UNDERSTANDING NETWORK PERFORMANCE INFORMATION PROVIDED TO USERS – FINAL REPORT

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EXECUTIVE SUMMARY

The objective of this study was to identify performance information that would be understood and used by all road users to make informed road transport decisions and that would assist road managers' to make decisions about the management and operation of the road network.

From the literature it was apparent that there was a finite number of basic measurable parameters from which an almost endless array of performance measures were developed. Those basic, or fundamental, measures were principally derived from travel time, volume, distance and people (vehicle occupancy). The measures that were identified as being used the most successfully directly reported conditions experienced by the traveller, such as travel time and delay. Indices derived from these measures were generally found to be less relevant.

Arguably the most important element to be derived from the literature is a clear indication of the necessity of clearly establishing the purpose of the measure. That purpose will dictate what measures and variants are required, ways in which they should be measured, and how they can be used.

Commuters, freight and public transport users identified in surveys that travel time and reliability are the most important aspects of road network performance. An overwhelming majority of users indicated that receiving timely information about changes in road conditions is important.

Users would like to receive such information expressed in minutes. This unit of measurement is simple and is the basis that users plan other activities that make up their entire day. The consistency of travel time and reliability being the important performance attributes across the three user groups facilitates a comparison of performance across modes, thereby helping users to make better informed travel decisions. The measures that would best meet users' needs were identified to be:

- Actual travel time and complementary information about road conditions, such as delays
- Planned travel time (travel time given a confidence interval or percentile)

Implicit in providing actual travel time is the additional travel time caused by delays.

Users indicated that receiving timely information about changes in road conditions was important. Almost a third of users indicated that they would like to receive information only when there is a problem or delay. Information provided continuously or only during peak hours were also popular. Media that could be

accessed whilst en-route were preferred, whilst about one in three stated that they would like to receive information through media more amenable for trip planning.

Currently, users are generally not receiving network performance information according to their preferences. A key suggestion resulting from this study is for road managers to consider how to provide network performance information that better reflects users' preferences. This would enable users to utilise this information to make decisions about the transport choices that are available to them.

Road managers draw upon a wide range of measures when network planning, but identified that actual travel times complemented with some indication about delays and speeds are the most important type of information to receive in real time for operations management. An approach to alert road operations managers of roads that are potentially experiencing a non-recurrent delay or incident in real time was presented, which involves comparing actual and planned travel times.

Furthermore, the continuous collection of travel time data would enable a more robust calculation of a wide range of performance information used for network planning and improve real time operations management of the road network. It is anticipated that technological developments in the short to medium term and falling costs of implementation will enable the automatic and continuous capture of travel time data.

Providing actual and planned travel time therefore fulfils the requirements of users and road managers alike as shown in Table E. 1.

Table E. 1: Assessment of Preferred Performance Indicators Against User and Road Managers' Requirements

Requirement	Actual Travel Time	Planned Travel Time	Comments
Users			
- Relevant to travel decisions relating to different modes, timing and routes	✓	✓	
- Expressed in minutes	✓	✓	
- Able to be timely conveyed	✓	✓	Emerging technology to be implemented
Road Managers (Analysis tasks)			
- Used to determine deficiencies, incidents and service levels	✓	✓	Fundamental indicator that is used to derive other indicators
- Appropriate across all modes (including freight and public transport)	✓	✓	
- Scalable	✓	✓	
- Robust and cost effective	✓	✓	Emerging technology to be implemented
Road Managers (Reporting tasks)			
- Used to determine the achievement of network objectives	✓	✓	Fundamental indicator that is used to derive other indicators
- Measures mobility	✓	✓	
Road Managers (Action tasks)			
- Readily applied in project evaluation	✓	✓	
- Application for a range of projects (eg HOV, freight lanes, toll roads and bus lanes)	✓	✓	
- Determine impacts from improvements	✓	✓	

This study identified gaps in the Austroads National Performance Indicators (NPIs) and provided suggestions as to how these gaps could be addressed. These suggestions are provided in

Table E. 2.

Table E. 2: Suggestions to Address NPI Gaps

Findings/ Gap	Suggestion
Methodology	
Sample size of data collected for NPIs is low	Explore ways to increase sample size using emergent technologies and therefore improve confidence in the indicators.
Altered NPIs	
Lane Occupancy NPI does not convey proportion of peak that the lane operates at optimal utilisation	Explore ways how the utilisation of road space could be measured, particularly during the peak. Such an example could include the proportion of peak that a lane operates at optimal throughput
Lane Occupancy NPI does not consider public transport or HOV lanes separately	Consider whether there should be a separate measure for HOV/ public transport lanes
Speed, travel time variability and congestion NPIs are only applied for cars	Explore how the existing set of indicators could be applied to public transport and freight
New NPIs	
There is no NPI that measures the delivery or utilisation of timely information	Consider introducing a new indicator that measures the availability and utilization of timely information. The implementation of this NPI should take into consideration the characteristics of the various jurisdictions
There is no NPI that measures the year to year change in the length of the peak period due to peak spreading	Develop an NPI that reports the duration of a peak period to monitor how peak spreading changes over time. This duration should be measured using a traffic based definition.
There is no NPI that measures accessibility	Review the merits of this measure following the imminent implementation of such a measure in New Zealand.

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1 INTRODUCTION

Over the last decade Austroads has developed and provided a range of national performance indicators (NPI) for the road system and road authorities. Those measures have formed the basis for the comparative assessment of the efficiency and effectiveness of the road network throughout Australia and New Zealand.

Since the NPI program's inception Austroads and the road authorities have reported the performance of the road network by collecting data over a limited time period a few times each year. While those efforts have yielded valuable results there is growing recognition of the potential to improve the collection and reporting methods to accommodate the changing needs of road users and managers, and in recognition of the evolution in technologies.

In order to address these concerns Austroads commissioned this project "*Understanding Network Performance Information Provided to Road Users*", which aims to investigate alternative methodologies for road managers to collect and report network wide performance measures.

The objectives of this study are to identify performance information that:

- is understood and would be used by all road users to make informed road transport decisions
- would assist road managers' in decision making in relation to the management and operation of the road network.

The central objective of the review is focused on operational performance indicators, rather than safety or physical infrastructure which are covered under other Austroads programs. Specifically, this project aims:

"To provide a methodology for road managers to collect and report network wide performance measures that:

- Are understood and used by all road users for making informed road transport decisions, and
- Will assist road managers in decision – making in relation to the management and operation of the road network"

This report presents the findings of the road user survey. It specifically details:

- Methodology: describes the overall project approach
- Literature Review: presents key findings from the literature review
- Users' Perspective: details what are the most important performance attributes for road users and how they would like this reported.
- Road Managers' Perspective: outlines existing road agency objectives, performance indicators and their utilisation
- Performance Information Selection: identifies performance indicator gaps and recommends indicators to overcome these gaps
- Austroads National Performance Indicators (NPIs): suggests improvements to existing NPIs
- Conclusion

2 METHODOLOGY

This chapter provides an overview of the methodology which is illustrated in Figure 1. The methodology involved undertaking primary and secondary research into performance information that would best meet users and managers' requirements. It includes undertaking a literature review, users' survey and road manager surveys and workshops.

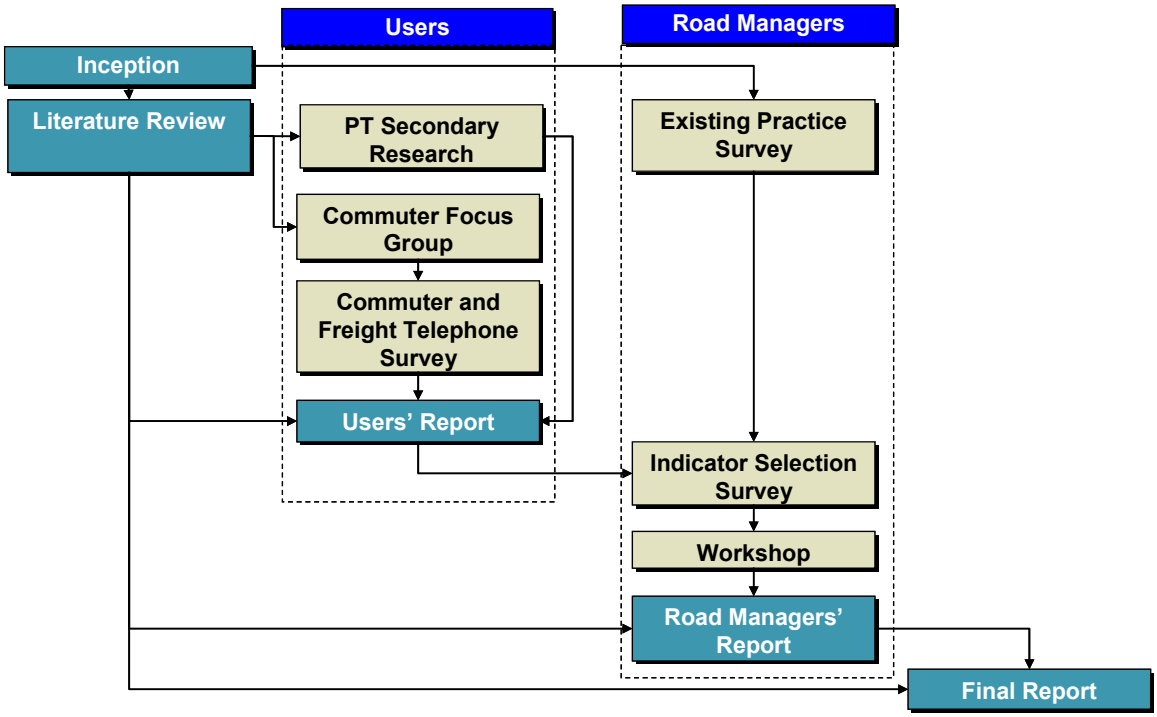


Figure 1: Study Methodology

Note: PT = Public Transport

An international literature review was firstly undertaken that determined the range of performance indicator options and associated data collection and derivation.

Road users' views were obtained by using a combination of focus groups, telephone surveys and drawing upon results of relevant past public transport surveys.

The engagement of road managers occurred throughout the project. Road managers were firstly invited to provide an overview of their existing practices. Following the user survey, managers were invited to select their preferred indicators and participate in a workshop to discuss findings to date and possible directions forward.

This final report presents an overview of key findings and recommends performance indicators that could meet user and road managers' needs. This report represents the culmination of research that is documented in interim reports that have been produced throughout this study. These reports are:

- Literature Review
- Users' Survey Results
- Road Managers' Survey Results

The following sections provide an overview of findings from the research undertaken.

3 LITERATURE REVIEW

From a broad perspective, performance measurement is being used at several levels, ranging from day-to-day operations to long-term capital planning that enhances system operations. Performance measurement is also being used at the project level to identify design features that improve operations and at the policy level to allow stakeholders to evaluate the benefits of highway improvements.

From the literature it was apparent that there was a finite number of basic measurable parameters from which an almost endless array of performance measures were developed. Those basic, or fundamental, measures were principally derived from:

- Travel time
- Volume
- Distance
- People

Travel time is critical to the calculation of other important measures associated with:

- Delay
- Speed
- Travel time variability

The measures that were identified as being used the most successfully directly reported conditions experienced by the traveller, such as travel time, speed, and delay. Indices derived from these measures were generally found to be less relevant.

These fundamental measures were also used in more esoteric performance measures related to the concepts of:

- Congestion
- Availability
- Accessibility

The definition and usage of these more complex measures did however, vary significantly and there was little consistency or consensus on what definitions were most useful. In general it was evident that added complexity was not an advantage.

The literature review also highlighted the potential for different variations (or variants) associated with each of the principal measures. Those variants provide differences associated with dimensions, metrics, segmentation, and geography.

Beyond the definitional issues, the literature also highlighted the array of methods available for collecting the necessary data, and importantly the relationship between the method of data collection and the subsequent use that the data could be employed for. Most notably the limitations imposed on the frequency and medium of delivery required for real time information provision, and the concept of error.

Arguably the most important element to be derived from the literature is a clear indication of the necessity of clearly establishing the purpose and objective of the performance measures. That purpose will dictate what measures and variants are required, ways in which they should be measured, and how they can be used.

4 USERS' PERSPECTIVE

4.1 Aims

During the study, primary and secondary research was undertaken to determine what performance information is understood and could be used by road users for making informed road transport decisions. In particular, the research aimed to determine:

- Which aspects of road network performance is important to users
- What are users' preferred performance information
- Whether providing timely information is important to users and how would users like this information provided

The three key road user segments to which the research was structured for were:
- Commuter: road users that travel in private car, including business purpose trips
- Freight: road users that carry freight from couriers to heavy haulage
- Public transport: those who use road-based public transport such as buses and trams.

4.1 Approach

As there has been considerable Australian research into public transport users' perspective as to what aspects of performance is important, it was decided to focus of this project's primary research towards understanding commuter and freight users' perspectives where there has been relatively less research. The research techniques applied for each road user segment are shown in Table 1.

Table 1: Research Technique by Road User Segment

Technique	Commuter	Freight	Public Transport
Literature Review(1)	✓	✓	✓
Focus Group	✓		
Telephone Survey	✓	✓	
Previous Surveys			✓

Note: (1) Results of the Literature Review are reported in Paterson (2004) Understanding Network Performance – Literature Review

Survey results from relevant public transport agencies across Australia were used to address these research objectives from a public transport perspective.

Focus groups with commuters were initially held to identify key issues about road performance, preferred approaches to convey performance and potential approaches to deliver information. It was also used to clarify terminology to be used in the telephone survey. A focus group of eight participants each was held in Melbourne and Sydney.

A telephone survey of 1,200 commuters and 300 freight road users across Brisbane, Melbourne and Sydney was then conducted. The survey was structured into three parts:
- A series of questions that enabled the relative importance of various aspects of road network to be quantified
- Stated importance of receiving timely information and how and when they would like to receive it
- Respondent profiling questions

The proceeding sections outline the key findings from this research.

4.2 Aspects of Performance Important to Users

The research found that reliability and travel time are consistently the most important attributes across all three types of road users that the road manager can influence. Commuters regard speed as a somewhat important attribute. The relative importance of these attributes for commuters and freight users is represented along the horizontal axis, with corresponding level of satisfaction on the vertical axis provided in Figure 2 and Figure 3 respectively.

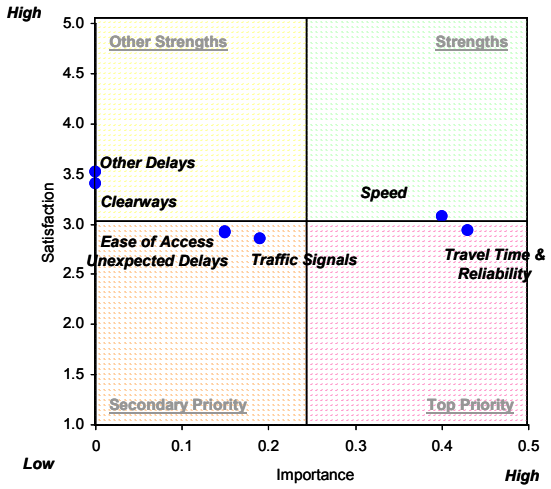


Figure 2: Commuter Overall Satisfaction: Priority Analysis

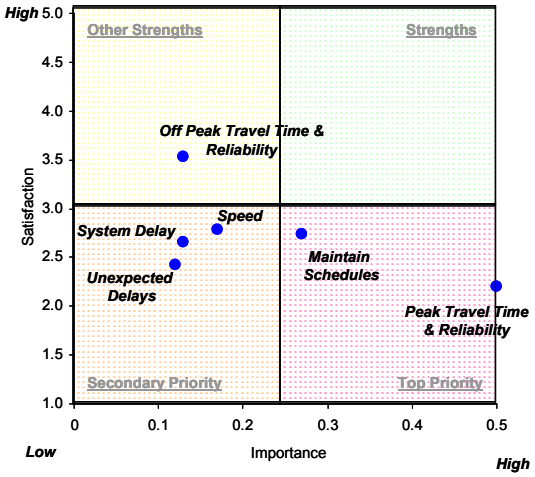


Figure 3: Freight - Priority Analysis

Of the public transport attributes that road managers can influence, results from other surveys found that reliability was the most important attribute followed by travel time and ease of access to stops.

Across all user groups, categories that reflected the overall performance of the trip, such as overall reliability and travel time, were considered to be generally more important than specific operational attributes of the road network. Examples of these operational attributes include clearways and specific types of delays.

A comparison of results from the three user groups is presented in Table 2. It should be noted that there was a significant margin between the most important attributes of travel time, reliability and speed to the next

ranked attribute of accessibility. For freight users, there was a wide margin between travel time and reliability to the next ranked attribute of speed.

Table 2: Relative Importance and Ranking of Categories by Road User Group

Attribute	Commuter(1)	Freight(1)	Public Transport
Travel Time	1	1	2
Reliability	1	1	1
Ability to Maintain Schedules	-	2	-
Speed	2	3	-
Accessibility/ B Double Network Coverage	3	4	3
Traffic Signals	4	5	-
Unexpected or Temporary Delays	5	6	-

Note: (1) Results from "Overall' Key Driver Analysis – results vary by time period. Attributes are limited to those that the road manager can influence.

The consistency of reliability (similar day to day travel times) and travel time as the most important attributes that the road manager can influence across the three user groups suggests that performance information about these attributes would be the most useful for road users. This consistency across all types of users would enable road users to directly compare attributes by mode (i.e. commuter versus public transport travel time and reliability).

Travel time is widely regarded in the Australian literature as being important, as exemplified by its recognition in road project evaluations. Not as well recognised in the Australian context is the importance of reliability. Reliability was rated as being equally important as travel time in the primary research. This importance is consistent with international literature review that cited a significant benefits of consistent travel times for commuters, freight and public transport (Paterson, 2004).

4.3 Preferred Performance Indicators

Consistent with their ranking of attributes, the most useful performance indicators for all user groups are actual travel times and travel time reliability. When providing travel time information, users also stated that providing complementary information about anticipated traffic conditions would be useful. Information about unexpected delays for users, including anticipated time to clear the delay and alternative routes, would also be useful.

Time is the preferred unit of measurements as minutes are readily transferable to road users' wider daily time management tasks and as part of maintaining and reorganising freight schedules.

This finding is consistent with literature reviewed that the most successful and useful performance indicators are those that report conditions that are directly experienced and comprehended by the road user.

Users expressed that travel time indicators are preferable rather than speed. This is because time is transferable with other activities and users have difficulty or do not want to determine what the distances are between two points in order to calculate time. Another complication that users, particularly users undertaking unfamiliar trips, would find difficult is relating average speed to the fluctuations of actual speed when driving in traffic along roads other than freeways.

4.4 Delivery of Timely Information

The overwhelming majority of surveyed users regard receiving timely information about changes in road conditions as being important to very important (rating of 4 or more) as illustrated in Figure 4.

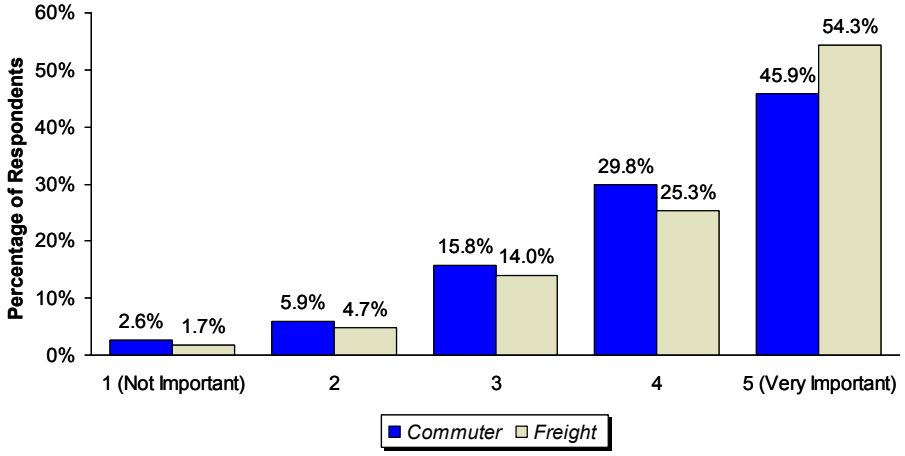


Figure 4: Importance Rating of Respondents Who Were Asked "How would you rate the need for timely information on changes in road conditions?" (Scale 1 to 5)

This finding is consistent with literature review, particularly for freight users as the increasing adoption of just in time arrangements is tightly defining delivery windows. From this perspective, users have indicated information that is tailored to their trip and is reflective of the overall quality of their entire journey provides the best value to them. For example, the provision of timely information in selected road tunnels in Sydney and Melbourne by radio intervention and electronic road side signs is regarded by users as being ideal.

The value of providing timely information is reinforced by that on-going implementation of systems that inform public transport passengers of changes to scheduled and actual times implying that such information is highly valued by users.

When commuter and freight users were asked how often they would like to receive the information, the most common responses was either when there is a problem or during peak hours or on a continuous basis as illustrated in Table 3.

Table 3: Preferred Frequency of Receiving Timely Information About Changes in Road Conditions (One Response)

Frequency	Commuter	Freight
Continuous	32.2%	39.3%
Only when there is a problem	34.3%	28.9%
Peak hours only	15.8%	16.9%
Other time intervals (eg 30 minutes, hourly etc)	7.3%	3.6%
Other traffic related (i.e. on-demand)	0.4%	0.3%
Don't know	9.2%	6.2%
Other	0.6%	4.2%
None	0.2%	0.6%

The most popular media were road-side signs or radio audio breaks, which could be sourced whilst en-route. Media that would be sourced as part of planning a trip, such as an internet site, email or continuous television channel were nominated by more freight users. This higher rate for freight users reflects the greater planning function that they have in organising their fleets and schedules Table 4.

Table 4: Useful Media (Multiple Responses)

Useful Media	Commuter	Freight
Electronic roadside signs	71.1%	72.6%
Audio break ins in commercial radio	66.1%	70.8%
Traffic Internet Site	26.0%	34.5%
Permanent TV Traffic Channel	25.8%	23.5%
Text message to your mobile phone	19.6%	24.9%
Email to Work or Home	12.5%	28.1%
Two Way Radio	-	25.3%

The literature review identified that there are several alternative technology options available that could capture relevant data associated with changing traffic conditions. These include vehicle tracking, vehicle tags, mobile phone tracking and inductive loop systems on freeways and arterials.

4.5 Existing Information Delivery and Gaps

Whilst road agencies provide a range of performance information on a regular basis, it was found that few agencies were providing timely information in the form desired by users.

Most agencies have electronic roadside signs that report incidents whilst en-route and general traffic information is conveyed over the radio. However, travel time information is not provided to users aside from users of selected sections of Victorian freeways.

5 ROAD MANAGERS' PERSPECTIVE

5.1 Aims

From the road managers' perspective, this study's aim is to identify network wide performance information that would assist road managers' to make decisions about how to manage the road network.

To identify this information, the following were determined:

- What are the current objectives of road agencies and how are they currently measured?
- What are road managers' preferred measures (and how do they compare with users)?
- How can the data for these measure be collected and applied?

5.2 Approach

The approach to research these aims was by engaging road managers on several occasions throughout the project and a literature review.

Road managers were firstly invited to provide an overview of their agency's objectives and existing practices. Following the user survey, managers were invited to select their preferred indicators and participate in a workshop to discuss findings to date and possible directions forward.

5.3 Objectives and Existing Performance Information

All road agencies have objectives that can be categorised into either throughput, quality of travel, multi-modal or accessibility classifications. Examples of the objectives within each category is provided in Table 5.

Table 5: Sample Objectives

Classification	Sample Objectives
Throughput	- Maximise throughput (vehicles, persons, freight) - Efficient movement of people or freight
Quality of Travel	- Minimise delays - Reliable travel - Maintain/ improve/ optimise travel times - Manage congestion
Multi – modal	- Integrate public transport - Integrate walking and cycling
Land Use and Accessibility	- Land use integration/ access

Source: Road Managers - Existing Practices Email Survey Responses (November, 2004)

Despite the commonality in the objectives, agencies use different sets of performance information to measure the extent to which these objectives are achieved. This information tends to focus on objectives relating to throughput and quality of travel, with very few indicators relating to modes other than car (see Table 6).

In achieving road network objectives, managers have two broad roles of real time operations management and network planning. Real time operations management involves immediately responding to occurrences, such as incidents or non-recurrent congestion. Planning involves developing traffic management policies, measures and projects that are not implemented in real time. The difference between the two are illustrated in Figure 5.

Table 6: Network Performance Measure by Agency Jurisdiction

Attribute	NSW	Vic	Qld	WA	ACT	NZ	NPIs
Throughput							
- Lane occupancy rate (persons in cars)	✓	✓	✓		✓	✓	✓
- Lane occupancy rate (freight)		✓					✓
- Car based vehicles occupancy rate	✓	✓					
- Vehicle kms travelled		✓					
- Unplanned lane closures	✓				✓	✓	
Quality of Travel							
- Actual travel time (cars)	✓	✓	✓				
- Nominal travel time (cars)	✓	✓					
- Reducing travel time (cars)							
- Variability of travel time (cars)		✓					✓
- Travel speed (cars)	✓			✓		✓	✓
- Vehicle hours of delay (cars)				✓			
- Delay (cars)			✓			✓	✓
- Duration of congestion							
- Incident response and duration			✓				
- Level of service (cars)						✓	
Multi – modal							
- Bus/ tram speeds	✓	✓					
- All indicators expressed by mode				✓			
Land Use and Accessibility							
- Alignment of road network to local plan						✓	

Source: Road Managers - Existing Practices Email Survey Responses (November, 2004), Objectives for Queensland were sourced from corporate documents on the web.

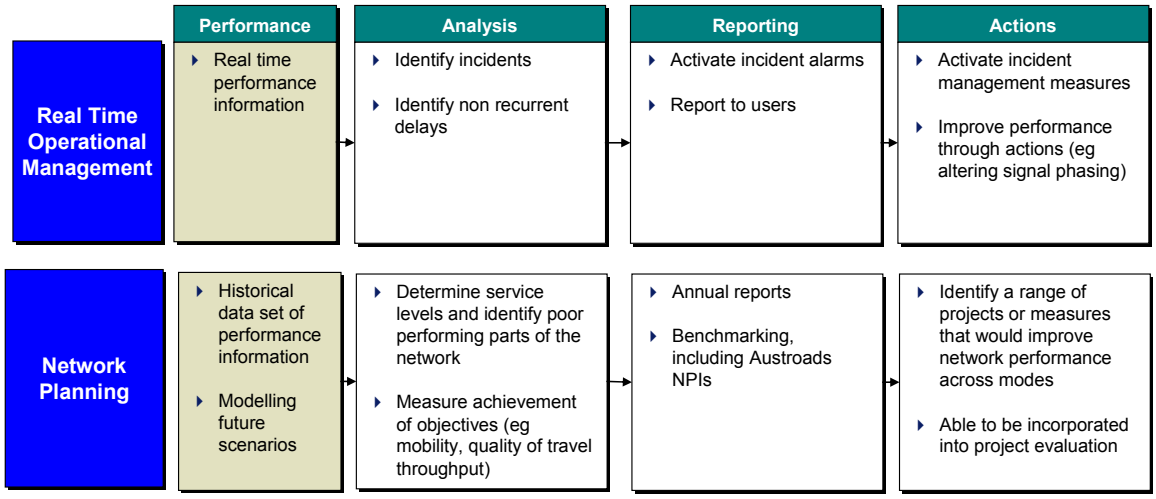


Figure 5: Broad Road Manager Roles

5.4 Preferences

In the second survey, road managers were asked to identify their preferred performance indicators. This was done by asking managers to:

- Rank each category of performance information by importance
- Rate the usefulness or relevance of around sixty indicators across all categories.

An overview of the results are presented in Figure 6, with detailed results available in the supplementary report. There was general consistency across road managers about the first four ranked categories of travel time, reliability, congestion and delay. For the remaining indicators, there was a range of views which could be a reflection of local priorities and conditions[1].

[1] Refer to Waingold (2005) Road Manager Survey Results for detailed results

Victoria placed greater emphasis on volumes and people throughput, where as South Australia placed more emphasis on accessibility and multi-modality. In contrast, the Northern Territory emphasised stops and queue which is probably due to the relatively significant increase in signalised intersections over recent times.

Road managers indicated that a broad cross section set of performance information is important, with information belonging to highly ranked information categories rating slightly higher. Discussion at the workshop suggested that when planning road improvements, road managers take into account a wide range of performance information to define the problem accurately when network planning. That is, one indicator alone is usually insufficient for the manager to determine the issues and develop an appropriate planning solution.

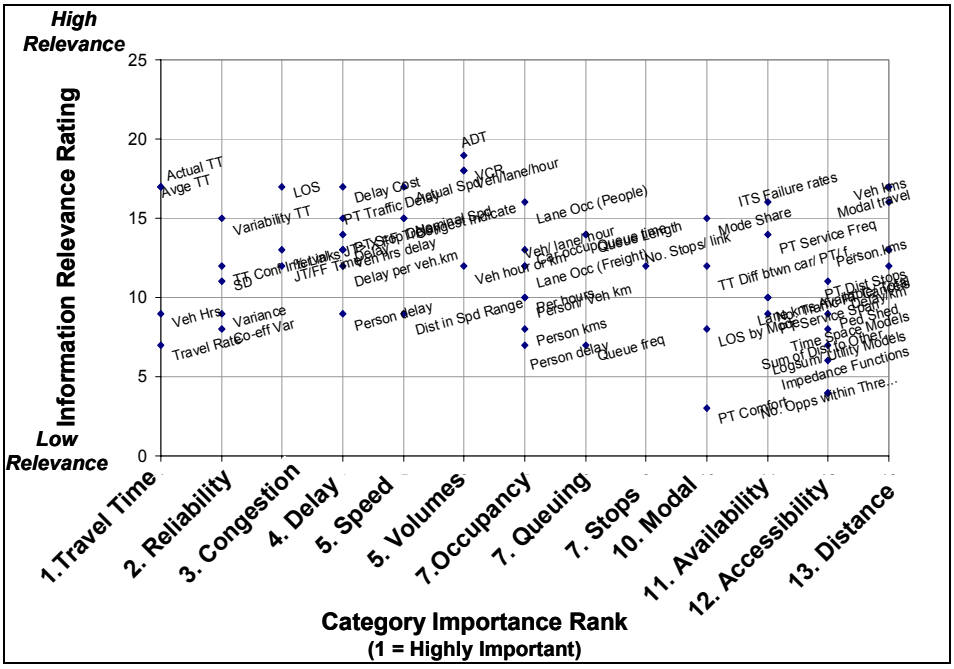


Figure 6: Road Manager Category Rankings and Rating of Relevance of Information

Source: Road Managers Survey, Rankings is the average rank provided by road managers responding to the survey.

Within the survey, road managers also expressed that performance information should be able to be:

- Scaleable across various time periods, such as the peak, off peak, daily, weekly and annually
- Scaleable across elements across the road network i.e. links, corridors, road hierarchy classifications, networks
- Be able to be segmented by road user type, i.e. cars, trucks and public transport

Whilst information about most attributes should be collected periodically, road managers indicated that travel time is the most important information to collect in real time. Some road managers indicated that information about delays and congestion would also be useful in real time as illustrated in Table 7.

Table 7: Road Managers' Preferred Reporting Frequency for Various Performance Information

Rank	Attribute	Real Time	Daily	Weekly	Annually
1	Travel time	100%	33%	17%	100%
2	Reliability	0%	33%	0%	67%
3	Congestion	17%	33%	33%	83%
4	Delays	33%	33%	17%	67%
5	Speed	50%	17%	33%	83%
5	Volumes	0%	50%	50%	83%
7	Occupancy	0%	0%	17%	67%
7	Queuing	33%	17%	33%	67%
7	Stops	0%	17%	17%	67%
10	Modal	33%	0%	0%	67%
11	Availability	17%	67%	50%	50%
12	Accessibility	0%	17%	0%	0%

13	Distance	0%	17%	33%	83%

Source: Road Managers Survey.

These results reinforces the earlier finding that road managers would like a wide cross section of performance information for the network planning. For real time operations management, travel time is the main type of performance information required. Supplementary with information about speed, queuing, delays and congestion would also be useful.

5.6 Data Collection

Data that can be automatically generated by traffic management systems, such as SCATS, include volume are collected on a continuous basis. Continuous travel time or speed data is collected on some freeway sections in Victoria and Western Australia.

Otherwise, data such as travel times on other parts of the network, is collected a few times a year using surveys and reported on annual basis. A number of agencies commented that the high cost of collection and low confidence in the data given the small sample size are drawbacks to either collecting or applying travel time data more widely in their activities.

Models could potentially be used to estimate performance information. However, the limited accuracy of models results in modelling methods not being used as the basis of measuring road network performance.

Table 8: Road Managers' Preferred Reporting Frequency for Various Performance Information

Rank	Information	Real Time	Daily	Weekly	Annually
1	Travel time				✓
2	Reliability				✓
3	Congestion				✓
4	Delays				✓
5	Speed				✓
5	Volumes	✓	✓	✓	✓
7	Occupancy		Public Transport		✓
7	Queuing				
7	Stops				
10	Modal				
11	Availability		✓	✓	✓
12	Accessibility				✓
13	Distance				✓

5.7 Gaps

A range of information that road managers have indicated as being useful to them is currently not available. In particular:

- Travel time information for the majority of the network is not collected in real time to facilitate real time operations management
- There is an inadequate sample size of the collection of other types of information. Subsequently, the confidence in this information is low and its application is limited.

6 PREFERRED PERFORMANCE INFORMATION

6.1 Users

Road users have indicated that they would like timely information about changes in traffic conditions, particularly about travel time and reliability expressed in minutes. Supplementing this is general information about traffic conditions and an alternative course of action that they could take when there is a delay.

Logically, conveying actual travel times in minutes to users would fulfil the need for travel time information. Implicit in the calculation of actual travel times are any delays and congestion. This, along with supplementary information, would be presented to users who are about to or already undertaking their trip.

Planned travel time was identified as the most appropriate indicator for users seeking a travel time for a journey that they are planning to undertake sometime in the future, which could be even later that day. Planned travel time is the is the travel time given a confidence level of a relevant set of historical travel times (Figure 7).

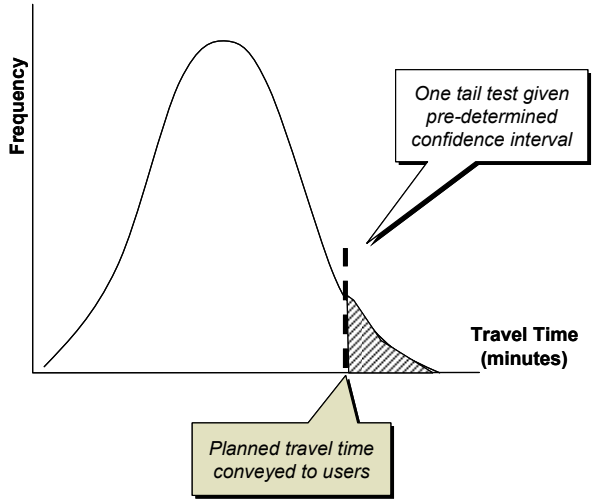


Figure 7: Planned Travel Time – Illustrative Example

In determining what are the relevant sets of historical travel time, consideration would need to be given to how quickly travel patterns changes and an appropriate confidence level. For instance, traffic patterns may vary markedly during the peak with congestion levels changing every 15 minutes. Therefore, in this situation, planned travel times at quarter hour intervals may be required. This would assist users "trade off" various journey start and travel times. Whilst local research is required into what this confidence level would be, typical confidence levels that have been applied internationally is in excess of 90%.

The use and application of actual and planned travel times logically suggests the media that should be utilised to convey this information. Actual travel time would be utilised by users that are about to or already undertaking their journey, and therefore media that can be accessed to both planning and whilst en-route. By definition, planned travel time information should be conveyed by media that are sourced by users planning their trips, such as the internet. Table 9 shows suggested media to convey this information.

Table 9: Suggested Media to Convey Travel Time Information

Media	Actual	Planned
Electronic roadside signs	✓	
Audio break ins in commercial radio	✓	
Traffic Internet Site	✓	✓
Permanent TV Traffic Channel	✓	✓
Text message to your mobile phone	✓	?
Email to Work or Home	✓	?
Two Way Radio	✓	

Users have indicated a range of frequencies that they would like to receive this information. By their nature, the media tends to define the frequency that travel time information is conveyed. For example internet sites and TV channels would infer that this information would always be available. Text messages and emails infer either a delay or incident responsive message.

Table 10: Reporting Frequency by Type of Media

Media	Continuous	Only When Problem	Peak Hour	Regular intervals	Traffic Related (On Demand)
Electronic roadside signs	✓				
Audio break ins in commercial radio		✓		✓	
Traffic Internet Site	✓	✓	✓	✓	✓
Permanent TV Traffic Channel	✓				
Text message to your mobile phone		✓		✓	✓
Email to Work or Home		✓		✓	✓
Two Way Radio		✓			✓

6.2 Road Managers

The potential application of performance information by road managers to assist them with decision making will be presented in the following sections. It will be addressed in terms of their broadly defined roles of real time operations management and network planning.

6.2.1 Real Time Operations Management

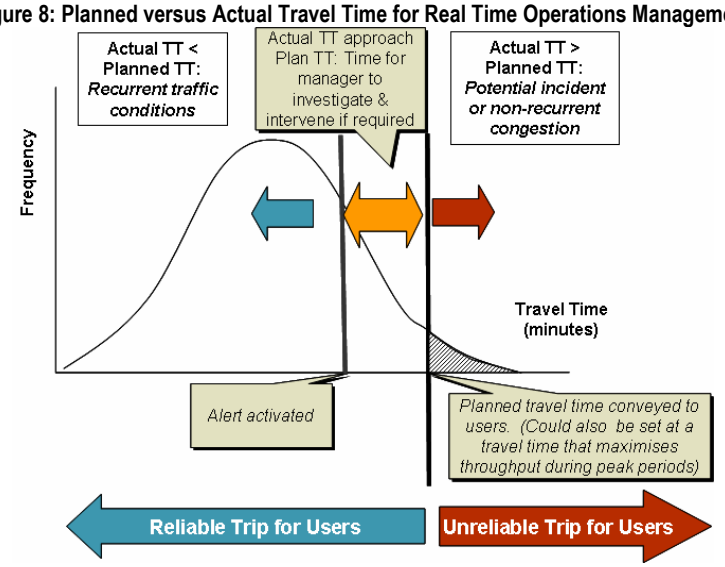
Road manager survey results indicate that travel time performance information is the most important type of information to receive in real time. This could be complemented with information about congestion, delays and speed. This information could be used to determine whether intervention is required by road managers to address incidents and non-recurrent delays.

Road managers could monitor actual travel time and compare it to the planned travel times. Under normal traffic conditions, the actual travel time would be less than the planned travel time. However, the road manager could be alerted when the actual travel time exceeds the planned travel time. In these instances, non-recurrent congestion or an incident may have occurred and therefore this alert suggests to the road manager that the traffic conditions on a particular road section requires further investigation and possible intervention.

Actual travel time exceeding planned travel time should also prompt the road manager that users are experiencing an unreliable trip as the journey time is exceeding their expectations. This measure could complement other indicators in assisting road managers to decide whether they should intervene to improve the reliability of the trip, or advise them of how to minimise delays. In this regard, the planned "alert" travel time for road managers may be set lower than that for users so that road managers could potentially act before the trip is perceived by users as being an unreliable trip.

Planned travel time, from the perspective of the road manager of achieving the objective of maximizing utilisation, may also wish to "set" the time that enables the road to operate at maximum throughput. Therefore, an alert would arise if there is a likelihood that the actual travel time may deviate from this planned travel time that is optimised for throughput.

Figure 8: Planned versus Actual Travel Time for Real Time Operations Management



6.2.2 Network Planning

Road managers have indicated that they draw upon a wide range of performance information when planning the network. The benefits of planned and actual travel time could assist managers to:

- Monitor the network and determine whether there are significant changes in performance over a period
- Utilise travel time data to provide a more robust calculation of delays
- Use it is an input to calculate a wide range of other performance information

These measures could be equally applied across all modes.

Monitoring

Collecting travel times continuously or at regular intervals would enable better tracking of network performance. From this, trends can be identified and a comparison of actual performance to either predetermined targets, policies or standards could be undertaken. Should performance become unacceptable, this monitoring could prompt the road manager to review the particular situation.

One such example is to be able to determine whether the travel time distribution curve is significantly changing, which can be determined using statistical analysis to ensure a robust result. Figure 9 illustrates a deterioration in traffic conditions in year two as the curve is shifting to the right. Subsequently, the planned travel time is highly likely to shift to the right given the confidence interval should remain the same. Conversely a network improvement would result in the latter year curve shifting to the left.

Furthermore, changes in the curves shape (i.e. standard deviation) also provides an insight as to how reliability is changing.

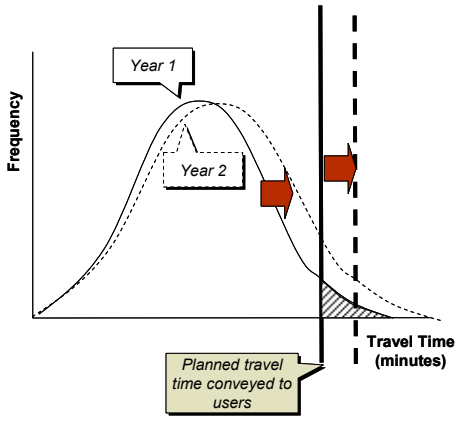


Figure 9: Monitoring Network Performance: Comparing Travel Time Distribution Curves Over Time

Calculating Delays

Delays could be determined by the road manager by comparing to a nominal travel time that is used as a benchmark across all time periods. For instance, the nominal travel time could be designated as the travel time as the lower tail of a two tailed statistical test for a weekday twenty four hour distribution of travel times (Figure 10). An alternative could be to nominate a percentile and deem it to be the nominal travel time. Travel times throughout the day are then compared to this time to determine the delay.

Also shown is users' perception of delay, which would they would perceive from the planned travel time.

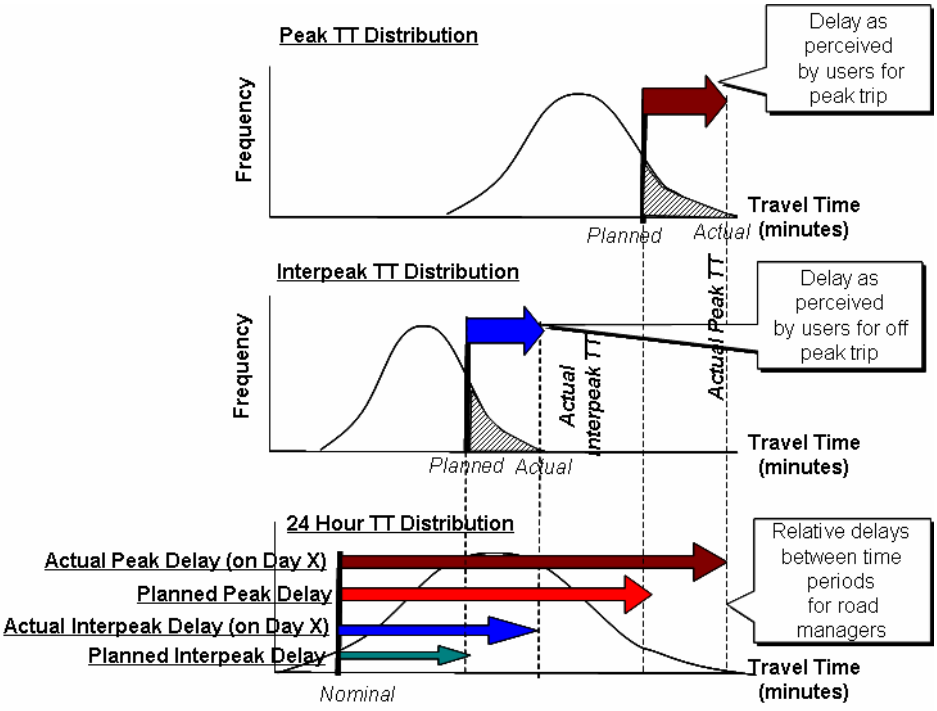


Figure 10: Calculating Delay (Illustrative Example)

Derivation of Other Performance Information

The literature review identified travel time is one of the fundamental or primary units of measurement for a range of performance information. The collection of travel time would enable a range of other performance information that road managers regard as being useful for their network planning functions to be derived as shown in Figure 11.

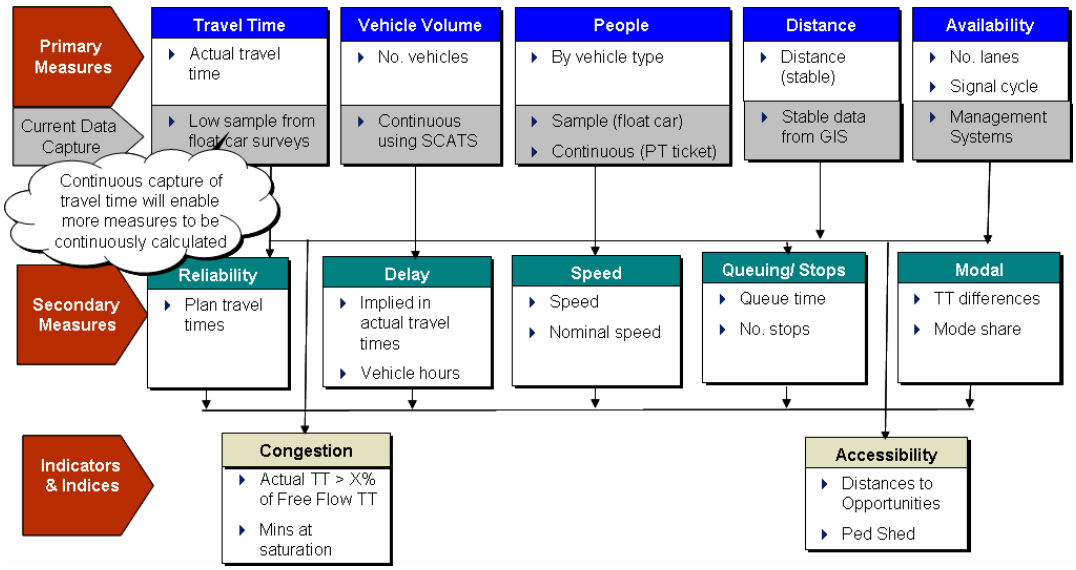


Figure 11: Derivation of Network Performance Information from Primary Measures

Note: Example performance measures are those identified at the Road Managers Workshop as being the most relevant measures

The vast majority of other primary measures are currently being collected using robust methodologies. These include vehicle volumes, distances and availability. The robust collection of travel time data is the main outstanding data that is currently not being collected.

6.3 Data Collection

Travel time information is currently collected using a small sample of floating car surveys held across a representation of the arterial road network. However, emerging technologies and their falling implementation costs are anticipated to enable this data to be collected in the short to medium term. Emerging technologies include:

- Automatic number plate recognition
- Vehicle tracking
- Vehicle tags
- Mobile phone tracking
- Inductive loops

These approaches are anticipated to cost effectively collect robust samples of travel time information by type of road user. Travel time information could be derived from either one or multiple sources.

An important consideration in collection is that of data error. Small sample sizes can result in low confidence in the data and therefore limited application by road users and managers alike. Other errors may also be introduced as a result of the data collection method, and these include estimation and expansion methodology and changing conditions.

7 AUSTROADS NATIONAL PERFORMANCE INDICATORS

7.1 Purpose

The National Performance Indicators (NPI) that have been used by Austroads and the road authorities provide a broad cross section of measures. They are used to measure the effectiveness of road system investment and management and enable each agency to benchmark their own performance against others. The measures that are relevant to this study are provided in Table 11.

Table 11: Relevant Performance Measures

NPI	Description	Unit
Actual travel speed	Average of actual speeds measured using a floating car on a sample of roads that is representative of the arterial road network Surveyed three times per year during peak and off peak periods	km/h
Congestions (Delay) Indictor	Difference between Actual Travel Time and Nominal Travel Time Aggregation of delay per kilometre on a representative sample of arterial roads Nominal travel time is derived from the nominal travel speed which is the average of nominal travel (posted) speeds on a sample of roads	Min/km
Variability of travel time	VTT – 1.44 * Standard Deviation/ Time * 100% Measurement of travel time variability on a representative sample of the network	%
Lane occupancy	Average number of persons or tonnes per hour during a specified period on a representative sample of arterial roads and freeways in the urban metropolitan area	Persons or tonnes/ hour/ lane

7.2 Findings

The study identified seven gaps in the NPIs, of which one relate to methodology, five to road agency objectives and one about users' information preferences.

Road managers have expressed that the small sample size of primary data that is used to derive these indicators results in them not being applied to other analysis or functions due to the low confidence in the results.

Secondly, the current methodology does not take into account peak spreading. The current methodology involves measuring performance at the same time during the peak across the sample days from year to year. This does not take into consideration of peak spreading. Upon confronting peak congestion, a proportion of new and existing users elect to reschedule the trip thereby increasing the span of the peak period.

The existing NPIs do not measure all agency objectives. In particular five gaps that have been identified are:

- Speed, travel time variability and congestion indicators are not measured for freight and public transport
- Peak spreading is not monitored
- Occupancy rates do not measure the proportion of the peak period that the road is operating at optimum utilisation
- Occupancy rates: do not measure persons on road based public transport
- There is no measure for accessibility or land use integration

Finally, road users have indicated that receiving timely information about traffic conditions is important. Despite NPIs aiming to measure the various aspects of road management, there is currently not an NPI that measures the extent that timely information is provided to road users.

7.3 Suggestions to Address Findings

This section outlines suggestions to address findings and overcome the identified gaps. These suggestions include considering how to improve the robustness of the data collected, reporting peak spreading, approaches to measure lane utilisation, expanding existing indicators to all modes and introducing an information indicator(s).

Emerging technologies are anticipated to enable more extensive sample sizes, if not continuous sampling, of travel times to be collected. These data collection methods are currently at an immature stage of development. An interim step suggested at the road managers' workshop is for a working group to be formed to explore how various approaches to collect this data, or a study to be undertaken to explore various technological options to collect this data.

A common objective amongst road agencies is to maximise the utilisation of road space. Developing or modifying the lane occupancy indicator to measure the proportion of peak periods that lanes are optimally utilised could be explored.

It is suggested to expand existing NPIs to encompass all road users, including public transport and freight users. In considering how this should be approached, factors to take into account include how imperative it is to provide continuity with existing indicators and whether they should be reported by type of user or as an aggregate indicator.

Given the importance to users of receiving timely information about changes in traffic conditions, it is suggested an indicator be developed that measures the availability and utilisation of this information by users.

Currently, the changes in the peak period due to peak spreading are currently not monitored. Developing an indicator that reports the length of the peak period would provide an insight into peak spreading. Peak periods should be measured using a traffic based methodology.

It is suggested that a NPI for land use integration and accessibility could be reviewed in light of the outcome of the imminent introduction of such a measure in New Zealand. These gaps and suggestions to address them are summarised in Table 12.

Table 12: Suggestions to Address Findings and Gaps

Findings/ Gap	Suggestion
Methodology	
Sample size of data collected for NPIs is low	Explore ways to increase sample size using emergent technologies and therefore improve confidence in the indicators.
Altered NPIs	
Lane Occupancy NPI does not convey proportion of peak that the lane operates at optimal utilisation	Explore ways how the utilisation of road space could be measured, particularly during the peak. Such an example could include the proportion of peak that a lane operates at optimal throughput
Lane Occupancy NPI does not consider public transport or HOV lanes separately	Consider whether there should be a separate measure for HOV/ public transport lanes
Speed, travel time variability and congestion NPIs are only applied for cars	Explore how the existing set of indicators could be applied to public transport and freight
New NPIs	
There is no NPI that measures the delivery or utilisation of timely information	Consider introducing a new indicator that measures the availability and utilization of timely information. The implementation of this NPI should take into consideration the characteristics of the various jurisdictions
There is no NPI that measures the year to year change in the length of the peak period due to peak spreading	Develop an NPI that reports the duration of a peak period to monitor how peak spreading changes over time. This duration should be determined from traffic based definitions.
There is no NPI that measures accessibility	Review the merits of this measure following the imminent implementation of such a measure in New Zealand.

8 CONCLUSION

The objective of this report was to identify performance information that is understood and would be used by all road users to make informed road transport decisions and that would assist road managers' in decision making in relation to the management and operation of the road network.

From the literature it was apparent that there was a finite number of basic measurable parameters from which an almost endless array of performance measures were developed. Those basic, or fundamental, measures were principally derived from travel time, volume, distance and people. The measures that were identified as being used the most successfully directly reported conditions experienced by the traveller, such as travel time and delay. Indices derived from these measures were generally found to be less relevant.

Users expressed that they would like a measure that expresses the overall performance of their journey so that they could plan or schedule other activities and manage their time. Users expressed that travel time and reliability were the most important aspects of road network performance.

The measures that would best meet users' needs were identified to be:

- Actual travel time and complementary information about road conditions, such as delays
- Planned travel time (travel time given a confidence interval)

Implicit in providing actual travel time is the additional travel time caused by delays.

Users indicated that receiving timely information about changes in road conditions was important. Almost a third of users indicated that they would like to receive information only when there is a problem or delay.

Users are generally not receiving network performance information according to their preferences. A key suggestion resulting from this study is for road managers to consider how to provide network performance information that better reflects users' preferences. This would enable users to utilise this information to make decisions about the transport choices that are available to them.

Road managers draw upon a wide range of measures when network planning, but identified that actual travel times complemented with some indication about delays and speeds are the most important type of information to receive in real time for operations management. An approach to alert road operations managers of roads that are potentially experiencing a non-recurrent delay or incident in real time was presented.

Furthermore, the collection of travel time data will enable trends to be identified, a more robust calculation of delay and the calculation of a wide number of measures that road managers use in network planning. It is anticipated that technological developments in the short to medium term will enable the automatic and continuous capture of travel time data.

Suggested improvements to the existing set of NPIs are to expand them to encompass all modes, to improve the data collection methodology and better measure utilisation. It is also suggested that an NPI that measures the extent of information delivery and peak spreading be developed and implemented.

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