow appropriate road safety improvements to be identified and costed to indicate how the road can be made safer.

The stated AAA policy position (AAA, 2013, p. 8) is that no highway should have less than a 3-star rating. It indicates that almost 40% of the total of 21 921 km of Australia's national highways are rated as 1-star or 2-star. The report goes on to indicate that countermeasures such as roadside barriers, central median barriers, shoulder rumble strips, skid resistance (on paved roads), protected turn lanes, additional lanes, clear roadside hazards and shoulder sealing could save about 36,000 lives and serious injuries over a twenty-year period. These benefits are estimated to be more than $16 billion over 20 years with a benefit cost ratio of 3.49, according to AAA (2013, p.).

7.1.3 Australasian New Car Assessment Program (ANCAP)

The Australian New Car Assessment Program began in 1993 and in about 2000 it was extended to include New Zealand, becoming the Australasian New Car Assessment Program. ANCAP is supported by the Australian and New Zealand motoring clubs, Australian federal, state and territory governments, the New Zealand government, the Victorian Transport Accident Commission, NRMA Insurance and the FIA Foundation (UK).

Through its star rating program, ANCAP provides consumers with independent and transparent advice and information on the level of occupant and pedestrian protection provided by new vehicles in the most common types of crashes. ANCAP safety ratings are determined based on a series of internationally recognised crash tests, with vehicles awarded an ANCAP safety rating of between one and five stars, indicating the level of safety provided in the event of a crash and their ability, through technology, to avoid a crash. Section 8.7 provides more detailed information on ANCAP, including the crash tests.

7.1.4 Benchmarking the Performance of the National Road Safety Strategy

The AAA regularly benchmarks the performance of the National Road Safety Strategy (NRSS) described in Section 8.2.1).The results for the year ending December 2014 are set out in *Benchmarking the performance of the national road strategy* (AAA 2015b). In summary, the national road toll for 2014 was 1153 deaths, a reduction of 34 deaths compared with 2013. The review indicates that, at this stage, Australia is on track to achieve one of the targets set under the NRSS 2011-2020 to reduce fatalities by 30 per cent by 2020. The AAA expresses concerns about vulnerable road users, with cyclists and motorcyclists currently on track to fall short of the NRSS fatality target. It is also concerned about the estimated 32,500 serious injuries incurred each year, and points out that, because the state and territory governments have no common definition of what constitutes a serious injury, it is difficult to monitor whether safety measures have had an effect on serious injuries.

The review also highlights the differences in the performance (in terms of the current fatality rate per 100,000 population) between the various states and territories, for the year 2014, as shown in the table below (AAA 2015b). The table indicates that, if the New South Wales fatality rate for 2014 could have been achieved by the other states and territories, 193 lives would have been saved nationally.

	2014 number of fatalities	2014 fatality rate per 100,000 pop.	Number of fatalities at 4.11 per 100,000 pop.	Potential lives saved
NSW	309	4.11	309	0
VIC	249	4.26	240	9
QLD	223	4.72	194	29
SA	107	6.35	69	38
WA	181	7.03	106	75
TAS	35	6.8	21	14
NT	39	15.91	10	29
ACT	10	2.59	10	0
National	1153	4.91	960	193

7.2 The State and Territory Associations

Over the years the state and territory automobile associations have:

- been strong advocates for the interests of their members and have actively promoted many traffic engineering and road safety measures at the three levels of government and, where appropriate, have made recommendations to the relevant authorities
- made submissions on traffic engineering and road safety issues to various Inquiries
- made regular prebudget submissions to the state and national governments
- been represented on many national and state committees dealing with various aspects of traffic engineering and road safety matters
- along with the AAA, taken a lead role in AusRAP (Section 7.1.2)
- supported the ANCAP (Section 8.7)
- supported the Decade of Action for Road Safety (Section 8.6)
- supported the national and relevant state road safety strategies
- as appropriate, arranged or participated in relevant conferences or symposia
- been represented on, and actively participated in, the activities of various professional organisations such as the Australasian College of Road Safety, ITS Australia and others.

Some examples of reports, submissions and other activities by the various Associations are set out below.

7.2.1 National Road and Motorists' Association (NRMA)

Over the years, the NRMA has submitted reports or submissions to a number of national and state inquiries and partnered others in safety-related activities, typical examples being:

- A submission to the NSW coronial inquiry into the Grafton and Kempsey coach crashes (both in 1989).
- A submission to the Australian Government about making the Pacific Highway part of the national highway system (about 1993).
- A partnership with Questacon to develop an interactive travelling exhibition *Tomorrow's Drivers* aimed at children (about 1991).
- A partnership with Westmead Hospital to develop a road safety awareness program aimed at Year 11 and Year 12 students (about 2000).
- Established the NSW Safe Driving School, including the first full-scale driving simulator in Australia (2006).

A detailed list of reports and submissions since 2009 is available at <http://www.mynrma.com.au/about/reports-and-submissions.html>

Currently the NRMA is represented on the NSW Road Freight Industry Council and, from time to time, serves on government committees to review speed cameras, speed zones, highway safety, younger and older drivers and other road safety measures.

7.2.2 Royal Automobile Club of Queensland (RACQ)

The RACQ has submitted reports or submissions to a number of national and state inquiries relating to traffic engineering and road safety issues, typical examples being:

- A submission to Infrastructure Australia's National Land Freight Strategy (2011).
- A submission to the Queensland Government's draft *Moving freight: a plan for more efficient freight movement* (2013). This submission concludes that a major freight issue is safety, and the necessity to accommodate heavy vehicles at high speed, sharing the road with other motorists. It states further that this needs to be better understood and reflected in the strategy. Moving freight does not emphasise key aspects of safety.
- A submission to the Queensland Government's speed limit review (2013).

The RACQ is represented on a number of state committees including The Traffic Management Alliance Group and the Safer Roads, Safer Queensland Forum. It is also represented on the Black Spot Program Committee.

7.2.3 Royal Automobile Association (RAA) (South Australia)

Key publications by the RAA have included:

- Living with the Motor Car – Road Safety (2001).
- Backwater to Benchmark – RAA's Vision for South Australia's Roads (2005).
- Towards 2020. RAA's Vision for South Australia's Roads (2009).
- Metropolitan Travel Times – Annual report of the performance of key metropolitan travel routes.

Key submissions by the RAA have included:

- Graduated licensing scheme initiatives to protect young drivers (2011)
- Motorcycle licensing proposals to protect motorcyclists (2012)
- South-eastern freeway heavy vehicle safety (2014).

The RAA has sponsored research at the University of South Australia into older drivers and road safety, and at the University of Adelaide (CASR) into pedestrian safety in vehicle crashes.

The RAA is represented on various national and state committees including:

- The Australian Road Rules Implementation Committee
- The Australian Standards Committee – Child Restraints, Part 3 Traffic Control and Part 4 Speed Limits
- Australian New Car Assessment Program
- Australia's Best Cars – Chief Judge
- Road Safety Consultative Committee - Seat Belts and Child Restraint Task Force.
- Australian Road Assessment Program (AusRAP)
- The South Australian Consultative Black Spot Committee

- A key stakeholder involved in the development of the South Australian Government's Integrated Transport and Land Use Plan.

7.2.4 The Royal Automobile Club of Tasmania (RACT)

The RACT plays an important role in actively advocating, on behalf of its members, traffic engineering and road safety initiatives at the three levels of government in Tasmania. It regularly makes public statements on these matters.

RACT has a close co-operative relationship with the RAA of SA, and it also draws on the expertise of the other state automobile associations as appropriate.

Over a period of 27 years, the RACT was well served by DJ Ling who was appointed to its staff in 1981, predominately in a traffic engineering position. Later he was promoted to the position of Chief Engineer, a position that he held until his retirement in 2008. He was very well respected and his views were regularly sought by community groups and by Tasmanian government agencies on current traffic engineering and safety issues.

7.2.5 Royal Automobile Club of Victoria (RACV)

The RACV plays a strong advocacy role on behalf of its members. Its Directions 2015 (RACV 2015) outlines the issues that are important to its members in the areas of mobility, safety and affordability. It details the policy positions and the advocacy, education and information programs that have been developed to address these issues. Three key issues have been identified, namely: a better integrated transport system, a safer transport system and a fairer deal for its members and the broader Victorian community.

The RACV regularly carries out, or sponsors, research and makes submissions relating to various aspects of its activities, typical examples (and for which more details are available on the RACV website) being:

- A report on speed and crash risk represents an expert opinion provided to the RACV by Professor Ezra Hauer, University of Toronto (RACV 2004).
- Eastern Professional Services Pty Ltd was commissioned by the RACV to investigate the potential involvement of fatigue in young driver crashes (RACV 2006).
- Response to the Victorian Government's discussion paper on iTransport (RACV 2010).
- Neuroscience Research Australia was commissioned by the RACV to determine the safety risk associated with placing children in child restraints close to airbag systems (RACV 2013a).
- The effectiveness of driver training/education as a road safety measure (RACV 2011). Also see RACV Driver Training Policy Position (RACV 2013b).
- Emerging vehicle safety technologies and their potential benefits in Australia (RACV 2014).

The RACV is represented on the following committees/groups that deal with traffic engineering and road safety matters:

- Intelligent Transport Systems Australia – Brian Negus, GM Public Policy RACV is the president
- Chair of the AusRAP Technical Working Group
- Member of the Roads Australia, Congestion Chapter – road user charging is the key issue
- Observer on the Global Technical Committee for the International Road Assessment Program
- Member of the Motorcycle Advisory Group to VicRoads
- Member of the Infrastructure Reference Panel advising the Minister for Roads and Road Safety
- Member of the Cycling Reference Group to the Department of Transport, Planning and Local Infrastructure

- Member of the Speed Limits Advisory Group to VicRoads
- Member of the Road Safety Camera Commissioner Reference Group
- Member of the Road Freight Advisory Council
- Member of the Federal Blackspot Program consultative committee for Victoria
- Alliance for the Victorian Community Road Safety Partnership Committee.

Each year since 1983 the RACV has awarded a scholarship, the RACV Sir Edmund Herring Memorial Scholarship, to help prevent road trauma and to improve the quality of care of the victims of road trauma. Sir Edmund Herring was a Lieutenant-Governor of Victoria and patron of the RACV for 14 years.

7.2.6 Royal Automobile Club of Western Australia (RAC WA)

The RAC regularly carries out, or sponsors, research and makes submissions relating to its traffic engineering and road safety activities, typical examples (and for which more details are available on the RAC website) being:

- Submission on Regional Roads Rescue Program (2009)
- A joint submission by RAC and the WA Police on fatal and serious injuries on WA roads (2011)
- A discussion paper on Road Safety Reform (2012)
- RAC response to the Main Roads WA Intelligent Transport Systems Master Plan (2014)
- Traffic signals safety and efficiency. Transport analysis report prepared by Aurecon Australia for the RAC WA (RAC WA 2013)
- Response to the Review of Road Safety Governance in Western Australia (2014)
- RAC Ageing and Driving Survey (2015).

The RAC is represented on the following groups/committees that deal with traffic engineering and road safety matters:

- Road Safety Council WA
- WA Bicycle Network Plan Implementation Reference Group
- Motorcycle Safety Advisory Group
- Vulnerable Road Users Group
- Safer Roads Committee
- Federal Black Spot Committee
- Vehicle Safety Research Group
- Regional Integrated Transport Strategy Implementation Advisory Group
- Main Roads Cycling and Pedestrian Advisory Group.

7.2.7 Automobile Association of the Northern Territory (AANT)

The AANT has been proactive in advocating better roads and road safety initiatives, particularly given the high fatality rate per 100,000 population compared with the rest of the country (Section 7.1.4), and the over-representation of indigenous drivers. Drink-driving has also been an issue of concern. The AANT does not employ a specialist traffic engineer nor does it normally use consultants.

In the past, the AANT has received significant support from the RAA (SA) as detailed in a book on the history of the RAA (Nicol 2003), which was produced on the occasion of its centenary. In recent years the AANT has tended to take more direct control of its advocacy activities.

The AANT has an active representative on the Local Government Association of the Northern Territory Road Safety Black Spot Committee.

8 ROAD SAFETY

8.1 An Overview

As early as 1936 Sherrard (1936) wrote about the need to consider the road, the vehicle and the driver in road safety. Other Australians who wrote on road safety included Irvine (1939), Toyer (1940) and Darwin (1946). By the late 1940s/early1950s a number of studies of road user behaviour and characteristics and vehicle performance and geometric characteristics were being carried out, and it was well accepted that ‘it is fundamental that the planning, design, construction maintenance and operation of road facilities be based on the behaviour of all road users and their realistic expectations, and on the performance and geometric characteristics of road vehicles’ (Underwood 1956).

Until about the mid to late 1980s, there was steadily increasing interest in, and concern for, road safety, when ground breaking work by Trinca et al. (1988) put forward an overall approach to tackling the road toll by considering exposure control, crash prevention, behaviour modifications, injury control and post-crash injury management. This work won the authors the Volvo International Traffic Safety Award in 1988.

In the latter half of the 1990s, the concepts of Vision Zero and Sustainable Safety were introduced. In October 1997, the Swedish Parliament passed a road traffic safety bill based on the concept of Vision Zero. The fundamental approach of Vision Zero is that it is not acceptable that people are killed or seriously injured in road crashes. Its long-term goal is that no-one will be killed or seriously injured on the Swedish road system (SNRA 1999, Fildes 2001, Tingvall 1998, Tingvall & Haworth 1999). The Netherlands adopted the concept of Sustainable Safety to reduce the probability of crashes and, in addition when they occur, to reduce their severity so that serious injury is virtually excluded (IRSR 2002). It will be noted that neither concepts aims to eliminate all crashes. Rather they accept that some crashes will occur, but they attempt to limit the energy transfer to the human body in the event of a crash to a level that does not threaten life or long-term health. Thus, they attempt to eliminate all deaths and serious injuries, but not all *minor* injuries.

The concept of the safe system approach evolved from the Vision Zero and the Sustainable Safety concepts outlined above. This concept, illustrated in Figure 8.1, emphasises the way different elements of the road transport system combine and interact with human behaviour to produce an overall effect on total road trauma (Howard 2004). A key principle of this concept is that, while road users still have a responsibility for safe behaviour, there must be a greater emphasis on road designers and operators and vehicle makers building safeguards into the system to eliminate deaths and serious injuries (Rechnitzer & Grzebieta 1999, Grzebieta & Rechnitzer 2001 and Mooren et al. 2011). Incidentally, Grzebieta and Rechnitzner won the Institution of Engineers, Australia 2003 Warren Medal for their 1999 and 2001 papers.

In 2011–12, an Adelaide Thinker in Residence, Professor F Wegman (Managing Director, SWOV Institute for Road Safety Research, Netherlands) prepared a report *Driving down the road toll: building a safer system* (Wegman 2012*)* in which he made a series of recommendations on specific safety initiatives for applying safe system principles in South Australia. Basically his recommendations were an input to South Australia’s Road Safety Strategy 2020 and complement the National Road Safety Strategy 2011 to 2020.

The safe system approach was adopted by the Australian Transport Council in 2004 and included in its National Road Safety Action Plan 2005 and 2006 (ATC 2004). It is now the foundation for successive national road safety strategies and for the state and territory strategies.

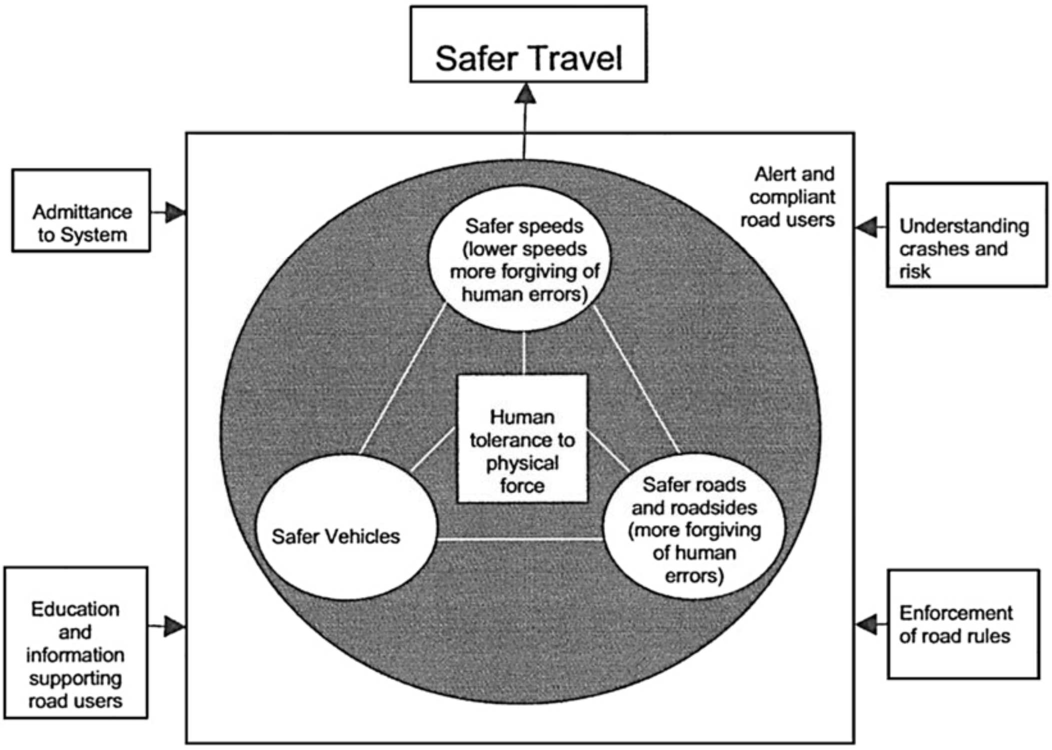

Figure 8.1: The Safe System Framework

Source. *ATC (2004), p.13*

Eric Howard, who was General Manager Road Safety at VicRoads for seven years from 1998, had a significant role in introducing and implementing the safe system concept in Australia and overseas. He was the Chair of a working group of the Joint Transport Research Committee of the OECD/International Transport Forum that produced a report titled *Towards zero: Ambitious road safety targets and the safe system approach* (OECD 2008). The report examined recent developments and initiatives in OECD and International Transport Forum countries to meet increasingly ambitious road safety targets. It highlights the institutional management changes required in many countries, builds the case for implementing effective interventions through a strong focus on results and builds the economic case for road safety investment (OECD 2008). Howard was also the team leader and principal author for the preparation of the Global Road Safety Partnership *Speed management manual* (GRSP 2008).

In Australia, the 1990s saw the introduction of road safety strategies at national, state and local government levels, and the introduction of road safety audits. These and other road safety considerations are outlined below.

8.2 National Road Safety Strategies (NRSS)

8.2.1 The First NRSS 1992 to 2000

Australia's first National Road Strategy for the period 1992 to 2000 (ATC 1992) was endorsed by all federal, state and territory ministers in April I992. It was a very significant document that provided a framework for Australia-wide collaboration on road safety action and has proved to be a sound base for national, state, territory and local government strategies since.

The fundamental aim of the strategy was stated to be ‘to save lives and reduce serious injury and loss of quality of life resulting from road crashes’ (ATC 1992). Its overall goals were maximum reductions in road deaths and serious injuries before the year 2001, Australia taking advantage of major developments in technology that would help reduce the frequency and severity of road crashes in the early part of the 21st century and ensuring that, by the turn of the century, road user behaviour would be improved throughout the community. Key priorities were identified as alcohol and drug abuse, speeding, protection of vehicle occupants, driver fatigue, road hazards, heavy vehicles, novice drivers and riders, and improved trauma management.

Eight strategic objectives were listed, namely:

- major stakeholder ownership and participation in road safety
- road safety as a major public health issue
- road safety as a major economic strategy
- road safety as a priority in the management of transport and land use
- safer vehicles, safer roads and safer road users
- integrated framework for road safety planning and action
- strategic research and development program
- rationalisation of federal, state and territory programs.

Strategies and outcomes for each of these strategic objectives were summarised. The strategy indicated that it aims to keep road trauma below current levels despite an expected 18% increase in population and a 25% increase in road travel by the year 2001. It did not specify any specific target, but stated that formal national targets would be resolved by stakeholders setting their individual strategies. It noted that Victoria and New South Wales had already formally set goals of 30% and 25% reductions in the road toll respectively.

8.2.2 The Second NRSS 2001 to 2010

Australia's second National Road Safety Strategy 200 l to 2010 (ATC 2000a) stated its vision as safe road use for the whole community. It listed the following principles behind the formation of the strategy:

- The road toll should not be accepted as inevitable.
- The priority given to road safety should reflect the high value that the community places on the preservation of human life and the prevention of serious injury.
- The community, in turn, has an essential role in the development of positive approaches to safe road use, a role that requires its widespread support and participation.
- There is a balance to be struck between furthering many legitimate community objectives and increasing exposure to the risk of road trauma.
- The Road Safety Strategy seeks to realise these community objectives by making travel safer. Recognising that safety must be integrated with other legitimate community objectives, all safety measures that can be justified in terms of overall community benefits should be implemented.

The strategy stated that its target was to reduce the number of road fatalities by 40%, from 9.3 persons per 100,000 population in 1999 to no more than 5.6 persons per 100,000 population in 2010. It listed eight strategic objectives, namely:

- improve road user behaviour
- improve the safety of roads
- improve vehicle compatibility and vehicle protection
- use new technology to reduce human error
- improve equity among road users
- improve trauma, medical and retrieval services

- improve road safety policy and program, through research of safety outcomes
- encourage alternatives to motor vehicle use.

In accordance with the strategy, a series of two-year action plans (ATC 2000b, ATC 2002, ATC 2004, ATC 2006, ATC 2008) were issued progressively, to address each of the strategic objectives that would be developed. The third action plan for 2005 and 2006 (ATC 2004) highlighted the safe system concept, shown in Fig.8.1, as an overarching framework for road safety intervention. It emphasised the way different elements of the road transport system combine and interact with human behaviour to produce an overall effect on total road trauma. It also indicated that this approach was not new, as it was implied in the structure of the national strategy.

In fact, the target of a 40 % reduction in the number of road fatalities per 100,000 population over the decade was not achieved. Instead a reduction of 34% to 6.1 persons per 100,000 population (which was still a significant reduction) was achieved.

8.2.3 The Third NRSS 2011 to 2020

Australia's third National Road Safety Strategy 2011 to 2020 (ATC 2011) stated its vision as being that 'no people should be killed or seriously injured on Australia's roads'. The strategy is based on the safe system approach and specifies a range of specific road safety actions and interventions in each of the four cornerstone areas of safe roads, safe speeds, safe vehicles and safe people. These actions and interventions are set out in Chapters 5 to 9 of the strategy. The target is to reduce the annual number of fatalities by at least 30%, and to reduce the annual number of serious injuries by at least 30%, by 2020.

The NRSS indicated that the Strategy would be reviewed in 2014. The review was carried out by Austroads in accordance with terms of reference approved by transport ministers. It was largely informed by an independent study carried out by the Centre for Automotive Research (CASR). This included a review of recent research literature, collation and analysis of a range of data, and discussions with key road safety stakeholders (Lydon et al. 2015b).

The main findings of the review included:

- Good statistical progress was made in the first three years of the NRSS. The number of deaths in 2013 represented a 16.5% reduction relative to the strategy baseline period of 2008-10.
- Fatality trends were less positive for certain subgroups particularly cyclists, motorcyclists and older drivers.
- Progress in reducing serious injury numbers was difficult to determine because of the lack of reliable consistent non-fatal crash data nationally. Available hospital data provided some evidence that serious injury levels had no declined in line with the general downward trend in fatalities.
- Progress in implementing the specific road safety actions was varied, although there was evidence that most had progressed to some extent. Progress had been particularly strong in the vehicle safety area.
- The guiding vision, targets, key directions and safe system principles remain valid and appropriate for the 10-year period.

The main outcome of the review is the three-year Action Plan 2015–2017. It contains 19 actions in four areas of prioritising investment in infrastructure, improving the safety of the vehicle fleet, encouraging safer road use and advancing the safe system. It specifies how each action should be implemented and allocates responsibility for them. The Action Plan was endorsed by the Transport and Infrastructure Council in November 2014 (TIC 2014).

8.3 State and Territory Strategies

The Australian states and territories have each prepared a series of road safety strategies consistent with the national strategies, but also reflecting local imperatives. In general, these strategies set out the challenges and key issues in road safety, targets and actions to achieve the strategies, generally in accordance with the safe systems concepts. Mooren et al. (2011) have examined the slightly different approaches to adoption of the safe system concept in New South Wales, Victoria and Western Australia and have summarised challenges of its successful introduction.

Since many of the measures in the various state and territory strategies are similar to those in the national Strategy, and in order to avoid too much repetition, details of these measures are not summarised. However, all the strategies are listed below so that those desiring details can consult the original documents.

8.3.1 New South Wales

- *Road Safety 2000. The Strategic Plan for Road Safety in NSW 1990's and beyond.* Prepared by Roads and Traffic Authority (1991).
- *Road Safety 2000. Progress Report. The Plan for Road Safety in NSW, 1991 to 1994.* Prepared by Roads and Traffic Authority of New South Wales (1996).
- *Road Safety 2000. The Plan for Road Safety in NSW, 1995 to 2000.* Prepared by Roads and Traffic Authority of New South Wales (1995).
- *Road Safety 2010. Road Safety 2010. A Framework for Saving 2,000 lives by the Year 2010 in New South Wales.* Prepared by Roads and Traffic Authority of New South Wales (2000).
- *NSW Road Safety Strategy 2012–2021.* Prepared by NSW Centre for Road Safety and the NSW Road Safety Advisory Council. (2011).

8.3.2 Queensland

- *Queensland Road Safety Action Plan 1996*. Prepared by Queensland Government, Queensland Transport and Queensland Police.
- *Queensland Road Safety Action Plan 1997–1998*. Prepared by Queensland Government, Queensland Transport, Main Roads and Queensland Police.
- *Queensland Road Safety Action Plan 1998–1999*. Prepared by Queensland Government, Queensland Transport, Main Roads and Queensland Police.
- *Queensland Road Safely Action Plan 1999–2000.* Prepared by Queensland Government, Queensland Transport, Main Roads and Queensland Police.
- *Queensland Road Safety Action Plan 2000–2001.* Prepared by Queensland Government. Queensland Transport, Main Roads and Queensland Police.
- *Queensland Road Safety Action Plan 2002–2003.* Prepared by Queensland Government, Queensland Transport, Main Roads and Queensland Police.
- *Queensland Road Safety Strategy 2003.* Prepared by Road Safety Division, Queensland Transport.
- *Queensland Road Safety Action Plan 2004–2011. Safe4Life.* Prepared by Department of Transport and Main Roads Queensland.
- *Queensland Road Safety Action Plan 2013–2015.* Prepared by Department of Transport and Main Roads Queensland.

8.3.3 South Australia

- *A Strategic Plan for Road Safety in South Australia till the Year 2000.* Prepared by Government of South Australia (1995).
- *The South Australian Road Safety Strategy 2003–2010. Road Trauma. Facts and Figures.* Prepared by Government of South Australia (2003).

- *Towards Zero Together. South Australia's Road Safety Strategy 2020*. Prepared by Government of South Australia (2011).

8.3.4 Tasmania

- *Tasmanian Road Safety Strategy 2002–2006.* Prepared by Department of Infrastructure, Energy and Resources.
- *Our Safety, Our Future. Tasmanian Road Safety Strategy 2007–2016.* Prepared by Department of Infrastructure, Energy and Resources.

8.3.5 Victoria

- *Safely First: Victoria's Road Safety Strategy 1995–2000.* Prepared by VicRoads, Transport Accident Commission and Victoria Police.
- *Arrive Alive 2002–2007. Victoria's Road Safety Strategy.* Prepared by VicRoads, Transport Accident Commission, Victoria Police and Department of Justice.
- *Arrive Alive 2008–2017. Victoria's Road Safety Strategy.* Prepared by VicRoads, Transport Accident Commission, Victoria Police and Department of Justice.
- *Safe Roads for all Victorians. Victoria's Safe Roads Strategy 2013–2022.* Prepared by VicRoads, Transport Accident Commission, Victoria Police and Department of Justice (2012).
- *Safe Roads for all Victorians. Victoria's Road Safety Action Plan 2013–2016.* Prepared by VicRoads, Transport Accident Commission, Victoria Police and Department of Justice (2013).

8.3.6 Western Australia

- *Facing the Future. Road Safety Strategy 1997.* Main Roads, Western Australia.
- *Road Safety Strategy for Western Australia 2003–2007. Arriving Safely.* Prepared by Government of Western Australia and Road Safety Council.
- *Road Safety Strategy. To Reduce Road Trauma in Western Australia 2008–2020*. Prepared by Government of Western Australia and Road Safety Council (2009).

8.3.7 Australian Capital Territory

- *ACT Road Safety Strategy 1995–2001.* Prepared by ACT Urban Services.
- *Safety on the Roads in the 21st Century. ACT Road Safety Strategy 2001–2005.* Prepared by ACT Urban Services.
- *ACT Road Safety Strategy 2007–2010.* Prepared by ACT Territories and Municipal Services Directorate (2007).
- *Road Safely Strategy 2011–2020*. *Road Safety, Its Everyone's Responsibility.* Prepared by ACT Territories and Municipal Services Directorate (2011).

8.3.8 Northern Territory

- *Northern Territory Government and Road Safety Council. The Northern Territory Road Safety Strategy 2004–2010.* Northern Territory Government, Darwin, NT.
- *Road Safety Action Plan 2012–2014.* Prepared by the NT Road Safety Executive Group (2012).

8.4 Local Government Strategies

Local government road safety strategic plans should be prepared within the framework of the relevant national, state and territory road safety strategies, taking into account the local conditions. They should provide a framework for action, and set the context in which council officers and groups can take initiatives in the knowledge that they are all aiming at the same goals. They should set out a number of objectives and action plans focussing on achievable and effective low-cost programs that complement their normal community and works programs.

A Guide to Developing Council Road Safety Strategic Plans, published by the New South Wales Division of the Institute of Public Works Engineering Australia (de Rome 2006), provides a detailed discussion on the topic, including sections on an introduction, getting started, identifying road safety issues, consultation, developing the plan, production and completion, and revising/updating an existing road safety road safety strategic plan.

For a summary of objectives, action plans and basic steps in developing local road safety strategies, see Underwood (2003).

Many municipal councils throughout Australia have prepared strategic road safety plans for their area. Those desiring to see examples of such plans should consult the relevant council.

8.5 Road Safety Audits

A road safety audit is a formal examination of a future road or traffic project or an existing road, in which an independent, qualified team reports on the project's crash potential and safety performance (Austroads 2002).

Road safety audit had its origins in the United Kingdom in the 1980s, and in 1990 the Institution of Highways and Transportation published *Guidelines for the Safety Audit of Highways* (IHT 1990). These Guidelines were revised in 1996 (IHT 1996). In 1994, Austroads produced the first edition of its Road Safety Audit (Austroads 1994). Austroads conducted an International Road Safety Audit Forum in Melbourne in 1998 (Austroads 1998).

Austroads published a second edition of its *Road Safety Audit* in 2002 (Austroads 2002). This edition reflected the knowledge and experience gained since the publication of the first edition in 1994, including much of the material shared at the 1998 Forum, and other available information, such as for example writings by Jordan and Barton (1992), Ogden (1994) and Morgan (1996). In 2009, this 2002 document was revised and issued as *Guide to Road Safety Part 6. Road Safety Audit* (Austroads, 2009a). Since then, several of the relevant state authorities have produced guidelines for road safety audit, for example Main Roads Western Australia (2009) and Roads and Traffic Authority, New South Wales (2011).

8.6 Decade of Action for Road Safety 2011-2020

Each year, approximately 1.3 million people die on the world's roads and up to 50 million people sustain non-fatal injuries. In response, in March 2010 the United Nations (UN) Assembly proclaimed 2011–2020 as the Decade of Action for Road Safety. The Decade of Action was launched on 11 May 2011. The UN resolution called on all member states to set their own road casualty reduction targets and to implement road safety activities, particularly in the areas of road safety, management, road infrastructure, vehicle safety, road user behaviour, road safety education and post-crash response. These objectives are supported by the Global Plan for the Decade of Action, which provides for a Global Plan for the Decade of Action, based on safe system principles, with specific areas of activity being (Dept. of Infrastructure and Regional Development, 2011):

- building road safety management capacity
- improving the safety of road infrastructure and broader transport networks
- further developing the safety of vehicles
- enhancing the behaviour of road user
- improving post-crash care.

Australia's National Road Safety Strategy 2011-2020 is closely aligned to these areas.

As part of the 24th ARRB Conference in October 2010, a workshop was held in association with the Road Engineering Association of Asia and Australasia to provide background information on the Decade of Action, and to discuss how Australia could usefully contribute to this new initiative (Turner 2010).

Since the workshop had limited scope to address all the issues relating to global road safety, it suggested that further workshop events be held to more thoroughly explore them. As a result, ARRB decided to hold a follow-up round-table session in early 2011, involving peak road safety bodies, motoring clubs, road authorities and other key stakeholders. The round-table meeting was held in Parliament House, Canberra on 3 March 2011, initiated by ARRB Group and the Australasian College of Road Safety to:

- provide information on the Decade of Action
- help plan a co-ordinated response on how Australian organisations and agencies can contribute to regional and global road safety
- help plan an Australian launch of the Decade of Action on 11 May 2011.

The meeting unanimously supported the resolution that the Canberra Road Safety Round Table supports the Global Plan for the Decade of Action for Road Safety 2011–2020. The participants of the round table and the organisations they represent expressed concern at the high level of death and injury on the world's roads and acknowledged that road death and injury is preventable. The participants and their organisations undertook to seek ways to contribute to the Decade of Action in the Asia-Pacific region and globally in preventing millions of deaths and serious injuries. Turner, McIntosh and Ogden (2011) provide a detailed discussion on the round-table meeting.

In May 2014, a Decade of Action for Road Safety Policy and Donor forum was held in Melbourne. The forum followed the April 2014 resolution by the UN General Assembly that encourages governments to consider including road safety in the new global development roles. The forum brought together governments, non-government organisations, automobile clubs, and the private sector from across Australia and the Asia/Pacific, as well as global organisations, including the World Bank and World Health Organisation. The forum was hosted by RACV, and co-organised by the Australian Automobile Association, the Commission for Global Road Safety, Road Safety Fund and the FIA Foundation. The forum called for road safety to be included in the new post–2015 goals for global development.

8.7 Australasian New Car Assessment Program (ANCAP)

The Australian New Car Assessment Program began in 1993 and in about 2000 it was extended to include New Zealand and became the Australasian New Car Assessment Program. ANCAP provides consumers with independent and transparent advice and information on the level of occupant and pedestrian protection provided by new vehicles in the most common types of crashes through its star rating program.

ANCAP safety ratings are determined based on a series of internationally recognised crash tests, with vehicles awarded an ANCAP safety rating of between 1 and 5 stars, indicating the level of safety provide in the event of a crash and their ability, through technology, to avoid a crash. The ANCAP crash test program is supported by the Australian and New Zealand motoring clubs, Australian federal, state and territory governments, the New Zealand Government, the Victorian Transport Accident Commission, NRMA Insurance and the FIA Foundation (UK).

Crash testing of cars under ANCAP began in early 1993, and was based on the American program which began in 1979. During the second half of 1999 ANCAP adopted the test procedures and rating system used by the European New Car Assessment Program.

ANCAP buys and tests cars that are available to Australian and New Zealand consumers. Car manufacturers can examine the test cars before and after tests, and view the tests and results.

ANCAP uses a range of internationally recognised crash tests, undertaken by specialist independent laboratories. The tests include (ANCAP 2015):

- *Frontal offset test* simulates hitting another car of the same mass travelling at the same speed. In the test, 40% of the car on the driver's side initially makes contact with a crushable aluminium barrier at 64 km/h. The test car has two adult dummies in the front seat. The rear seat has an 18-month-old child dummy and a three-year- old child dummy, both in appropriate child restraints.
- *Side impact test* simulates two cars colliding at 90 degrees. It consists of running a 950 kg trolley onto the driver's side of the vehicle at 50 km/h. The trolley has a crushable aluminium face to simulate the front of another vehicle.
- *Pole impact test* simulates an accident in which a car collides with a fixed object, such as a tree or pole. In the test the car is propelled sideways at 29 km/h into a rigid pole lined up with the driver's head. The pole is relatively narrow resulting in major penetration into the side of the car.
- *Pedestrian test* simulates accidents in which a pedestrian is hit by an oncoming car. It is used to estimate head and leg injuries to child and adult pedestrians when struck by a test vehicle at 40 km/h.
- *Whiplash test* assesses likely head and neck injury resulting from a rear- impact crash. The car's seat is mounted on a test sled which propels forward to simulate a rear-end crash equivalent to a stationary car being struck at 32 km/h.

Each of the crash tests uses sophisticated test dummies to measure the risk of injury.

To simplify the crash test results and the pedestrian impact results, ANCAP assigns an occupant rating and a pedestrian rating in stars to each vehicle model tested.

ANCAP recommends that consumers buy only ANCAP 5-star rated vehicles.

From 2008, cars must be fitted with electronic stability control (ESC) to earn a 5-star rating, and from 2013:

- cars must be fitted with ESC
- 3-point seat belts for all forward facing seats
- head protecting technology (side airbags) for front seats
- seat belt reminders for front seats and electronic brake force distribution (EBD) as well as 3 additional safety assist technologies (SAT) such as automatic emergency braking (AEB)
- adaptive cruise control (ACC), and blind spot monitoring BSM) to earn a 5-star rating.

8.8 Australian Road Assessment Program (AusRAP)

AusRAP is a program run by the Australian Automobile Association (AAA) and the state and territory motoring clubs, with financial support from the Federal Government. AusRAP is part of the International Road Assessment Program (iRAP) to improve the safety of roads. AusRAP is discussed in detail in Section 7.1.2.

8.9 Overview of Road Safety Management

The overall objective of road safety management is to reduce the number and severity of road crashes, and the associated pain and suffering, on the road system by the adoption of a comprehensive road safety strategy and its implementation through the application of effective safety measures. An overview of road safety management is shown in Figure 8.2. An effective road safety management is discussed in detail in Underwood (2006) Chapter 3, and involves:

- a co-operative partnership between the responsible agency(s), the community and other relevant agencies
- an adequate database and resources

- a clear definition and understanding of the problem, including estimates (or predictions) of future conditions
- consideration of the key elements involved, namely safer road users, safer vehicles, safer roads and safer speeds, i.e. the safe system concept discussed earlier in this section
- an overall approach to tackling the problem by exposure control, crash prevention, behaviour modification, injury control and post-crash injury management
- consideration of alternative road safety strategies
- adoption of an overall road safety target
- defining strategic objectives and action areas to achieve the target
- adopting appropriate action plans
- implementation of the action plans
- monitoring and evaluation to demonstrate the effectiveness or otherwise of the implemented measures and any desirable changes to them.

ROAD SAFETY MANAGEMENT – AN OVERVIEW

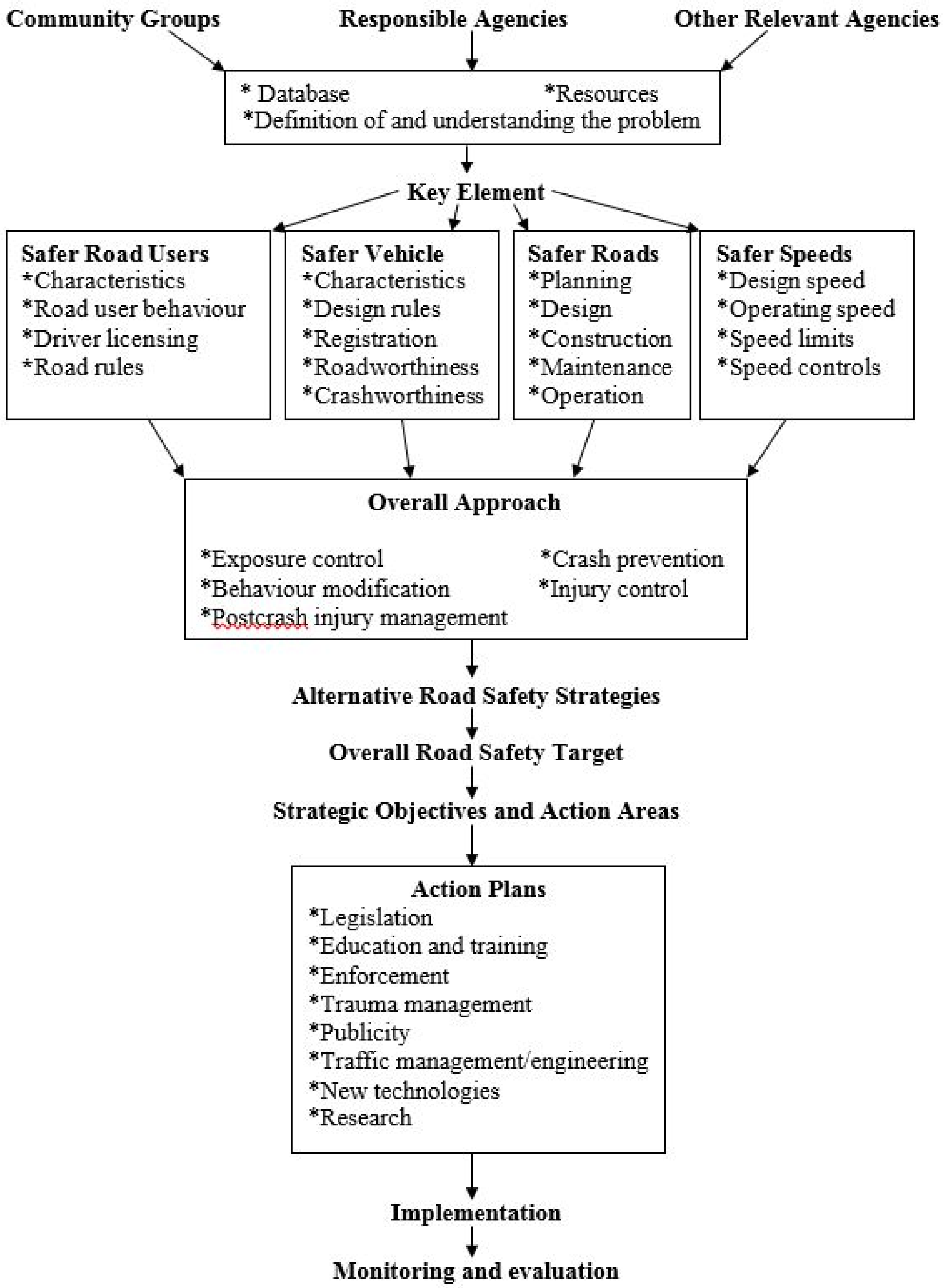

Figure 8.2: An overview of road safety management

Source: *Underwood (2006), p. 42, slightly amended*

9 TRAFFIC MANAGEMENT

Since 1988 traffic management principles and practices have continued to evolve in Australia. Some of the more significant developments relate to traffic management centres, speed management, road-rail level crossings, local area traffic management and safety provision for heavy vehicles, and these aspects are discussed below.

There have also been significant developments in traffic modelling including traffic generation, traffic assignment and estimation and prediction of future traffic demand. In recent times, these aspects and the justification for new major works and their environmental impacts have become quite controversial. These factors all impinge on traffic management, but perhaps they could be more appropriately considered to be in the transport planning area. While recognising their importance, this view has been adopted for present purposes, and they have not been considered in any detail in this report.

9.1 Traffic Management Centres

Computer based co-ordinated signal systems along selected arterial roads and area-wide were first introduced in Sydney in 1963 and in Surfers Paradise in 1969. In 1975 the SCATS (Sydney Co-ordinated Adaptive Traffic System) commenced in Sydney. Over the next several years the basic system, sometimes with local modifications, was adopted for use in other Australian cities.

Now there are computer-based traffic control systems in all of the Australian states, with the most extensive being in New South Wales, Queensland and Victoria. Basically these three systems, and those in South Australia (Adelaide) and Western Australia (Perth), all provide some or most of the following:

- detection and response to incidents, such as traffic signal faults, vehicle crashes, debris and spills, hazards reported by the public, natural disasters such as flood or fire
- monitoring and operation of intelligent transport systems including traffic signal co-ordination, automatic incident detection, freeway management, estimated travel times, variable speed limits, and road and freeway conditions
- maintaining communication with the public by means of appropriate signing, emergency telephones, radio, and surveillance cameras
- provision of traffic management services for major sporting, social and other special events
- means of responding to emergencies such as floods, bushfires and other potential disasters
- co-operation with public transport services to provide smooth and reliable services
- consideration of requests for road occupancy maintenance and other roadworks.

The NSW Traffic Management Centre (TMC) monitors and manages the state's road network 24 hours a day, 365 days of the year. Transport for NSW (2014a) provides detailed information on the Centre.

In Queensland, the Department of Transport and Main Roads (DTMR) traffic manages the state-controlled road system and, in addition, the Brisbane Metropolitan Transport Management Centre (BMTMC) is the principal transport management centre for south-east Queensland, acting on behalf of the DTMR and Brisbane City Council. DTMR (undated) provides information on traffic management in Queensland.

In Victoria, the Traffic Management Centre (TMC) operates 24 hours a day, every day of the year. Vicroads (2012a) provides details of the Vicroads TMC.

In Adelaide a Traffic Management Centre went into full-time operation in February 1998 and since then there have been progressive incremental changes as the Centre evolved and the extent of its coverage increased, and as new technology became available. For example, in 2008, STREAMS ® was adopted as the primary Intelligent Transport System (ITS) management tool.

In Perth, SCATS was introduced in 1983. CCTV for traffic monitoring was introduced on the Kwinana Freeway in 1996 and variable message signs (VMS), providing real-time traffic information and displaying average travel speeds for road sections ahead, were introduced on the Kwinana Freeway and Canning Highway in 1997. The Perth Traffic Operations Centre (TOC) commenced operation in March 2001, and provides a 24-hour /7-day service. The main function of the TOC is the utilisation of real-time traffic data to optimise traffic flows and minimise disruption on the metropolitan road network. This includes the provision of proactive responses to incidents and events and the co-ordination of all works on the road network. It also includes the development and provision of traffic communications to the travelling public as well as providing traffic signal priority to emergency services and heavy vehicle escorts. An Incident Response Service (IRS) operates on major CBD roads and sections of the Mitchell and Kwinana Freeways. An additional IRS vehicle provides a dedicated response to the Northbridge Tunnel. While the focus of the TOC is on the monitoring and management of traffic in the Perth metropolitan area, it also has a state-wide role and monitors traffic signals in regional centres across the state and manages CCTV and VMS in regional areas.

In Hobart peak-period weekday traffic flows are monitored and optimised through manual overrides at signalised intersections operating under SCATS. Operators have access to live cameras scattered across the road network. They also conduct live phone reports to radio stations. In Launceston, major traffic routes within the CBD are connected to SCATS.

In the ACT there is currently no traffic management control system, although the operation of traffic signals is currently managed through SCATS terminals. The ACT commissioned a consultant to undertake a scoping study of advanced traffic management systems using ITS technologies. The motivation behind this study was a desire to enhance the ACT's traffic management capabilities by exploring the role of advanced transport technologies in managing the road network and optimising the performance of existing road infrastructure. The Consultant's report included a summary of best practice in traffic management as follows (AECOM 2013):

- Network Management Systems: These systems aim to maximise the efficiency of existing infrastructure through better utilisation of existing road capacity. They rely on adaptive and dynamic system controls to analyse traffic conditions in real time and optimise network performance. Examples include adaptive traffic signal control, incident management, variable speed limits, demand responsive management, environmental traffic management, lane use control, ramp metering, ITS platforms, and road user charging.
- Travel and Traveller Information: The aim of these systems is to influence traveller behaviour in terms of route and mode choices. These systems provide pre-trip and en-route information and include broadcast congestion information and multimodal trip planning.
- Public Transport and Emergency Vehicle Priority: These include systems that provide priority to public transport and emergency vehicles through considerations in traffic signal design, in addition to provision of passenger information about estimated arrival times, schedules and delays to services. They include public transport priority, emergency vehicle priority, passenger information systems, public transport payment systems, and public transport security.
- Parking Management: These include systems that provide motorists with information about availability of parking spaces within a certain geographical area, or directions to the nearest available parking space. They also include parking payment systems and car park security systems.
- Road Safety and Enforcement: These include a variety of detection systems aimed at enhancing the safety of motorists and assisting police and road agencies with enforcement. They include red-light monitoring, speeding detection, dedicated lane enforcement and freight vehicle enforcement.

- Data Collection and Monitoring: These are the technologies used to collect data about traffic, weather and environmental conditions. They include traffic detection and sensing technologies, weather stations that can be linked to traffic control systems to provide fog detection and measure localised pollutant levels, communication systems that comprise the backbone of ITS applications, and variable message signs for display of incident information and other messages.

9.2 Speed Management

Speed management involves the speed zoning of roads and sections of roads according to their geometric standard, the natural and built environment and traffic conditions, providing traffic engineering measures to support the desired speed limit, educating the public about speed management principles and practice, and enforcing speed limits.

9.2.1 Speed Limits in Australia

The Australian states and territories use two default speed limits that apply automatically in the absence of posted speed restriction signage, namely 50 km/h in urban areas (except in the Northern Territory where 60 km/h applies) and100 km/h in rural areas (except in Western Australia and the Northern Territory where 110 km/h applies).

Typical school zone signings are:

- 40 km/h in New South Wales, the ACT and the Northern Territory
- 40 km/h or 60 km/h in Tasmania, Victoria and Western Australia depending on the speed limit on the approach roads
- 40 km/h, 60 k/h or 80 km/h in Queensland depending on the speed limit on the approach roads
- 25 km/h in South Australia on roads with a speed limit of 60 km/h or less on the approach roads. On roads where the normal speed limit is greater than 60 km/h, it is usual to use transitioned speed zoning to reduce the speed to 60 km/h prior to introducing the school speed zone of 25 km/h.

Other speed zones may be:

- 10 km/h or 20 km/h in shared zones where pedestrians and motor vehicles share the same space
- 20 km/h or 30 km/h in areas where special conditions are considered to exist, such as in areas of significant pedestrian activity or in parking areas
- 40 km/h in certain areas such as shopping centres or local residential areas
- 60 km/h for sub-arterial roads in otherwise 50 km/h default urban areas
- 60 km/h, 70 km/h, 80 km/h or 90 km/h on arterial roads in otherwise 50 km/h default areas
- 110 km/h on selected highways and freeways
- 130 km/h on most sections of the Stuart, Arnhem, Barkly and Victoria Highways in the Northern Territory
- No speed limit on a section of the Stuart Highway between Alice Springs and Tennant Creek currently being trialled (for details see Section 9.2.5 below).

9.2.2 Known Facts

- Speeds just 5 km/h above average in urban areas and 10 km/h above average in rural areas are sufficient to double the risk of a casualty crash (Kloeden, Ponte & McLean 2001 and Kloeden, McLean & Glonek 2002).

- Speed reductions in average speeds (even one or two per cent) result in substantially greater reductions in deaths and injuries (ATC 2008).
- The chances of surviving a crash decrease rapidly above certain impact speeds, depending on the nature of the collision (Austroads 2005, Oxley et al. 2004):
  - car/pedestrian: 20–30 km/h
  - car/motorcyclist: 20–30 km/h
  - car/tree or pole: 30–40 km/h
  - car/car (side impact): 50 km/h
  - car/car (head-on): 70 km/h
- Past improvements to speed enforcement have resulted in substantial reductions in deaths and injuries (Cameron et al. 2003a).
- Reducing speed limits can reduce deaths and injuries and reduce the severity of injuries (ACT 2008).
- There is evidence that advisory intelligent speed adaption systems can provide significant safety benefits (Austroads 2003).

9.2.3 Speed Enforcement

Speed enforcement is an essential part of speed management. It has two mechanisms, namely general deterrence and specific deterrence. General deterrence is a process of influencing a potential offender to avoid offending because of a fear of detection, whereas specific deterrence is a process of encouraging an apprehended offender to avoid re-offending because of the experience of detection and its consequences. Speed enforcement technology may be fixed (located at one particular spot) or mobile (portable and operated at any particular point for a short time only). It may be overt (where the enforcement sites are known) or covert (where they are unknown).

Speed enforcement may be by the use of mobile or fixed speed cameras, mobile radar speed detection devices in marked or unmarked cars, handheld laser speed detection devices, or point-to-point speed detection. Underwood (2006, Chapter 16) provides a general discussion on these matters.

Speed cameras were first introduced on a trial basis in Victoria in 1985, mobile radar speed detectors in 1994 and handheld laser speed detectors in 1996. Point-to- point speed detection was introduced in about 2005. Mobile speed cameras were introduced in Western Australia in 1988 and in New South Wales in 1991, and later in other jurisdictions.

Cameron et al (2003a) Cameron et al. (2003b), Delaney et al. (2003), Auditor-General, Victoria (2006, 2011) all provide specific information on the Monash University Accident Research Centre studies of speed enforcement in Victoria. Delaney et al. (2005) provides a discussion on the history and development of speed camera use in Australia, North America, Great Britain and Europe.

9.2.4 Review of Victoria’s Speed Enforcement Practice

In 2006 the Auditor-General, Victoria (2006) examined the effectiveness of the State’s speed enforcement practice. He concluded the following:

- The number of motorists speeding and the degree to which they speed had reduced over the previous five years and road trauma had also reduced.
- There was no evidence that the speed enforcement program was focussed on revenue raising.
- Speed cameras were being used at sites and times matching identified speed risks and crash histories, and sound quality assurance had been introduced to minimise errors in detecting speeding motorists.

- The program was aimed at deterring speeding across the whole network as well as at high risk sites, while demerit points were used to ensure that repeat offenders could lose their right to drive.
- Some changes were desirable to ensure that the effectiveness of the program was maintained.

In 2011 the Auditor-General, Victoria (2011) examined the State's road safety camera program. He concluded that the following:

- Road safety cameras improve road safety and reduce road trauma. The supporting technology used, and the way that the system operates, provide a high degree of confidence that infringements are issued only when there is clear evidence of speeding or red-light running.
- A strong body of research shows that road safety cameras improve the behaviour of road users and reduce speeding and road crashes.
- Revenue raising is demonstrably not the prime purpose of the program.
- The deployment and siting of fixed and mobile cameras is based on the road safety objectives of the program.
- The processes and controls in place provide a high level of confidence in the reliability and integrity of the system.
- There are aspects of the program that can be strengthened, and a number of appropriate recommendations were put forward.

Following this report, VicRoads made a number of changes to their speed zoning practice, (VicRoads 2012b) including:

- Simplifying speed zoning, including removal of 80 km/h buffer zones on the approaches to rural towns, reviewing the 90 km/h and 70 km/h speed limits on Victorian roads, and reviewing speed zones at locations identified by the community.
- Making speed limit signs easier to see and understand, including reducing sign clutter, removing or relocating regulatory speed limit signs that are close to advisory speed signs, and removing of 'end limit' signs and replacing them with regulatory speed limit signs.
- Developing guidelines for 40 km/h limits in pedestrian activity areas, including in the vicinity of schools, strip-shopping centres and residential streets.
- Helping road users to understand and comply with speed limits, including developing awareness campaigns to help Victorians understand how and why speed limits are set, and providing information at sites with unexpected speed limits.

VicRoads (2013a) sets out detailed information on current VicRoads speed zoning practice.

9.2.5 Speed Zoning Reviews

In ***New South Wales*** there have been a number of changes in speed zoning since 1988. *Speed Zoning Guidelines* were first produced in 1997, and since then have been regularly updated in 2003, 2009 and 2011. In the preparation of the 2009 and 2011 revisions, input was received from a number of independent bodies, including local councils, the NSW Police and the NRMA. Significant changes include the introduction of school zones from 2000, and the reduction and implementation of a general urban speed limit from 60 km/h to 50 km/h. In 2010, Roads and Maritime Services introduced the Safer Roads website which enabled the community to nominate roads for review and for the public to receive updates when speed limit changes are being implemented.

In ***Queensland,*** as the result of wide scale community consultation in 2013, to which over 3300 submissions were received, the Department of Transport and Main Roads (DTMR) identified 100 priority roads for speed limit reviews across the state. The submissions raised a number of speed related issues. The DTMR and local governments are carrying out the review and the results will be published on the Department's website as they become available. The reviews are being conducted in accordance with the *Manual of Uniform Traffic Control Devices* (DTMR 2015).

In ***South Australia*** the Department of Planning, Transport and Infrastructure, in collaboration with the Adelaide Hills Council and supported by the Royal Automobile Association (RAA), Motor Accident Commission (MAC) and the Centre for Automotive Safety Research (CASR), undertook a review of the speed limits in the Adelaide Hills Council area during 2014 in response to a higher number of requests for a speed limits review than in many other areas of the State in 2013. The review consisted of a technical assessment of sealed roads within the Council area and community engagement to seek a better understanding of community perceptions in regard to speed limits in the Adelaide Hills and to gain community input on how a consistent set of safe speed limits could be applied. As a part of the process a number of workshops were held, pertaining to township speed limits, rural speed limits, changing speed limits, signage including advisory speed limits, driver behaviour and enforcement, vulnerable road users (pedestrians and cyclists), and road maintenance and infrastructure. Kath Moore and Associates (2014) provides a detailed report on the review.

In ***Western Australia*** speed limits have been updated since 1988, most noticeably in accordance with the Road Traffic Code 2000, which was changed to reflect the Australian Road Rules. As a policy in Western Australia 's*peed zones and all associated speed signing will be provided in accordance with statutory requirements of the Road Traffic Code 2000, taking into consideration road safety, the expectations of drivers, adjacent land use, transport efficiency, information published by Australian Standards and subject to guideline conditions*' (Main Roads Western Australia, 2014d). In Western Australia speed zoning policy is managed centrally through Main Roads WA on all roads regardless of whether they are controlled by state or local Government.

In ***Tasmania*** an urban 50 km/h was adopted statewide in 2002 for local residential streets, with major collector roads remaining at 60 km/h. In 2012, in response to a government proposal to reduce the speed limit on rural roads from 100 km/h to 90 km/h, a legislative council select committee conducted a review of rural road speed limits and, as a result or this, the only change was to reduce the speed limit on rural unsealed roads to 80 km/h in 2014 (Parliament of Tasmania 2013).

In the ***Northern Territory*** open speed limits were abolished in 2006 and replaced with a 130 km/h limit. In 2014 a 12-month trial of replacing the 130 km/h limit with an open limit on a 200 km section of the Stuart Highway between Alice Springs and Tennant Creek was commenced. In early 2015 the Northern Territory Government decided to extend the trial section to a total length of 272 km and to extend the trial period, with the Department of Transport undertaking a review of the trial to determine its success and future viability (Northern Territory Government 2015).

9.3 Road–Rail Level Crossings

In Australia there are about 9500 road-rail level crossings. About 30% of them have 'active' protection (i.e. signals and/or boom gates which operate automatically when a train approaches) and about 65% have 'passive' protection (i.e. signs and/or pavement markings). In addition, there are numerous private and occupational level crossings and several grade separated crossings.

At an existing level crossing, several ways of improvement may be considered, namely:

- doing nothing
- closing the crossing
- improving signing and markings at, or on the approaches to, the level crossing
- improving visibility on the road and rail approaches to the crossing to give drivers adequate visibility of an approaching train, by removing sight obstructions
- realignment of the road approaches to the crossing to give drivers better visibility of an approaching train by improving the crossing angle at the crossing
- upgrading the form of protection, for example from signing and markings only to flashing lights and/or gates or boom barriers

- grade separating the crossing.

In 2003, the Australian Transport Council agreed to adopt the Australian Level Crossing Assessment Model (ALCAM) as an assessment tool to identify key potential risks at level crossings and to assist in prioritising railway level crossings according to their comparative safety risk. It is used to support a rigorous defensible process for decision- making for road and pedestrian level crossings, as well as a method to help determine the most cost-effective treatments. The model takes into account road and rail geometry, road and rail traffic volumes and speeds, visibility obstructions, sighting distance from road and rail at various positions, and the existing protection to determine an overall comparative risk score. RTA NSW (2010) provides comprehensive details of ALCAM. In addition to ALCAM risk ratings, individual hazard needs and stakeholder input should be considered when determining priorities.

9.3.1 National Railway Level Crossing Safety Strategy

In 2003 the Australian Transport Council adopted a National Railway Level Crossing Safety Strategy (ATC 2003) that set out a number of actions to be taken in the following key areas:

- train conspicuity
- car and truck driver responses
- pedestrian responses
- site assessment, prioritisation and treatment
- stakeholder education and information
- data collection
- funding
- railway industry involvement
- legislation, regulation and enforcement
- Co-ordination.

The National Railway Level Crossing Safety Strategy 2010–2020 (ATC 2009) builds on the 2003 National Railway Level Crossing Safety Strategy. It complements the National Road Safety Strategy (Section 8.2) and adopts the safe system view that recognises that it is not possible to prevent all incidents, but aims to prevent those that result in death and serious injury. Principles adopted to achieve this objective were:

- a safe system approach
- a shared responsibility using a co-operative approach
- engagement with industry, government, road and rail stakeholders and the community
- an evidence-based approach using existing information and building on research and international developments.

To achieve these principles, a number of opportunities were identified, namely:

- Create a nationally aligned approach to safety at railway level crossings.
- Address the lack of nationally available data relating to railway level crossings.
- Learn from road safety practices and apply these to railway level crossing safety management.
- Apply the safe system approach in the railway level crossing environment.

- Recognise the complexity of the ownership, responsibilities and management of railway level crossings thereby requiring stronger relationships between all levels of government, the road and rail industry, road and rail users and the community.
- Improve community understanding of the risks and the importance of compliance.
- Harness the potential of rapidly emerging new technologies applicable to railway level crossings.

The strategy identified six key areas of focus, and actions that must be taken in each focus area to reduce crashes and near misses at level crossings. These were:

- Safe system: To adopt and apply, in a railway level crossing control context, internationally recognised safety practices based on a safe system approach.
- Governance: To achieve nationally consistent and co-ordinated arrangements across jurisdictions, including sharing of good practice, and to identify opportunities to work together to achieve common aims and goals.
- Risk management: To understand and effectively manage risk at rail level crossings to evaluate, prioritise and inform the development of countermeasures and investment strategies.
- Technology: To examine and continue trialling new engineering and technological measures that alert or guide road users as safely as possible through railway level crossings, and ultimately to identify cost-effective means to reduce railway level crossing incidents.
- Education and enforcement: To use educational measures that generate awareness of level crossings, establish understanding of the required behaviour by road users at level crossings, and ensure through ongoing enforcement that road users always comply with level crossing controls.
- Data improvement and knowledge management: To capture incidents at rail level crossings in a nationally consistent manner that enables better understanding of the characteristics surrounding incidents.

9.3.2 States and Territories.

New South Wales

In New South Wales, the rail and road agencies are responsible for managing safety at level railway level crossings (Transport for NSW 2014b). State regulatory oversight is provided by the independent transport safety regulator, Roads and Maritime Services, and the NSW Police.

The Level Crossing Strategy Council (LCSC) is an agency that promotes co-ordination between agencies regarding level crossing safety. It consists of representatives from Transport for NSW, Roads and Maritime Services, Country Rail Infrastructure Authority, John Holland Rail, RailCorp, Australian Rail Track Corporation, Independent Transport Safety Regulator, Office of the National Rail Safety Regulator, NSW Police and local government. The LCSC is supported by a Level Crossing Working Group (LCWG). Transport for NSW provides secretarial support and assistance to both the LCSC and the LCWG, co-ordinates the implementation of the Level Crossing Improvement Program and manages the application of the Australian Level Crossing Assessment model in NSW.

Queensland

In Queensland, the Department of Transport and Main Roads has prepared the Queensland Level Crossings Safety Strategy 2012–2020 (DTMR 2012). This strategy complements the National Railway Level Crossing Safety Strategy 2010–2020. Its vision and aims are to eliminate level crossing collisions, to reduce the number of near misses at level crossings and to minimise the impact of any incidents that do occur. It sets out twelve key actions grouped under focus areas of people, vehicles and infrastructure and knowledge. (DTMR 2012).

A Queensland Level Crossings Safety Group, consisting of representatives of the state and local governments and industry, has been established to provide advice on level crossing strategies and to oversee a memorandum of understanding that defines management and funding, responsibilities of railway managers and road authorities at level crossings.

South Australia

The State Level Crossing Strategy Advisory Committee (SLCSAC) was established in 2003 to improve the co-ordination efforts between government agencies and key stakeholders in improving level crossing safety, and to act as an advisory body to the Minister for Road Safety. The committee has the long-term aim to develop recommendations for the Minister for Road Safety to reduce crash trauma at level crossings in South Australia. The committee produced a State Level Crossing Safety Strategy and Action Plan for 2010–2012 (Government of SA 2010), which aligns with the National Railway Level Crossing Safety Strategy 2010–2020.

Tasmania

In Tasmania a review of crashes at level crossings was carried out in 2013 to quantify the scale of the problem and to improve understanding of the circumstances surrounding these crashes (Howatson 2013). During the 10-year period 2003–2012 there were 36 reported crashes involving vehicles colliding with trains. It was concluded that, while the number of crashes was comparatively low, the rail and relevant road authorities need to continue to collaborate to maintain a high standard of traffic management at level crossings.

Victoria

In Victoria the road authorities and the rail infrastructure managers have a mutual obligation to jointly manage road/rail crossings. An overview of the roles and responsibilities of the various departments, agencies and stakeholder groups is set out in Table 11.1 of VicRoads (2014a).

The Victorian Railway Crossing Safety Steering Committee (VRCSSC) advises the Minister for Public Transport on policy directions, level crossing safety strategies and action plans and the management and standards for railway level crossings, oversees the state-funded level crossing upgrade program, and oversees the development and delivery of other statewide initiatives to improve rail level crossing safety. VRCSSC membership comprises Public Transport Victoria, VicTrack, VicRoads, Municipal Association of Victoria, Victoria Police, V/Line Passenger, Metro Trains Melbourne and Public Transport Safety Victoria.

A 2008 Victorian Parliamentary Road Safety Committee (VPRSC 2008) inquiry into improved safety at level crossings concluded that:

- Ideally, all crossings should either be grade separated or designed and maintained to recognised standards and equipped with flashing lights and boom barriers. However, because of cost, this is not feasible in rural areas where crossing use is low.
- One measure to improve safety at crossings is to introduce lower cost new and developing technologies. Accordingly, a priority should be to facilitate the introduction of reliable systems, including intelligent transport systems, that can warn drivers of approaching trains and assist them to comply with the road rules when approaching and using a crossing (See Section 10.2.4).
- Another priority should be the introduction of technology that supports enforcement of the road rules at level crossings and, in the longer term, the introduction of technologies that can actively control trains and vehicles as they approach level crossings should be facilitated.
- Two measures that could be introduced immediately are to close surplus crossings and to reduce the road speed limit on the approaches to level crossings.

Western Australia

In 1968 a Railway Crossing Protection Committee was appointed to undertake reviews of railway crossing protection requirements. In 1996 the commissioners of Main Roads and Railways agreed to restructure the roles and composition of the committee to allow for the separation of the strategic and policy areas of railway crossing protection from the operational areas. A Strategy and Policy Railway Crossing Protection Subcommittee and an Operational Railway Crossing Protection Subcommittee were formed. The purpose of the Strategy and Policy Subcommittee is to provide a forum for discussion of the state's level crossing protection program by representatives of state and local government, private railways and road users. The purpose of the operational subcommittee is to co-ordinate the day-to-day operational roles for all parties involved in the management of railway crossing protection in WA. MRWA (2005) sets out details of the roles and operations of these two subcommittees.

In Western Australia, a policy and guidelines for railway crossing protection was first prepared in1968, and updated in 1980, 1992 and 1998. The latest version (MRWA 2005) has been prepared by Main Roads Western Australia and endorsed by the Railway Crossing Protection Committee. Matters concerning policy were reviewed and recommended by the Strategy and Policy Railway Crossing Protection Subcommittee, with the Operational Railway Crossing Protection Subcommittee endorsing the technical content.

Northern Territory

Prior to the building of the Alice Springs to Darwin railway line in 2000 there were 44 level crossings in the NT. With the completion of the Alice Springs to Darwin line there are now a total of 229 level crossings, of which 31 are active (i.e. fitted with train-activated devices such as flashing lights or bells and boom barriers that warn of approaching trains) and the remainder are passive (i.e. constant and stationary signs that warn of the possibility of an approaching train). Following two significant level crossing crashes in 2006, the Chief Minister announced measures to address level crossing safety in the NT, including an assessment of all level crossings in the NT (DPINT 2007). The assessment was carried out using the Australian Level Crossing Model (ALCAM), and has been the basis of a number of improvements to level crossings since.

9.4 Local Area Traffic Management

The purpose of local area traffic management (LATM) or traffic calming is to control the movement and speed of traffic in residential areas (or local area traffic precincts) to discourage through traffic, to minimise accidents and to improve the level of environmental amenity. It involves the use of various techniques such as road closures, reduced pavement width or slow points, traffic islands, one-way streets, local speed limits, road humps and the like.

The concept that the environmental amenity of local areas could be protected against the adverse effects of motor traffic by measures designed to prevent the entry of extraneous traffic, and to reorganise internal traffic to reduce its effects, was put forward in a report on the long-term effects of motor traffic on British cities by Professor Buchanan (1963). In Australia, by about the mid-1970s, starting with *Streets for living* (Coleman 1978), ARRB developed and actively promoted an approach based on the philosophy that suburban streets were 'places to be and not traffic arteries' and 'road function was redefined to reflect the needs of non-motorists as well as traffic movement' (Sharp et al. 2011).

As a result, ARRB became involved in programs that led to the development and expansion of LATM in Australia, e.g. Brindle (1996a) reported on 27 contributions to the art and practice of traffic calming from 1979 to 1992. Also, during the late 1970s, work conducted by ARRB examined the road crash problem in local areas and promoted a range of ways in which speed and traffic flow could be reduced. The earliest speed management device to be researched and tested was the road hump, resulting in guidelines for its use in Australian conditions (Jarvis 1980).

During the 1980s, various contributions relating to LATM appeared (Brindle 1983, Brindle & Sharp 1983, Daff 1989, Hawley & Gennaoui 1984, Newton, Taylor & Sharp 1988, Pak-Poy & Kneebone 1987 and Tonkin & Associates 1985). In 1988, NAASRA produced Part 10 of its *Guide to traffic engineering practice*, titled *Local area traffic management (NAASRA 1988)*.

By the end of the 1980s, ARRB's active research program, supported by its local government committee and some local government engineers, and contributions to the literature, such as those examples listed above, led to the development and implementation of LATM schemes. As a result of the increasing experience and increasing knowledge of LATM, the procedure for developing LATM schemes (including assessment of need, definition of road classification and local area precincts, the preparation of a study plan, the setting of objectives, development of alternative schemes, selection of a preferred scheme, detailed design, implementation, and monitoring and evaluation), techniques for use in LATM (physical traffic control devices, regulatory traffic control devices and land use and streetscape measures) and principles of design of LATM devices were being enunciated(Underwood 1990).

The development and increasing knowledge and use of LATM continued through the 1990s (Brindle 1996b, O'Brien 1996) and beyond. As the result of increasing experience, Part 10 of the NAASRA *Guide to traffic engineering practice* (1988) was revised and updated in 2008 as *Part 8. Local area traffic management* of the Austroads *Guide to traffic management* (Austroads 2008a).

In 1991, Standards Australia published its *Manual of uniform traffic control devices. Part 13. Local area traffic management* (AS 1742.13 – 1991), and this was revised and updated in 2009 (SAA 2009).

In 1996, VicRoads produced a first draft of *Chapter 8. Local area Traffic management* of its *Traffic engineering manual volume 1 (VicRoads 1996)*. Since then it has been updated several times, the latest version being Edition 5, 2014 (VicRoads 2014b).

In 2003, Main Roads Queensland produced the first issue of *Part 13. Local area traffic management* of its *Manual of uniform traffic control devices*. It too has been updated, the latest version being Issue 4, 2014 (TMR 2014a).

In 2008, Main Roads WA issued *Guidelines for local area traffic management*. This has since been revised and updated, the latest version being Revision 2C, 2013 (MRWA 2013).

In 2013, Roads and Maritime Services NSW issued Version 2.1 of a guide supplement to the Austroads *Guide to traffic management:* Part 8. Local Area Traffic Management 2008. (RMS 2013).

In 2012, the South Australian Active Living Coalition, which was formed in 2008 and includes government and non-government organisations, and which aims to improve the health and well-being of South Australians, produced *Streets for people: compendium for South Australia*, which goes a step beyond LATM and also considers land use and related issues to encourage a healthy and active life style (SAALC 2012).

9.5 Safety Provision for Heavy Vehicles

9.5.1 Design Vehicles and Turning Templates

When a vehicle travels around a curve, it occupies a greater width than when travelling on a straight section of road. This extra width is not significant on the larger radius curves, but on smaller radius curves, and particularly at turning roadways at intersections, it may be appreciable, and must be allowed for in the placement of traffic islands, road furniture and road signs. Vehicle turning templates show the width (or swept path envelope) required for different types of vehicles turning through various angles on curves of different radii and are available for design purposes.

In 1986 NAASRA produced design vehicles and turning templates. Austroads published a revised edition of this document in 1995, a second revision in 2006 and a third revision in 2013. This latest revision (Austroads 2013a) contains user information and a guide covering the basis of turning templates and road hierarchy, design vehicle dimensions and drawings in PNG and PDF formats, and turning templates in DWG (Autocad 2010) and PDF formats. It contains templates for various types of vehicle, namely passenger vehicle, service vehicle, single unit truck/bus, long rigid bus, articulated bus, prime mover and semitrailer, passenger vehicle and prime mover and semitrailer, prime mover and long semitrailer, B-doubles, B-triple and A-double (Type 1 road train).

9.5.2 Design for Heavy Vehicles

Austroads carried out a study (Austroads 2015b) to:

- update design criteria for intersections to allow appropriate opportunities for heavy vehicles to safely enter, and to investigate gap acceptance behaviour of heavy vehicle drivers at intersections
- identify improvements in the current road design standards that will more safely accommodate heavy vehicle movements into the future.

The study involved:

- obtaining field data on the gaps accepted by heavy vehicle drivers at a range of types of intersections
- a literature review to identify road design standards and practices that accommodate heavy vehicles and road design elements that may contribute to increased risk of crash occurrence or crash severity
- analysis of heavy vehicle crashes across Australia and New Zealand
- identification of sections within parts of the Austroads design guides that have implications for heavy vehicle operation
- consulting with a representative group of key jurisdictions and heavy vehicle industry stakeholders to identify key safety issues and possible solutions.

Section 7 of the report resulting from the study (Austroads 2015c) summarises those parts of the Austroads Guide to Road Design that should be revised, and makes suggestions for amendments to enhance safety. Key matters raised in the consultations were the difficulty in negotiating small roundabouts due to swept width, proximity of roadside furniture and length of merge lanes to reach the design speed.

There are several other Austroads reports dealing with various aspects of heavy vehicle road safety, for example performance measures for evaluating heavy vehicles in safety-related manoeuvres (Austroads 2000), the safety benefits of improving interaction between heavy vehicles and the road system (Austroads 2008b), heavy vehicle safety in rural and remote areas (Austroads 2009b), heavy vehicle sight distance requirements at rail level crossings (Austroads 2009c) and a crash analysis and review of potential infrastructure and ITS countermeasures to improve the safety of heavy vehicles in urban areas: (Austroads 2013b).

10 INTELLIGENT TRANSPORT SYSTEMS

10.1 Background

Intelligent transport systems (ITS) cover any technology applied to transport and infrastructure to transfer information between systems for improved safety, productivity and environmental performance. They include stand-alone applications such as traffic management systems, information and warning systems installed in individual vehicles, as well as co-operative ITS (C-ITS) applications involving vehicle to infrastructure and vehicle to vehicle communications (DIRD 2014b).

In April 1998 the Australian Transport Council (ATC) requested Austroads to develop a strategy for ITS. Following this request, the ITS national strategy, e-transport, was subsequently commissioned by Austroads, and developed by Intelligent Transport Systems Australia. The Strategy was endorsed by ATC in November 1999. The vision of the strategy was:

> recognising the importance of transport to the quality of life of every Australian, and that information can improve the effectiveness of transport, Intelligent Transport Systems will be applied in an integrated program to the transport task to deliver a significant net contribution to Australia's economic, environmental and social needs and objectives over the next decade.

The strategy set out ten strategic goals and guiding principles, and summarised six key strategies, actions and accountabilities (Austroads 1999).

A policy framework for Intelligent Transport Systems in Australia was agreed at the Standing Committee on Transport and Infrastructure (SCOTI) meeting held in November 2011. This framework (SCOTI 2012) provides guidance to ensure that the technology used in each of the jurisdictions is compatible and is developed around a set of agreed policy principles. (Appendix 1 to this framework summarises the history of government involvement in ITS in Australia since 1988).

In August 2012 Austroads made available a report on Co-operative ITS-Strategic Plan (Green, Gaffney & Bennett 2012). This report explains that

> C-ITS is a new form of intelligent transport system that enables communication and real-time information sharing between vehicles and roadside infrastructure, as well as wireless consumer devices, in order to improve safety, productivity, efficiency and environmental outcomes of the road system, and to provide services to all road users and operators through giving advice or facilitating actions.

The report contains an introduction, overview of C-ITS, types of C-ITS applications, international developments in C-ITS, mission, vision, objectives and guiding principles of the C-ITS strategic plan, key areas for government decisions, the path to deployment of C-ITS, conclusions, references, and four appendices.

Since then, Austroads has produced several relevant publications, including Hewitt (2013), Han, Li and Espada (2014), Green, Faber and Levasseur (2014), Sweeney and Venz (2014a and 2014b) and Green, Karl and Faber (2015). The National Transport Commission also has some relevant publications, which can be found on their website.

In 2014 Main Roads Western Australia presented an Intelligent Transport Systems Master Plan as part of its 2020 strategy. The plan sets out a strategic vision for ITS in Western Australia, focus areas for action and a high-level action plan. It will be complemented by a detailed implementation plan to be developed in early 2015. It is intended that the master plan and the implementation plan will set out both the future of ITS in Western Australia and the multiyear plan for its future delivery (MRWA 2014a). The preparation of the master plan drew upon two technical reports that were developed to facilitate engagement with internal and external stakeholders and as a lead into collaborative discussion sessions at workshops. These reports were an international trends focus paper (MRWA 2014b) and a discussion paper (MRWA 2014c).

ITS Australia's Strategic Plan 2013–2018 (ITS Australia 2012) is a relevant high-level industry strategy. ITS Australia is an independent, not-for-profit organisation representing ITS suppliers, government authorities, automobile associations, academic and transport businesses and users that promotes the development and deployment of advanced technologies to deliver safer, more efficient and environmentally sustainable transport across all modes.

The plan states ITS Australia's vision to 'deliver safer, more efficient and environmentally sustainable mobility through the use of Intelligent Transport Systems (ITS) technology'. Its stated mission, as the peak body, is 'to promote and facilitate collaboration and partnering amongst industry, government and academic researching, developing and deploying ITS technologies'. Its strategies are (ITS Australia 2012):

- Engagement and advocacy: to strengthen engagement with stakeholders and advocate on behalf of its members and industry by being recognised as the central voice for ITS within Australia.
- Membership involvement: to operate nationally while creating a solid presence for local engagement.
- Connections: to actively contribute to discussion about ITS matters and ensure a recognised place in its sector locally, nationally and internationally.
- Collaboration: to work within the ITS industry but across sectors and competitors to foster collaborative outcomes that advance the industry.
- Financial sustainability: to have a strong financial and organisational foundation to deliver vision and mission.

The strategic plan sets out a number of actions to achieve each of these strategies (ITS Australia 2012).

10.2 Traveller Information

After some research into freeway incident detection in the early 1990s in co-operation with ARRB, VicRoads initiated a policy of installing dual loop detectors on urban freeways every 500 m for the collection of speed, flow and occupancy data (Luk & Sin 1992, Snell, Sin & Luk 1992). With this data, at a time slice of about 20 seconds, VicRoads was able to implement a range of applications on freeways, including incidence detection systems, advisory speed limit systems and the Drive Time Traveller Information System.

VicRoads first used its Drive Time System on the South Eastern Arterial (South Eastern Freeway) in 1995. The system monitors traffic conditions and provides current traffic and incident information both to motorists on the freeway and to those approaching the freeway. The signs include trip information signs (which provide current travel times to major exit points), traffic condition signs (light, medium, heavy or closed) and ramp control signs located on entry ramps to prevent traffic entering the freeway in the event of an incident on the freeway, dial-in emergency telephone and radio/television broadcasting.

ARRB Transport Research undertook an evaluation study including public acceptance, public understanding, driving behaviour, accident frequencies and traffic impact. It concluded that the scheme was successful in the provision of traffic data to the public (Ramsay, Catchpole & Luk 1997).

The Drive Time System has since been installed on all Melbourne's freeways. In general, the concept or something similar is an integral part of Managed Freeways (Motorways) used in several states. (See Section 10.4 below).

10.3 Smart Roads

Smart Roads is an approach that manages competing interests for limited road space by giving priority to different transport modes at particular times and places. Under it, all road users will continue to have access to all roads. At the same time (VicRoads 2014c):

- Pedestrian access into and within activity centres will be facilitated.
- Trams and buses on key public transport routes will be given priority.
- Cars will be encouraged to use alternative routes around activity centres to reduce the level of through traffic.
- Bicycle use will be encouraged through further development of the bicycle network.
- Trucks will be given priority on important transport routes that link freight hubs and at times that reduce conflict with other transport modes.

Key elements of Smart Roads are a road use hierarchy and network operating plans. The road-use hierarchy allocates priority road use by transport mode (pedestrians, bicyclists, trams, buses, trucks and cars), place (such as activity centres, strip-shopping centres) and time of day (AM peak, PM peak, high off-peak between the AM and PM peaks and evening off-peak). The network operating plans apply the road use hierarchy to the actual road system by identifying priority movements at individual intersections at different times of the day. (VicRoads 2010a, Wall 2011).

VicRoads has developed Smart Roads in the Melbourne metropolitan area in close consultation with local government, relevant government agencies, transport operators and other stakeholders.

In Western Australia a somewhat similar concept is being used in Perth and its CBD. Certain roads are designated for different modes, with some north-south links to the CBD being designated for public transport and others to accommodate active transport such as bicycles. The general concept extends to controlled-access roads such as freeways and higher level highways, with bicycle traffic being prohibited, and with alternative provision, such as principal shared paths, being provided.

In New South Wales the Smart Roads concept does not currently operate. However, Roads and Maritime Services is assessing the potential for developing a similar concept as part of a broader initiative to overlay a performance framework to managing its road assets.

10.4 Managed Freeways (Motorways)

A managed freeway brings together complementary technologies to achieve the best performance from the road infrastructure. Basically, a successfully managed freeway requires adequate intelligence (data) for the application of appropriate controls to optimise freeway performance, while maximising safety, reliability and capacity. Also, there should be adequate information provided to road users to assist them with making informed decisions about their travel. The basic elements of a managed freeway are set out below (VicRoads 2010b, revised 2014d):

The necessary intelligence may include:

- vehicle detection equipment to provide volume, speed, occupancy (density) and vehicle classification on a lane-by-lane basis
- Closed circuit television to provide vision of the freeway, enabling a more detailed assessment of conditions on the freeway and on the immediate approaches to it
- incident detection capabilities
- help phones to enable drivers to report incidents or broken-down vehicles
- environmental monitoring, such as temperature, wind speed or water levels
- travel time tracking equipment for travel time calculations.

Appropriate controls may include:

- freeway ramp signals to control access to the freeway to prevent capacity being exceeded by breaking up platoons of entering vehicles thereby avoiding overload of the merge area
- variable speed limits to assist in maximising safety in adverse conditions, such as wind, incidents and roadworks, and during times of high demand
- Lane use management.

Information to road users may include:

- real-time information signs or variable message signs located on arterial roads on the approaches to freeway entry ramps, providing travel time and other freeway travel conditions data to enable road users to make decisions before entering the freeway
- variable message signs for road users on the freeway, such as warning of hazards or disruptions ahead and any actions that drivers should take
- drive time information, such as estimated travel times for those on the freeway
- website travel information – generally for the pre-trip stage
- radio messages that can reach road users both before and during the trip.

The successful operation of a managed freeway requires:

- appropriate control system software
- a high quality communications system
- a reliable power supply
- full integration with any traffic management centre.

For more detailed information, see VicRoads (2013b, 2013c and 2014d), MRWA (2012), DTMR (2014b), and Austroads (2014).

The concept of managed freeways was first introduced to a limited degree on the Melbourne metropolitan freeway network in 2002 when ramp metering was installed on the outbound Thompsons Road on-ramp on the Eastern Freeway. This was followed a few months later by installations on the outbound on-ramps at Warrigal Road and at Huntingdale Road on the Monash Freeway. Now the Monash Freeway from High Street to City Link, the Westgate Freeway from Westgate Bridge to the Western Ring Road and sections of the Western Ring Road operate as managed freeways.

In New South Wales there are a number of motorways that have some elements of a Smart Motorway (the New South Wales term for a managed freeway) scheme. The M4 Motorway between Merrylands and Lapstone will be the first full Smart Motorway scheme to be commissioned. Current estimates for the M4 have full commissioning in 2020. In 2015–16 Roads and Maritime Services will also be planning Smart Motorway schemes on two additional corridors including General Holmes Drive and Southern Cross Drive (M1) and the Warringah and Gore Hill Freeways ((M1). The WestConnex and NorthConnex projects are making provision for Smart Motorway operation. A number of new motorway projects, such as the Western Harbour Tunnel, are making provision for Smart Motorway operation.

For more details of the M4 Smart Motorway project, see <http://www.rms.nsw.gov.au/projects/sydney – west/m4/index.html> and <http://nsw.liberal.org.au/m4-to-be-sydney’s-first-smart-motorway>. Morgante (2013) provides details of the NSW Managed Motorways Strategy Network.

In Queensland Managed Motorway technologies are installed on parts of the Pacific Motorway, Ipswich Motorway, Centenary Motorway, Port of Brisbane Motorway, Bruce Highway and Houghton Highway. They are also available on all traffic tunnels (except busways) and on sections of

Transurban controlled motorways (See 3.2.3). For details of the extent of the Managed Motorways program across South-East Queensland see <http://131940.qld.gov.au/Driving-in-Queensland/Managed-Motorways/about Managed-Motorways>.

In South Australia there are three operational Managed Motorways. It is intended that the whole north-south South Road corridor be a Managed Motorway in the future. Currently two sections have been completed, one at the northern end and one at the southern end. These two sections will be joined as the projects continue over many years. The South East Freeway and the Northern Expressway (the Stuart Highway north of Adelaide) operate as Managed Motorways.

In Western Australia there are currently no fully managed freeways. Foundation level ITS has been installed on Perth Freeways – Kwinana, Mitchell and Graham Farmer. On the Graham Farmer, tunnel lane control is operating with variable speed limits that are used when traffic conditions dictate, for example congestion or incidents such as crashes, debris on the road or broken-down vehicles.

10.5 Improved Safety at Road-Rail Level Crossings

A project, initially funded by the National Co-operative Research Centre for Advanced Automotive Research and Public Transport Victoria, has been carried out by the Latrobe University Centre for Technology Infusion and the Queensland University of Technology to research, develop, implement and trial a dedicated short-range communication (DSRC) based Intelligent Transport System solution to improve safety at road-rail level crossings.

The system aims to reduce and potentially to eliminate road-rail crossing accidents by enabling dynamic vehicle-to-vehicle and vehicle-to-infrastructure communications using DSRC technology. DSRC-enabling roadside units and on-board vehicle units are used. Communication can be directly between vehicles (train and road vehicles) or between vehicles and infrastructure. Basically, the system enables drivers to receive warnings of trains approaching the crossing. It delivers six levels of warning, graduating in urgency and volume. The lowest level of warning advises of the presence of the crossing ahead, with subsequent warning levels advising of a train in the vicinity in a similar way to conventional flashing light warnings. Finally, when a collision is imminent, an emergency train horn sound and an image that conveys the message to stop is used. Desai,Singh and Spicer (2010), Singh et al. (2012) and Spicer (2013) provide details of the proposed system.

In Victoria, field trials have been carried out at level crossings at Highett and Cheltenham on the Frankston line and at the regional town of Dingee on the Swan Hill line. In Queensland there has been a trial at level crossings between Charters Towers and Townsville. A report on the results of these trials is not yet available.

10.6 Introduction of Automated Vehicles

The introduction of automated vehicles is receiving increasing attention and concept vehicles are being developed in some countries. Automated vehicles are those in which some aspects of safety-critical control functions (such as steering, throttle or braking) occur without direct driver input. They may range from partly automated vehicles in which one or a few control mechanisms are automated to those in which all functions are automated (i.e. completely without a driver).

In 2012 KPMG and CAR produced a white paper on self-driving Cars (KPMG and CAR 2012), that examined the forces of change, the current emerging technology, the path to bring these innovations to the market, the likelihood that they will achieve wide adoption from customers, and their potential impact on the automotive ecosystem. The authors state:

> the pace of innovation is speeding up and the (automotive) industry is on the brink of a new technological revolution: self-driving vehicles. The new technology could provide solutions to some of our most intractable social problems – the high cost of traffic crashes and transportation infrastructure, the millions of hours wasted in traffic jams, and the wasted urban space given over to parking lots, just to name a few. But if self-driving vehicles become a reality, the implications would also be profoundly disruptive for almost every stakeholder in the automotive ecosystem.

Their findings were set out in four sections, namely:

- Market dynamics, which examined the social, economic and environmental forces that are making changes inevitable.
- Convergence, which discussed the ongoing convergence of the key enabling technologies.
- Adoption, which focussed on the path to widespread adoption of advanced automated driving solutions, which the authors believe will take place in stages, leading over time to reliance on increasingly autonomous or self-driving vehicles.
- Implications for investment, which addressed the social, political and economic implications of self-driven automobiles and their impact on the entire automotive ecosystem.

In 2013 the National Highway Traffic Safety Administration (USA) issued a *Preliminary Statement of Policy Concerning Automated Vehicles* (NHTSA 2013). The statement defines automated vehicles as those in which some aspects of safety-critical control function (such as steering, throttle or braking) occur without direct driver input. It defines five levels of vehicle automation, ranging from no automation to full automation. The five levels are:

- *Level 0. No automation*. The driver is in complete and sole control of the primary vehicle controls at all times, and is solely responsible for monitoring the roadway and for safe operation of all vehicle controls.
- *Level 1. Function-specific automation*. Automation at this level involves one or more specific control functions. If multiple functions are automated, they operate independently from each other. The driver has overall control, and is solely responsible for safe operation, but can choose to cede limited authority over a primary control (as in adaptive cruise control), the vehicle can automatically assume limited authority over a primary control (as in electronic stability control), or the automated system can provide added control to assist the driver in certain normal driving or crash imminent situations (e.g. in dynamic brake support in emergencies).
- *Level 2. Combined function automation*. Automation at this level involves at least two primary control functions designed to work together to relieve the driver of control of those functions. An example would be adaptive speed control in comparison with lane centring.
- *Level 3. Limited self-driving automation.* Automation at this level enables the driver to cede full control of all safety-critical functions under certain traffic or environmental conditions and, in those conditions, to rely heavily on the vehicle to monitor for changes in those conditions requiring transition back to driver control. The driver is expected to be available for occasional control, but with sufficiently comfortable transition time. The vehicle is designed to ensure safe operation during the automated driving mode.
- *Level 4. Full self-driving automation*. The vehicle is designed to perform all safety-critical driving functions and to monitor roadway conditions for the entire trip. The driver will provide destination or navigation input, but is not expected to be available for control at any time during the trip. This includes both occupied and unoccupied vehicles.

In 2014 the Society of Automotive Engineers put forward a summary of levels of driving automation for on-road vehicles (SAE International 2014). This summary was similar to that defined by the NHTSA (see above), except it provided for six levels from level 0 to level 5. Basically, the lower three levels were similar in both cases, but the NHSTA levels 3 and 4 were further subdivided into three levels – 3 to 5.

At its 26th biennial conference in Sydney, the ARRB Group:

> invited key stakeholders to participate in a roundtable discussion and featured self-driving cars as the topic for the closing plenary session. Interesting and divergent opinions raised at the conference sessions highlighted the need for the emerging technology to be better understood and its far-reaching impacts anticipated. In response ARRB has prepared a workshop report with a view to elucidating the issue. Key points

> and concerns surrounding self-driving vehicles include the road environment, human interaction with the technology, the impact on planning and public transport and the architecture of the digital systems required to integrate the network. The document provides some analysis of the considerable task at hand to be ready for self-driving vehicles and to enable their obvious benefits to be accrued for the national good (Hillier, Wright & Damen 2015).

Main Roads, Western Australia has produced two informative reports on Automated Vehicles. *Are We Ready*? (MR WA 2015a) and *Connected Vehicles. Are We Ready*? (MR WA 2015b). They define Automated Vehicles (AVs) as vehicles where some aspects of a safety-critical functions such as steering, throttle control or braking occur without direct driver input by use of on-board censors, cameras, GPS and telecommunications to obtain and analyse information using complex computer algorithms to effect control in safety-critical situations. Connected Vehicles (CVs) are capable of communicating with each other (i.e. vehicle to vehicle or V2V), with roadside infrastructure such as traffic control signals (i.e. vehicle to infrastructure or V2I and vice versa), or with other devices such as mobile phones carried by road users (V2X). They use Cooperative Transport Systems or C-ITS using wireless communication to share real-time information about the road environment (such as potential incidents, threats and hazards) with an increased time horizon and awareness distance that is beyond both what in-vehicle technologies (radars or cameras) and the driver can visualise. Fully automated driverless vehicles require use of both AVs and CVs technologies.

The reports were prepared to highlight the implications of the introduction and use of AVs and CVs on Western Australian roads. They discuss AVs and CVs in some detail, including the issues involved, the current position in Australia and internationally, including the USA, Europe and Asia-Pacific countries, their likely adoption rates and timelines, and implications for Western Australia. They look into how Main Roads needs to be prepared for their introduction by identifying and implementing the changes and improvements that may be required to infrastructure to enable their safe operation on Western Australian roads.

They indicate that their likely rate of adoption will depend on many factors, including the maturity of the technology, resolution of human factors issues (human-machine interface), the regulatory framework, customer acceptance, the critical mass of network effects and production cycles. Timelines for the introduction of AVs and CVs are somewhat speculative at this time, although there could be significant use of AVs in the 2020-2030 time frame. The use of CVs is likely to be slightly longer term, except in special circumstances. For example, driverless vehicles are now being used to a limited extent in the minefields of Western Australia.

In March 2015 the Institute of Transport Engineers (Australia and New Zealand section) held a seminar on *Automated vehicles – understanding the impact of disruptive change* at the ARRB Theatrette in Vermont South. There it was noted that **there are already** partly automated vehicles on Australian roads, with electronic stability control mandatory for new cars and features like adaptive cruise control and lane keeping assist increasingly available. Manufacturers around the world are working hard to introduce fully automated vehicles by 2020. The implications of this on the future of transport are far-reaching and transport professionals will need to start preparing for a future that may look very different from today.

The main speakers at the seminar were:

- Professor M. Regan on the human factors, challenges and solutions of animated vehicles.
- S. Ballingall on the role of connectivity with vehicle automation
- A. Somers on how driverless cars might transform demand for transport
- C. Liersch on vehicle automation from the perspective of a developer of vehicle systems

Slide presentations at the seminar by these speakers can be found at <http://www,ite.org.au/automated vehicles/>.

In October 2015 Austroads engaged a Consultant to carry out a study to assess the key issues road operators are set to face with the introduction of automated vehicles. The study will involve a literature study, discussions with stakeholders and the development of a document to understand the issues and to best guide their introduction (Engineers Australia 2015).

In November 2015 the first driverless car demonstration on Australian roads was carried out on a closed section of the Southern Expressway in Adelaide (DPTI 2015a). The trial was led by the ARRB Group and supported and hosted by the South Australian Government. Leading local and international experts from industry and academia were involved, using vehicles provided by Volvo. In conjunction with the demonstration an International Driverless Cars Conference, attended by over 300 local and international delegates, was held in Adelaide on the preceding two days.

In September 2015 legislation was introduced into the South Australian Parliament to allow for the trials of driverless cars on open public roads in South Australia (DPTI 2015b). At the end of 2015, the legislation had not been finalised. In this respect, the South Australian trials of driverless cars conducted in November 2015 did not require legislation because the relevant section of the Southern Expressway was closed to normal traffic during the trial.

11. OVERVIEW/REFLECTIONS

11.1 The Development of Traffic Engineering in Australia

Motor cars first appeared on Australian roads in about 1900. Prior to the 1950s traffic engineering activities, such as traffic counting, some traffic studies, signing and line marking, installation of traffic signals and some aspects of road safety were being applied, but the term ‘traffic engineering’ was not generally being used. The first SAA Road Signs Code appeared in 1935 (SAA 1935).

In 1947 the first engineering position in Australia with the word ‘traffic’ in it was created when the Country Roads Board appointed HP George as Traffic and Location Engineer. He relinquished the position in 1949 and it lapsed. He returned to the position in early 1953. In 1954 the Department of Main Roads (NSW) appointed RE Johnston as Traffic Services Engineer. Two other state road authorities made traffic engineering appointments in 1956, with other states following in 1963 and 1970.

A very significant step in the recognition of traffic engineering as a separate branch of engineering in Australia was the establishment in 1955 of a Traffic Engineering Standing Committee by the then Conference of State Road Authorities, which became the National Association of Australian State Road Authorities (NAASRA) in 1959 and Austroads in 1989. NAASRA produced a *Guide to Traffic Engineering Practice* in 1965. This guide was regularly reviewed and updated (as will be discussed later).

During the 1950s, twelve Australian engineers attended traffic engineering courses overseas (11 in the USA and one in Great Britain). Of these, six were supported by Sidney Highway Traffic scholarships, four were supported by their employers, and two by IRF scholarships.

In early 1955 the Department of Civil Engineering at the University of Melbourne conducted a one-week summer school in traffic engineering with attendees from all over Australia. This was the first intensive course in traffic engineering offered in Australia. In the same year, the Australian Automobile Association had provided support to establish a Chair in Traffic Engineering at the University of New South Wales and Professor WR Blunden was appointed as the Foundation Professor of Traffic Engineering in 1956. Professor Blunden introduced short courses in traffic engineering and transport planning and these, together with graduate studies and research opportunities, provided significant training opportunities for many Australian and overseas students.

During the 1950s traffic engineering activities grew rapidly and, by the end of the decade, traffic engineering was firmly established and recognised as a separate branch of engineering in Australia. Traffic management authorities were created in all states, municipal councils became increasingly involved in traffic engineering activities, and the automobile associations were becoming increasingly involved in traffic management considerations.

During the 1960s, 1970s and 1980s there were many significant developments in the theory and practice of traffic engineering, traffic engineering applications substantially increased, and much larger numbers of people became directly involved in traffic engineering.

In 1960 the Australian Road Research Board (now ARRB Group Ltd) commenced operation and since then it has played a significant role in encouraging and supporting research and disseminating research findings in traffic engineering (and in fact in all aspects of road engineering). For more detail see Section 4.2.

By the early 1970s there were significant changes to community attitudes to roadworks, perhaps largely due to concerns about the sociological and environmental implications of emerging proposals for major urban works, such as urban freeways, and sections of the community began to question the need for and desirability of such works. As a result, a number of interest (or action) groups formed, usually to oppose specific works. Some of these groups were well organised, very vocal and strong lobbyists. As a result, road proposals became political issues, and this led to environmental protection and assessment policies, and to requirements for community participation. In 1974, the Commonwealth Environment Protection (Impact of Proposals) Act and Regulations under the Act were enacted, and state legislation soon followed.

At about the same time, increasing inflation began to significantly increase the cost of roadworks, including the cost of land acquisition. In addition, there was increasing uncertainty about the future availability and cost of fuel for transport and population growth and vehicle ownership trends. Pressures emerged to make maximum use of existing facilities, and this tended to highlight the growing importance of traffic management practices.

During the 1970s and 1980s, significant events included (FORS 1998):

- Road improvements such as the provision of freeways, town bypasses, divided roads, road-rail grade separations, access control, improved (safer) roadsides, the extensive use of traffic management measures, including intersection improvements, signing and delineation, lighting and correction of black spots.
- In January 1970, under Australian Design Rules for Motor Vehicle Safety, the fitting of seatbelts became mandatory in new passenger vehicles. This requirement has been progressively extended to include other motor vehicles, retractable belts, and anchorages for child restraints. Other mandatory requirements include improved vehicle brakes, tyres, lights, indicators and glazing, head restraints, increased vehicle impact resistance and increased bus roll-over strength, occupant protection in buses and fitting of limiters to control the speed of heavy vehicles.
- By 1973 the compulsory wearing of fitted seatbelts in motor vehicles and the wearing of protective helmets by motorcyclists and their pillion passengers was mandatory in all states and territories.
- Random breath testing was introduced in Victoria in 1976, Northern Territory in 1980, South Australia in 1981, New South Wales and the Australian Capital Territory in 1982, Tasmania in1983, and Queensland and Western Australia in 1988.
- The compulsory wearing of bicycle helmets became compulsory in Victoria in 1990 and in the other states and territories through 1991 and 1992.
- Speed cameras were introduced in Victoria in the late 1980s and later in other jurisdictions. Laser-based speed measuring devices and red-light cameras were also introduced.

Since 1988, the more significant events have included:

- The continuing active role of Austroads (created in 1989 by reorganising and renaming the National Association of Australian State Road Authorities) in providing expert technical input to national road and transport policy development, by the preparation of various guides on all aspects of road and traffic engineering, especially the *Guide to Traffic Engineering Practice*, which was in the early 2000s by two sets of Austroads guides, a *Guide to Traffic Engineering Practice*, in 13 parts, and a *Guide to Road Safety,* in 9 parts, together with many other related publications. For more detail see Section 4.1.
- The continuing significant role of the Australian Road Research Board (which became ARRB Transport Research Ltd in 1995 and ARRB Group Ltd in 2004) in encouraging and supporting research, and in disseminating research findings through its publications, conferences, workshops and symposia. For more detail see Section 4.2.
- The continuing significant role of the Standards Association of Australia, which had produced a *Road Signs Code* as early as 1935 and which, over the years since, has produced a large number of traffic engineering related standards. For more detail see Section 4.3.

- The role of professional organisations, including The Institution of Engineers, Australia (which published a traffic engineering related paper as early as 1936), the Australian Section of the Institute of Traffic Engineers created in 1971 and which became The Australia and New Zealand Section of the Institute of Transportation Engineers in 1996, The Australian College of Road Safety established in 1988 and which became The Australasian College of Road Safety in 2004, and The Australian Institute of Traffic Planning and Management created in 1966. These organisations all have an active membership and a range of activities to promote best practice in traffic engineering, including road safety. They each are an authoritative voice on traffic engineering matters, including road safety and, as appropriate, they make submissions to government and other inquiries. For more detail see Section 5.
- Many of the Australian universities conduct undergraduate and postgraduate teaching and research activities relating to traffic engineering and road safety, and several have specialist centres. Typical examples of current specialist centres include the Transport and Road Safety (TARS) Research Unit at the University of New South Wales, the Centre for Accident Research and Road Safety (CARRS) at the Queensland University of Technology, the Centre for Automotive Safety Research (CASR) at the University of Adelaide, the Transport Systems Centre (TSC) at the University of South Australia (ceased operating in 2014, but now being reborn as the Flinders Centre for Transport Systems Engineering at Flinders University), the Monash University Accident Research Centre (MUARC), and the Curtin-Monash Accident Research Centre (C-MUARC) at Curtin University. For more detail see Section 6.
- Over the years, the automobile associations have actively promoted and given strong support to many traffic engineering and road safety measures, and have been represented on state and national committees associated with these types of activities. They have been strong advocates on behalf of their members, examined various traffic operations and safety problems, and have made representations to the relevant authorities on suitable corrective measures. Since 1992 they have run the Australian Road Assessment Program (AusRAP) with financial support from the federal government. For more detail see Section 7.

Since the late 1980s there has been continuing and increasing interest in, and concern for, road safety. In 1988, Trinca et al. (1988) put forward an overall approach to tackling the road toll by considering exposure control, crash prevention, behaviour modifications, injury control and post-crash injury management. In the latter part of the 1990s the concepts of *Vision Zero* (SNRA 1999) and *Sustainable Safety* (Wegman, F & Wouters, P 2002) were put forward in Sweden and in the Netherlands respectively. These two concepts accept that some crashes will always occur, but they attempt to limit crashes to those that do not result in death or serious injury. The concept of the safe system approach evolved from these concepts. A key principle of this approach is that, while road users still have a responsibility for safe behaviour, there must be greater emphasis on road designers and operators, and on vehicle makers, to build safeguards into the system to eliminate deaths and serious injury. The safe system approach was included in Australian National Road Safety Action Plan 2005 and 2006 (ATC 2004), and since then it has formed the basis of the various national, state and territory road safety strategies. For more detail see Sections 8.1 to 8.3.

Other significant road safety initiatives since the 1990s have included the widespread adoption of road safety audits, support for the United Nations Decade of Actions for Road Safety 2011 to 2020, the Australian New Car Assessment Program (ANCAP) and the Australian Road Assessment Program (AusRAP). For more detail see Sections 8.5 to 8.8.

While many of the traffic engineering procedures and practices were well established by the late 1980s, they have continued to evolve as more experience has been gained. In particular, traffic management centres, speed management, the treatment of road-rail level crossings, local area traffic management practices and safety provision for heavy vehicles have continued to develop in accordance with changing circumstances. For more detail see Section 9.

An emerging development is the application of intelligent transport systems (ITS). ITS covers any technology applied to transport and infrastructure to transfer information between systems for improved safety, productivity and environmental performance. It includes stand-alone applications such as traffic management systems, information and warning systems installed in individual vehicles, as well as applications involving vehicle-to-infrastructure and vehicle-to-vehicle communication. Applications of ITS include (for more details see Section10):

- provision of traveller information both on, and prior to, reaching the particular facility
- smart roads that manage competing interests for limited road space by giving priority to different transport modes at particular times and places
- managed freeways (motorways) to optimise the performance of these facilities, while maximising safety, reliability and safety, using some or all of variable speed limit signs, flexible lane control, ramp metering, travel time signing, electronic message signs and roadside data systems
- improved safety at road-rail level crossings
- introduction of automated vehicles.

In 1970 the number of deaths on Australian roads peaked at 3798 and, since then, the number has steadily declined. In 1970 the population of Australia was 12.5 million, there were 4.8 million registered motor vehicles (or 1 vehicle for each 2.6 persons) and 30.4 deaths per 100,000 population or 7.96 deaths per 10,000 registered vehicles on Australian roads.

Since 1970, improved and safer roads and traffic facilities, improved vehicle standards, improved and better observed legislation and road rules, coupled with more intensive road safety publicity, education, training, licensing and enforcement, and a more road safety conscious community, have all contributed to a significant reduction in the road toll.

In 2014 there were 1153 deaths on Australian roads, the population of Australia reached 23.7 million, there were 17.6 million registered motor vehicles (or 1 vehicle for each 1.35 persons) and 4.9 deaths per 100,000 population (or 0.66 deaths per 10,000 registered vehicles). It might be noted that, for each death, there are about 10 serious injuries and many more minor injuries and much property damage.

Over the period from 1970 to 2014, Australia’s population increased by 90%, the number of registered vehicles increased by 270 % and the annual deaths decreased by 70%. In the same period, the rate of vehicle ownership has increased from 1 vehicle per 2.6 people to 1 vehicle per 1.35 persons.

11.2 A Brief Look at the Future

Current projections indicate that Australia’s population could be in the range 36.8 to 48.3 million by the year 2061 (ABS 2013). This represents an increase of 13.1 million (55%) to 24.7 million (104%) over the 2014 population.

As far as future estimates of motor vehicle ownership and travel are concerned, it must be recognised that world oil depletion, global warming, safety concerns and noise are seriously emerging problems, and that increased use of upgraded public transport, cycling and walking should be encouraged as a means of reducing future dependence on the motor car, particularly in the larger urban areas. Similarly, socio-economic lifestyle changes, such as for example the increased incidence of working from home, more flexible working hours (or days), carpooling and the like have the potential to slightly reduce the amount of car travel. However, there is a limit to what these sorts of measures can achieve and, because the motor vehicle can provide a comfortable, convenient, private and flexible means of transport for a diverse range of trips of all types, including personal, goods, freight services and business, between widely dispersed origins and destinations, from door to door, at all times of the day and night, in all weather conditions, the car will always remain a significant mode of transport for the foreseeable future.

In the short term, increasing the use of smaller vehicles (particularly for urban travel), increasing the use of more fuel-efficient vehicles and increasing the use of alternative fuels, (such as LPG, compressed natural gas, ethanol, methanol, and synthetic fuels), hybrid (particularly petroleum/electric) and electric vehicles, improved driving practices and improved traffic management will reduce dependence on petroleum fuels. There is now much work on developing alternative fuels being carried out around the world and, in the longer term, electricity and/or hydrogen appear to be the most likely fuels, although future technical developments and costs will determine the eventual outcome. With respect to electric vehicles, their significantly increased use will depend on the availability of electricity from ‘clean’ sources, such as solar and wind power (and even tidal or thermal power).

Given that:

- from 1970 to 2014 there has been an increase each year in population from 12.5 to 23.7 million, in the number of registered vehicles from 4.8 to 17.6 million, and in the rate of vehicle ownership from 1 vehicle per 2.6 persons to 1 vehicle per 1.35 persons,
- current projections indicate that the population could reach between 36.8 and 48.3 million by 2061
- the motor vehicle still holds significant advantages (summarised above)

There seems no reason to expect that these trends will not continue at least for the foreseeable future. The motor vehicle will remain a significant form of transport, except that there may be a slight reduction in the percentage of total travel by motor vehicle (see above).

Since 1970, there has been a substantial reduction in the number of deaths (and in the number of injury and property damage only crashes). The safe system concept, now built into Australian national, state and territory road safety strategies, has the vision that no people should be killed or seriously injured on Australia’s roads (Section 8.2), and the National Road Safety Strategy 2011 to 2020 has set targets of at least a 30% reduction in annual deaths and in the number of serious injuries by the end of 2020. It indicates that target reductions are relative to the average number of deaths and serious injuries in the baseline period 2008 to 2010 (ATC 2011). The average annual number of deaths in 2008 to 2010 was 1425, giving a 2020 target of 998 deaths at most.

Chapter 9 of the *National Road Safety Strategy 2011 to 2020* sets out actions and interventions to achieve it targets by 2020, and the three-year action plan 2015–2017 (TIC 2014) contains 19 actions in in four areas of prioritising investment in infrastructure, improving the safety of the vehicle fleet, encouraging safer road use and advancing the safe system. It specifies how each action should be implemented and allocates responsibility for each one.

Present indications are that Australia is on track to achieve a reduction of at least 30% in the annual number of deaths in the decade 2011 to 2020. Of course, even if this target is achieved, there will still be a long way before realising the vision of no people killed or seriously injured on Australia’s roads. There will need to be continuing aggressive implementation of the safe system concept of managing the interactions between safer roads, safer vehicles, safer speeds and safer road users. In this respect, if it be assumed that the target 30% reduction in the annual number of deaths in the decade 2011 to 2020, and the target of at most 998 deaths by 2020, can be achieved and continued on in later decades, then the annual number of deaths by 2050 would be about 340 – still a fair way from zero road deaths. At the same time, the vision of zero deaths and serious injuries should remain the target.

The introduction of automated vehicles is receiving increasing attention, and concept vehicles are being developed in some overseas countries. Automated vehicles may range from partly automated, in which one or a few functions are automated, to those in which all functions are fully automated (i.e. they can operate without a driver) as discussed in Section 10.6.

Partly automated vehicles are likely to become increasingly present on Australian roads within the next five to fifteen years (i.e. 2020 – 2030). However, the introduction of fully automated (or driverless) vehicles is likely to take somewhat longer and possibly to be limited, at least for some time, to special circumstances, such as for example in remote areas (such as the minefields of Western Australia) and on high quality freeway (motorway) standard roads. It is difficult to see them being used on local and subarterial roads within the foreseeable future because of the presence of a range of traffic types (cars, trucks of all sizes and purposes, buses, trams), including bicycles and pedestrians, parking and unparking vehicles, access to and from abutting property and the like. It would seem probable that, at least initially, fully automated (driverless) vehicles could act as a hybrid, i.e. they could operate as a fully driverless vehicle on high quality roads such as freeways (motorways) and selected arterials, and then revert to driver control on lesser standard roads.

There seems to be no doubt that there will be significant advances in the development and use of automated vehicles in the relatively near future, and that their implications, opportunities, challenges and benefits will be enormous – and possibly far greater than can be realistically imagined at this time.

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