Suggestions for an Improved Davidson Travel Time Function

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ABSTRACT

Travel time functions (also known as speed/flow curves or congestion functions) form a central and key element of transport planning and policy analysis. This paper considers the performance of the functions incorporated in two widely used transportation planning packages, UTPS and Microtrips, and concludes that they have structural deficiencies which need to be overcome. The Davidson function, especially in the modified form suggested by Akcelik, is discussed as a superior alternative travel time function. We show that the modification given by Akcelik may have potential deficiencies, in particular that the slope of Akcelik's linear extension behaves poorly when the 'quality of service' parameter m approaches its upper limit of 1, and that the modified function is not time-dependent and thus static in nature. We identify an alternative linear extension derived from Akcelik's later and independent work, which avoids these potential deficiencies. Finally, we discuss the interpretation of the terms saturation flow and capacity in the context of the Davidson function and illustrate the capacity overestimation problem that can arise if all Davidson function parameters are estimated simultaneously.

INTRODUCTION

A travel time function is a mathematical relationship which relates the travel time on a segment of road (a link in transport network modelling terminology) to the traffic flow on that link. Since travel time plays such an important role in all aspects of urban travel demand estimation, the travel time function (also known as a congestion function, travel time/flow function, or a speed/flow relationship if time is replaced by speed) is one of the key components of any demand determination and analysis procedure.

This paper considers the performance of the functions incorporated in two widely used transport planning packages, UTPS (US DOT 1982) and Microtrips (MVA Systematica 1984), and concludes that they have deficiencies which need to be overcome. The Davidson function (Davidson 1966) is discussed as a superior alternative which has already had considerable use, particularly in Australia, for a variety of applications (Rose 1986; Taylor 1984; Taylor and Anderson 1983; Boyce et al. 1981; Travers Morgan 1983; Starrs and Starkie 1986).

Problems associated with use of the original form of the Davidson function in traffic assignments have been recognised for some time. A modification designed to overcome these problems (Akcelik 1978) has been successfully used (Taylor 1984; Travers Morgan 1983). Akcelik developed his modification as an example of one way of overcoming the problems experienced with the original Davidson function. Its aim was to generate sensible travel time values for the purpose of traffic assignment in transport planning modelling.

Akcelik's modification has proved to be very useful; however, we believe that it does possess a number of potential deficiencies. Accordingly, we suggest an alternative modification based on later and independent work by Akcelik (1980, 1981). In addition, we feel that other problems exist in relation to the interpretation of one of the key variables in the Davidson function, namely the saturation flow rate, and also in the approaches used to date for empirical estimation of the functions parameters.

ACKNOWLEDGEMENTS

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Dr Akcelik's reply will be published in a forthcoming issue of the journal.
TRAVEL TIME FUNCTIONS

The section below discusses the role played by travel time functions in demand estimation, and discusses the travel time functions used in UTPS and Microtrips and the Davidson function. In the following section (Specific Issues) we then present a possible alternative to the Akcelik modification, and discuss the interpretation of the saturation flow term, and the issue of estimation of the parameters of, the Davidson function. Finally, the last section provides a brief summary and conclusions.

ALTERNATIVE TRAVEL TIME FUNCTIONS

Use of Travel Time Functions in Demand Estimation

In the estimation of urban travel demand, travel time is treated as a cost which directly influences the travel decisions of individuals and firms. In some models it is the sole component of cost of travel, but more often it is just one of several cost elements which together make up the generalised cost of travel. In models where other cost elements are included, the time element still usually contributes a substantial proportion towards total cost, especially when volume approaches capacity and congestion builds. The importance of the time element becomes evident when one recognises that the cost of travel (of which time is a significant component) is a critical determining factor in several of the phases of demand estimation and also in any economic evaluation of road projects (Borins 1982).

In Adelaide, South Australia, the two packages used for travel demand estimation are UTPS and Microtrips within which locally estimated disaggregate (Pak-Poy & Associates 1977) and aggregate (Director-General Of Transport 1985) travel demand models reside. These packages are of the traditional four step variety, comprising four sequential phases of estimation: trip generation, trip distribution, mode choice and route choice. Cost of travel is a determining variable in each of the last three phases. Trip generation as currently modelled is completely price inelastic. However, it is feasible from a consumer theory point of view to incorporate some degree of elasticity for at least some types of travel, e.g. recreation travel. More sophisticated models incorporate cost (including time) of travel in modelling land use allocation, location decisions by individuals and firms, and the decisions governing the time of day at which travel is undertaken (Ben-Akiva and Lerman 1985). Travel time, as a significant component of the cost of travel, therefore plays a very important role in travel demand estimation.

Many different types of travel time functions have been used in transport planning applications. Branston (1976) provides a thorough review, though lack of data prevented the identification of a preferred form for a travel time function. Two of the most commonly used travel time functions are those found in the UTPS and Microtrips transportation planning packages.

BPR Travel Time Function

One of the most commonly used travel time functions is the one developed by the US Bureau of Public Roads (BPR) in the 1950s. The main reason for its widespread use is that it is incorporated in the UTPS transport planning package, developed by the US Department of Transportation (US DOT), and used extensively worldwide for travel demand estimation.

The BPR curve is expressed as (US DOT 1992):

\[ t = \rho (1 + 0.15(V SV)^4) \]

where

- \( t \) = estimated link travel time at volume \( V \) (min)
- \( t_0 \) = free flow travel time on the link (min), i.e. 'the time it takes a vehicle to traverse the link in the absence of traffic (i.e. at zero flow) but subject to such permanent traffic controls on the facility as signals or signs' (US DOT 1983)
- \( V \) = hourly link volume (veh/h)
- \( SV \) = the hourly service volume on link at level of service \( C \)

\[ SV = 0.75C \]
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where

\[ C = N_c c \]  \hspace{1cm} (3) \]

is the 'absolute' capacity of the road (veh/h)

\[ N_c = \text{number of lanes} \]

\[ c = \text{absolute capacity per lane (veh/h/lane)} \]

'Absolute' capacity is the true capacity of the road and is defined as the maximum number of vehicles that the road can carry, i.e. the volume on a road at the boundary between levels of service E and F, at which operating conditions break down completely (National Association of Australian State Road Authorities (NAASRA) 1982). \( SV \) was also referred to as 'practical' capacity in earlier versions of the formula (US Department of Commerce 1964). Practical capacity was defined as the volume that a road could carry without operating conditions exceeding what was considered, at the time, as an unacceptable level of service. UTPS defines practical capacity as 75 per cent of the absolute capacity of a road.

An expanded form of eqn (1) is then obtained by substituting (2) into (1):

\[ t = t_o (1 + 0.474x) \]  \hspace{1cm} (4) \]

where

\[ x = \frac{V}{C} \]

is the degree of saturation, or the volume/capacity ratio.

Values for the input parameters \( t_o, N_c \) and \( c \) for each link in the road network are provided by the user and the UTPS module UROAD then uses (4) to calculate travel time on links and thus also between origin and destination zones.

Two deficiencies can be identified with the BPR function used in UTPS. These are now discussed.

**Deficiency 1: Inconsistency with Queueing Theory**

Firstly, the shape of the BPR curve for oversaturated conditions on urban roads cannot be supported by traffic flow/queueing theory which suggests that as flow approaches capacity, queueing effects lead to large increases in travel time for small increases in volume. This can be demonstrated by comparing the increase in travel time on a link when \( x \) approaches and exceeds 1 using the BPR function and a theoretical delay function developed by Akcelik (1980, 1981). Although Akcelik's function is for delay at signalised intersections, it provides a good indication of the theoretical increase in travel time for a link as a whole in oversaturated conditions due to the fact that, at least for most urban roads, these conditions will occur at intersections.

Akcelik's delay function takes the form:

\[ d = \frac{c_v (1-u)^2}{2 (1-y)} + 900 \left[ \frac{z + \sqrt{z^2 + \frac{12 (x-x_0)}{CTf}}}{CTf} \right] \]

for \( x > x_0 \)

or

\[ \frac{c_v (1-u)^2}{2 (1-y)} \]

for \( x \leq x_0 \)  \hspace{1cm} (5) \]

where

\[ d = \text{delay/vehicle (sec)} \]

\[ x_0 = 0.67 + \frac{sg}{2.16 \times 10^6} \]

\[ s = \text{approach saturation flow (veh/h)} \]
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\[ g = \text{green time (sec)} \]
\[ cy = \text{cycle time (sec)} \]
\[ u = g/cy \]
\[ v = V/s \]
\[ V = \text{arrival traffic flow (veh/h)} \]
\[ \tau = \text{period (hours) during which } V \text{ persists} \]
\[ C = \text{approach capacity} = sg/cy \text{ (veh/h)} \] (which from (3) also equals \( M_c \))
\[ z = x - 1 \]

We should note that expression (5) for \( x > x_0 \), as it is given above, is for the case of isolated fixed-time signals. For the case of coordinated traffic signals, the number 12 in the last part of the expression is replaced by the number 6 (Akcelik 1981). For the range of \( x \) values important to our analysis in this paper, namely \( x \) approaching and exceeding 1, this alteration has a very small impact.

Akcelik (1980) recognised that traditional intersection delay functions were steady-state (and stochastic) in nature (i.e. demand was assumed to persist for a very long time) which resulted in them predicting infinite delay when volume approached capacity. As a result they are only really applicable to undersaturated conditions (i.e. \( x < 1 \)). He also pointed out that, whilst oversaturated conditions (i.e. \( x > 1 \)) did exist in the real world, they only occurred for a limited period of time during peak periods. He identified a deterministic time-dependent queuing model to represent delay in oversaturated conditions. Finally, he developed an integrated delay function by combining the steady-state and deterministic models with a transitional component describing delay in the region where conditions change from undersaturated to oversaturated. Expression (5) is the integrated delay function.

The increase in travel time for these two functions (BPR:(4); and Akcelik:(5)) is presented in Table 1 for two important ranges of degree of saturation (\( x \)) values: \( x = 0.8-1.0 \) where volume is approaching capacity; and \( x = 1.0-1.2 \) in the oversaturated range. Results for expression (5) are given for two \( \tau \) values (0.5 and 1 hour) and two \( u \) values (0.3 and 0.5) to cover a likely range of typical operating situations. (Note that Table 1 also presents information on Microtrips. This will be discussed in the next section.)

In the first two \( x \) increments (0.8-0.85 and 0.85-0.9), the two functions predict similar travel time changes. However, for any further \( x \) increments, the BPR function clearly increases travel time at a progressively smaller rate than Akcelik's theoretical delay function. In the last \( x \) increment before capacity is reached, the time increment for Akcelik's function is approximately \( 3 \) to \( 5 \) times greater than for the BPR function depending on the values of \( \tau \) and \( u \). In the oversaturated range, this ratio escalates to approximately \( 3.5 \) to \( 7.5 \) for \( x = 1.0-1.1 \), and to \( 3 \) to \( 7 \) for \( x = 1.1-1.2 \). We should note that varying the value of free flow travel time, \( f_0 \), will alter the comparison since it alters the slope of the BPR function but not Akcelik's function. If we reduce \( f_0 \) to 30 km/h, the BPR increments all increase by one third. The increment ratios then become approximately \( 2 \) to \( 4 \) for \( x = 0.975-1.0 \), \( 2.5 \) to \( 5.5 \) for \( x = 1.0-1.1 \), and to \( 3 \) to \( 5.5 \) for \( x = 1.1-1.2 \). We should also note that it is possible, for \( x < 0.9 \) and \( f_0 = 30 \), for the BPR function to yield a larger increment, but this only occurs for the case of \( u = 0.5 \).

The above results suggest that the BPR function underestimates travel time as we approach, and move to, oversaturated conditions compared to what traffic flow/queueing theory suggests. The effect of this is that use of the BPR function results in an underestimation of travel time on the road network which will lead to biased travel demand estimates.

**Deficiency 2: Inflexible Form**

The second deficiency of the BPR curve is that, with its constant coefficient of 0.474 and its constant exponent of 4, the same identical equation is used to calculate the travel time on all links in the network. There is therefore no way of designating different travel time functions
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Table I

Comparison of Travel Time Increments: BPR vs Microtrips vs Akcelik

<table>
<thead>
<tr>
<th>Change in ( x )</th>
<th>BPR</th>
<th>Micro-</th>
<th>( T_f = )</th>
<th>Akcelik</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>trips</td>
<td>( u = 0.3 )</td>
<td>0.5</td>
</tr>
<tr>
<td>(a) Approaching Capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8–0.85</td>
<td>0.080</td>
<td>†</td>
<td>0.08</td>
<td>0.06</td>
</tr>
<tr>
<td>0.85–0.9</td>
<td>0.095</td>
<td>†</td>
<td>0.14</td>
<td>0.09</td>
</tr>
<tr>
<td>0.9–0.925</td>
<td>0.054</td>
<td>†</td>
<td>0.12</td>
<td>0.08</td>
</tr>
<tr>
<td>0.925–0.95</td>
<td>0.059</td>
<td>†</td>
<td>0.17</td>
<td>0.12</td>
</tr>
<tr>
<td>0.95–0.975</td>
<td>0.063</td>
<td>†</td>
<td>0.26</td>
<td>0.21</td>
</tr>
<tr>
<td>0.975–1.0</td>
<td>0.066</td>
<td>†</td>
<td>0.37</td>
<td>0.34</td>
</tr>
<tr>
<td>(b) Oversaturated Conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0–1.1</td>
<td>0.33</td>
<td>0.75</td>
<td>2.37</td>
<td>2.48</td>
</tr>
<tr>
<td>1.1–1.2</td>
<td>0.43</td>
<td>0.75</td>
<td>2.87</td>
<td>2.96</td>
</tr>
</tbody>
</table>

* Average urban road data used was: link length = 1 km, average free flow speed = 40 km/h, \( s = 2000 \) veh/h/lane, \( c_y = 100 \) sec.

† Slope of second segment of Microtrips function defined by user (see section Microtrips Travel Time Function); therefore any increment is feasible.

The Microtrips transport planning package uses a step-wise linear travel time function. The function is specified as a series of three linear segments, the nature of which are defined by the user. Travel time \( t \) (min) can be expressed as follows:

\[
S_1 \quad t = t_0 \quad \text{if} \quad x \leq x_1 \\
S_2 \quad t_0 + a(x - x_1) \quad \text{if} \quad x_1 < x \leq 1 \\
S_3a \quad t_c \quad \text{or} \\
S_3b \quad t_c + 7.5(x - 1) \quad \text{if} \quad x > 1
\]

where

\( x_1 = \) the value of \( x \) chosen by the user to designate the end of segment 1 (S1)

\( a = \) the slope of segment 2 (S2)

\( t_c = \) the value taken by \( t \) when \( x = 1 \) (min).
The first segment (S1) defines the range over which free flow travel time prevails. Over the second segment (S2), travel time increases at a constant rate of 'a' minutes for every unit increase in \( x \), and terminates at \( x = 1 \). S1 and S2 therefore define the travel time relationship for undersaturated operating conditions. The third segment (S3), for oversaturated conditions, can take one of two forms. The first (S3a) keeps travel time constant at \( C \). This is not very realistic, but can be useful where it is necessary to identify potentially overloaded links. The second form (S3b) allows travel time to continue to increase as volume increases beyond capacity (i.e. \( x > 1 \)) and thus is more realistic because it reflects the expected build up in delay as volume exceeds capacity. The Microtrips user manual (MVA Systematica 1984) defines S3b in terms of travel speed, i.e.

\[
S = S_c/(1 + S_c(x - 1)/t_L)
\]  
(7)

where

- \( S \) = travel speed at flow \( V \) (km/h)
- \( S_c \) = speed when \( x = 1 \) (km/h)
- \( L \) = length of road link (km)

Given that \( t = 60L/S \) and \( S_c = 60L/t_c \), substituting into (7) yields S3b in expression (6).

Microtrips allows the user to specify a different step-wise linear travel time function for each of 32 different road link types by varying the values \( x_1 \) and 'a', and thus is more flexible than UTPS.

Some general observations can be made about the Microtrips function. Firstly, there is far greater scope in Microtrips to vary the shape of the travel time function over the range of undersaturated conditions and thus model better the unequal attractiveness of parallel roads with different characteristics. In this respect it is an improvement on the BPR relationship used in UTPS. Secondly, as was the case for the BPR curve, the Microtrips function falls short of matching queueing theory predictions of travel time increases for oversaturated conditions (as given by Akcelik's formula, expression (5)). Table I (see the section BPR Travel Time Function) provides a comparison of travel time increases for the Microtrips and Akcelik functions (obtained from expressions (6) and (5) respectively). Akcelik's function estimates increases in travel time approximately 1.5 to 3.5 times greater than for the Microtrips function for \( x = 1.0-1.1 \), and 2 to 4 times greater for \( x = 1.1-1.2 \), depending on parameter values. Therefore, as is the case for the BPR equation used in UTPS, the Microtrips function also underestimates travel time for oversaturated conditions relative to that suggested by traffic flow/queueing theory.

In summary, the ability to vary the shape of the travel time relationship for undersaturated conditions gives the Microtrips function an advantage when compared with the BPR curve used in UTPS. However, for oversaturated conditions the Microtrips function is deficient (like the BPR curve) in the sense that travel time increments are only quite moderate as congestion builds, contrary to what theory predicts, and thus travel time is underestimated.

The Davidson Travel Time Function

Another example of a mathematical travel time function is a hyperbolic curve which increases sharply as capacity is approached. Functions of this type were developed by Mosher (1963) and Davidson (1966) and both Akcelik (1978) and Taylor (1977) have identified the similarity of these two functions.

Davidson's function in particular has received much attention by researchers in the late 1970s and the 1980s. The function was derived from queueing theory considerations (Davidson 1978) and takes the following form (using notation from Akcelik, 1978):

\[
t = t_0 \frac{1 - mx}{(1 - x)}
\]  
(8)
TRAVEL TIME FUNCTIONS

where

\[ m = \text{‘quality of service’ parameter (unitless)} \]

\[ J = 1 - m \]

\[ J = \text{a delay parameter used in the original Davidson specification (unitless)} \]

For each link in the highway network, a unique function can be selected by using an appropriate set of \( t_0 \), \( C \) and \( m \) values.

The function has appeal for use in transport planning applications for the following reasons (Akcelik 1978; Davidson 1966, 1978):

1. It has a two-regime characteristic. It gives a small rate of increase in travel time as volume varies between zero and a critical value around 80 per cent of the road’s capacity. It also gives a large rate of increase in travel time as volume increases beyond the critical value. This two-regime form allows the effects of queueing to be effectively modelled.

2. By varying \( m \), a family of curves can be developed for each combination of \( t_0 \) and \( C \). Consequently, the differing degrees of midblock friction for different roads which have similar \( t_0 \) and \( C \) can be differentiated and can thus be assigned different measures of attractiveness. This is one of the major problems associated with the BPR curve.

3. It is based on queueing theory and thus has some underlying ability to explain behaviour rather than just developing a purely empirical relationship.

The Davidson function thus overcomes the structural problems associated with the BPR and Microtrips travel time functions. However, a new problem is encountered in its use. The problem arises from the fact that, as was the case with traditional intersection delay functions (see discussion in the section BPR Travel Time Function), steady-state demand conditions are assumed. Therefore, as traffic volume approaches capacity, the function predicts travel times which approach infinity. The resulting problem is that this causes computational difficulties in traffic assignment (Branston 1976; Taylor 1984). Branston suggested that the problem could be overcome by using a function which gave large but finite travel time values for oversaturated conditions, and showed that a linear extension into the oversaturated range was a way in which this could be achieved.

Akcelik (1978) gave two further examples of how Branston’s concept of a linear extension could be made operational. One of these two examples has since been used in other work (Taylor 1984; Travers Morgan 1983) and is incorporated below in Akcelik’s modified Davidson function:

\[ t = \begin{cases} 
   t_0 \frac{(1 - mx)}{(1 - x)} & \text{for } x \leq x_c \\
   t_0 \frac{(1 - mx_c)}{(1 - x_c)} + t_0 \frac{(1 - m)}{(1 - x_c)} (x - x_c) & \text{for } x > x_c 
\end{cases} \]

(9)

where

\[ x_c = 0.85 + 0.10m \]

This essentially involves replacing the hyperbolic Davidson function by a linear extension for \( x > x_c \). The slope of the linear extension is equal to the slope of the unmodified Davidson function (eqn (8)) at \( x = x_c \). In the oversaturated range, the modified function increases rapidly, but always to a finite value, in contrast to (8) which tends to infinity. Taylor (1984) demonstrated that the modification does overcome the traffic assignment computational problems encountered with expression (8). This modified Davidson function has had some limited use in Adelaide, South Australia in policy analysis. It was incorporated in a road investment policy model (Travers Morgan 1983) which was based on work previously undertaken by Keeler and Small (1977) where the entire road network was represented by a single (one-link) travel time function.
Akcelik (1978) has compared the modified Davidson function (a hyperbolic function) with a polynomial function (the BPR formula used in UTPS being an example) and with an exponential function (as used in the Australian Road Research Board's TRAFIC assignment program). He focused in particular on the ability of each function to predict queueing effects, i.e. a large rate of increase in travel times as flow approaches capacity. He concluded that the hyperbolic modified Davidson function gave best results.

Taylor (1984) tested the ability of several functions to predict observed travel time and volume data collected on the metropolitan Melbourne road network (Beard et al. 1974). The three functions studied were the modified Davidson function, a polynomial (BPR type) function and a step-wise linear function. He concluded that all three gave similar results and all gave traffic flows similar to observed volumes.

Inspection of Taylor's calibration results, however, show that a good fit of the data was obtained using the BPR type function due to the fact that the practical capacity used in that formula was allowed to vary in order to ensure a good correlation with the Beard et al. data. This produced estimates of practical capacity for the BPR type function which were around 40 to 50 per cent of the absolute capacity of the roads on which data was collected. However, as noted earlier in the section BPR Travel Time Function, the UTPS package uses a value of 75 per cent to convert from absolute into practical capacity. Therefore the conclusion drawn by Taylor does not apply to the function used in the UTPS package. The large difference in the capacity values in Taylor's work and those which he would have derived if he had used the UTPS definition, suggests that significantly different results would have eventuated. In particular, the larger practical capacities used by UTPS would have allowed much greater overloading of links compared with Taylor's results and the observed Melbourne volumes. This tends to support the view already established earlier that the function used in UTPS is deficient.

The results of Taylor's comparison between the Davidson function and the step-wise linear function are also significant. The results suggest that a Davidson function and a step-wise linear function fitted to it will produce similar estimates of travel time. Therefore a step-wise linear function could be used rather than the Davidson function without loss of predictive power. The choice between a step-wise linear function and the Davidson function therefore reduces to operational considerations. All else being equal, if use of one function results in significantly lower computational run time then it would possess a comparative advantage. This may be the case with the step-wise linear function in an equilibrium assignment in which travel time is repeatedly calculated. However, it is unlikely that there would be huge savings in computational effort since the modified Davidson function is still of a relatively simple form.

**SPECIFIC ISSUES**

An Alternative Linear Extension

The modified Davidson function appears to possess the best performance characteristics of any of the functions reviewed above. However, an important question which remains is the appropriateness of the linear extension defined by expressions (9) and (10). To be consistent with our earlier analysis of the BPR and Microtrips travel time functions, this question can be addressed by comparing the increase in travel time for oversaturated conditions predicted by the modified Davidson function with those predicted by traffic flow/queueing theory (see expression (5)). Table II presents the travel time increment results for this comparison.

Before we begin any comparison, there are a few points to clarify. Firstly, precise rules have not been established to date about the equivalence between values of \( m \) and different road types. The general intention of the \( m \) parameter is for it to increase as the degree of conflict from sources external to the traffic stream decrease. Therefore, as the class of road improves (e.g. from undivided arterial, to divided multilane arterial, to expressway, to freeway), one would expect \( m \) to increase. In the absence of empirical estimates, Blunden (1971) suggests the possible use of \( m = 0.4 \) to 0.6 for urban arterials and \( m = 0.8 \) to 1.0 for motorways.

Secondly, one would also expect \( t_s \) to gradually decrease as the class of road improved (and \( m \) increased) due to the expectation that the frequency, and amount of red time, at intersections would decrease as road class improved. Therefore, we can reasonably expect \( t_s \) to decrease in line with increases in \( m \). This is incorporated in Table II.
The most reasonable comparisons that can be made in Table II are between the traffic flow/queueing theory results and the modified Davidson results for $m = 0.4$ and $0.6$ since these all correspond to similar signalised urban arterial roads. In addition, we should compare $u = 0.3$ with $m = 0.4$, and $u = 0.5$ with $m = 0.6$ based on the comment just made with regard to red time. We see that, for these urban arterials, the modified Davidson function yields increases well in excess of those generated by traffic flow theory, with the ratio of increments ranging approximately from 2 to 12. Therefore, from the perspective of producing queueing type effects as we approach and move into oversaturated conditions the modified Davidson function is highly successful for urban arterial roads. Although, the fact that the increment ratio is so high it may be deemed to be a weakness.

When we consider higher classes of roads (e.g. freeways), which have $m$ values nearer to 1, the performance of the modified Davidson function requires closer scrutiny. The first thing to note is that as $m$ increases to values of 0.9 and above, the size of the travel time increment in oversaturated conditions for the modified Davidson function (i.e. the slope of the function) decreases appreciably. For $m = 0.9$, the increments are still comparable with those from traffic flow theory. However, as $m$ increases further, the modified Davidson function increments start to drop below those from traffic flow theory, especially for $x > 1$. This effect is disconcerting since, in the extreme, when $m$ approaches a value of 1, the slope of the linear extension tends to zero, i.e. the linear extension becomes horizontal, and thus the modified Davidson function predicts free flow travel time for all oversaturated conditions. This is totally inconsistent with notion of delay increasing rapidly as oversaturated conditions are reached. Let us be clear, however, that this problem only arises on the highest quality roads where $m$ moves towards its upper limit of 1. For the great majority of urban roads, which have lower $m$ values, say below 0.7 to 0.8, this problem does not arise as indicated by the discussion earlier in this section.

If it was considered desirable to develop a travel time function which was more consistent with traffic flow theory (as represented by expression (5)), then we could conclude that there are several potential deficiencies with the modified Davidson function based on the above discussion. Firstly, for the case of urban arterials, although the modified Davidson function does have the desired rapid increase in travel time as we move into oversaturated conditions, one could argue that the rate of increase may in fact be too great. Secondly, the slope of the linear extension in (9) varies with changes in the road type/quality of service' parameter, $m$. However, (5) suggests that this slope should tend toward a value which is determined independently of $m$, especially for $x$ in excess of 1. In addition, this can also cause peculiar results for high $m$ values as the slope of the linear extension tends to zero. Thirdly, (5) suggests that travel time prediction in the oversaturated range should be a function of the length of time over which oversaturated conditions persist ($T$) (i.e. time-dependent). The slope of the linear extension in (9), however, bears no relationship to $T$. 

* The increments for Akcelik (1981) come directly from Table I. The Akcelik (1978) results were generated for a link length of 1 km.
A good starting point for identifying an alternative form for the linear extension, which avoids these potential deficiencies, is the second example given by Akcelik in his 1978 paper in which the slope of the linear extension is initially set at a constant value, independent of \( m \), and the value of \( x_c \) then determined. Following Akcelik, from (9) the slope, \( D \), is given by:

\[
D = t_0 \frac{(1 - m)}{(1 - x_c)^2} \quad (11)
\]

Solving for \( x_c \):

\[
x_c = 1 - \left[ \frac{t_0 (1 - m)}{D} \right]^{0.5} \quad (12)
\]

This is the reverse of Akcelik's first example where \( x_c \) is initially determined knowing \( m \), which then implies a slope.

However, in Akcelik's second example, what value should the slope, \( D \), take? A logical approach would seem to be to ensure that it closely matched the slope of the theoretical intersection delay function (eqn (5)) in the oversaturated region. One option is to differentiate (5) directly and use the resulting expression for \( D \). However, the resulting expression would be unnecessarily complex. A simpler alternative is to base \( D \) on the much simpler oversaturation deterministic component of (5). From Akcelik (1980), oversaturated deterministic delay, \( d_d \) (sec), is given as:

\[
d_d = \frac{r}{2} + 1800 \frac{7}{z} \quad (13)
\]

where

\[r = \text{effective red time (sec).}\]

Differentiating (13) yields \( D \):

\[
D = \frac{\delta d_d}{\delta z} = 1800 \frac{7}{z} \text{ (sec/veh)} \text{ or } 30 \frac{7}{z} \text{ (min/veh)} \quad (14)
\]

Replacing the linear extension in (9) with (14) and substituting (14) into (12), yields an alternative modified Davidson function:

\[
t = \begin{cases} 
    t_0 \frac{(1 - mx)}{(1 - x)} & \text{for } x \leq x_c \\
    t_0 \frac{(1 - mx_c)}{(1 - x_c)} + 30 \frac{7}{z} (x - x_c) & \text{for } x > x_c
\end{cases} \quad (15)
\]

where

\[
x_c = 1 - \left[ \frac{t_0 (1 - m)}{30 \frac{7}{z}} \right]^{0.5} \quad (16)
\]

This function is illustrated in Fig. 1.

Using this approach, the slope of the linear extension is a function only of the time over which flow exceeds capacity (\( T_i \)) and yields an increase of \( 3 \frac{7}{z} \text{ min/veh} \) for every increment of 0.1 in degree of saturation (\( x \)). With this linear extension, the modified Davidson function therefore has a dynamic dimension which improves the realism of the travel time function, and thus overcomes one of the criticisms levelled at steady-state functions (Taylor 1984).

Table III provides a comparison of \( x_c \) and slope \( (D) \) results from Akcelik's first example linear extension (incorporated in (9) and (10)) with the alternative devised here.
TRAVEL TIME FUNCTIONS

NOTES: (1) Drawn for two values of \( m : m_2 > m_1 \)
(2) --- --- shows the new linear extension (LE) drawn for two \( T_f \) (hours) values \( (T_{f1} > T_{f2}) \) and both \( m \) values
(3) Four \( x_c \) values are shown for the four combinations of \( m \) and \( T_f \) values

**Fig. 1 — Alternative modified Davidson function**

**Table III**
Comparison of Results for Two Alternative Linear Extensions for Davidson Function

<table>
<thead>
<tr>
<th>( m )</th>
<th>( S_0 )</th>
<th>( x_e )</th>
<th>( D )</th>
<th>( T_f = 0.5 )</th>
<th>( x_c )</th>
<th>( D )</th>
<th>( x_c )</th>
<th>( T_f = 1 )</th>
<th>( x_c )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>30</td>
<td>0.85</td>
<td>8.89</td>
<td>1.5</td>
<td>0.635</td>
<td>3</td>
<td>0.742</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td>40</td>
<td>0.89</td>
<td>7.44</td>
<td>1.5</td>
<td>0.755</td>
<td>3</td>
<td>0.827</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>50</td>
<td>0.91</td>
<td>5.93</td>
<td>1.5</td>
<td>0.821</td>
<td>3</td>
<td>0.874</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td>80</td>
<td>0.94</td>
<td>2.08</td>
<td>1.5</td>
<td>0.929</td>
<td>3</td>
<td>0.950</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.95</td>
<td>100</td>
<td>0.945</td>
<td>0.99</td>
<td>1.5</td>
<td>0.955</td>
<td>3</td>
<td>0.968</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.99</td>
<td>100</td>
<td>0.949</td>
<td>0.23</td>
<td>1.5</td>
<td>0.980</td>
<td>3</td>
<td>0.986</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>100</td>
<td>0.95</td>
<td>0.00</td>
<td>1.5</td>
<td>1.000</td>
<td>3</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The slopes are in units of mins per 0.1 increase in \( x \).
TRAVEL TIME FUNCTIONS

The slope results are consistent with the results in Table II, namely, that the alternative extension has a lower slope than Akcelik's extension for $m$ values up to around 0.9, but a higher slope thereafter. There are some significant differences between the $x$ values for the lower to middle $m$ values, but the size of this difference declines and becomes quite small once $m$ exceeds about 0.8 to 0.9. Overall, the most significant difference between the two extensions is the contrasting behaviour of their slopes.

Interpreting Saturation Flow

In Davidson's original paper (1966), he used the term saturation flow in place of capacity as used in (8). This has resulted in some confusion over the meaning of the term, especially in the context of signalised urban roads. Part of the confusion has been caused by the use of the saturation flow in a different context in traffic engineering theory.

Davidson indicated that, when the volume on a road approaches a particular value, the road would become saturated with traffic and travel time would correspondingly increase dramatically. He denoted this value as saturation flow. When the road is saturated with traffic, it is carrying the maximum number of vehicles possible. In queueing theory terms it is the service rate. Davidson (1966) suggested that saturation flow, as defined in his function, was essentially equal to 'possible' capacity, although he was of the opinion that saturation flow rate may be slightly higher than possible capacity. In practical terms, however, this difference is insignificant.

As defined earlier (see the section BPR Travel Time Function), the maximum number of vehicles that can be passed by a road is also known as the 'absolute' capacity of the road. Therefore, the terms saturation flow as used in Davidson's original function, possible capacity, and absolute capacity can essentially be interpreted as being equivalent.

In an urban context, the term saturation flow rate has also evolved (Akcelik 1981; US Transportation Research Board 1985) to mean the maximum number of vehicles that can be discharged per hour of continuous green time from the queue at a stop line at an intersection approach. A case exists (Blunden 1978) where it appears that this notion of saturation flow has been incorrectly interpreted as being equivalent to Davidson's saturation flow rate for urban signalised roads. The correct term to use in the Davidson function for signalised roads is the absolute capacity, which is the saturation flow rate from traffic engineering theory factored by the ratio of green time allocated to the road in question and total time (i.e. $g/c_y$). Akcelik's (1978) notation provides a correct interpretation.

Estimation Issues

Taylor (1977) described a non-linear least squares statistical estimation technique for estimating simultaneously all three parameters of the Davidson function $t_\text{e}$, $C$ and $m$ or $J$ where $m = 1 - J$ from travel time and volume data. However, the results of applying this technique (Taylor and Anderson 1983; Taylor 1984) appear to give high estimates of $C$. Table IV gives the value of $C$ estimated by Taylor for Melbourne.

A commonly accepted value of the maximum lane saturation flow for a road with uninterrupted flow conditions is of the order of 2000 veh/h/lane (Yagar 1983; Akcelik 1981; US Transportation Research Board 1985). We should note that we are using the term saturation flow here as defined in traffic engineering theory (see discussion in last section). For a freeway this is also equal to lane capacity. This is well below the lane capacity for a freeway in Table IV. Taylor has thus overestimated the capacity of a freeway lane.

The accuracy of Taylor's values for signalised roads is more difficult to judge. The first point to note is that, for inner roads that do not have additional 'short' through lanes at intersections, Taylor's capacity values imply $g/c_y$ values of 0.67 and 0.80 for undivided and divided roads. These values are too high when compared with most real world examples, thus capacity is overestimated. If these roads did have extra 'short' through lanes at intersections, and one assumed that they were fully utilised, then Taylor's values are more acceptable. For middle and outer urban roads, Taylor's values are also reasonable if one again assumes fully utilised short through lanes at intersections. However, full or even considerable utilisation of short through lanes is unlikely to occur (Akcelik 1981; Guell 1983; McCoy and Tobin 1982). Therefore, it can be concluded that, for roads with interrupted flow (i.e. non-freeway), there is a tendency for Taylor's estimation method also to overestimate capacity as was the case with freeways.
Table IV

Capacity of Melbourne Roads Resulting from Estimation of Davidson Functions by Taylor

<table>
<thead>
<tr>
<th>Road Type</th>
<th>Area</th>
<th>Lane Capacity (veh/lane)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undivided multilane</td>
<td>Inner</td>
<td>1344</td>
</tr>
<tr>
<td>Undivided multilane</td>
<td>Middle</td>
<td>1675</td>
</tr>
<tr>
<td>Undivided multilane</td>
<td>Outer</td>
<td>1741</td>
</tr>
<tr>
<td>Divided</td>
<td>Inner</td>
<td>1607</td>
</tr>
<tr>
<td>Divided</td>
<td>Middle</td>
<td>1861</td>
</tr>
<tr>
<td>Divided</td>
<td>Outer</td>
<td>1911</td>
</tr>
<tr>
<td>Two-lane road</td>
<td></td>
<td>1934</td>
</tr>
<tr>
<td>Freeway</td>
<td></td>
<td>3055</td>
</tr>
</tbody>
</table>

A possible reason for these results is that the functions were estimated by Taylor using data points representing essentially the undersaturated portion of the curves. No travel time/volume data points were available for oversaturated conditions resulting in a situation shown in Fig. 2. It is therefore difficult to get a reliable estimate of capacity, C (Golding 1977). In fact the set of data points used can produce different combinations of estimates of C and m which all produce similar travel time estimates over the range of observed data. Rose (1988) highlights the importance of conducting estimation using data points over as wide a range as possible.

The problems of trying to estimate all three parameters $t_o$, $C$ and $m$ simultaneously has been previously recognised and an alternative approach suggested (Blunden 1978; Davidson 1978). This alternative approach consists of estimating either $t_o$ or $C$, or both $t_o$ and $C$, independently and therefore reducing the exercise to estimating the remaining parameters. The external estimates of the forced parameters must be determined with a high degree of accuracy for this approach to be successful.

Fig. 2 — Possible capacity overestimation when estimating with undersaturation data points only
SUMMARY AND CONCLUSIONS

Travel time plays an important role in travel demand estimation. It is therefore critical for travel time to be modelled accurately. Two widely used travel time functions are those found in the UTPS and Microtrips transportation planning packages. We have shown that they have structural deficiencies which result in the development of biased travel demand estimates. The most critical deficiency is that both functions fail to predict rapidly increasing travel time as volume approaches and exceeds capacity as suggested by queueing theory.

The Davidson function has superior structural properties and overcomes the problems encountered with both of these two functions, although the original Davidson function has operational problems of its own. To date, these operational problems have been overcome by applying a linear extension to the Davidson function in the region where degrees of saturation approach, and enter, oversaturated conditions. The example linear extension given by Akcelik has proved useful and has been used to advantage in transport policy and planning analyses. However, we have identified a number of possible deficiencies with Akcelik’s extension, namely, that it predicts travel time increases well in excess of those given by traffic flow theory for small to medium sized m-values, it has a slope which tends towards zero as m tends towards 1, and is not time-dependent.

We have developed an alternative form of linear extension from Akcelik’s later and independent work, which we believe is superior in the sense that it is more consistent with the predictions of traffic flow/queueing theory. The slope of this alternative linear extension is unrelated to road type but is strongly influenced by the length of time over which oversaturated conditions persist. The resulting travel time function can thus be called time-dependent, giving the function a dynamic characteristic which has been lacking in functions used to date. The resulting function has the potential to produce improved and more realistic travel time estimates for oversaturated conditions.

Confusion over the interpretation of the saturation flow term in the original Davidson function can be reduced by interpreting the term as the absolute capacity of the road. Finally, the process of simultaneous estimation of the parameters of the Davidson function leads to overestimation of road capacity, a problem which could be reduced by external estimation of some of the parameters of the function.

REFERENCES


TRAVERS MORGAN PTY LTD (1983). Road pricing, investment and service levels - an economic model. Report to the Director-General of Transport, South Australia.


The author is currently Lecturer, Economics Department, University of Adelaide. At the time the research for this paper was undertaken, the author was Transport Planner, Policy and Research Division, Department of Transport, South Australia. Previous employment has also included Economist with the Engineering and Water Supply Department, South Australia. Research interests include transport economics and the economics of public utilities and infrastructure generally.
New Publications

Special Reports
(ISSS 0572-144X)

Improving Truck Safety In Australia
by P.T. Cairney
SR No. 46, ISBN 0 86910 482 9
$40 plus $2 handling fee

Five research tasks have been carried out as Phase One of the Australian Truck Safety Study. The study is being undertaken to provide objective technical evaluation of truck safety issues and to develop a strategy to improve truck safety in both the short and long term.

This report covers a number of factors affecting truck safety, including road and traffic factors, vehicle factors, and driver, organisational and enforcement factors. It also provides details, including costs and responsible authorities, of the action and research plans developed as a result of the five research tasks.

A Study of Heavy Vehicle Swept Path Performance
by P. Sweatman, R. George, Y. Tso and E. Ramsay
SR No. 48, ISBN 0 86910 472 1
$40 plus $2 handling fee

The results of a study carried out by ARRB and Road User Research P.L for AUSTROADS are described. The study looked at developing acceptable swept path criteria and a practical means of verifying compliance. Detailed recommendations for swept path assessment of all heavy vehicle classes are included in the report.

It will interest government and industry people involved with heavy vehicles, as well as people involved in designing and maintaining the road network.

Research Reports
(ISSS 0518-0728)

Traffic Load Survey, Port Wakefield Road, South Australia
by C. Koniditsiotis
ARR No. 193, ISBN 0 86910 459 4
$20 plus $2 handling fee

Traffic Load Survey, Rooty Hill Road, New South Wales
by C. Koniditsiotis
ARR No. 195, ISBN 0 86910 480 2
$20 plus $2 handling fee

Traffic Load Survey, Warrego Highway, Queensland
by C. Koniditsiotis
ARR No. 196, ISBN 0 86910 474 8
$20 plus $2 handling fee

A series of reports presenting the results of traffic load surveys conducted around Australia has been produced. The data from these surveys were used to compare the initial traffic estimation methods given in the AUSTROADS Pavement Design Guide. The results will interest pavement practitioners and users of weigh-in-motion equipment.

Road User Behaviours Which Contribute to Accidents at Urban Arterial/Local Intersections
by P.T. Cairney and J.E. Catchpole
ARR No. 197, ISBN 0 86910 465 9
$20 plus $2 handling fee

The methods and outcomes of a study of road accidents are described. The study focussed on accidents at the intersections of local streets with arterial roads in Metropolitan Melbourne, and was based on data obtained from police accident files.

Australian Road Research, 21(2), June 1991
The results clearly show that visual factors played a major role in accidents involving more than one road user. Many drivers failed to see the other vehicle in time to avoid a collision.

This information is relevant to behavioural scientists, traffic and vehicle engineers with an interest in driver behaviour, and driving instructors with an interest in curriculum development.

The Performance of Overlay Treatments and Modified Binders Under Accelerated Full-Scale Loading - the Callington ALF Trial
by P. Kadar
ARR No. 198, ISBN 0 86910 476 4
$20 plus $2 handling fee

ARRB and the Department of Road Transport, South Australia, conducted a series of full scale pavement tests using the ARRB Accelerated Loading Facility, to test the relative performance of alternative forms of asphalt rehabilitation. The test results and conditions are presented in a summarised format, and will interest practitioners involved in the maintenance, repair or strengthening of existing road pavements.

Asphalt Recycling in Australia — 1990
by R.H. Bowering
ARR No. 199, ISBN 0 86910 478 0
$20 plus $2 handling fee

A review of asphalt recycling in Australia has been produced for the Australian Pavement Research Group. The review aimed to identify areas where there may be scope for improving the technology and practices currently used.

Local procedures and the general experience reported by overseas users and researchers are identified and reported on. Recent advances in recycling equipment are also noted in the report.

Road Rehabilitation Workshop Proceedings
edited by R. Yeo
ARR No. 206, ISBN 0 86910 484 5
$20 plus $2 handling fee

A workshop looking at road rehabilitation in Australia was held on 25-26 March 1991. One of the main messages to come out of the workshop was that more information about the field is required, covering areas such as materials and performance characteristics. Integration of existing information was also identified as an issue of importance.

Summary notes from the workshop and a full set of papers are included in this report. It will be relevant to anyone involved or interested in road rehabilitation.

Technical Manuals
( ISSN 0313-895X)

by C.J. Hoban, R.J. Shepherd, G.J. Fawcett and G.K. Robinson
ATM 108, ISBN 0 86910 468 3
$20 plus $2 handling fee

A new version of TRARR, version 3.2, has recently been released. TRARR is a rural traffic simulation model developed at ARRB, and the new version provides improved transportability and simplified user requirements. TRARR has been used at ARRB on specific case studies requested by road authorities and in general investigations of level of service and guidelines for rural road improvements.

Readers are reminded that all AUSTROADS publications are now distributed by ARRB. Recent new publications from AUSTROADS are:

Road Demand Management
AUSTROADS Code AP 9/91
$20 plus postage

Proceedings — Road Demand Management Seminar
AUSTROADS Code AP 10/91
$12 plus postage

AUSTROADS recently commissioned a review of road demand management from PPK Consultants and Halcrow Fox & Associates. This report will interest those authorities concerned with the development of demand management measures.

A seminar was held on 10-11 April 1991 to disseminate findings of this report and to identify problems and options for Australia — proceedings of this seminar are also available. This volume will include Professor May's paper and the summary paper from Professor Ogden together with other material presented at the seminar.

A combined price of $30 will apply if these publications are ordered together.
This second edition of the Handbook of Road Technology is a significant update of the first edition which was published in 1986 and which was based on the author’s earlier Source Book for Australian Roads. The first edition and the Source Book have both enjoyed wide acceptance and extensive use, and there is no doubt that the same will apply to this second edition.

The book is in two volumes. Volume 1 comprises 15 chapters in 337 pages. Its chapters cover an introduction, definitions, history of roads, the organisation of roads, road needs, road location, residential streets, pavement materials, moisture in pavements, stabilisation, pavements, bituminous pavements, drainage, pavement performance and bridges. Volume 2 comprises 20 chapters in 432 pages, there being chapters on driver behaviour, traffic flow and capacity, speeds, road geometry, intersections, traffic signs, pavement markings, traffic signals, lighting, construction, maintenance, road vehicles, safety, road user costs and charges, road transport, environmental factors, economics of road transport, transport planning, appendices and information sources.

Dr Lay is currently Director Technical Resources, VIC ROADS, and previously was Executive Director, Australian Road Research Board. He deservedly enjoys an international reputation in the area of road technology, and is eminently qualified and experienced to write this text. As with all his writings, it is logically and lucidly written, and easy to read.

In the first chapter, the author defines his intended audience, and he very effectively addresses this audience. As he indicates, the book ‘is not an introduction to roads for the untrained’. In this respect, undergraduate students would not find it a suitable text unless they were given some guidance in its use. In any case, the price (just under $200 for the two volumes) would rule out its use as a prescribed students’ text. However, it would be a valuable library reference book for them.

In addition to the wealth of up-to-date technical information in the Handbook, features of it include:

- comprehensive and extensive referencing. (It is perhaps a little surprising that, for a text directed towards an international audience, about 80 per cent of the references are Australian. This however, is by no means a criticism, and in fact it illustrates the strength of the Australian contribution to knowledge in this area over the years).
- an extensive index. Also, reference to sections rather than to pages is novel and helpful.
- the list of acronyms and the glossary, both in Chapter 34.
- the list of information sources in Chapter 35.

In summary, the Handbook of Road Technology is a comprehensive and authoritative text, which should be regarded as an essential reference for anyone involved in any aspect of road technology.

R.T. Underwood,
Department of Civil Engineering,
Monash University
16th ARRB CONFERENCE

The Australian Road Research Board will hold the 16th ARRB Conference in Perth, Western Australia on 8-13 November 1992. The main venue for the conference will be the Sheraton Hotel.

The theme for the conference will be announced at a later date with a call for papers to be made late in 1991. Further details will be in future issues of this journal or on request from ARRB on telephone (03) 881 1555 or fax (03) 887 8104.

CHANGES TO ARRB MEMBERSHIP

Two new members were recently appointed.

Dr Ken Michael is the Commissioner of Main Roads, Western Australia. Dr Michael holds a first class honours degree of Bachelor of Engineering, and joined the Main Roads Department on graduation. As a result of postgraduate studies in the United Kingdom, he also holds a Diploma of Imperial College and the degree of Doctor of Philosophy from the University of London.

Dr Michael's career includes experience in bridge and road design and in the management of regional road activities. On his appointment to Assistant Commissioner Operations in 1988 he became responsible for all the construction and maintenance activities of the Main Roads Department and the formulation and management of Programs of Works.

In April 1991, Dr Michael was appointed Commissioner of Main Roads, Western Australia. In his capacity as Chief Executive, he is responsible for administration and operation of the Department. As Commissioner, he is a member of the Metropolitan Planning Council and a member of the Traffic Board which administers the Road Traffic Act in Western Australia. He is a Fellow of the Institution of Engineers, Australia, and has held the positions of National Vice President and Chairman of the Western Australian Division.

Colin Fuller, Secretary of the Department of Transport & Works, Northern Territory, was also appointed. At time of publication, information about Mr Fuller was unavailable but will be included in the next issue of Australian Road Research.

WORKSHOPS ON 'TRAFFIC ANALYSIS' AND ' PARKING POLICY AND DESIGN'

The University of South Australia is running two workshops on traffic management in the week 8 - 12 July 1991. The workshops are 'Traffic Analysis' (8 - 10 July) and 'Parking Policy and Design' (10 - 12 July).

'Traffic Analysis' is concerned with methods and technologies for collecting, handling and analysing traffic data. There is an emphasis on the use of personal computers, and the focus is on traffic management problems that affect Local Government and arterial road management.

'Parking Policy and Design' will consider recent developments in parking policy, information systems, design and data collection. Particular emphasis is given to
For information about registration and services, contact Ms Karen English, Techsearch, on (08) 267 1755. For information on the technical content of the workshops, contact Professor Mike Taylor, School of Civil Engineering, University of South Australia, on (08) 343 3330.

PARKING SIMULATION SOFTWARE

Monash University has released PARKSIM 1.0, a microcomputer simulation model for comparing the 'level of service' for different parking lot layouts and traffic demands.

PARKSIM 1.0 simulates interactions between parking vehicles and other traffic, and the driver's total travel time and utilisation of the parking system can be measured. The package is user friendly and makes extensive use of colour graphics for preparation of input and presentation of the output.

The graphics input has drawn heavily on the MULATM package (developed by Professor Michael Taylor), which is used by more than 100 firms throughout the world. Compatibility between MULATM and PARKSIM allows data interchange between the two packages.

The output procedures used in PARKSIM are related to the microcomputer package TRANSTAT, which was developed by Russell Thompson and Associate Professor William Young and is used around the world.

PARKSIM runs on IBM XT and AT microcomputers. It can accommodate 500 parking spaces; 50 two-way right angle aisles and circulators; 10 land use entrances; any angle of parking; and 20 parking lot entrances and exits.

A dynamic presentation of vehicle movement in the lot provides the user with an opportunity to assess the performance of the parking lot and the model. Overall measures of the performance of the parking system are presented in summary, map and distribution form. Maps of the parking

computer-aided procedures (e.g. PARKSIM - see next article, CENCIMM and MONSTER), dynamic parking advisory systems, the new Australian Standard for signage and parking lot design, and the environmental impacts of parking. The workshop is aimed at Local Government, State Road Authorities, developers and consultants. It will be led by Professor Bill Young from Monash University (Victoria).
space utilisation, turning movements and link flows provide an idea of the performance of components of the systems throughout the parking lot.

The location and types of links, parking stalls and boundaries can be specified using coordinates, spreadsheet or graphical techniques. Traffic demands and origin-destination matrices are specified graphically. Aisles and circulators are identified using verbal descriptors for the ease of the user.

For further information contact:

Assoc. Prof. William Young
Department of Civil Engineering, Monash University
Clayton Victoria 3168
Ph: (03) 565 4949
Fax: (03) 565 4944.

NOTED TRAFFIC ENGINEER ACHIEVES DOCTORATE

Robin T. Underwood has been admitted to the degree of Doctor of Engineering in the University of Melbourne. He is currently with the Caulfield Division of the Department of Civil Engineering, Monash University, where his interests are in municipal, highway and traffic engineering.

Mr Underwood has served on Australian and international traffic engineering committees and has published on various aspects of road planning, design and operations. He is the author of A History of Traffic Engineering in Australia, Traffic Management - An Introduction and The Geometric Design of Roads.

ASPAC '92

ASPAC '92 is a regional road conference being organised jointly by the International Road Federation and the Australian Road Federation, and will be held in Queensland on March 22 - 27, 1992.

The conference aims 'to share the knowledge and experience gained in providing and managing road infrastructure within the most vibrant region of the world economy'. The proposed program will cover:

- innovative planning and financing of roads
- recent advances in design and traffic management
- quality and productivity in construction and maintenance
- road and bridge asset management
- trucks, loads and roads
- road safety, accidents and legal liability
- roads and traffic - opportunities for international cooperation and business

Proposed workshops will include: roads in cities; roads in wet tropics; roads in developing countries; and evaluation of pavement condition. Other topics of interest may be added prior to the conference program being finalised.

International speakers include Mr Clell G. Harral (Principal Transport Economist, China Department, World Bank) and Dr Damian J. Kulash (Executive Director, Strategic Highway Research Program (USA)).

Full details of the conference program, social activities, accommodation, travel arrangements and registration will be available during October 1991.

NEW AAPA TECHNICAL DIRECTOR

The Australian Asphalt Pavement Association (AAPA) has announced the appointment of John Bethune as its new Technical Director.

John brings to the Association a wealth of knowledge and experience in the field of flexible pavements. He has joined AAPA following a lengthy and distinguished career with the Victorian State Road Authority, VIC ROADS.

John's experience covers both the State roads and municipal areas. His professional and respected technical knowledge will greatly benefit AAPA, industry and, in particular, State Road Authorities and municipalities.

1991 AAPA AUSTRALASIAN CONFERENCE


The theme of the Conference is 'Quality, Performance and Excellence', and reflects the Association's desire to present attendees with an update of asphalt construction issues. The Conference will consider all aspects of asphalt and flexible pavement construction.
ARTF ANNUAL CONVENTION

The Australian Road Transport Federation (ARTF) will be holding its Golden Anniversary Annual Convention in Hobart, Tasmania, from October 1 - 5 this year.

The ARTF, which is celebrating its 50th anniversary, has selected the theme ‘Road Transport and Multi-modalism - From Confrontation to Cooperation’, to reflect the current emphasis on transport reform and multi-modal freight tasks. The Convention will include sessions on the interface between road, rail and sea transport. It will also have a local Tasmanian flavour, with some of Tasmania’s leading industrialists and politicians present to help delegates gain a deeper understanding of Tasmania.

Any queries about the Convention can be made to Mr Jack Blackburn, Executive Director, Tasmanian Road Transport Association, on (002) 34 4689.

SHRP UPDATE

SHRP at its mid-point

The US Strategic Highway Research Program (SHRP), is a US$150 million research program funded through State-apportioned Federal highway aid funds. It was established in 1987 in response to concerns about the ageing US road infrastructure, and is now halfway through its five year life.

Research in SHRP is being undertaken in four broad areas:
- asphalt
- long-term pavement performance (LTPP)
- concrete and structures
- highway operations

The program will terminate in March 1993, except for the LTPP study, which will continue for another 10 - 15 years under a new program.

A summer workshop was held by SHRP to review progress and consider future directions. Workshop sessions in the four program areas (asphalt, highway operations, concrete and structures, LTPP) were run in parallel. Contractors presented information on the results of their research, future plans and expected outputs. This
information was then considered in interactive sessions where delegates proposed changes to the future program.

The proceedings of the Workshop have been published as SHRP-GWP-90-001 Making the Most of the Second Half of SHRP (copies can be obtained by applying to SHRP or from the Australian Road Research Board library). Two trip reports which contain important information about SHRP have been published by the Australian Road Research Board (ARRB). They are ARR 185 Group report on an asphalt study tour of the USA: January-February 1990, edited by K.G. Sharp, and ARR 189 SHRP asphalt program mid-term review and associated topics, by J.W.H. Oliver.

**Australian SHRP Liaison Committee**

Concern about ageing road networks is not confined to the US. Concern about the ageing Australian network is taking a strategic rather than a technical focus because significant changes in procedure are required, rather than marginal improvements in technology, if the demands of greater cost-efficiency are to be met.

The Australian Pavement Research Group (APRG) is linked to SHRP through its provision of Australian loan staffers to SHRP for the duration of the program. The APRG also established a SHRP Liaison Committee which monitors the SHRP program and is charged with disseminating SHRP findings relevant to Australia.

A meeting of the Liaison Committee was held in Sydney at the beginning of November 1990. The main work of the Committee was directed towards preparing a strategy document. This will examine expected SHRP outputs from the viewpoint of their potential benefit to Australia. Outputs will be prioritised and implementation plans developed for those meeting acceptance criteria.

SHRP tends to generate a lot of paperwork and this will increase dramatically in volume as projects reach the reporting stage. The Liaison Committee representatives are setting up networks in each expert area, consisting of people who will review and summarise SHRP documents in the light of Australian practice. The networks will also assist in communicating SHRP information and act as implementation pathways.

Anyone wishing to receive regular information about SHRP should contact the appropriate representative:

**Bitumen & Asphalt:**
Ian Rickards (Australian Asphalt Pavement Association) Ph: (03) 819 4999, Fax: (03) 819 5278

**LTPP:**
David Potter (ARRB) Ph: (03) 861 1555, Fax: (03) 867 8104

**Concrete & Structures:**
John Fenwick (QLD Department of Transport) Ph: (07) 834 2385, Fax: (07) 834 2722

**Highway Operations:**
David Thomson (NSW Road Traffic Authority) Ph: (02) 218 6621, Fax: (02) 218 6970.

**TRANSPORT & PLANNING CONFERENCE, SEPT. 1991**

The Singapore Ministry of National Development is holding a transport and planning conference and exhibition on September 14 - 17 this year, at the World Trade Centre in Singapore.

The event, City Trans Asia '91, will be held biennially and will focus on the transport needs of an urban society. This one will bring together some of the world’s best on transport advances while ‘showing the important role urban planning plays in integrating the transport infrastructure into the cityscape’.

The program includes plenary sessions and symposia on electronic road pricing and underground roads, integrated approaches to transport, and information technology applications in urban planning and transport. Confirmed speakers include Jack Lemley, the President and CEO of Transmanche-Link (Chunnel Project), Professor Anthony May (University of Leeds), Liu Thai Ker, CEO of the Singapore Urban Redevelopment Authority, and Dr Peter Jones (Transport Studies Unit, Oxford University).

Exhibits will include computerised systems for traffic control, road networking, tunnelling, electronic road pricing and people-moving. The exhibition aims to bring together both users and suppliers/manufacturers from the fields of land transportation and city planning.

For more information contact

Magdalene Sik (Marketing Director) or Maria Choy (Marketing Chairman) City Trans Asia '91, 2nd Floor, 20 Kallang Avenue, Pico Creative Park Singapore 1233 Ph: (65) 297 2822 Fax: (65) 296 2670
LOCAL AREA TRAFFIC MANAGEMENT EXPERT SYSTEM

A group of researchers at the University of New South Wales has developed a prototype decision support system for aiding in the design of local area traffic management (LATM) schemes.

The system, which will potentially be used by Local Government engineers and planners, was developed by researchers in the Department of Transport Engineering and was funded by a Faculty of Engineering Special Research Grant.

The structure of the LATM knowledge base is divided into three parts: LATM for new developments; LATM for existing local areas; and an index and reference section.

The limitation of the prototype is that the knowledge base is restricted to about 40 published journal articles and guideline documents. Information on quantitative assessment of LATM schemes or on individual LATM devices is especially thin. However, an advantage of an expert system is the capability to incrementally develop the knowledge base, so the software developers are now expanding the knowledge base by obtaining feedback from potential users of the system.

The developers are seeking copies of any unpublished reports or evaluations of LATM schemes and control devices (including their installation and maintenance costs) to expand the knowledge base. If you can help with this phase of the research, send your contributions to Mr T.T. Ton, School of Civil Engineering, University of NSW, PO Box 1, Kensington NSW 2033.

For further information about this research contact:

Professor John Black,
Ph: (02) 697 5018 Fax: (02) 663 2188

Road Topics is a forum for short articles containing information that is current, relevant to Australasian conditions and/or of interest to Australasian researchers and practitioners. Illustrations and photographs are welcomed, and good quality black and white originals are preferred.

If you would like to have an item published in Road Topics, send it to:

Anita Coia, Editor of Road Topics
Australian Road Research Board
PO Box 156
Nunawading Victoria 3131
Australia
Ph: (03) 881 1526
Fax: (03) 887 8104

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We are taking steps to ensure the journal maintains its relevance during the 1990s.

Emphasis is being given to publication of papers focused on issues of current concern particularly reports of original research, 'state of the art' reviews and theoretical and applied analyses of topical issues and practices. We cover road infrastructure, traffic operations and management, road safety, environmental issues, transport planning and economics — anything that impacts on the role of roads in transport services.

Submissions of the following are welcome:

- research papers and review articles
- news items
- letters to the Editor
- book reviews
- advance notice of a conference etc.

Contact Peter Milne, the Editor of the Journal — Telephone (03) 881 1540 Fax (03) 887 8104

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