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A REVIEW OF TRANSPORT DEMAND MODELLING FOR THE SCHOOL RUN IN BRUNEI DARUSSALAM

F. Ariffin, Y. H. Yap, E. S. M. M. Zahran, S. J. Tan

Civil Engineering, Faculty of Engineering, Universiti Teknologi Brunei, Brunei Darussalam
fhariffin@gmail.com

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Abstract

Brunei Darussalam is one of the most car-dependent countries in the world. The low cost of running a car, driven by a Government policy of subsidising fuel, continues to ensure the car is the preferred option for almost all trips including school run. This high car dependency leads to heavy traffic congestion outside schools and this is exacerbated as Brunei has an atypical school traffic pattern due to its unique education systems. This causes many urban roads in Brunei to have a unique traffic flow profile, with a very prominent midday peak. Transportation planning is essential in order to improve and increase the efficiency of the country's transportation system. This study thus attempts to present an overview of state of art of various methods of travel demand modelling, in order to find the most suitable method for modelling the school run situation and enable potential solutions to be proposed and evaluated. It is found that research is still required in order to develop travel demand models for school run and also to find other solutions to solve the issue of school-related congestion.

1 Introduction

School-related traffic congestion brings more than just an inconvenience to people using the roadway, as such congestion also jeopardizes the safety of the students, teachers, parents and residents in and around school locations. Hence, it is a significant problem in communities around the world, and the small country of Brunei Darussalam is not an exception.

According to the Land Transport White Paper for Brunei Darussalam, as of the year 2013, there were 216,000 licensed motor vehicles with the vast majority being private cars. In comparison to that, the population of the country in that year was a total of 404,600 [1], this shows that in ratio of 1 car to 2 persons. Also every month, there were about 1,400 newly registered private vehicles with an annual vehicle growth rate of 9% [2]. These statistics, together with very high rates of private car usage compared to other transport modes [3], indicate that Brunei is one of the most car-dependent countries in the world.

The private car is the preferred option for almost all trips in this country, including the school run [4]. There is found to be reluctance from parents and their children to consider alternatives [3]. These attitudes and behaviour are reinforced by lack of traffic and parking enforcement, limited investment in walking and cycling initiatives and negative preconceptions of the safety and security of public transport and school buses [3].

2 The School Run Transport Challenge

The school season in Brunei is synonymous with traffic congestion. The school run leads to a major increase in the occurrence of traffic congestion, especially at areas near education institutions. One major example of school-related congestion hotspot is in the part of Bandar Seri Begawan shown in Figure 1, where there are three secondary schools (Sekolah Tinggi Perempuan Raja Isteri, Maktab Sultan Omar Ali Saifuddien, Sekolah Menengah Sultan Muhammad Jamalul Alam) and one primary school (Sekolah Rendah Raja Isteri Fatimah) located within an area only 400 metres across.

Figure 1: Bandar Seri Begawan map (*Source: Google Maps*).

The typical traffic flow profile on roads in Brunei as shown in Figure 2 shows two dominant peak periods during AM (07:00-08:00) and PM (16.30-17.30), where people go to work or school. Two very significant peaks are also observed around mid-day, where the first afternoon peak is the time people leave work for lunch and pick up children while second afternoon peak is the time people return to work after lunch and drop off children to the religious schools. This shows that Brunei has an atypical traffic pattern, where school-related congestion is very important. Due to the

country's Islamic heritage, Muslim students below a certain age are required to attend classes in religious schools after the normal schooling hours and since 78.8% of the population is Muslim [5].

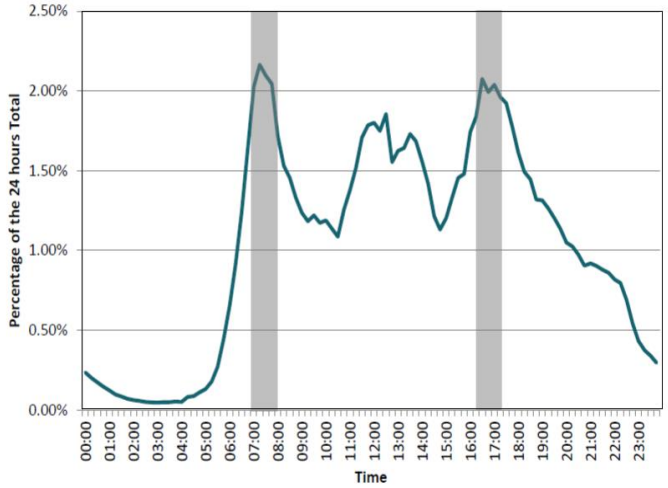

Figure 2: Road flow profiles in Brunei [3].

In addition, large families in Brunei are relatively common [6], and siblings of different age groups can often end up dispersed across different schools located in different areas of the districts. This results in long trip distances, and adds to overall traffic volumes. Congestion on roads near schools occurs due to drop-off and pick-up activities, as double-parking and temporary stoppages result in through traffic flows getting partially blocked. Police personnel may attend on the sites of critical routes as to ensure smooth-running of the traffic.

These issues and solutions are not sustainable, and hence, there is a need for a better way of alleviating the traffic congestion problem caused by the school run. To propose feasible and effective measures to address this problem, it is necessary to develop a model of the transportation problem, to enable the planning and development of suitable schemes to improve and increase the efficiency of the transportation system. Towards this, this paper critically reviews the various methods of travel demand modelling available, in order to identify and develop a suitable modelling approach for the school run problem.

3 Travel Demand Modelling Methods

3.1 Introduction to travel demand modelling

This section explains how travel demand modelling works, and provides a critical review on the general types of travel demand model. Travel demand models are used to predict future travel patterns so that they can be accommodated through the development of transportation plans and schemes. To predict travel patterns, household and population information, and population growth forecasts must be first collected, and then combined with any specific highway and transit network usage data. These are then used to develop, calibrate and validate a model in which users can run predictions for a predetermined time period. Various planning scenarios can then be implemented in the model to compare the effects of changes to the transportation system, provided that the model has been developed to investigate these solutions. Travel demand modelling is thus a key part of transportation planning process that develops information to help make decisions on the future development and management of transportation systems, including new or expanded highways, transit systems and/or the management of their demand.

Some examples of travel demand modelling approaches including four-step modelling, tour-based modelling and activity-based modelling.

3.2 Four-step modelling

Four-step modelling is a classic method of travel demand modelling, and is trip-based. As the name implies, it has four basic phases; trip generation, trip distribution, mode choice and trip assignment.

These four stages respectively consider the number of trips people make based on their household and income characteristics, where those trips go, how the trips are divided among the available modes of transport, and how those trips are split among the routes on the network. Compared to other modelling approaches, four-step modelling can be applied to any well-defined situation, and the approach is easy to understand due to its aggregate characteristics. However, McNally [7] has briefly summarised some limitations of the approach that have been widely discussed in the literature, including:

- Travel is not considered as a demand derived from participation in activities;
- The approach focuses on individual trips;
- Misrepresentation of overall behaviour as an outcome of a true choice process;
- Inadequate specification of the interrelationships between travel and activity participation and scheduling; and
- The approach neglects substantial evidence of alternate decision strategies involving household dynamics and habit formation.

Gu [8] also states that the model is based on the average of a group of travellers instead of independent individuals, as opposed to the approach used by simulation models. Hence, the limitations above show that four-stage modelling may have insufficient sensitivity to changes in policy. For example, it is unable to incorporate the effects of demand management approaches, such as varying working hours, carpooling, etc. [9]

In addition, the desired roles of different transportation modes are usually not clearly defined [10] as there is limited focus on other travel modes that can have a significant share. For example, they cannot be used to assess the impact of proposed bicycling and pedestrian infrastructure investments without "post-processing" of model outputs.

This model also has difficulty in modelling time-of-day related issues, especially departure time choice and peak spreading.

3.3 Tour-based modelling

In contrast to four-step models in which trips are considered independently, tour-based modelling uses tours as the travel unit, defined as the tour from home to one or more destinations and then back home. This thus better takes into account the dependence of mode choice of a given trip on preceding trips. This approach predicts tours based on factors which affect the tour patterns of individuals such as household size, lifecycle stage, age, gender of household members and children [11]. Hence, this form of modelling generally does not require significantly more data beyond that required to develop a four-step model system [11].

The key features of tour-based modelling are the obvious representation of tours and trip chaining within tours. However, the key weakness is more likely the same as four-step model, which it is lacking of an overarching pattern connecting the day's tours, and the failure to incorporate the time dimension into the model structure.

3.4 Activity-based modelling

Activity-based models are an extension of tour-based models, based on the principle that travel is derived by the desire or need to participate in activities. Activity-based models typically involve simulation and/or econometric methods, such as that implemented in TRANSIMS [12], to model travel choices as the outcome of a sequence of desired activities. The three major advantages of this activity-based models are the ability to model traveller behaviour, the assumption that travel is taken in response to the desire to perform an activity within a given activity schedule and the sensitivity to transportation policy implementation.

Activity-based models treat daily activity-travel patterns as a whole and can create unique travel patterns based on the simulated demographic characteristics of individuals [13]. Some examples of the demographic characteristics are income level, availability of automobiles, the household makeup and the relationships between members of the household. Activity-based models also retain the connections between all the activities and travel. Activities are also spread out throughout a 24-hour period in a continuous manner, rather than simple categorisation of 'peak' and 'off peak' events.

4 Discussion

The differences in the three types of travel demand modelling approaches above affect their suitability for modelling school run traffic and the possible solutions. Trip-based models have difficulty in modelling time-of-day related aspects, especially departure time choice and peak spreading. An alternative is to split the 24-hour demand matrix into several time-of-day matrices based on the observed demands in different time periods. This model uses different ranges of time such as the morning peak, mid-day, and afternoon peak periods, but the aggregation of time does not generally allow for an accurate description of when traffic congestion is worst, which is critical to know when implementing congestion management strategies around the school areas.

The four-step model is also focused on individual trips and ignores the interrelationship between all trips and activities completed by individuals. Hence, it is not suited for school run problem which involves a sequence of activities. For example, in Brunei, many parents drop their children at school in the morning on their way to work, before driving them to religious schools in the afternoon. The travel behaviour of both parents and children are thus different from each other as well as other individuals. The four-step model sees an individual as a decision-maker isolated from the household context. The aggregation within the model in the representation of the average of a group of travellers in terms of travel behaviour therefore limits its ability to predict the behaviour of individual travellers [14]. This is a disadvantage as the travel behaviour of parents, teachers and children are greatly different in the case of school run.

Trip-based modelling also has difficulties in analysing changes in travel behaviour as a result of future changes. An example would be the changes resulting from parents deciding that their children are to use a school bus or walking, instead of using their car. This is key, as Brunei has high dependency on cars for school runs where up to 80% travel to school by private car, with only 10% of the students travelling to school by school bus [4]. There are proposals to promote safe and healthy travel to school by public transport and non-motorised modes, including the improvement of existing bus services. However, given that children's modal choices are influenced by the service quality of motorised modes [15], there is therefore a need to model the impacts of these proposals. Trip-based models may thus be insufficient, given their inability to precisely model how certain groups respond to future policies such as improved school bus provision.

In contrast, activity-based modelling is better able to predict travel patterns based on a host of variables related to the personal preferences and behaviour of the individual. It is also able to provide insightful information about the change in travel patterns due to the implementation of transportation policies. It also has a greater ease of extensibility [16] due to its disaggregate nature, as a new descriptive variable can be included more simply compared to trip- or tour-based models. For example, a 1991 Boston area resident survey illustrated the complexity of the work commute tour among all workers, males with small children and females with small children [17]. The inherent ability of activity-based model to treat travel as a response to the desire to perform an activity within a given activity schedule enables it to model variety in people's travel patterns. It can thus differentiate between single men who may have more recreational trips, compared to single working mothers who work, run errands and perform school runs. Hence, the presence of children affects activity decisions, and they themselves also have activity-travel characteristics that are unique and different from adults, while requiring adults to escort them to and from out-of-home activities locations [18].

The school bus is particularly of interest, given its proven effectiveness in improving the school run [19]. Hence, Brunei is also working to improve the national school bus system to tackle the school-related congestion issues. The school activity has a unique school bus mode that is not available for

other activities, thus increasing the importance of modelling the school activity separately from other activity types. Again, activity-based modelling is suitable for this kind of transport planning situation.

5 Conclusion

The traffic flows of roads in Brunei Darussalam are highly influenced by the effect of the school run, where students often travel between different schools between the morning and afternoon sessions, particularly in urban areas. Coupled with the high dependence on cars, and the limitations of existing public transport and school bus services, there is a need to model the travel demand impacts arising from this particular issue, in order to develop and evaluate effective policies and measures to reduce the impact of road congestion, such as improved school bus provision. The review of the models in this paper has shown that activity-based models are more suitable compared to tour or trip based models for modelling the school run. This has been shown by trip-based or four-step models not having been effectively applied to model changes in policies involving management and control of existing infrastructure. The trip-chaining between work commute and school runs in Brunei needs to be considered by modelling the activity program and schedule decisions of parents escorting their children to schools. This is to enable more accurate travel demand forecasts, and activity based model is best suited for this purpose. In addition, activity-based models would be suited to modelling the impact of the greater provision of walking and cycling facilities, given the need to consider children's travel patterns separately. Very few studies have examined the transport demand issues raised by the school run, and activity-based models are likely the best avenue to research this problem and develop adequate solutions to mitigate school-related congestion.

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