Traffic Impact Assessment of Land Use Proposals: Fifty Years of Australian Experience

Gholamreza Shiran[1], John Black[2], Kam Tara[3]

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Abstract

A Traffic Impact Assessment (TIA) provides information on the projected traffic expected from a proposed development. A TIA also evaluates the impact of proposed development on the roadways in the immediate proximity of the proposed development. The TIA should identify potential traffic operational problems or concerns and recommend appropriate actions to reduce impacts. Draft traffic impact assessment (TIA) guidelines for various land uses in general, and for high traffic generating buildings in particular, were proposed in Iran in the middle of 2016. In formulating that report the Traffic Committee of the Iranian Building Engineering Order reviewed international experience, including that of Australia. Traffic impact assessment started in Australia in the 1960s when the traffic police exercised much authority in trying to prevent land-use developments from taking place abutting main roads. Concepts derived from queuing theory where the application of the mean service time to establish maximum traffic generation rates for a proposed development was introduced. Attached to that theory was the absorption capacity of a priority traffic stream. This latter one found its way into traffic engineering practice to provide a rational basis for assessing development applications. As experience accumulated the guidelines became refined and a second edition of Austroads' traffic impact assessment was released in 2016. This paper presents the documentation which is expected from a developer, traffic models available to the consultants working for the developer, and importance of developer contributions require by the developer for changes to the surrounding transport network. To illustrate the process, a simple case study of a school expansion is provided. The steps taken to show the impact of an increase from 185 to 600 pupils in Sydney is illustrated. The process include traffic data collection on the surrounding streets to forecasting future traffic using appropriate models and community workshops. In the light of a practical case, the process then ends with proposing options to mitigate adverse traffic impacts of the development application. The overall work illustrates the principles of TIA and to point to the onus on all developers to manage travel demands to achieve more sustainable outcomes from urban development.

Keywords: Traffic impact assessment, development guidelines, TIA, traffic generating building,

Corresponding author E-mail: gh.shiran@trn.ui.ac.ir

[1] Assistant Professor, Faculty of Transport, University of Isfahan, Isfahan, Iran

[2] Emeritus Professor, School of Civil and Environmental Engineering, Sydney, Australia.

[3] Director, Urban Research and Planning (URaP), International, North Strathfield, NSW, Australia

1. Introduction

Traffic impact assessment (TIA) – or, more precisely, traffic and car-parking assessments of developments - is the process of compiling, analysing information on, and documenting the effect that a development is likely to have on the operation of adjacent roads and transport networks. TIA also identifies the quality and ease of pedestrian circulation and promotion of safety and separation of any movement friction in the building itself. Many countries throughout the world mandate that traffic impact assessments are undertaken for development proposals. For instance, Wisonsin Department of Transport (WisDot) is accountable for operating a safe and efficient state highway system and in doing so, proactive access management is vital in maintaining the overall safety and efficiency of this system (WisDot, 2017), or; City of San Jose in Silicon Valley has developed methodologies and requirement guidelines on the subject to be coupled with an environmental review of a proposed project to satisfy California Environmental Quality Act (CEQA) requirements. Because of the involvement of the authors mainly in Australian practice and research in the area of TIA, this paper considers guidance advice given to developers and their consultants in Australia (NSW Roads and Maritime Services, 2002; Queensland Government, Department of Main Roads, 2006; Tasmania, Department of Infrastructure, Energy and Resources, Roads & Traffic Division, 2007; Vicroads, 2015; Western Australia, Department of Planning and Western Australian Planning Commission, 2016).

A TIA is undertaken by professionally qualified experts on behalf of the proponent of the development application and is documented in a report. The report is typically prepared for a planning body or road agency as the development consent authority to consider. Planning, in general, and transport planning, in particular, sets the scene for TIA through land-use policy, parking policy and various strategies and plans that determine the accessibility within and through an area – and the transport modes that will provide that accessibility. For many developments, the traffic impacts and the options for accommodating the generated movement of people and goods cannot be considered in isolation from this planning context, because these policies and strategies provide a framework within which any traffic impact assessment needs to be considered. However, this wider context of TIA is beyond the scope of this paper.

On 5th October 2016, The Traffic Committee of the Iranian Organization for Engineering Order of Building (IOEOB), convened the First Iranian National Conference on Traffic Impact Assessment of Buildings, held at the Iranian Building and Housing Research Centre, Tehran, to launch draft guidelines. The need for preparation of guidelines was approved by the Preparation & Documentation Advisory Council of the National Building Regulation of Iran (NBRI) during their meeting of July 2013. The draft proposed guidelines have been reviewed by the council and amended by the Traffic Committee members and are now waiting final approval. Many Iranian metropolitan areas are coping with heavy road traffic congestion and high levels of traffic-related urban air pollution so the adoption of these guidelines would contribute to more efficient vehicular traffic flows.

The paper is structured as follows. **The first section** describes the context in Australia covering both periods of 1960's and the current practice. For instance, Blunden (1966) made the first fundamental theoretical contributions to traffic impact analysis. Section One also presents the practices made by NAASRA *Guide to Traffic Engineering Practice,* and, most recently, in the 2nd Edition of *Part 12: Traffic Impacts of Developments* as part of *Austroads Guide to Traffic Management* that was released in 2016. The second section draws on these guidelines to outline the documentation required of a developer when lodging a development application (DA) to a consent authority. This section also shed light on the documentation of the existing road network and modal split issues on the neighboring roads. Because most development applications relate to land uses being developed in the future, traffic modeling becomes a necessary tool applied by consultants on behalf of the developer, hence Section Three provides a brief introduction to the analytical techniques (computer software packages) currently available in Australia. If demonstrated by modeling of the traffic impacts of a proposed development that additional road and transport works are required the consent authority may impose contributions from developers – this is shown in section Four of this paper. To demonstrate traffic impact assessment in practice a simple case study of a school being expanded in a pre-dominantly residential neighborhood is described which forms section Five of this work. Conclusions are drawn as the final section of this paper followed by the references which provide resource material employed in preparation of this paper.

2. Traffic Impact Assessment _ Australian Context

Australian practice - the 1960s

The post-second World War economic prosperity in Australia lead to high levels of private vehicle ownership and use and a high level of road trauma at a time when investment in road infrastructure was lagging behind rising demand and road congestion was a national issue. The Federal Government’s response with support from the Automobile Association of Australia was to fund a Chair in Traffic Engineering – the first of its kind anywhere in the British Commonwealth – that was eventually established in 1956 at the University of New South Wales in Sydney. Ten years later a research publication by the late Professor Ross Blunden (Blunden, 1966) lead to traffic impact assessments of development applications incorporated into the National Association of Australian State Road Authorities guide to traffic engineering practice first published in 1965.

The context for the fundamental analysis of the traffic problem analyzed by Blunden was the road rules of the time in the State of New South Wales and the power of the traffic police in matters of traffic control and veto over proposals to develop land abutting onto main roads that had then relatively few intersections controlled by traffic signals. Vehicular traffic entering from a minor side road into a traffic stream on the main road had priority of right of way over traffic on the main road. Police frequently gave hand signals to direct motorists as busy, uncontrolled intersections and their accident investigations qualified traffic police as the *de facto* traffic experts. Some officers would have been familiar with the work of Sir H. Alker Tripp (1942). In 1932, Tripp was appointed Assistant Commissioner "B", in charge of traffic in London and the Home Counties, and devoted the next fifteen years to the study of London's traffic problems becoming a widely-recognized international authority on the control of traffic. Following these planning guidelines, the Police in New South Wales were intuitively against any commercial developments being approved on land abutting a main road.

Against this background of conflict between the government consent authority and the development industry, and with development pressure for drive-in/drive-out land uses on main roads, such as petrol service stations, fast-food outlets and small clusters of retail commercial activities Blunden (1966) devised an evidence-based methodology for the analysis of the traffic effects of main road frontage land-use developments. The approach was later adopted (without bibliographic reference) by the National Association of Australian Road Authorities (NAASRA) *in Guide to Traffic Engineering Practice* [NAASRA, 1970].

Blunden made two fundamental contributions: the estimation of the vehicular traffic generation rate by the proposed development; and an assessment as to whether or not the adjacent road had enough traffic carrying capacity to absorb more traffic entering the priority traffic stream from that proposed development. Against the background that little empirical data had been collected in Australia at the time on trip-generation rates, and there were few precedents of successful development applications of comparable land uses and their traffic generation characteristics to guide any proposal, Blunden drew on the service time concept of queuing theory to make an estimation of the likely traffic generation rate. Observations could be made of the mean service time for such activities as obtaining petrol at a service station or the time parked to obtain take-away food. Observations could be made in car parks to obtain the mean parked time for drivers shopping or on personal business. By knowing this mean service time and the number of service channels (petrol pumps or parking spaces available) an estimate of the *maximum* amount of traffic in and out of the development can be readily obtained from Equation 1.

$$Q_{max} = (60/u) \times M \qquad (1)$$

Where,
Q_{max} = maximum traffic generation rate per hour in vehicles;
u = mean service time in minutes;
M = number of service channels in the proposed development.

As time went by, government authorities assembled traffic generation rates for different kinds of land use (NSW Roads and Traffic Authority, 2002).

Blunden then drew on the classical traffic flow theory paper by Adams (1936) – on the delay to an isolated vehicle waiting to enter a priority traffic stream, and modified by Tanner (1961) when the demand rate for gaps exceeds about 200 vehicles per hour. Assuming that the distribution of successive headways in the priority traffic stream was random the absorption rate of a priority traffic stream (Q_a) can be conceptualised by considering a reservoir of stored vehicles (for example, in a parking lot in the proposed land-use development) that is discharging into a traffic stream of flow level, Q. The rate per hour at which vehicles can be absorbed is [Blunden and Black, 1984].

$$Q_a = [Q.\ e^{-QTc/3600}]/1 - e^{-QTf/3600} \qquad (2)$$

Where,
Q_a = Rate at which vehicles can be absorbed into the priority traffic stream (veh/hr);
Q = Priority traffic stream flow level (veh/hr);
Tc = The time headway in seconds between passing vehicles in the priority traffic stream into which it is safe for a stationary vehicle in the reservoir to merge into (or cross);
Tf = The follow-up headway in seconds when a priority traffic stream gap is long enough to permit a group of vehicles in the reservoir to merge into (or cross).

Table 1 gives some results of applying Equation 2 to typical Australian driver behavior in terms of field observations of gap acceptances and follow-up gap acceptances. This must be noted that similar tables can be formed using other values of Tc and Tf for different driving environments. The critical gap is taken as 4 seconds and the follow-up headway is assumed to be either 2 or 3 seconds. When the traffic flow on the priority traffic stream to be entered is low (say 200 vehicles per hour) then the discharge from the proposed development can be from 1000 to 1500 vehicles per hour. Obviously, as the traffic on the frontage road builds up, there are fewer opportunities to exit such that a priority traffic flow of 1800 vehicles per hour allows only 300 – 400 vehicles per hour to exit the development.
When applying these two theories to the traffic impact assessment of a proposed development, the worst-case scenarios are assumed. The traffic flow on the main road (Q) is the peak hour flow, meaning Q = Qmax and therefore, a maximum hourly traffic generation rate from the land-use development, coincides with the peak period flow. If the absorption rate (Q_a) is sufficient the development will be operationally satisfactory for all other times of the day. Various ranges of Q_a for varying values of Priority Traffic Flow and Critical Gap of 4 seconds and Follow up Gaps of 2 & 3 seconds are listed in Table 1.

3. Australian Practice - Current Situation

NAASRA is now called Austroads and the latest guide to traffic impact assessment was issued recently [Austroads, 2016]. The guidelines help traffic and transport practitioners identify and manage the impacts

Table 1. Absorption rate of a priority traffic stream based on the critical gap and follow-up headways

Priority Traffic Flow (veh/hr)	Tc = 4 seconds Tf = 2 seconds	Tc = 4 seconds Tf= 3 seconds
200	1522	1043
600	1086	782
1000	772	582
1400	546	429
1800	385	313

(Source: based on Blunden and Black, 1984, Table A.3, p. 237)

of the road system arising from land-use developments. The impacts being considered are those directly affecting road use and road users of all classes, from large freight vehicles and buses to cyclists and pedestrians. Guidance is given on how: to identify the types of traffic impacts and interactions which will result from a specific land use development proposal; to assess the size of those impacts; and to determine how those impacts need to be managed, either within existing infrastructure or through the provision of additional infrastructure. Car parking is subject to a separate guideline [Austroads, 2008]. Depending on the type, scale and location of a development, the traffic impacts may need to be assessed for a considerable distance on the approach route(s) along an arterial road. Furthermore, geometric elements of the road may need to be expanded, modified or redesigned at mid-block locations and at intersections.

The ***Austroads Guide* to *Traffic Management*** now has 13 parts and provides a comprehensive coverage of traffic management guidance for practitioners involved in traffic engineering, road design, town planning and road safety. The most recent edition of *Part 12: Traffic Impacts of Developments*, issued in 2016, is concerned with identifying and managing the impacts on the road system arising from land use developments. The first edition was issued in 2009 and the latest edition includes editorial changes and technical changes including: reordered sections and sub-sections to prioritise road safety; additional and updated sources of traffic generation rates; logistics plans; new an introduction to the notion of link-and-place; electric vehicles and parking; Light Rail and Bus Rapid Transit Systems; and Network Operating Frameworks and Plans.

It provides guidance for planners and engineers associated with the design, development and management of a variety of land-use developments. The aim is to ensure consistency in the assessment and treatment of traffic impacts, including addressing the needs of all road users, and the effect upon the broader community. It gives guidance on the detailed procedure for identifying and assessing the traffic impacts, and mitigating their effects. Assessment of safety, infrastructure and environmental effects is also covered. Examples are given of checklists, report structures, traffic generation rates and case study projects. What follows is an outline of the documentation that is required to be submitted by the developer to the consent authority.

Many local government councils in the state of New South Wales have extensively used the guidelines prepared by the then Roads and Traffic Authority of New South Wales (now the Roads and Maritime Services, RMS) and the joint Australian and New Zealand standards to control and manage the impacts of traffic in both inside and outside buildings. In practice, and as a part of the process of development application (DA) for any proposal, the plans and the reports prepared by a hired traffic and transport consultant on behalf of the applicant or developer, has been reviewed and assessed against a number of guidelines. These include local guidelines, Australian/New Zealand joint standards (mainly, AS/NZS 2890.1 - Parking facilities for off-street car parking) as well as Australian Standard 2890.2 & 2890.5 – for off street commercial vehicles and on- street car parking facilities coupled with Guide to Traffic

Generating Developments (mainly, version 2.2) of the then NSW Roads and Traffic Authority. These ready-to-use guidelines have been employed by transport and traffic sections of the local councils to ensure that the prepared plans comply with the standards in the areas of required parking spaces, internal circulation, safety and ease of maneuvering inside the building as well as the access, queuing length and area and the impact of generating traffic on the immediate streets and road network.

4. Documentation by Developer

As the starting point of providing a traffic impact assessment is to know the process and the information and/or documents that the developer and/or his legal representative, in this case a consultant, need to submit to the consent authority. The proposed development may hand in the following documents to the consent authority for the assessment processes. The tasks for the consultant acting on behalf of the developer in documenting the proposal can be summarised below [Austroads, 2016].

- Provide a plan, or plans, which show the layout of all the traffic and pedestrian areas on the site, plus the locations of vehicle and pedestrian accesses onto roads, plus the position and layout of all nearby driveways and intersections.
- Check that each type of internal access (e.g. cars, pedestrians, trucks, etc.) is direct, connected, continuous and makes sense.
- Check that the approach roads and paths are clearly understood and are practical.
- Check that the correct design vehicle and checking vehicle has been used in the various sections of the development.
- Check that basic design requirements have been applied.
- Document the land-use planning zonings in the vicinity, for use when assessing impacts later.
- Summarise/list the traffic-related features of the development, including those which may be taken directly from the plans (e.g. total number of parking spaces, access points to roads, internal access to different sections for pedestrians, cars, trucks, bicycles, etc.).
- Describe the timing and phasing of the development and note any connection with external events and activities (e.g. sporting events, community events, other nearby developments, etc.).

Large developments may have internal roads to which legislated road rules apply. Therefore, it is desirable that the internal layout achieves the following:

- Minimizes conflict between pedestrians and motor vehicles;
- Provides delineated, direct, safe and well-signed paths for pedestrians (e.g. moving from local areas, public transport stops, interchanges or stations to the development);
- Provides efficient, safe, and well-signed and delineated lanes or paths for cyclists accessing the development from roads, dedicated cycle paths or the shared network;
- Encourages and reinforces safe speeds;
- segregates the movement of trucks servicing the development from all other traffic within the site;
- Enables all deliveries by truck to be made on-site (i.e. no loading or unloading from the external road network) and all trucks to enter and leave the site in a forward direction;
- Supports the safe and efficient movement of public transport within the site and between the site and the external road network; and
- Incorporates bus interchange facilities, which are safe and readily accessible for users.

4.1 Documentation of the Existing Road Network

- Document the existing traffic conditions (for critical periods of the day or week).
- Select the design year (or years, for a staged development) and document the same types of traffic conditions for that time (Exclude the traffic generated by the development).
- Show the traffic volumes on a plan.
- Describe the parking conditions to the extent this will be relevant, e.g. parking controls, parking locations, parking occupancy, existing parking spill-over or problems.
- Document the traffic crashes at the potentially impacted locations.
- Document any known traffic safety or operational problems and any proposals to address them. Document any traffic, transport or parking policies that affect the proposed development.

4.2 Traffic and Modal Split

- Determine the number of trips that will be generated by the development (e.g. daily, peak period). Do this for the design year or years.
- Determine the generated volume of general traffic, commercial vehicles, public transport vehicles (including taxis), bicycles and pedestrians and their proportions of the total number of trips.
- Determine the approach and departure directions of traffic.
- Take account of traffic that returns to its point of origin and traffic that stops while passing by.

5. Traffic Analytical Methods used in Australia

Traffic impact analysis in Australia is facilitated by the application of land-use and transport models and traffic models that are validated on the local situation. Today, these analytical methods are commercially available in the form of computer programs. In making forecasts about future land use (including development applications) and about future traffic there is always uncertainty in their projected levels of accuracy given the planning horizons may be ten or twenty years away. However, the models applied when undertaking traffic impact assessments are regarded as being fit for purpose. In fact, there is a suite of suitable analytical models (Figure 1). Although the source of this illustration is from the USA the internationalisation of the consulting industry means that many of the acronyms mentioned are available throughout the world. (A word of caution for the Iranian reader: unlike in Iran Australian road rules are such that vehicles drive on the left-hand side of the road).

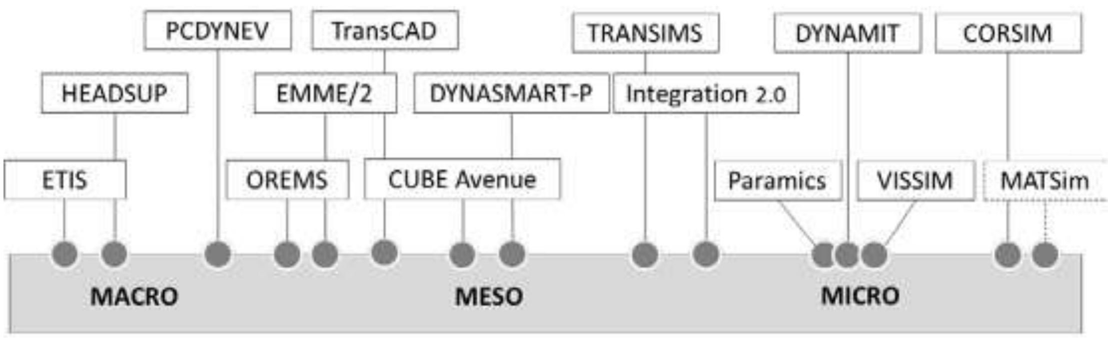

Figure 1. Spectrum of Macro-, Meso- and Micro-Traffic Models

(Source: based on US Department of Transportation, 2009, Figure 4)

In Australia, a strategic 4-step land use and transport model would be calibrated for a metropolitan-wide transport network (see, Black, 1981, Chapter 3) and a stochastic -user equilibrium traffic assignment model, such as EMME/2, would give peak-hour road traffic flows for a base year and for a future planning horizon based on land-use growth and its spatial distribution. In essence, this model gives the priority stream traffic on roads around the proposed development. The traffic generation of the proposed development, based on empirical data (see, for example, NSW Roads and Traffic Authority (2002) *Guide to Traffic Generating Developments, Version 2.2*) is, in essence, a regression-type model with peak hour trip generation rates as the dependent variable and a measure of land-use activity (floor-space, employment) as the explanatory variable. To assess the impact of this traffic generation on the surrounding road network a number of micro-models (such as Paramics, VISSIM and SIDRA) are deployed, especially for intersection performance. The case study below uses SIDRA.

The SIDRA INTERSECTION software – now in its seventh version (http://www.sidrasolutions.com, accessed 24 November, 2016)) - is for use as an aid for design and evaluation of individual intersections and networks of intersections. It can be used to analyse signalised intersections (fixed-time / pretimed and actuated), signalized and unsignalised pedestrian crossings, roundabouts (unsignalised), roundabouts with metering signals, fully-signalised roundabouts, two-way stop sign and give-way / yield sign control, all-way stop sign control, single point interchanges (signalized), freeway diamond interchanges (signalized, roundabout, sign control), diverging diamond interchanges. It can also be used for uninterrupted traffic flow conditions and merge analysis.

Detailed evaluation of the traffic impacts of intersection treatments - signed intersections, roundabouts and signalized intersections - is usually undertaken with intersection analysis software specially developed for the purpose, such as SIDRA, the CARP model developed by Queensland Department of Transport and Main Roads (TMR) and ISEVAL developed by VicRoads. Naude, Lloyd and Bennett (2016) explain the development of the Small Intersection Evaluation (SIE) Tool, including its overall design, methodology and data requirements (base case and project case) for the estimation of traffic impacts at signed intersections, roundabouts and signalized intersections. Results of the intersection evaluation are presented in terms of economic decision rules - net present value (NPV) and benefit cost ratio (BCR).

6. Developer Contributions

The New South Wales Environmental Planning and Assessment Act 1979 - Section 94 – covers the contribution towards the provision or improvement of amenities or services when development applications are lodged. If a consent authority is satisfied that the development will, or is likely to, require the provision of, or an increase in the demand for public services within the affected area, the consent authority may grant the development a conditional consent. Such a consent requires developer the dedication of land free of cost, or the payment of a monetary contribution to the consent authority. The latter, in New South Wales, is the local government. Local government have the statutory authority to collect and expend Section 94 contributions according to the Act. In practice, the money might be allocated to public footpaths, intersection improvements, road widening providing a nexus can be established between the need for these improvements and the additional demands imposed by the proposed development.

Moreover, it is the responsibility of local government as the development consent authority to formulate "Developer Contribution Plans". Urban Research and Planning Pty Ltd have undertaken a number of calculations on behalf of Councils and the following is an illustrative example of the methodology to estimate the amount of the money contribution from developers (Urban Research and Planning, 1999). Leichhardt is an inner western suburb of metropolitan Sydney where planning studies had identified the need to improve the town centre, especially Norton Street which is the main retail and commercial road – much along the lines of the guidelines issued by the state road authority (NSW RTA, 1999). The complete package of transport works was estimated to cost Aus$4.28 million including traffic calming, pavement and drainage, pedestrian crossings and other amenity upgrades. Contributions are in proportion to floor space of existing and proposed developments and are applied only to commercial properties in the defined Town Centre. Only Aus$2.8 million (amenity upgrade) is applied to the cost allocation and all existing, approved and potential floor space is divided into this amount equally a developer contribution of approximately Aus$5000 per 100 meters of commercial floor space.

Historically, it has been the growth and the rapid rise of large new developments in the Sydney metropolitan area that has called for new avenues of funding for transportation facilities. Such initiatives have been taken due to the shortage of funds in the public sector and the significant impact of the developments on the regional transport facilities. The case studies examined by Smith and Tara (1990) give examples of how private contributions have been sought for traffic improvements in the Sydney area. The paper reviewed the then new methods of funding in overseas countries, describing private involvement in shared funding for transport facilities. The paper concluded that there is a need for research and study to formulate a better methodology as to how to fund transport improvements in light of new developments. The required methodology should assess the economic and traffic aspects of new developments on the basis of their local and regional impacts.

7. Simple Case Study

The principles of undertaking a traffic impact study can be illustrated by a case study of a school. The NSW Department of Education is the proponent for a planning proposal to increase the number of pupils at an infants school in a local government area (local government is the consent authority) of Sydney. The proponent has engaged traffic-engineering consultants to undertake the appropriate technical analyses and stakeholder consultations submitting to Council a TIA to increase the number of pupils from 185 to 600 on the existing site.

The main steps followed by the consultant – as the third author of this paper has been engaged in this study, are reproduced in Figure 2. The methodology includes: data collection on streets surrounding the streets; analysis of existing data on vehicular traffic flows on the surrounding road network; assumptions about the future modes of traffic to and from the school; traffic impact studies in terms of road capacity and intersection delays; and robust conclusions about the future traffic conditions. From suggestions and ideas generated at community workshops the consultants proposed options for the mitigation of any adverse impacts of the development application.

Whilst the future number of pupils and staff are robust numbers from which to start a traffic impact assessment arrival and departure times, mode of travel, the extent to which parents and carers drive to drop off and pick up children are all highly uncertain. The consultants made the following assumptions:

1. An increase of students from 185 to 600 (for a primary school).
2. Use of RMS Guide to traffic generating development trip generation rates for pre-school. This is a higher rate than could occur for primary schools, however, as a worst case scenario, this measure has been adopted.
3. Use of additional trip generation and its distribution at related intersections in the vicinity of the school.
4. Including a traffic growth factor of 1.5% per annum (per general RMS growth factor for the area) for 5 years for background traffic, for staging of the project. Therefore, intersection assessments for future case (after the school reclassification) are based on additional traffic from the school and additional background traffic growth.
5. The pick-up and set down activities are based on future school operation management plan to coordinate a staggered time of classes during the start and finish times.
6. An accessible parking space and a

waste collection space are included as part of the master plan.

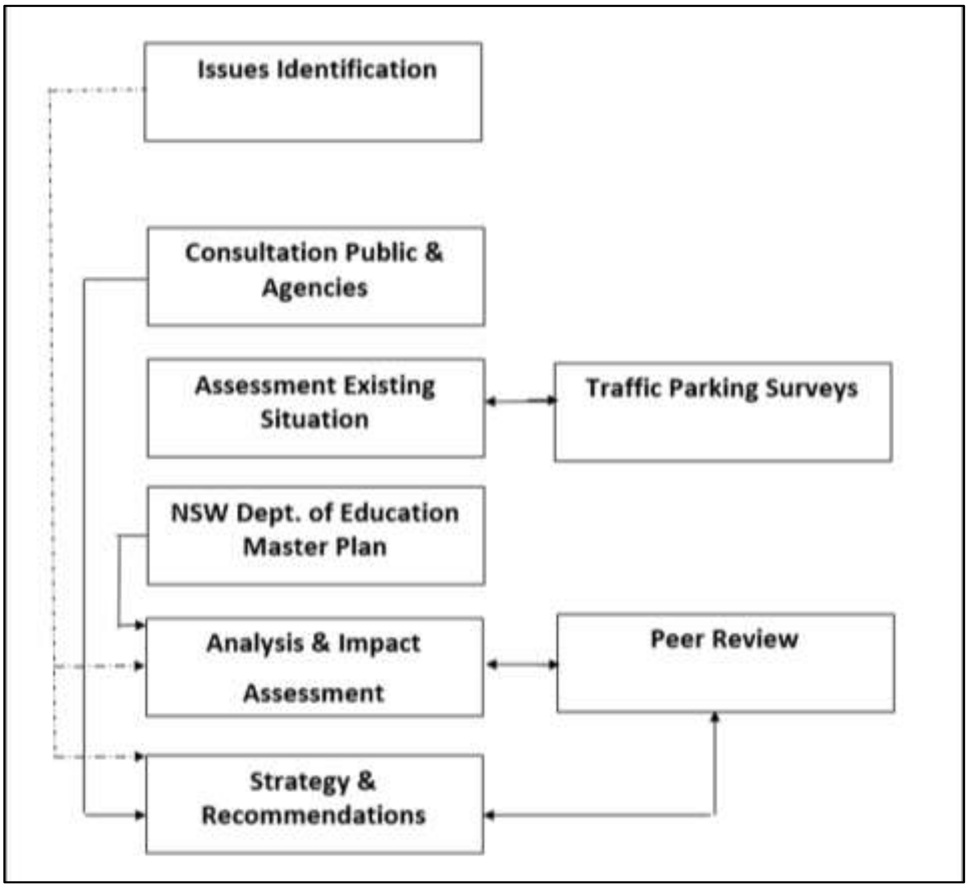

Figure 2. Summary of Consultants' Study Methodology for Traffic Impact Analysis (TIA) of an Infants School Planning Proposal

The assessment criteria are drawn from the Austroads Guidelines, as is standard traffic engineering practice in Australia. In order to relate the traffic flows recorded against the assessment criteria for intersections near to the school the computer program SIDRA was applied to mathematically simulate delays at single intersections and their qualitative levels of service for road users. As noted by the NSW Government, Transport Roads and Maritime Services (2013, p. 6): "SIDRA is the most commonly used single intersection modeling software in NSW…" Table 2 gives the results for signalized intersections in the vicinity of the school for the base year (current situation) and for 2021 when it is assumed the school will be expanded in size and there will be a growth in traffic. In this example, the calculated queuing distance is based on the highest or maximum of the averaged delays for the base and the target year being the year 2021. In the assessment of this particular development application the road intersections are expected to continue to operate at a level of service A and therefore the consent authority should have no objections to an increase in the size of the school on *traffic grounds*. Parking is one of the most vexing of issues when development applications are made in areas of predominantly residential land use. The consultants conducted parking utilisation surveys at seven different times. The recommendations to solve access issues during the busy times are:

1. Provision of on-street parking with appropriate signs for pick-up and set down activities during school peak hour times adjacent to the School's site.
2. Introduction of a "No Stopping" zone during the School peak hour periods.

Table 2. Performance of Intersections Near the School Morning Weekday Peak Hour (7.15 to 9.30 AM)

Intersection	Degree of Saturation DOS		Level of Service LOS		Average Delay Seconds		Queue Distance (m) Highest delay
	BASE	2021	BASE	2021	BASE	2021	BASE
L Rd/L St	0.36	0.39	A	A	1.10	1.40	13.00
L Rd/ St	0.62	0.72	A	A	9.10	11.70	129.00
W St/M St	0.06	0.26	A	A	1.70	2.30	0.20
W St/L St	0.04	0.11	A	A	3.70	2.20	1.00
W St/St	0.26	0.40	A	A	0.90	2.60	3.10
L Rd/MSt	0.36	0.36	A	A	0.80	0.80	9.80

3. Installation of marked pedestrian crossings at various locations
4. Improvements in School Zone signage in the area.
5. The extension of a pedestrian footpath to cater for the new pick-up and set-down zone. This would also provide the possibility of a shared zone for students as a bike route.
6. Consideration should be given to a one-way system along some of the roads surrounding the school.

The capital costs of some of these recommendations would form the basis of calculating the developer contribution under Section 94 of the NSW Environment and Planning Act.

The evolution of practice with TIA in Australia has included putting responsibility of the proponent to better manage traffic demands – often referred to as "Green Travel Plans" (see for example, Black, Mason and Stanley, 1999). In this case study, the NSW Department of Education - as the proponent - should formulate a School Operation Management Plan in consultation with the school principal. Such a plan might comprise: the initiation of the "Walking School Bus"; the introduction of car-pooling initiatives amongst staff and parents; the development of a "Active School Travel Program"; the establishment of a road safety and parking committee; and the preparation of a "Green Travel Plan" to show public transport access points and active transport accessibility areas e.g. "marked safe route to school".

7. Conclusions

On 5 October, 2016, the Traffic Committee of the Iranian Organisation for Engineering Order of Building (IOEOB), convened the First Iranian National Conference on Traffic Impact Assessment of Buildings, held at the Building and Housing Research Centre, Tehran, to launch draft guidelines. The Committee, in formulating these guidelines, reviewed international experience, including that of Australia. This paper has traced experience in Australia now spanning some fifty years. Traffic impact assessment started in Australia in the 1960s when the traffic police exercised considerable authority in trying to prevent land-use developments from taking place abutting main roads. Concepts derived from queuing theory (Blunden, 1966) – the application of the mean service time to establish maximum traffic generation rates for a proposed development and the absorption capacity of a priority traffic stream – found their way into traffic engineering practice to provide a rational basis for assessing development applications on their merits. As experience accumulated, the guidelines became refined to the extent that Austroads issued the *Guide to Traffic Management Part 12: Traffic Impacts of Developments as a Second Edition in 2016.*

This paper has explained developments over time by outlining what documentation is expected from a developer, by describing the traffic models available to the consultants working for the developer, and explaining the importance of developer contributions should the proposed development require changes to the surrounding road, pedestrian and transport network. A simple case study of a school expansion was provided to illustrate the principles of TIA and to point out that the onus on all developers (in this case the state Education Department) is to manage travel demands to achieve more sustainable outcomes from urban development. The references cited at the end of this paper provide material for more detailed study. What is not covered in this review of TIA experience in Australia – and it is a most significant omission – is that TIA must take place within broader policies for urban development, especially metropolitan transport policy.

8. Acknowledgements

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