MICROSIMULATION MODELLING OF TRAFFIC FLOW ON TWO-WAY TWO-LANE RURAL ROADS: PAST, PRESENT AND FUTURE

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ABSTRACT

Two-way two-lane roads provide the backbone of the nation’s road system in regional Australia and will do so for the foreseeable future. Whilst some aspects of the traffic operations of two-way two-lane roads are reasonably well understood, having been the subject of considerable R&D in the 1970s and 1980s, there are new factors that have not been subject to intensive study. These include the growing use in volume and spatial coverage of large combination vehicles such as b-doubles.

This paper describes research at the Transport Systems Centre in collaboration with Quadstone, the developers of Paramics, to devise a rural two-way two-lane road simulation module and incorporate it in Paramics. This module allows for high speed traffic operation with limited overtaking in the face of restricted sight distance or oncoming traffic. It also considers vehicle performance on gradients, including a range of vehicle types. The research uses the outcomes of previous studies as the basis of the new model, along with collection of new data from rural roads in South Australia. The paper describes applications of the new model to freight vehicle performance on rural roads and of the effects of large vehicle (b-doubles) in rural traffic streams and their interactions with other vehicles. Further developments of the overall model to consider multi-modal transport systems, e.g. the balance between road and rail-based freight transport, are outlined.

INTRODUCTION

Two-way two-lane roads provide the backbone of the nation’s road system in regional Australia and will do so for the foreseeable future. Whilst some aspects of the traffic operations of two-way two-lane roads are reasonably well understood, having been the subject of considerable R&D in the 1970s and 1980s, there are new factors that have not been subject to intensive study. These include the growing use in volume and spatial coverage of large combination vehicles such as b-doubles. Further, whilst previously there were useful analytical tools for studying the traffic performance of two-way two-lane roads (e.g. ARRB’s TRARR simulation model), many if not all of these tools have fallen into disrepair and disuse, if not complete obsolescence as a result of the recent advances in computer technology, and the apparent disappearance of expertise in the use of the models.

At the same time, the advances in computer technology have seen the development of powerful new traffic network modelling tools, especially microsimulation models of traffic flows in road networks. By and large these models have been designed for urban conditions, and generally for multi-lane roads or local residential streets where overtaking is seldom an important issue. This paper describes research at the Transport Systems Centre (TSC) in collaboration with Quadstone, the developers of the Paramics microsimulation model, to devise a rural two-way two-lane road simulation module for incorporation in Paramics. This module allows for high speed traffic operation with limited overtaking in the face of restricted sight distance or oncoming traffic. It also considers vehicle performance on gradients, including a range of vehicle types.
The paper briefly reviews research on two-way two-lane rural road traffic from the 1960s to the present, and then describes the development and testing of the new Paramics-based microsimulation model. The present research uses the outcomes of previous studies as the basis of the new model, along with collection of new data from rural roads in South Australia. Future data collection in Queensland is also expected. The paper introduces applications of the new model to freight vehicle performance on grades and of the effects of large vehicle (b-doubles) in rural traffic streams and their interactions with other vehicles. Further developments of the overall model to consider multi-modal transport systems, e.g. the balance between road and rail-based freight transport, are outlined.

**REVIEW OF PREVIOUS STUDIES**

There has been a long history of research on the traffic performance of two-lane rural roads, in Australia and in other countries such as Canada and the USA. This research may be traced in a continuous line from the 1930s until the mid 1990s. The research culminated in significant understanding of traffic behaviour on two-lane two-way roads (e.g. McLean, 1989) and in the development and application of powerful simulation models of traffic flow, such as the TRARR model – see Robinson (1980) and Hoban, Shepherd, Fawcett and Robinson (1991).

Reported research on traffic flow and overtaking on two-lane roads dates from the 1930s, when major studies were conducted in the USA (Norman, 1940, Prisk, 1941). Australian research is reported from the 1960s onwards (e.g. Underwood, 1963, Miller and Pretty, 1968), with extensive work then undertaken in the 1970s and 1980s. See Cowan (1971), Troutbeck, Szwed and Miller (1972), Taylor, Miller and Ogden (1974), Troutbeck (1980, 1982ab, 1984), Hoban (1980, 1982, 1983, 1984a) and McLean (1986) for examples. Troutbeck’s research on overtaking, as reported in Troutbeck (1982ab, 1984), provides a good overview of the general findings of the research of the time. He produced a series of regression equations relating overtaking performance parameters to the length and speed of the overtaken vehicle for various overtaking manoeuvre types, and the effects of height, type of overtaken vehicle and information signs (on long vehicles) upon overtaking behaviour. The main findings included:

- no significant differences in overtaking behaviour when sight distance was terminated by a curve or crest in the road
- most of the probability distributions of the overtaking parameters were best represented by the log-normal distribution
- increases in overtaken vehicle length resulted in longer overtaking times
- overtaking times increased by about 14 per cent for each 10 km/h increase in the speed of the overtaken vehicle
- headways of a manoeuvre are different depending upon if the overtaken vehicle is a car or truck
- there was a good level of correlation between many of the recorded overtaking parameters.

A general summary of the Australian research on traffic behaviour on two-lane rural roads and the planning and design implications from that research was given by McLean (1989).

In parallel with the research on traffic behaviour and performance came research and development of simulation models of traffic flow. The first of these models were developed by Taylor, Miller and Ogden (1972), Boal (1974) and Hoban (1980). Consequently ARRB undertook a major R&D project which led to the development of the TRARR simulation model for rural roads (see Robinson, 1980, Hoban and McLean, 1982, Hoban, 1984b and Hoban, Shepherd, Fawcett and Robinson, 1991).

International research on rural road traffic simulation in the same period was extensive, and drew to a large degree on the Australian studies. Yagar (1983), Brannolte (1984), Morrall, Werner and Kilburn (1986), Gipps (1990) and Okura and Matsumoto (1990) amongst others provide a full account of the range of model development and application.
TRARR found extensive use in Australia during the 1980s and early 1990s, and was put to productive use in the studies that consequently led to the widespread introduction of passing lane sections on major two-lane highways throughout Australia. Indeed, its use spread further, so that researchers in other countries – e.g. Canada, see Archilla and Morrall (1995) – then recommended that the model be applied in their countries.

Thus there were useful and tested analytical tools for studying the traffic performance of two-way two-lane roads available within the last decade. However, the situation then deteriorated, so that now many if not all of these tools have fallen into disrepair and disuse, if not complete obsolescence, as a result of the recent advances in computer technology and an evaporation of the specialist knowledge and expertise required to maintain and utilise the models. The old models may just not run on the presently available computers, and the modelling expertise has faded from view.

At the same time, the advances in computer technology have seen the development of powerful new traffic network modelling tools, especially microsimulation models of traffic flows in road networks – the Paramics (Quadstone, 2002), VISSIM (PTV, 2002) and AIMSUN (Transport Simulation Systems, 2002) models are good examples. By and large these models have been designed for urban conditions, and generally for multi-lane roads or local residential streets where overtaking into oncoming traffic is seldom an important issue. An independent evaluation of Paramics and VISSIM may be found in Connolly, Gray and Wade (2001). This report noted the inability of these otherwise excellent packages to model traffic flow on two-way, two-lane roads.

**PARAMICS**

Paramics (Quadstone, 2002) is a software package for microscopic traffic simulation, which models the progression of individual vehicles through a network from trip origin to trip destination. It provides detailed traffic flow information for the analysis of road networks and different planning and design scenarios. The name Paramics is an acronym derived from PARAllel MICroscopic Simulation. Development of the package began in the early 1990s, with its roots in a large number of European research and development projects. The main focus of the package has been on the analysis of congested urban road networks, including the implementation of ITS technologies. The package is in widespread use around the world, including the UK, France, The Netherlands, the USA, Canada, Japan, Singapore, Argentina and Australia. Its users include consultants, government agencies, and university researchers, many of whom are contributing to the ongoing development of the software. The TSC was the first user of Paramics in Australia and is playing a substantive role in the ongoing development and application of the model.

One of the basic features of Paramics is to provide transport modellers with a system in which every aspect of the study network is displayed visually, in ways that can be rapidly assessed and comprehended. It provides a comprehensive 3-D visualisation system which allows the user to view the network model from any angle at any position. Network layouts, road and intersection geometry are displayed in detail. Individual vehicles using the network are displayed, and their journeys may be traced through the network. This provides planners and engineers with detailed information on average and range of variation in traffic conditions. Vehicle movement is governed by three interacting models representing vehicle following, gap acceptance and lane changing. A range of vehicle and driver types can be included, allowing study of the physical and behavioural characteristics of the traffic system. Individual driver behaviour is determined through random sampling of ‘aggression’ and ‘awareness’ characteristics for the driver of each vehicle. Vehicle dynamics are based on a combination of driver behaviour and limitations imposed by vehicle physical type and kinematics (e.g. size, mass and acceleration and deceleration capabilities). The package is thus:

- a dedicated traffic simulation model
- a visualisation tool for traffic planning and management
• a productivity tool, for studying the impacts of variations in traffic control parameters (e.g. traffic signal settings)
• a high performance computation model, using advanced computing techniques to provide fast simulation model execution times

Travel demand in *Paramics* is described by time-dependent origin-destination matrices, with the vehicle trips in these matrices assigned to the network dynamically. Driver route choice can vary in response to traffic conditions in the network, and allowance can be made for the degrees of familiarity that different drivers may have for the network.

**A RURAL ROAD MODULE FOR PARAMICS**

The major impediment to freely flowing traffic on two-way, two-lane rural roads is the enforced following of faster vehicles behind slower vehicles. This results in the phenomenon of platooning whereby vehicles can end up travelling in bunches. In effect, all vehicles in the platoon are reduced to the speed of the slowest vehicle, which is at the head of the platoon. A platoon can only be dispersed when an opportunity for overtaking arises. Overtaking opportunities are restricted by a number of factors including horizontal and vertical sight distance as well as a vehicle’s ability to accelerate. Acceleration capabilities are particularly significant on gradients. Platooning is increased by the presence of large vehicle combinations like semi-trailers and b-doubles whose acceleration and speed capabilities are adversely affected by medium to steep downgrades and upgrades.

Hence in order to develop a realistic and accurate microsimulation model of traffic on two-lane, two-way rural roads, these two behavioural aspects need to be considered very carefully and on separate terms. They were implemented through two separate Application Programming Interfaces (referred to as APIs) to the main *Paramics* software suite:
• the gradient API, and
• the overtaking API.

**Gradient API**

The gradient API logic flowchart is outlined in Figure 1.

It is based upon the theory of limiting speeds, which states that there is a speed that each vehicle will tend to on any particular section of road. This has been shown to be true for flat sections, upgrades and downgrades (Bennett, 1994). If the vehicle is travelling on a flat then the model reverts to the default *Paramics* acceleration model. On the other hand, if a vehicle is travelling on a gradient of any type or level, the API calculates the limiting speed. On an upgrade the limiting speed is a function of the grade and the power to weight ratio of the vehicle. On a downgrade the situation is more complex as the limiting speed is a function of braking capacity and more importantly driver behaviour. This results in far larger standard deviations in observed speeds on downgrades as compared to flats or upgrades. Once the limiting speed for any vehicle is calculated the model either accelerates or decelerates the vehicle to that limiting speed at predefined rates for each vehicle type. An exception occurs when the vehicle is travelling at a speed below its limiting speed and does not have sufficient power to accelerate. In such cases the acceleration of the vehicle is zero and the vehicle maintains its crawl speed. The gradient acceleration API has been fully outlined in Fry, Woolley and Taylor (2002) and readers interested in a more detailed account are directed to that paper.

**Overtaking API**

For the purposes of this study, an overtaking manoeuvre is defined as being made up of three phases:
• *Phase 1*: this phase begins at the point where an overtaking opportunity becomes available which includes the driver perception reaction time. It continues to the point at which the first part of the overtaking vehicle crosses into the overtaking lane.
• **Phase 2**: this phase starts at the end of stage one and continues throughout the overtaking manoeuvre whilst the overtaking vehicle occupies the match lane, where the match lane is the lane containing oncoming traffic. Phase 2 concludes once the first point of the overtaking vehicle re-enters its own lane.

• **Phase 3**: this phase starts at the end of phase 2 and lasts until the last part of the overtaking vehicle has re-entered its own lane.

Figure 2 illustrates these three phases.

Overtaking manoeuvres may be classified into flying or accelerative overtakings and single or multiple overtakings (Prisk, 1941). Flying overtakings occur when the trailing vehicle overtakes the impeding vehicle without any period of enforced following. Flying overtaking manoeuvres generally are initiated at or near free speeds and hence generally do not require large accelerations. Accelerative overtakings, on the other hand, occur after a period of enforced following where the trailing vehicle has been forced to slow to a speed lower than its desired speed. Accelerative overtaking manoeuvres require significant acceleration. They are also the most common types of manoeuvre. Single overtakings occur when a single vehicle is overtaken in the manoeuvre whereas multiple overtakings occur when more than one vehicle is overtaken within one manoeuvre.

There are four main functions in the API, which control the entire overtaking manoeuvre. These functions are:

1. **pull out**
2. **gap exists**
3. **pull in**
4. **headway**

Each function is described more fully in the following subsections of this paper. However, it is useful to include a general outline of the overall API at this point.

The logic behind the control process is simple. In each simulation time-step, the API checks if overtaking is suitable by looking at a variety of factors. If overtaking is suitable it introduces smaller headways in anticipation of the manoeuvre. The API then checks to see if a suitable gap exists in the oncoming traffic. Once both of these conditions are met, the vehicle pulls out into the oncoming traffic and accelerates beyond the impeding vehicle into the direction of oncoming traffic. The API then chooses the appropriate time and position for the overtaking vehicle to move back into its normal lane. The vehicle does so if it needs to abort, or if the manoeuvre is complete. Once the vehicle pulls back into its own lane the normal headway is resumed. Figure 3 explains the logic of this process in the model.

**Pull out function**

The **pull out** function tests to see if an overtaking manoeuvre is potentially possible. It first eliminates the situations whereby the vehicle or the impeding vehicle is already overtaking - in the case of an overtaking vehicle the impeding vehicle would actually be oncoming. It also eliminates the situations whereby the vehicle is in an incident or if there is no impeding vehicle.

If there is an impeding vehicle, the function checks if the impeded vehicle is within a five second headway. If it is not, the vehicle is deemed to be not platooned (HCM, 1985; McLean, 1985) and hence not close enough to consider overtaking. It is important to note here that a flying overtaking manoeuvre will still be possible as the conditions are checked again in the next simulation time step and the vehicle will eventually come within that five second headway without having slowed down.

If the conditions are met, the function calculates the desired and existing gaps between the impeding vehicle and the vehicle ahead of the impeding vehicle or end of the overtaking zone. As is already known from previous research (Troutbeck, 1982) and indeed from common observation, different drivers will deem overtaking suitable with differing gaps. A small proportion of drivers will never overtake no matter how favourable the conditions are whereas other drivers will attempt to overtake when the barest of conditions are met. This phenomenon
is catered for within the *pull out* function by considering ‘driver aggression’, in keeping with the normal operation of *Paramics* with respect to driver behaviour. The following rule applies.

If desire > overtaking level then overtake if a suitable gap exists

where

\[ \text{desire} = \text{vehicle aggression} \times \text{speed difference} \]

and

\[ \text{speed difference} = \text{max overtaking vehicle speed} - \text{max impeding vehicle speed} \]

[Vehicle aggression is defined as an integer value assigned to the vehicle from 1 (unassertive) to 9 (highly aggressive), in line with the general use of this factor in *Paramics*.]

If a sufficient gap exists for the impeded vehicle to move into and the desire level is sufficiently high, then the *pull out* function returns ‘true’, and the manoeuvre may be initiated. *Figure 4* explains the logic of the *pull out* function.

**Gap exists function**

The purpose of the *gap exists* function is to check if a sufficient gap exists in the oncoming traffic for the impeded vehicle to overtake. The logic behind the function is outlined in *Figure 5*. The logic checks:

1. if the vehicle is able to accelerate
2. if it is at the end of an overtaking zone
3. if there is no impeding vehicle
4. if it is already overtaking.

If all of the above conditions are favourable then it goes on to calculate the distance travelled by the overtaking vehicle during the manoeuvre. The distance is used to check for potential collisions with oncoming vehicles or the end of the overtaking zone. It is calculated as follows:

\[ d = s_1t_1 + \frac{at_1^2}{2} + s_2t_2 \]

where

\[ d = \text{distance travelled by the overtaking vehicle during the manoeuvre (m)} \]
\[ s_1 = \text{current speed of the vehicle (m/s)} \]
\[ a = \text{overtaking vehicle’s maximum acceleration under current conditions (m/s}^2) \]
\[ s_2 = \text{maximum speed of the vehicle under current conditions(m/s)} \]
\[ t_1 = \text{time spent accelerating to the maximum speed (s)} \]

The time spent accelerating to the maximum speed is determined as follows. If the vehicle reaches its top speed during the manoeuvre then:

\[ t_1 = \frac{(s_2 - s_{if}) - (s_1 - s_{if})}{a} \]

otherwise

\[ t_1 = \frac{-(s_1 - s_{if}) + \sqrt{(s_1 - s_{if})^2 + 2ad_{rel}}}{a} \]

where

\[ s_{if} = \text{maximum speed of the impeding vehicle (m/s)} \]
\[ d_{rel} = \text{distance to impeding vehicle (front bumper to rear bumper) + length of impeding vehicle + desired headway to next vehicle (m)} \]
\[ t_2 = \text{time spent travelling at maximum speed (s)} \]
This time is found as follows. If the vehicle reaches its top speed during the manoeuvre then

\[ t_2 = \frac{d_{rel} - (s_1t_1 + \frac{at_1^2}{2} + s_2t_2)}{s_2 - s_{fr}} \]

otherwise

\[ t_2 = 0 \]

The distance travelled by the oncoming vehicle during the manoeuvre \((d_{oc})\) and travelling at speed \(s_{oc}\) is also calculated. If this vehicle is overtaking, then:

\[ d_{oc} = -(t_1 + t_2)s_{oc} \]

If the oncoming vehicle is not overtaking, then

\[ d_{oc} = (t_1 + t_2)s_{oc} \]

The critical passing sight distance \((SD_c)\) (m) is then calculated, using the model proposed by Hassan, Easa and Abd El Halim(1996):

\[ SD_c = 2v(t_c + h_0) \quad \text{if } \Delta_c \leq 0 \]
\[ SD_c = 2v(t_c^* + h_0) \quad \text{if } \Delta_c > 0 \]

where

\[ \Delta_c = L_p + (v - m)h_i - mt_c \]
\[ t_c = P + t_b - \frac{aDt_b^2}{4v}(t_b + 2h_0) \]
\[ t_c^* = \frac{(v - m)h_i + L_p}{m} \]
\[ t_b = \left[ \frac{2vh_i - mh_0}{2v - m} \right] + \sqrt{\left[ \frac{2vh_i - mh_0}{2v - m} \right]^2 + \frac{L_p + L_i + (2v - m)h_i}{a_d (2v - m)}} \]

in which

\( \Delta_c \) = critical position (m)
\( SD_c \) = critical sight distance (m)
\( v \) = design speed of highway (km/h)
\( m \) = differential speed (km/h) between impeding vehicle and passing vehicle

\(^1\) The minus sign in this equation indicates that the oncoming vehicle is travelling in the opposite direction and is on the wrong side of the road.
hi

\[ h_i = \text{minimum headway between front bumper of the passing vehicle and rear bumper of the impeding vehicle (s) [assumed value 1.0 s]} \]

\[ h_0 = \text{minimum headway between front bumper of the passing vehicle and front bumper of the opposing vehicle (s) [assumed value 1.0 s]} \]

\[ L_p = \text{length of passing vehicle (m)} \]

\[ L_i = \text{length of impeding vehicle (m)} \]

\[ t_c = \text{time required to complete overtaking from the critical position (s)} \]

\[ t_b = \text{time required to abort overtaking from the critical position (s)} \]

\[ a_d = \text{deceleration rate during abort (m/s}^2) \]

A check is also required to ensure that no rear end shunt will occur if the passing vehicle were to move into the match link. The gap exists function then returns ‘true’ if there is a sufficient safety margin to any oncoming and behind vehicles and there is also a sufficient safety margin to the end of the overtaking zone. Otherwise it returns ‘false’.

**Pull in function**

The pull in function is used to control the return of the overtaking vehicle to its own lane once the manoeuvre is complete or if it needs to be aborted to avoid a collision. Figure 6 indicates the logic of this function. It begins by checking whether the vehicle is indeed overtaking and returns false if it is not. The gap between the overtaken vehicle and the next vehicle in front is then calculated. If the vehicle is found to be within the safety margin for the oncoming vehicle or the end of the overtaking zone then the function also returns false. Finally a check is performed to decide if the vehicle is faster than the next impeding vehicle's maximum speed. If it is not then the function returns true. If it is then the function returns false and the vehicle continues overtaking in the match lane. This section of the function allows multiple overtakings to take place when several slower vehicles in a platoon trap a fast vehicle.

**Headway function**

The headways between vehicles are obviously different when they are freely travelling to when they are platooned. However the headways within platoons are also significantly different when a vehicle is travelling freely or waiting to overtake. The headway between queued vehicles is altered to simulate more realistic levels within the API. There is a separate function called headway factor but control is shared between it and the pull out and pull in functions. If the pull out function returns true then a flag is set to indicate that the vehicle is waiting to overtake. This triggers the headway function to enforce closer following. The headway \((h)\) is taken as a sample from a normal distribution as described in Troutbeck (1982):

\[ h = \exp(2.5663 + 0.0143(3.6S_{ij} - 70) + 0.525547z) \]

where \(S_{ij}\) is the speed of the impeding vehicle in km/h and \(z\) is a random normal deviate. The impeded vehicle retains this value as a desired headway until the overtaking manoeuvre is completed and the pull in gap function resets the flag to indicate the resumption of normal headway levels.

**Scope of the model**

The rural road simulation model currently caters for five vehicle types but it is extendable to any number of specific vehicles where appropriate data are available. The present vehicle types are:
<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Mass (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger car</td>
<td>1.22</td>
</tr>
<tr>
<td>Goods van</td>
<td>1.70</td>
</tr>
<tr>
<td>Light commercial vehicle</td>
<td>2.25</td>
</tr>
<tr>
<td>Semitrailer</td>
<td>25.76</td>
</tr>
<tr>
<td>B-double</td>
<td>51.55</td>
</tr>
</tbody>
</table>

The mass of each vehicle type is based upon the 85th percentile load factors as published by Bennett (1994). The proportion of each vehicle type may be altered to suit the requirements of the specific application of the model.

The APIs are implemented through the programmer section of the Paramics software suite. The models are written in the C language and compiled to form Dynamic Linked Libraries (DLLs). The software then reads these DLL files and the behaviours within them are thus available for use in the simulation.

APPLICATION OF THE MODEL

Initial applications of the simulation model are now being made (see Figure 7). One such application involved the micro-simulation study of the mean percent time delay to an entire traffic stream conducted with limited overtaking opportunities available. Two grades were chosen (zero and six percent) with varying volumes of b-doubles in the traffic stream. As may be seen in Figure 8, increasing the percentage of b-doubles in the traffic stream steadily increases the percentage of travel delay to the entire traffic stream. Increasing the grade however sharply increases the percent delay. The rate of increase in mean percent delay for increasing b-double numbers is also higher for steeper grades. Obviously the results in the figure are highly dependent upon specific network geometries however the utility of the model for transport investigations is clearly demonstrated.

FURTHER DEVELOPMENTS

The primary purpose of this research is to provide a new and updated tool to assist the highway engineer in two-way, two-lane rural road design and upgrading. The API consists of five vehicle types including passenger cars, commercial vehicles and b-double articulated trucks.

In its final form the rural road simulation model will allow study of individualised comparisons between road and rail networks in regional areas in terms of pollution, economics, time of travel and safety. Potential applications of the fully validated model are wide ranging. One major aspect of interest is in the planning of overtaking lanes on grades where there are significant percentages of heavy vehicles in the traffic stream, or on level sections of road to provide passing lanes and so accelerate the dissipation of vehicle bunches under conditions of restrictive overtaking opportunities. The previous generation of simulation tools are close to becoming obsolete due to rapid advances in computing technology in recent years, which has tended to leave the existing software packages behind. The API system devised for Paramics can be used to compare several different scenarios in the planning stages with confidence. An additional benefit with the advent of laptop computers is the ability to use the models in the field. This can be useful to the engineer who has to make decisions quickly in the event of unforeseen or changing circumstances.

A detailed simulation model of multimodal freight transport modes for regional networks would be an extremely useful and indeed valuable tool for the transport planner. The road simulation model described in this paper can provide the initial basis for such a model, given that Paramics has the capability of modelling train operations as well as road traffic flow. The balance between rail freight and road freight is an increasingly important consideration in regional transport planning. One application of this project may be to build a microsimulation model that will allow direct comparisons of road and rail freight for particular freight tasks in a given region. The model would need to compare parameters including road safety, pollution, economics and delivery time. It would be possible to model particular routes for specific
commodities and manufactured goods. The information gained from the model could then be used as input in regional transport planning.

Another area of potential usefulness is in the study of new vehicle combinations. The larger vehicle combinations like b-doubles can be used to transport larger volumes of goods and hence result in smaller economic unit costs. However, the positive aspects of using b-doubles are balanced somewhat by a significant gap in detailed knowledge on how they affect the behaviour of other vehicles in the traffic stream, or indeed the capacity of the road and the quality of traffic flow. In particular there is a deficiency in the knowledge of how they affect overtaking behaviour. The Level of Service (LOS) of a road is strongly affected by the number and ease of overtaking opportunities on it. The introduction of significant numbers of these long combination vehicles into the road system may significantly decrease the overtaking opportunities available. In turn this would lead to increases in vehicle delay, driver frustration and flow. The knock on effects of this could result in increased pollution from vehicle exhausts, poorer road safety and decreased economic benefit. The Paramics API for rural road traffic flow will allow a faster and cheap method of detailed study of the effect of large vehicle combinations on the traffic stream. Very little research has been published about the effects of very high percentages of heavy vehicles in the traffic stream. For instance, the requirements of a b-double to successfully overtake a slow road train are largely unknown at this stage. The model could be used to provide some insight into the overtaking requirements of large trucks around other large trucks.

CONCLUSIONS

This paper describes research in traffic modelling aimed at developing a modern simulation model for traffic behaviour on rural two-way, two-lane roads, as the successor to a previous generation of simulation models that is now almost lost. The model development uses the state of the art Paramics microsimulation model as its basis, and thus takes advantage of the advanced computing techniques, graphical visualisation capabilities, and data analysis procedures available in that model. The new model is designed as a plug-in module for Paramics, providing modelling capability for traffic flow where overtaking opportunities are restricted by limited sight distance or opposing traffic – i.e. the common situation on rural two-way, two-lane roads. The broad aim of the research is to restore our capability and expertise in traffic modelling, and to do so using the latest available technology for computation and visualisation. It is building on the extensive research conducted in the field in previous times, supplemented by new investigations and data.

The products of the research will provide vital tools to assist in the study and evaluation of existing and emerging issues concerned with rural road planning and traffic operations, including the possible impacts of new freight vehicle types. The modelling tools also have potential for use in detailed multimodal regional transport studies, for which similar tools have not previously been available. Future research will explore this issue.

REFERENCES


Figure 1: The gradient acceleration API logic flowchart
Figure 2: The three phases of the overtaking manoeuvre
Figure 3: Flowchart of the overtaking API logic
Figure 4: Flowchart of pull out function logic
Figure 5: Logic flowchart of the gap exists function
Figure 6: Logic flowchart of the pull in function
Figure 7: Visualisation of a rural road network showing passenger cars and a semi-trailer as part of the simulation model
Figure 8: Mean per cent time following with 95 per cent confidence limits (each point represents ten simulation runs)