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NZTA research

NZ TRANSPORT AGENCY
WAKA KOTAHI

SYSTEMS OFFER COST-EFFECTIVE MEANS OF REDUCING SPEEDS

A study into the potential introduction of an intelligent speed adaptation system in New Zealand showed that it would offer safety benefits and be economically viable, but that there were barriers to implementation and uptake that would need to be worked through.

Intelligent speed adaptation (ISA) is an in-vehicle technology that helps drivers know the speed limit that applies to the road they are travelling on and aids compliance with that speed limit.

ISA systems use global positioning systems (GPS) to locate themselves on an in-vehicle speed limit map. The systems then use in-vehicle displays to advise drivers of the current speed limit, and audio prompts when that limit is being exceeded. In recent years, the systems have advanced and their implementation costs reduced to the point where it has become viable for one to be introduced in New Zealand.

TYPES OF ISA

Various ISA systems have been the subject of research and field trials overseas since the early 1990s. A review of the international research has identified ISA typologies based on the level of interaction with the driver, and the types of speed limit information displayed.

In terms of interaction with the driver, the typical ISA types are as follows.

- Advisory – displaying the speed limit and reminding the driver of changes in the speed limit.
- Voluntary (driver select) – allowing the driver to enable and disable control by the vehicle of the maximum speed.
- Mandatory (intelligent governor) – the maximum speed of the vehicle is limited at all times.

In terms of the currency of the speed limit information being supplied by the ISA, there are a further three categories.

- Fixed – the vehicle is informed of the posted speed limit.
- Variable – the vehicle is additionally informed of certain locations where a lower speed limit or advice is recommended or implemented, eg around pedestrian crossings or on the approach to sharp bends. In this case the speed limits (or advice) may vary spatially.

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- Dynamic – in addition to the fixed and variable functionality, speed limits may vary both temporarily and spatially, ie lower speeds may be implemented due to weather conditions, in response to incidents or congestion, or around schools when students are arriving or leaving.

While international research suggests there are significant safety benefits associated with ISA systems, in almost all cases, the European and the more recent Australian studies have focused primarily on urban road safety issues. However, the predominant crash problem in New Zealand relates to rural, not urban roads, and in particular loss of control on rural roads.

The current study looked at experiences with ISA systems overseas, and conducted local field trails and focus groups to gather information on the barriers to implementation, and assess the economic viability of two advisory ISA systems. The first ISA variant used only posted speed limit information (fixed ISA) while the second looked at a system that provides additional speed advice when approaching out-of-context or low-speed corners (variable ISA).

In addition to investigating drivers' experiences using the two systems and compliance with the speed information being provided, the research included a survey of potential incentives to encourage driver uptake of the technology; a review of how speed limits are currently set in New Zealand and the development of a nationwide speed limit map; an evaluation of the coverage and accuracy of global navigation satellite systems in New Zealand; focus groups and experimental trials to identify user acceptance issues; a benefit–cost analysis; and consultation with local and central government and the motor industry to identify potential institutional, regulatory and other barriers.

VISUAL DISPLAY OF THE ISA SYSTEM

A MIXED, BUT MOSTLY POSITIVE, RESPONSE

Driver feedback from the four focus groups involved in the study varied. Each of the groups represented a different segment of the driver population (older, young, fleet and general drivers), and trialled and discussed the acceptability of ISA systems. Although the first three groups were positive about the technology, and indicated that they would be likely to use it, the general group (representing drivers aged 25 to 64 years) saw it as having limited usefulness or difference from GPS systems already available.

However, the field trials indicated that both the fixed and variable systems significantly reduced driver speeds and increased compliance with speed limits, especially on rural roads where compliance with advisory speed signs on curves increased dramatically. This was true even when drivers had only been using the ISA system for a relatively short time (one day), suggesting that New Zealand drivers would respond well to the introduction of the technology.

ISA DEVICE IN USE ON THE TRIAL ROUTE

a) Driving below the speed 100km/h zone speed

b) Exceeding the limit in a limit in a 50km/h zone

c) Driving below the advisory speed on a 45km/h advisory curve

d) Exceeding the advisory speed on a 45km/h curve

This response enabled the study's authors to conclude that variable ISA systems offer a proactive and potentially cost-effective solution to a key crash risk in New Zealand, namely loss-of-control crashes on rural roads.

From an economic viewpoint, the systems also stacked up well, with the fixed costs of deploying an ISA system in New Zealand found to be exceptionally low when compared with its potential benefits (predicted crash reduction rates flowing from the system's use ranged from 1% to 22%, depending on the different crash severities, road types and ISA conditions considered). Some of the costs of introducing ISA would be borne by the users. It was considered that uptake was likely to be relatively high, and even on low-uptake scenarios, the benefit–cost ratios were still high on the benefit side.

BARRIERS TO DEPLOYMENT

There are few institutional or regulatory barriers to an ISA system's uptake in New Zealand. However, there are a large number of technical issues relating to mapping, speed measurement, speed limit databases, radio frequencies and confidentiality, which would need to be worked through with industry groups and may involve expensive policy work and legislative change.

There are also unknowns about whether particular ISA devices would comply with any future legislation or regulations, and whether vehicle manufacturers would be willing to do so. Extensive promotion may be needed among drivers in the 25 to 64 year age group who currently appear to be resistant to the idea of ISA and unsure of its usefulness.

An investigation into the deployment of an advisory ISA system in New Zealand, NZ Transport Agency research report 521

Available online at **www.nzta.govt.nz/resources/research/reports/521**

MODEL PAINTS LONG-TERM PICTURE OF TRANSPORT DEMAND

The National Long-term Land Transport Demand Model adds another dimension to scenarios of how demand for transport is likely to evolve over time.

The National Long-term Land Transport Demand Model uses top-down macro-forecasting methods to evaluate transport demand scenarios for the next 30 years. It is used by the NZ Transport Agency for strategic planning, and complements qualitative scenarios about changes in transport demand over time.

The National Long-term Land Transport Demand Model was developed by the New Zealand Institute of Economic Research (NZIER) during 2011 and 2012.

John Stephenson of the NZIER says, 'Our intention was to provide a tool that the Transport Agency and others can use to consider the ways in which transport demand might evolve over time, rather than provide estimates of what future transport demand is likely to be at any given point. This very precise purpose means that the model has some limitations, but in our report, we've identified areas where it could be developed in future to make it better suited to other uses.'

The National Long-term Land Transport Demand Model is capable of evaluating scenarios taking into account trends in population growth, spatial demographics, technology, income and economic growth, industry, policy and prices, particularly fuel price trends and volatility.

It features an easy-to-use interface, meaning that even people who are not modellers can use it; and a facility for users to input their own assumptions about what will happen in controversial areas (for example, oil prices), and how responsive demand is likely to be to changes in key variables such as fuel prices and income (known as elasticities).

It can be used to model scenarios for 12 different regions, enabling the effects of differing urbanisation and density trends, and regional differences in economic growth and industrial composition to be captured. It also includes a stochastic mode that reflects the uncertainty around how demand will evolve in coming decades.

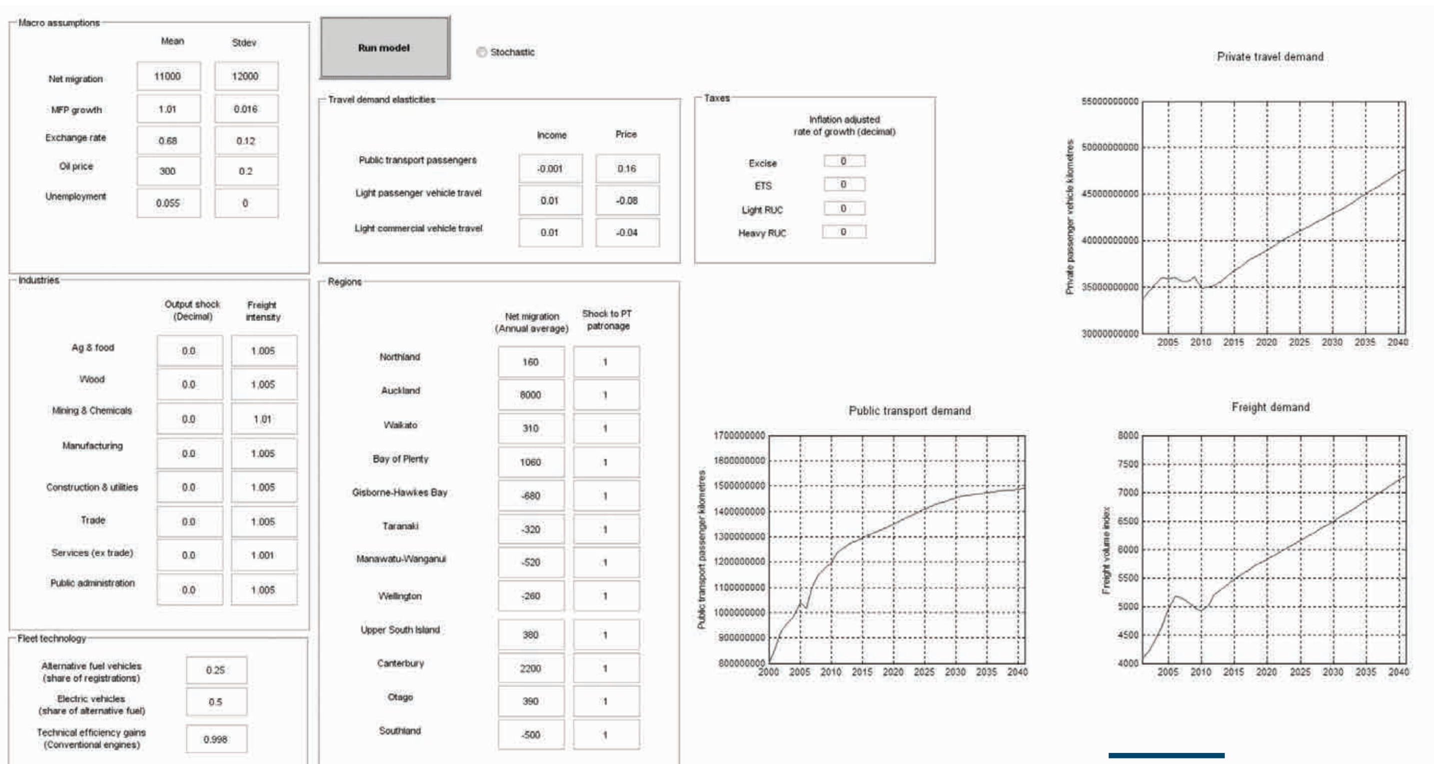
LIMITATIONS AND FUTURE DEVELOPMENT

Because of its specific purpose and long-term focus, the National Long-term Land Transport Demand Model has limitations on the kinds of issues it can take into account and address. So for example, the model is not well equipped to deal with short-term fluctuations in demand or drivers of transport demand. It is not a forecasting tool.

Another important limitation is that the model cannot be used to assess the impacts (costs and benefits) of specific transport network investments or other supply-side issues (such as congestion).

John explains, 'The model doesn't have the necessary detail for judging the impacts of investment at the level of a particular network. It can, however, be used to help assess high-level investment priorities or to provide context for investment-specific impact assessment.'

To be useful as a strategic planning tool, the model purposefully gives only limited consideration of supply-side issues, so as not to confuse demand trends with supply-side responses that are, in part, determined by the Transport Agency.



Model graphic user interface - example

John also stresses that, despite the model's ability to take into account regional differences in demand, it is a national-level model.

'The model uses regional differences as factors that affect national growth in demand for transport and the location of that growth. It is not intended to provide a complete description of region-specific transport activity,' he says.

All of these issues and limitations could be dealt with by adapting the model and the modelling approach. However, John points out there are already models available that address many of these issues.

'The value added by our research and approach was that it was filling a gap for decision-makers – it was a complement to these existing models,' he says.

Despite this, the full report outlines four areas where the model could be usefully extended, including revenue forecasting, fiscal sustainability, freight demand and impacts, and supply-side constraints.

The research report includes an in-depth description of how the National Long-term Land Transport Demand Model was developed, and the assumptions that underpin it. It also contains a sample of the types of results that the model produces.

See also the article in this edition on *Research report 534 Drivers of demand for transport*, about research commissioned by the Transport Agency in response to information gaps identified during this research project.

National long-term land transport demand model,
NZ Transport Agency research report 520

Available online at **www.nzta.govt.nz/resources/research/reports/520**

GROUND LAID FOR DEVELOPING TRANSPORT DEMAND MODELS

A recent project has taken the first steps in developing long-term road transport forecasting models.

As part of its 2011/12 research programme, the NZ Transport Agency commissioned the development of a National Long-term Land Transport Demand Model, which could be used to project future demand for freight and passenger vehicle transport, for different scenarios at a regional and industry level. (See the previous article on *Research report 520: National long-term land transport demand model*, for a summary of this project.)

One of the issues to come out of this research was the lack of empirical evidence about the effect that changes in income and economic activity have on transport demand, and the lack of statistical rigour in estimating the effect of these factors.

In response to this, the Transport Agency subsequently commissioned Frontier Economics to identify a best fit method and suitable data sources for developing demand models that reflected the relationship between:

- economic activity and road freight activity
- income growth and passenger vehicle travel.

The main criteria for selecting a best fit method was data availability, as this would enable the Transport Agency to use the recommended methods to develop models based on currently available data. Other criteria included model accuracy and lack of bias, ease of validation and testing, and transparency and reproducibility.

The authors presented their findings, based on literature reviews and data exploration, in terms of the key analytical steps they recommend the Transport Agency consider when developing the models. The actual development of the demand models, and the estimation of the key parameters that fed into them, were outside the scope of the project, and would be the subject of future research.

Although growing out of the previous research to develop the National Long-term Land Transport Demand Model, this project and recommendations about models were viewed as a separate research activity. This was because the Transport Agency intended to use the National Long-term Land Transport Demand Model for analysing scenarios at a regional and industry level, while any models developed as a result of Frontier Economics' research would be used for investigating long-term trends at the national level.

DEVELOPING THE MODELS

The project used as its starting point existing New Zealand transport models.

Aleksandra Simic of Frontier Economics says, 'Over the past few years, the Transport Agency has commissioned a number of research projects on modelling the relationship between transport demand and economic activity. These studies were a starting point in our investigation, as they provided an insight into data availability and the existing transport demand models in New Zealand. The reviewed studies all developed econometric models using data aggregated at the national or regional levels.'

The project then undertook an extensive review of the international literature on transport demand modelling, especially as it relates to the relationship between transport demand and economic activity. This included studies on recent models developed by overseas agencies in a similar position to the Transport Agency. The report summarises the key findings of this review with respect to data preparation, selection of candidate demand drivers, data investigation and model specification, and model testing and validation. It also includes a summary of the most frequently used econometric techniques for modelling transport demand.

With respect to modelling freight demand (and its relationship to economic activity), the report recommends that the Transport Agency develop models by vehicle type, using road user charges (RUC) data on vehicle kilometres travelled.

Aleksandra explains that the recommendation is motivated by what is now widely accepted amongst transport experts, that the increase in industrial output, rather than gross domestic product growth, is the primary driver behind freight transport.

'As different types of trucks tend to be used for different purposes, their use may, at least to some extent, proxy freight transport demand by different industries and hence reflect the changing structure of the economy,' says Aleksandra.

'Smaller trucks are usually used for shorter distances and time-sensitive deliveries, so their changing use may reflect changes in retail sales. Larger trucks are used for long-distance heavy freight and hence may be more responsive to changes in goods-producing sector output.'

RUC vehicle kilometres travelled data is available both by heavy vehicle class and by weight category, which makes this type of modelling feasible.

With respect to modelling passenger vehicle travel (and its relationship to changing income levels), the report recommends that the Transport Agency develop a panel model using its regional vehicle kilometres travelled data.

The reason for this recommendation is that data for passenger vehicle travel is available for, at the most, 11 years. Such a relatively short time series severely limits any analysis of how the effect of income on travel demand has changed over time. Income levels, however, differ across regional council areas in New Zealand, and this difference can provide some insight into the relationship between income and travel demand.

Aleksandra points out that developing the econometric models will not be simple, and should be treated as an iterative process.

'Some analytical steps will need to be repeated several times before a preferred forecasting model is selected from a set of candidate models, and even after the preferred model has been selected, its forecasting performance will need to be checked on a regular basis,' she says.

This project has provided a solid starting point for the development of econometric models to forecast road transport demand in relation to economic activity and income levels. The report sets out the most frequently used econometric models for the Transport Agency to consider when it comes to the development stage. No one econometric model is recommended for adoption, with the report authors instead stressing that model selection is an integral part of model development, and will be guided by the nature of the available data and diagnostic checks.

Drivers of demand for transport, NZ Transport Agency research report 534

Available online at **www.nzta.govt.nz/resources/research/reports/534**

A FRESH LOOK AT THE COSTS OF CONGESTION

A fresh approach to assessing congestion and its associated costs throws new light on Auckland's congestion problems, and can do the same for all our larger cities.

Congestion is generally considered to be one of the biggest drawbacks of living and doing business in Auckland, with the costs to the country of the city's congestion problems commonly cited as being around $1 billion per year (an average of $2000 each year for every Auckland household).

Ian Wallis Associates (David Lupton and Ian Wallis) examined how road congestion is commonly defined and its costs to society measured. The $1 billion figure compares actual travel times with the travel time when the road is empty (eg at 3am), which they consider unrealistic.

The new study defines congestion as occurring when the demand for the road exceeds its capacity. This is consistent with the common engineering definition of congestion, and is also when the road is operating at its economic optimum.

Calculations based on this definition show that not only are the annual costs of congestion in Auckland substantially lower than the previous estimate, but also that, at a network-wide level, the Auckland road network is not far from its optimal capacity.

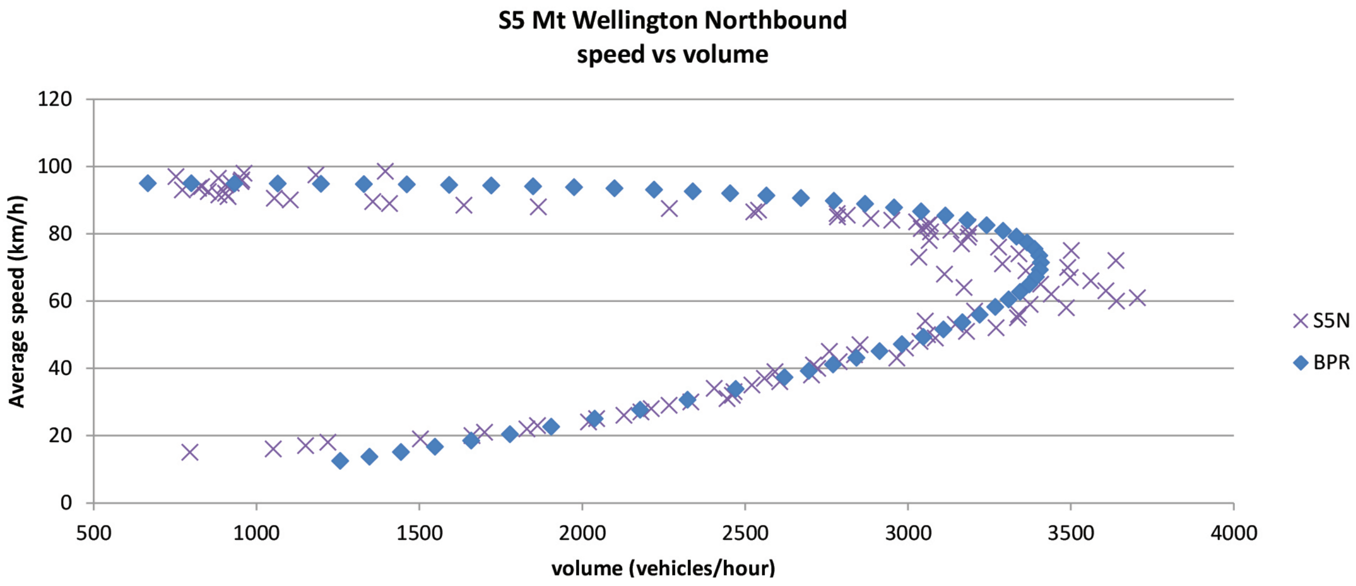
CONGESTION AND THE COSTS OF CONGESTION DEFINED

Ian Wallis, who headed the research project, says, 'Our overall objective was to develop better and more useful approaches to assessing the costs of congestion in urban areas, and to apply these to make improved estimates of the costs of congestion to Auckland.

'While the topic of congestion is widely discussed, the precise definition is somewhat elusive. Three different perspectives are currently commonly used to define congestion – economic, road-user and engineering – and they all have their shortfalls. We concluded that the engineering definition best encapsulates what people generally understand congestion to be, and also has the benefit of providing a clearly defined measure of the costs of congestion that is meaningful and quantifiable.'

Engineers classify a road as congested when more vehicles are attempting to use it than it has the capacity to carry. As more and more vehicles enter a road network, the total traffic flow slows incrementally with each new vehicle. When there is hardly any traffic, the effect is minimal (free-flow), but when traffic is heavy there comes a point when traffic slows to a crawl and sometimes stops. A road's capacity is the point when the traffic's flow rate is at a maximum; that is, a new vehicle entering the flow slows the traffic stream by an amount that leaves the total flow rate unchanged.

This is clearly illustrated by data from NZ Transport Agency monitoring stations on the Auckland Southern Motorway. Plotting this data results in a 'backward bending' demand curve, where increasing demand leads eventually to lower speeds and the flow falls below the road's capacity.



David Lupton points out that this phenomenon is not intuitively obvious. 'People don't realise that when demand exceeds a road's capacity the flow actually drops. In these situations, demand restraint measures, such as ramp metering or congestion pricing, will actually increase the traffic throughput of the road.'

The definition of congestion adopted by the research project was that: 'Congestion occurs when the demand for the road exceeds its capacity'. When this occurs, new vehicles entering the traffic will reduce its flow rate below the maximum. Based on this definition, the costs of congestion can be derived from the difference between people's actual travel times and the estimated travel times when the road is operating at capacity.

However, Ian points out that observed delays are only one part of the true costs of congestion. Other impacts from congestion include people changing their travel schedules (leaving earlier or later) to avoid peak traffic, and adding extra time to their schedules to accommodate unexpected delays.

'We defined the cost of congestion as "the difference between the observed cost of travel and the cost of travel when the road is operating at capacity". In our definition, the cost of travel takes into account costs arising from schedule delays and reductions in travel reliability, and other social and environmental costs, as well as actual travel times.'

AUCKLAND'S COSTS OF CONGESTION REASSESSED

The $1 billion figure widely quoted as the annual cost of congestion in Auckland was based on a 1997 study (using traffic estimates from 1991) that compared actual travel times with 'free-flow' travel times (which might be achieved at 3am). While this methodology is easy to understand, it is potentially misleading: no city would attempt to expand its road network so that the 3am travel speeds could be achieved throughout the day. The limitations of this approach, and the age of the data used, led the team to propose that a new and updated assessment was warranted.

'The cost to the economy of Auckland's congestion problems is often used as justification for increasing the region's road capacity or imposing some type of congestion charge,' says Ian. 'When people use these figures, the implication is that this is the scale of cost savings that could be made by fixing congestion. But on this definition, zero congestion would require virtually empty roads, which is impractical and uneconomic. Our new definition compares the costs with the situation where the network is operating optimally – a much more useful basis for comparison.'

The research used data from the Auckland Regional Transport Model (ART3) to estimate travel times for congested (morning peak), uncongested (off-peak) and free-flow situations. These times were then used to calculate annual congestion costs based on travel time delays, schedule delays, and other congestion-related costs (vehicle operating, environmental and crash costs).

When all these cost components were taken into account, the study found that the annual costs of congestion in Auckland were approximately $1250 million per year when compared with free-flow conditions (ie generally consistent with the previous $1000 million estimate, based on similar assumptions), but only $250 million per year when compared with the network operating at capacity.

Using these new estimates, the study then compared the short- and long-run marginal costs imposed by vehicles using the network at peak times. (The short- and long-run marginal costs are essentially the estimated costs of providing for additional road users with and without adjusting the network's capacity through providing additional infrastructure.) The difference between these two figures, based on the new estimated costs of congestion, was not large, suggesting that the current capacity of Auckland road network's overall is 'not far from being optimal'.

However, Ian cautions that this analysis is at 'an abstract network-wide averaged level' and that, 'a real network contains many links, each with different demands, and demand on individual links may exceed capacity (and hence result in at least local congestion) even when the capacity of the network is adequate overall. More work would clearly be needed to optimise the capacity of the "real" network.'

The costs of congestion reappraised, NZ Transport Agency research report 5489

Available online at **www.nzta.govt.nz/resources/research/reports/489**

HELPING TO GET THE BUSES RUNNING ON TIME

Reliability is one of the most important attributes for urban bus services from the viewpoint of people using, or potentially using, the services. Recent research examines how bus service reliability can be improved in New Zealand's largest cities.

Market research, in New Zealand and overseas, into what users and potential users think are the important attributes of urban bus services, shows that service reliability is consistently considered one of the most important (and often the most important) attributes. Yet, despite this, users also consistently perceive it to be an attribute where performance is poor, ie services are unreliable.

Research by Ian Wallis Associates, in conjunction with The TAS Partnership, sought to provide practical guidance for regional authorities and bus operators on diagnosing and understanding service reliability (or unreliability) issues, and monitoring them over time. The project also developed an approach for improving reliability, with actions targeted at three levels of service delivery.

The research looked at service reliability policies, standards and actual performance for bus services in Auckland, Wellington and Christchurch. 'Reliability' was taken to encompass both reliability (whether or not a service operates) and punctuality (whether it runs to timetable). The research was concerned with the variability in delays on a service – from trip to trip and day to day – which prevent it running to timetable.

WHAT THE DATA TELLS US

Historically, service reliability reporting in the three centres has been based on manual self-reporting by service operators. However, this has changed in recent times with the availability of electronic vehicle monitoring and real-time information systems. These developments mean that much more comprehensive and accurate data is now available in all three centres, on a continuous basis.

The research project used data from these electronic sources (supplied by each of the three regional authorities) to show the proportion of scheduled services that were operating within their reliability and punctuality thresholds. (A related finding of the research was that these thresholds, and reliability standards and targets they are based on, varied across the regions, both in terms of how they were structured and the specific standards they set.)

Ian Wallis of Ian Wallis Associates says the data confirmed that the reliability problem was significant in all three regions.

'Operator self-reporting, which was the old way of monitoring service reliability, considerably understated the true extent of the problem. Electronic systems provide a much more accurate picture, which confirms that there are real problems with bus service reliability in our urban centres,' Ian says.

From the user perspective, these problems include services running late or early, missing services (not running at all), bus bunching (services all coming together, with attendant overcrowding issues), and slow and variable speeds for routes.

There are no New Zealand specific studies into the causes of these problems, but international research indicates that the main causes of service delays (and variations in the extent of these delays) are time spent at bus stops (for passengers boarding, purchasing and validating tickets, and alighting), time spent at traffic lights and traffic congestion.

IMPROVING RELIABILITY PERFORMANCE

The research included a review of international literature and best practice for bus service reliability measurement and monitoring, with the aim of putting together a 'package' of preferred performance measures.

Ian says, 'Ideally the package needed to cover service reliability (whether the service runs or not), service punctuality and running times, and passenger perceptions of reliability. In the full report, we've set out a range of performance measures that operators and authorities can use to monitor each of these aspects. We've also included information about the practices of a number of international bus operators, by way of guidance.'

Efforts to improve reliability need to start from a root-cause analysis of what is causing the problems in the first place. Once these causes are analysed, the research team recommends that actions to address any identified problems occur at three levels: service planning, operational planning and on-the-day interventions.

At the service planning level, the aim is to develop the ideal timetable, which will minimise the probability of unreliable operation in normal conditions, while being robust enough to allow for expected variations. One of the findings to emerge from the analysis of the local data was that the current scheduled running times for many services did not match their typical running times, meaning that the services were significantly late (or early) on most occasions.

Such inconsistencies are easily addressed through more accurate timetabling (and are in fact already being addressed in all three centres). Aspects to look at included the time taken for whole trips and sections of them, and typical variations in these times, and the need to coordinate timetables for different services operating over common sections of route (to minimise bus bunching). Timetables should also be 'sensitivity tested' to understand how they respond to variables such as traffic congestion and variations in passenger demand.

At the operational planning level, the aim is to formulate operating plans that enable services to respond effectively to anticipated short- and medium-term problems. This may include measures such as adjusting schedules or timetables; addressing driver adherence to schedules; and developing contingency plans, for example to cater for times when routes are congested or affected by road works.

At the on-the-day level, the focus should be on responding rapidly and effectively to unanticipated problems as they arise, in order to minimise any adverse effects on the service's reliability. The role of the operations supervisor is critical in this context, supported by contingency guidelines on the procedures and responses that operators and drivers should adopt in certain situations.

As inputs to all three levels, the research team recommends that automated electronic data sources should continue to be used and refined, as the primary means of monitoring service reliability, largely replacing operator self-reporting methods (where these are still used).

The report recognises that a perfectly reliable service can never be achieved on all occasions, especially as most bus services have to operate in mixed traffic. In this regard, real-time information systems are very valuable in keeping passengers informed of any delays. Such systems should be regarded as a complement to, but not a substitute for, making the services as reliable as possible.

The research also acknowledges that tackling reliability problems needs to be a joint endeavour between regional authorities and operators (with inputs from city and district councils) and is best addressed through a partnership approach.

Improving bus service reliability, NZ Transport Agency research report 527

Available online at **www.nzta.govt.nz/resources/research/reports/527**

NEW RESEARCH REPORTS

Ongoing domestic freight volume information study

NZ Transport Agency research report 542

Available online at www.nzta.govt.nz/resources/research/reports/542

The availability of comprehensive and reliable information on the movement of freight is increasingly seen as an important element in the effective planning for the transport sector, both by those providing infrastructure and those providing services. However, the main source of data on freight movements, the Ministry of Transport's National Freight Demand Study, was based on data that is now outdated. Given the substantial changes that have subsequently taken place, there is a need to consider how this might be updated. This should be undertaken in a way that as far as possible minimises the burden to data providers and is easily repeatable.

The purpose of this study was to identify ways this updating might be achieved. In particular, it recognised that new methods of collecting data on freight movements had developed since 2008, and the extent to which these might be used formed a part of the investigation. The study was conducted in New Zealand from 2011 to 2013.

Based on a review of the approaches used, both in New Zealand and overseas, it was concluded that a hybrid approach drawing data together from a number of sources would be the most appropriate and would provide the best opportunity to effectively update the earlier work.

Measuring the resilience of transport infrastructure

NZ Transport Agency research report 546

Available online at www.nzta.govt.nz/resources/research/reports/546

Internationally there is a growing call to improve the resilience of our critical infrastructure. This is in response to a realisation that the services we take for granted may be robust in the face of predictable hazards/failures, but are in fact extremely fragile in the face of unanticipated shocks.

In the context of transport infrastructure, operators strive to ensure that transport assets and services function continually and safely in the face of a range of existing and emerging hazards. This has led to a specific focus on the concept of resilience and how this can be defined, measured and improved across the transport system.

The theory of resilience was researched and a measurement framework has been proposed that broadly covers both technical and organisational dimensions of resilience and breaks these down into specific principles and measures which can be utilised to qualitatively assess resilience.

The measurement of resilience was approached from a view that a risk management approach alone is not sufficient and needs to be complemented by an awareness that resilience requires both consideration of events that fall outside the realms of predictability and, importantly, that failure is inevitable.

OBTAINING TRANSPORT AGENCY RESEARCH REPORTS

All research reports published since 2005 are available free of cost for downloading from the Transport Agency's website www.nzta.govt.nz/planning/programming/research

PDF scans of research reports published prior to 2005 are available by emailing research@nzta.govt.nz

A NOTE FOR READERS

NZTA research newsletter

NZTA research is published quarterly by the NZ Transport Agency. Its purpose is to report on research invested in through the Transport Agency's Research Programme, to act as a forum for passing on national and international information, and to aid collaboration between all those involved. For information about the Transport Agency's Research Programme, see www.nzta.govt.nz/planning/programming/research.html.

Advertisements of forthcoming conferences and workshops, that are within the newsletter's field of interest, may be published free of charge when space permits.

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DID YOU KNOW...

That there is a spreadsheet on the Transport Agency website listing all published Transport Agency research reports?

The spreadsheet is searchable by several criteria and can be found at **www.nzta.govt.nz/planning/programming/research.html**

The spreadsheet has two worksheets; the first worksheet lists research reports with associated key words and the second lists research reports with the report abstracts.