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AUSTROADS RESEARCH REPORT

Network Operations Planning Framework




Austroads

promoting improved road transport outcomes

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Network Operations Planning Framework

Austroads

Sydney 2009

Austroads profile

Austroads' purpose is to contribute to improved Australian and New Zealand transport outcomes by:

- providing expert advice to SCOT and ATC on road and road transport issues
- facilitating collaboration between road agencies
- promoting harmonisation, consistency and uniformity in road and related operations
- undertaking strategic research on behalf of road agencies and communicating outcomes
- promoting improved and consistent practice by road agencies.

Austroads membership

Austroads membership comprises the six state and two territory road transport and traffic authorities, the Commonwealth Department of Infrastructure, Transport, Regional Development and Local Government, the Australian Local Government Association, and NZ Transport Agency. Austroads is governed by a council consisting of the chief executive officer (or an alternative senior executive officer) of each of its eleven member organisations:

- Roads and Traffic Authority New South Wales
- Roads Corporation Victoria
- Queensland Department of Transport and Main Roads
- Main Roads Western Australia
- Department for Transport, Energy and Infrastructure South Australia
- Department of Infrastructure, Energy and Resources Tasmania
- Department of Planning and Infrastructure Northern Territory
- Department of Territory and Municipal Services Australian Capital Territory
- Department of Infrastructure, Transport, Regional Development and Local Government
- Australian Local Government Association
- New Zealand Transport Agency.

The success of Austroads is derived from the collaboration of member organisations and others in the road industry. It aims to be the Australasian leader in providing high quality information, advice and fostering research in the road sector.

SUMMARY

The increase in the demand for transport services which is forecast to continue into the foreseeable future has placed greater focus on infrastructure and non-infrastructure solutions to meet that demand. Further, there is growing recognition of the importance of incorporating non-infrastructure solutions into the planning of new infrastructure in order to preserve productivity gains into the longer term through better management of the supply of and the demand for infrastructure. The purpose of this paper is to develop a high level reference document as a Framework to assist Network Operations planning.

The purpose of a framework for Network Operations is to assist network managers to monitor the performance of road networks, identify gaps in performance and service delivery, and determine which measures may best address those gaps most efficiently against the needs of a broad range of road users. The Framework is designed to facilitate the attainment of objectives for both the road agency and road users, while recognising that the needs of road agencies and road users may often conflict. The Framework also plays a key role in infrastructure planning by aiming to enhance the longer term efficiency with which we use our road infrastructure.

The seven key steps, outlined in this paper, that should be included in a Framework for Network Operations are:

- network operations objectives and scope
- network and services definition
- network performance
- management options for network operations
- development of network operation plans
- implementation of network operation plans
- evaluation of plans and network performance.

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1 INTRODUCTION

1.1 Overview

The purpose of this paper is to develop a high level reference document as a framework to assist network operations planning. The purpose of the framework is to complement the *National Guidelines for Transport System Management in Australia* (ATC 2006) by outlining the important role of Network Operations in increasing the efficiency with which we use our road networks. In this sense, there is a clear relationship between:

- the planning, construction and management of roads
- the provision and use of roads infrastructure
- the preservation of the road asset.

In developing such an approach, there are several key issues which need to be addressed, including:

- defining and identifying the scope of and inter-relationships between infrastructure and non-infrastructure solutions to meet the demands by road users
- the hierarchy of roads and needs that combine to form a road transport system
- the users and uses of roads
- the iterative nature of road provision and management from an institutional perspective
- the target of application of the Framework in the roads hierarchy.

These issues constitute some of the main parameters of the Framework that is developed in this Report that could be used to guide Network Operations management and services.

1.2 Concepts

In developing a Framework to guide Network Operations, there are several concepts that are critical to thinking in this area:

- ***Capital:*** In economics literature, capital includes all non-human resources that may be used either singly or in combination for the purpose of consumption. Capital is a means of production to generate outputs for end consumers, and may include assets such as machinery, buildings, land, mineral resources, raw materials and inventory. Road systems, railway systems, airports and ports represent capital, and form part of the inventory of public assets that are used to generate end products for consumption whether they are leisure or business. These assets may comprise infrastructure and non-infrastructure components.

- ***Infrastructure:*** Hirschman (ECMT 2003) classifies transport infrastructure systems as *social overhead capital* with four characteristics:
  - it is basic to a great variety of economic activities
  - it is typically provided by the public sector or by regulated agencies
  - it cannot be imported
  - it is *lumpy* in the sense of technical indivisibilities.

In this way, a key role of infrastructure is to support productive activity, and may be regarded as an enabler of economic growth and development. *National Guidelines for Transport System Management in Australia* (2006) defines transport infrastructure as civil engineering structures that have been built to facilitate the movement of people and/or goods for various social and business reasons – it is a network of bridges and pavements. Infrastructure represents the *hardware* of the road system.

- ***Non-infrastructure:*** Road system assets also comprise a significant component of elements which may be imported and are not *lumpy* in their construction. *National Guidelines for Transport System Management in Australia* (2006) defines non-infrastructure solutions as initiatives that make better use of existing infrastructure and avoid the need for large capital expenditures. They include initiatives such as traffic management systems, traveller information systems, incident response. These represent the *software* of the road system.

- ***Initiative:*** *National Guidelines for Transport System Management in Australia* (2006) defines an initiative as any action to address a transport challenge. It could consist of an infrastructure or non-infrastructure intervention. The term *project* is often used for such actions but is limited by a perceived association with civil engineering generated infrastructure.

- ***Network Management:*** Access to a road network may span a wide continuum of possibilities, from an almost Laissez-faire approach in which there are very few rules or governing principles through to a highly regulated and managed approach in complex urban environments. Under the former approach, there is little to no application of non-infrastructure initiatives with the key factor being the hardware or lumpy asset that provides access to remote communities, particularly in developing countries. With the latter approach, there is increasing focus on the use of techniques and regulations to better manage access and use through supply and demand options to extract the maximum output from the fixed or lumpy asset. In this sense, network management refers to application of non-infrastructure measures to manage the demand for and supply of road space. There are two aspects of network management: network operations and regulations.

- ***Network Operations:*** The World Road Association Handbook (2003) defines road Network Operations as '*maintaining optimal conditions on the road network in relation to demand and supply*'. Supply is based on a hierarchy of service levels that determines the methods, organisational structures and resources needed to support strategies for road network operations, maintenance and incident response. Demand reflects the needs of the various customers and stakeholders (road network operators and users) and their operational objectives (World Road Association). A distinguishing feature of Network Operations is the application of Intelligent Transport Systems through the use of Information Technology.

- ***Services (Road User Driven):*** The move by Road Authorities towards the role of network operator should be driven by understanding the requirements of the road users. User driven services can be expressed broadly as support for something the road user wishes to do on the network. Network Operations includes both management and service functions. Management functions include network monitoring, demand management (price and non-price initiatives such as real-time traffic information), traffic control (tidal flow, lane allocation, ramp metering). Service functions include incident response, emergency response, route guidance, traveller information (including parking, as well as both private vehicle use and public transport services such as bus and tram).

- ***Network Operation Plan(s)**:* These plans should typically include a description of the key objectives for the operation of the road network, definition of the road network and major road user services to be delivered; the *service levels* to be deployed across the network, based on an agreed road network hierarchy/priority; and suitable road network maps/plans. An appropriate network hierarchy for the *service levels* to be deployed across the network should be determined by factors such as road function/type, traffic levels, multi-modal priorities, traffic disturbances etc.

- ***Regulation:*** Access and use of the road network is governed by road rules and regulations. The National Transport Commission is responsible for developing regulations for use of the road network by heavy vehicles (greater than 4.5 tonnes Gross Vehicle Mass (GVM)) in consultation with Australian, State and Territory Governments. A set of National Road Rules have been developed through Austroads, while State and Territory Governments are responsible for developing and administering regulations governing road use within their own jurisdictions. Examples of regulations include driver licensing and vehicle registration which grant access for use of the road network. Other examples include, mass and dimension limits for heavy vehicles, driving hours, speed limits, alcohol limits for drivers, access to the road network for higher mass limit vehicles, etc.

- ***Framework for Network Operations:*** This encompasses the development of a set of principles and process to assist and guide road agencies in the identification and deployment of Network Operations to improve management and use of existing road infrastructure. The application of the Framework gives explicit recognition to the iterative nature of Network Operations both within the Network Operations function and between supply/demand management of the network and infrastructure provision.

1.3 The Roads Challenge

The increase in the demand for transport services which is forecast to continue into the foreseeable future has placed greater focus on infrastructure and non-infrastructure solutions to meet that demand. Further, there is growing recognition of the importance of incorporating non-infrastructure solutions into the planning of new infrastructure in order to preserve productivity gains into the longer term through better management of the supply of and the demand for infrastructure. The application of Network Operations into the planning, construction and use of both new and existing infrastructure raises important questions of:

- Which options should be used to best manage the demand for infrastructure use?
- Where on the network should those options be deployed?
- What is the appropriate mix of infrastructure and non-infrastructure solutions?
- How can planning for operating the network be integrated with traditional asset management planning and investment planning?
- When should these options be deployed across the network?
- How can Network Operations better meet the need of road users?

Network Operations has application to all road networks – both urban and non-urban. However, urban congestion is now considered to be one of the major contributors to inefficiency and delay in urban transport. In February 2006 the Council of Australian Governments (COAG 2006) committed to reducing current and projected urban transport congestion within existing jurisdictional responsibilities.

For the COAG Review of Urban Congestion (COAG 2006), the BTRE (2007) estimated that total urban vehicle kilometres travelled in Australia are projected to grow by 37% between 2005 and 2020 which could lead to a doubling of the cost of congestion. Recent increases in public transport patronage suggest that rising fuel prices may help to moderate this forecast growth in congestion. However, it is likely that the forecast increase in the cost of congestion will add to the cost of business activity in Australia which could reduce Australia's competitiveness on international markets.

The BITRE (2008) has forecast a 2.6% annual growth rate in the national freight task (bulk and non-bulk tonnages) from 2005 to 2030 which will result in a near doubling of the task over that period (see also NTC 2006). In aggregate, the BITRE has estimated that the road freight task will increase at 2.2% per annum over that period, while the rail freight task is estimated to increase at 3.7% per annum. A key concern before governments is that of meeting this forecast increase in demand while managing broader social concerns surrounding infrastructure use and management, road safety and the environment.

The COAG Review of Urban Congestion (2006) considered non-infrastructure options to tackle the issue of increasing congestion in the face of growing demand for transport. However, the Review concluded that there is no silver bullet to solving the congestion issue, and that a range of infrastructure and non-infrastructure solutions must be included as part of an integrated set of measures to improve transport efficiency. At the same time, the application of such measures need not necessarily be confined to urban networks. Non-infrastructure solutions to improve transport efficiency such as traveller information systems also have application to the non-urban road network (e.g. incident warning systems; fog warning systems to improve safety of road corridors such as Sydney-Wollongong; and flood monitoring and warning systems).

Increasing attention is being given by road agencies in Australia to a range of measures to manage the forecast growth in the demand for transport over the next 30 years. In recognition of this problem, the general approach is increasingly focusing on an integrated package of options that encompass both infrastructure and non-infrastructure solutions. This requires more coordinated interaction within road agencies across planning, project implementation, asset preservation, and network management of traffic operations to achieve greater efficiency of infrastructure use in the longer term.

1.4 What is the Balance?

The World Road Association Handbook (2003) emphasises the need for *the Big Shift* to occur in the provision and management of road networks. This reflects the growing recognition among road agencies of the importance of addressing the service requirements of road users, as well as encompassing the dual responsibilities of infrastructure providers and network managers. This shift to improved management of road networks rather than the '*predict and provide'* approach of the past is placing greater attention on increasing the efficiency of use of existing (and planned) infrastructure, including its implication for asset management. These approaches are complementary – net additions to the stock of infrastructure will continue to be required to meet forecast increase in the demand for transport. The key issue is that of *optimising* the provision and use of infrastructure by incorporating traffic management and road user services initiatives which have the capacity to:

- reduce the level of investment required to meet forecast demand more efficiently
- meet the needs of road users in terms of expected service requirements (*the outside-in view*)
- balance the policy objectives and resource constraints of road agencies to meet the service expectations of road users (*the inside-out view*).

Further, the World Road Association has promoted the concept of *services* for road users and a road hierarchy of network operating levels to help determine what services should be deployed across the network. The World Road Association also introduced the concept that Network Operations can be considered at three levels:

- 'Strategic' – indicates *why* Network Operations is important and involves setting the key network objectives and performance requirements for effective operations
- 'Tactical' – indicates *what* will be delivered in terms of road user driven services
- 'Operational' – indicates *how* the effective operation of the network and delivery of user driven services will be achieved.

While road agencies appear to have focused more at the operational level in the past, greater emphasis needs to be directed towards strategic and tactical planning to achieve effective operation of the network. This should help to ensure that operational measures are consistent with strategic road network objectives (MRWA 2007).

The World Road Association also promotes the concept of '*Operating levels'* to guide the deployment of road user services across the network, based on a network ranking or priority. The network '*Operating levels'* should depend on agreed objectives and performance, road network hierarchy, road user types, frequency of traffic disturbances and impact on traffic flow. '*Operating levels'* could typically include freeways (permanent and automated Intelligent Transport Systems (ITS)), major arterials (similar to freeway but lower level of ITS systems), and higher order local roads (targeted systems).

The COAG Review of Urban Congestion (2006) was clear in its conclusion: effective congestion management requires a range of measures of which Network Operations is one. Hence, the focus needs to be on measures that can provide added value to investment in road networks and preserve the productivity benefits of infrastructure investments. The Review emphasised the need to improve our management of road networks and thereby increase the efficiency of infrastructure use in response to growing user demands on the network. In essence, it is a package approach of infrastructure and non-infrastructure solutions that is required to meet the forecast increase in demand for transport. This also re-emphasises the importance of clear linkages between infrastructure planning and Network Operations as two complementary aspects of roads provision and management.

There are three implications for road Network Operations flowing from these approaches:

- the *Big Shift* infers a change in direction from infrastructure provision only (the predict and provide approach) to infrastructure management – this does not mean that one proceeds without the other
- the management of infrastructure needs to be factored into both the planning and use of infrastructure
- road agencies need to incorporate both infrastructure and non-infrastructure solutions in their planning, assessment and implementation of options to address constraints to the effective functioning of road networks.

Not withstanding the application of other measures (i.e. Travel Demand Management) to reduce travel demand, there will continue to be demand for use of the road network. The underlying challenge then is that of balancing the supply of road infrastructure (predict and provide by adding to the capital asset as well as managing its availability) with the demand for that infrastructure (rationing access to that capital stock by managing demand for its use). In most markets, price is used as the equilibrating mechanism to balance the demand for and the supply of a product. To date, this approach has been rarely applied to road transport infrastructure. Access charges (such as vehicle registration) and fuel prices are non-discriminatory in their approach to balance demand and supply at any given location and/or point in time. As a result, demand for road infrastructure has generally outstripped supply resulting in increasing levels of congestion and the avoidance of the real cost of infrastructure use by those using it.

In the absence of a pricing approach being adopted to manage demand for infrastructure, road agencies have applied a range of operational measures to tackle road use. These measures may be broadly characterised as:

- *demand*: traveller information systems and (non-price) demand management
- *supply*: incident management and active traffic management.

The advance in Intelligent Transport Systems (ITS) technologies have enabled many of these measures to be implemented to better balance the supply and use of road infrastructure. This approach focuses on the operational aspects of road infrastructure provision – that is, making the best use of the existing and planned stock of capital (the road asset).

Together, these issues highlight the need for a Network Operations Planning Framework, and the importance of an approach that integrates infrastructure provision with management of its use. For road agencies this requires greater interaction between those planning and implementing road construction projects and those responsible for the long term management of that infrastructure. This applies both at the planning and implementation phases of the road asset, and emphasises the need for Network Operations to be part of the planning and assessment process. The parallel issue is that of determining where on the existing network, what non-infrastructure measures should be deployed and when. Given the maturity of our road network, a key challenge is that of identifying and determining which non-infrastructure measures should be used to increase the efficiency of use of existing infrastructure.

National Guidelines for Transportation System Management in Australia (2006) is designed to support transport decision making and provide a national approach for planning and developing land transport networks. It was developed collaboratively at all levels of government in Australia and incorporates a top-down, objectives led, multi-phase, strategic approach to transport system management. It is focussed on moving beyond the traditional infrastructure, single mode solution towards multi-modal, technological and management based system solutions. The use of the term *initiative* is deliberate to emphasise the importance of both infrastructure and non-infrastructure measures to improve transport safety, reliability and productivity. Volume 4 of the *National Guidelines* focuses on technological solutions to assist in enhancing the efficiency with which urban roads (and rail) infrastructure is used to address congestion problems.

The development of the *National Guidelines for Transport System Management in Australia* (2006) was driven by the need to provide an objective approach to the identification and assessment of infrastructure investment options to improve transport efficiency. It was conceived as part of the national infrastructure reform agenda under AusLink, and explicit in their application to both infrastructure and non-infrastructure initiatives.

1.5 Scope of a Planning Framework

The primary focus of a Network Operations Planning Framework is at the network level – that is, how does the network function overall? In this case, network may be assumed to refer to a range of applications – urban, regional, and inter-urban. In this way, the focus of Network Operations for a complex metropolitan network would be different from that designed for a regional network. However, within that perspective, there is a cascading down in focus to identify the best options that could be deployed on links within the network to address location specific problems. There is then a reversal of the perspective to assess the implication of the deployment of a location specific initiative on the surrounding corridor/network.

A Network Operations Planning Framework needs to encompass several dimensions in order to develop an effective strategy for management of the roads sector:

- capacity to manage congestion on urban networks
- facilitate planning of both urban and non-urban networks, corridors, routes and links and their management, including land use, asset implementation and preservation, road maintenance and rehabilitation
- adopt an integrated approach that incorporates both infrastructure and non-infrastructure solutions
- include the appropriate setting of objectives, performance indicators and performance monitoring against network objectives, assessment of options to achieve target levels of performance, and implementation of actions as an integrated part of infrastructure planning and management.

A Network Operations strategy should typically be high level in its approach, identifying the key drivers that influence the operation of the road network, have a focus on road user driven services and identify the key activities required to deliver the desired outcomes required. It should aim to improve:

- road safety
- efficiency of use of road infrastructure and options for enhancing the capacity of road networks
- the allocation of funds for network improvements in terms of the timing of construction activities and the application of non-infrastructure solutions for better demand and supply management
- efficiency and safety of the road transport sector including the wider use of higher productivity vehicles such as Higher Mass Limit (HML) vehicles, B-triples, and the application of performance based standards for heavy vehicles where appropriate and consistent with asset preservation
- efficiency and safety of the road based public transport sector
- access to travel and traffic information for industry, private commuters and public transport users
- reliability of travel times, including improved response times and procedures for incident management
- sustainability of transport systems that result in reduced congestion and hence transport emissions.

The forecast increase in the demand for transport has long term implications for the role of Network Operations. With the prospect of higher levels of congestion being experienced on our urban networks, and greater pressure being placed road infrastructure, Network Operations will play an increasingly important role in balancing the demand for and supply of infrastructure. Uncertainty in energy markets resulting in higher fuel prices is likely to lead to a change in travel behaviour and travel patterns in the longer term. Network Operations has the capacity to be more responsive to these types of changes than does the ability to meet those changes in demand with supply of infrastructure. Part of those changes, in some measure also could be induced by increasing concerns about emissions and climate change, could lead to greater use of public transport through better combining transport options. In this respect, intelligent road networks and the provision of real time information has the capacity to facilitate these changes.

In terms of a roads hierarchy, the primary focus of a planning framework for Network Operations should be at the network or corridor level. From a management perspective, the focus should be at the strategic and tactical planning levels to assist in translating policy, objectives and strategy to guide the development and deployment of practical network operation plans at the route and link level. Route and link level planning are not specifically addressed in this framework. However, it should be noted that the development of practical network operation plans will involve consideration of how the road system operates at the link/route level.

2 OVERVIEW OF ISSUES

2.1 Review of Literature

In developing the Framework, a comprehensive literature review was undertaken of domestic and international experience, including consultation with road agencies in Australia on current practice for Network Operations.

From the international arena, key reference material was sourced from the World Road Association, UK Ministry for Transport, Federal Highway Administration of the USA (FHWA), and the Netherlands. The main Australian sources of information used during the course of the literature review included Austroads, Main Roads WA, Queensland Main Roads, VicRoads, *National Guidelines for Transport System Management in Australia* (ATC 2006) and the COAG Review of Urban Congestion (COAG 2006). A detailed review of literature and Australian experience is contained in a separate report (see Meyrick and Associates 2008).

The key lessons from the Literature Review are discussed in Section 2.2.

2.2 Overview of Issues

There are several key underlying elements to the development of a framework for Network Operations. At the outset, the primary focus is the balancing of government objectives for road transport with the expectations of providers and users of road transport services. Road agency objectives for the provision and operation of road infrastructure may be set by governments at the State/Territory level, and in some cases they may be a function of Australian Government objectives as they relate to the AusLink National Network. For road agencies, a third consideration is their relationship with Local Government and other State/Territory agencies, such as land use planning. For the most part, this function may be described as comprising the supply side of the infrastructure equation with three components:

- planning and construction of roads infrastructure
- management of the road network and provision of services to road users
- development and implementation of regulations governing road use.

These three functions are inter-related, with Network Operations being a key ingredient of infrastructure planning and playing a continuing role in monitoring/enhancing network performance. Network Operations also play a role in the effective deployment of regulations that are designed to ensure the efficient and safe functioning of the network (e.g. through the use of red light and speed cameras to reduce the occurrence of incidents), as well as asset preservation (e.g. monitoring of heavy vehicle movements). For example, the implementation of demand management initiatives may allow construction of new road infrastructure to be deferred by improving the efficiency with which an existing link is being used. Similarly, expansion of the network to accommodate Higher Mass Limits (HML) for heavy vehicles may have implications for infrastructure investment and use on certain links of the network to enable HML vehicles to access key distribution centres. Also, the potential for such productivity gain may be facilitated through the use of GPS systems to monitor heavy vehicle movements to ensure asset preservation.

These inter-relationships across infrastructure provision, Network Operations and regulation are shown in Figure 1.

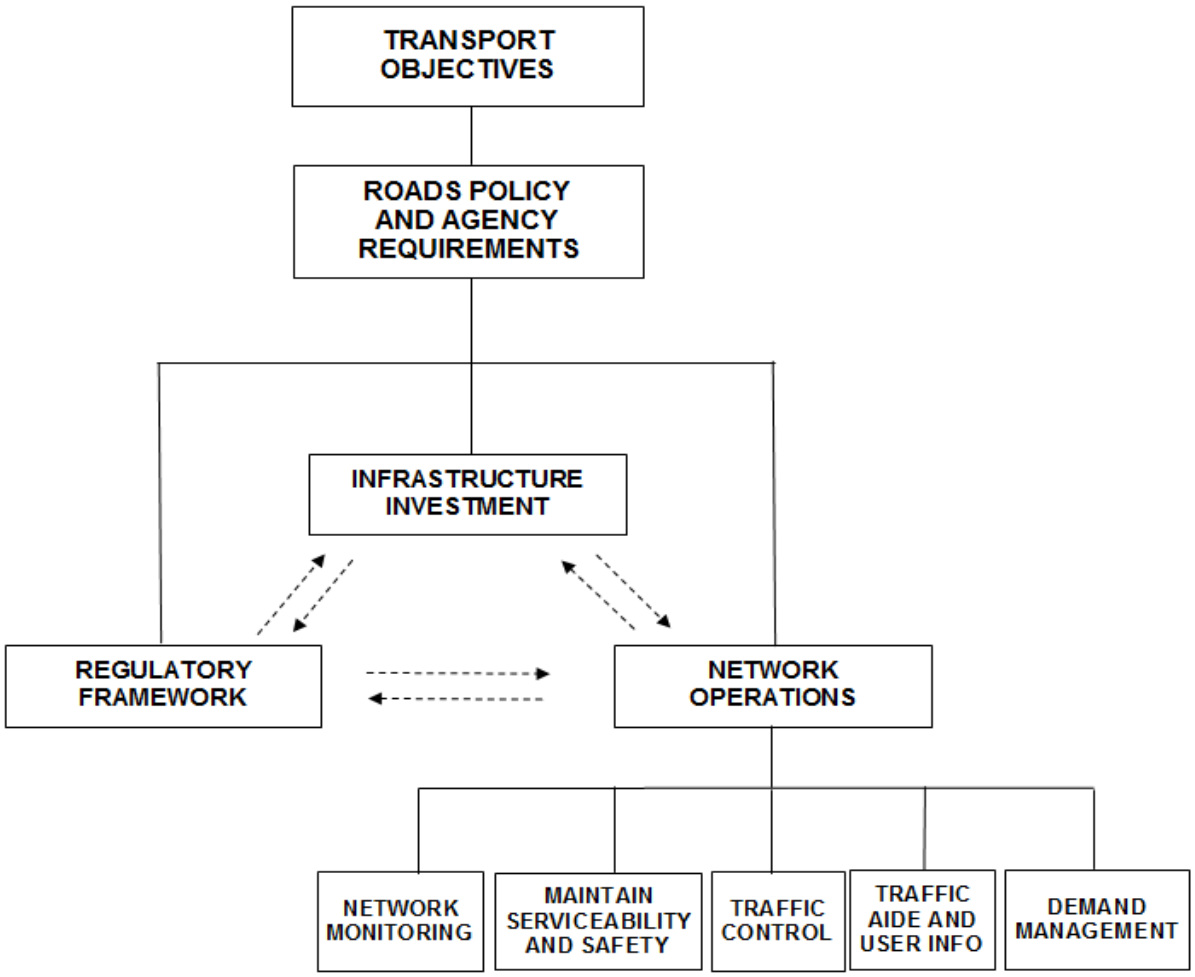

Figure 1: Provision and Operation of Road Infrastructure

Two examples of jurisdictional approaches illustrate this relationship. Queensland Main Roads has as its objectives 'improving Queensland's prosperity, quality of life and safety by:

- Planning
- Providing
- Managing
- Operating

an efficient road network, as part of an integrated transport system' (Queensland Main Roads 2008, http://www.mainroads.qld.gov.au/web/careerCR.nsf/). Similarly, Main Roads Western Australia states that it's '*purpose is to provide safe and efficient road access that will enhance community lifestyles and ensure economic prosperity*' (Main Roads WA 2008, http://www.mainroads.wa.gov.au/NR/mrwa/).

State road agency objectives have the potential to directly contribute to the attainment of broader transport objectives, such as those recently agreed by the Australian Transport Council (ATC 2008):

- Economic – promote the efficient movement of people and goods *in order to support economic development and prosperity.*

- Safety – provide a safe transport system *that meets Australia's mobility social and economic objectives without killing or maiming its users.*
- Social – to promote social inclusion *by connecting remote and disadvantaged communities and increasing accessibility to the transport network to allow equitable access to community resources.*
- Environmental – protect our environment and improve health *by building and investing in the efficient movement of goods and people which minimises emission and consumption of resources and energy.*
- Integration – promote effective and efficient integration and linkage of Australia's transport system *with urban and regional planning at every level of government and with international transport systems.*
- Transparency in funding and charging.

On the demand side, road users include a wide range of road agency stakeholders: freight economy, service economy, commuters, leisure travel, public transport, community access to employment and services (such as health and education), cyclists and pedestrians. The demands of road users vary across stakeholders groups and across the hierarchy of the road network. For example, the use of Higher Mass Limits vehicles by road transport operators on the road network highlights the inter-relationship across infrastructure provision, regulation and Network Operations in seeking to achieve common objectives of safety, productivity, network efficiency and asset preservation in their access to/use of different parts of the network. This potential was recognised earlier by Austroads (2002) in their work on Intelligent Transport Systems and its role in asset management.

On the road agency or supply side, the development of network operation plans is an iterative process involving all stakeholders, across the whole spectrum from setting broad policy objectives for transport infrastructure investment and use at the national level for strategic road networks/corridors through to implementing policy options at the micro levels of routes and links. The feedback of information from an intelligent transport system provides road managers with a mechanism for continuous monitoring of the performance of the network, and the capacity to adjust policy and operational interventions on a shorter and in some instances real-time basis compared to infrastructure policies.

Main Roads WA (2007) has identified three characteristics of network operation planning:

- Decisions made through a planning process can be complex. Therefore, collaboration, engagement and co-ordination with key network operator partners, and engagement of key stakeholders (internal and external) and the community is a key component through all steps in the operations planning framework.
- This involvement is required to clarify roles and responsibilities and understand the range of views. The engagement process and timing must be carefully planned to achieve successful outcomes. The establishment of key stakeholder and road user group registers and databases may assist in this task.
- Road agencies collaborate with other government agencies involved in planning and delivery of infrastructure, delivery of transport services and community engagement processes. This approach forms a whole of government approach to understanding stakeholder and community issues and developing integrated solutions. Effective stakeholder engagement may also result in identifying opportunities for other funding sources for Network Operations needs.

2.3 Conclusions from the Review of Literature

The literature review undertaken for this project drew several conclusions. First, the following key elements should be considered for effective operations planning:

- an understanding of the broader transport system
- engagement with road users to identify user requirements
- proactively plan and manage demands on the road system
- selecting the best package of measures including build, innovative non-build and management solutions
- making best use of existing road infrastructure
- engaging and developing partnerships
- collaborative planning based on achieving integrated transport system outcomes; and
- review of measures/policies adopted.

Second, the development of a Network Operations planning and management framework requires:

- the clear identification of transport system objectives, including the specification of objectives for the road network
- the identification of performance indicators linked to key objectives to monitor the road network and targets for its performance
- understanding the importance of planning by key stakeholders including inter-agency, cross agency and cross modal inter-relationships (e.g. the interaction between road network (infrastructure), transport and land use planning)
- an assessment framework to establish the cost-effectiveness of interventions and their likely impacts
- a process of performance review to evaluate the contribution of interventions against Government's and road agency objectives, and their impact on network performance in terms of key performance indicators.

Third, the complexity of urban transport networks demands that the Framework should have the capacity to identify and assess broader indirect impacts. For example, the introduction of High Occupancy Vehicle (HOV) lanes for private vehicles coupled with free parking for such users may lead to an increase in transit vehicle use but also a reduction in bus patronage.

Fourth, the successful implementation of such a Framework to improve the management of our road networks will require the development of a sound road network information database to support decision-making at all levels – infrastructure planners and developers, road managers/operators, public transport managers/operators, and users. The generation of such data through an intelligent road network may also allow the development of new analysis tools and techniques which will be required for the 'optimal' implementation of network operation plans.

Fifth, the Review highlighted the wide range of non-infrastructure solutions being used to improve network safety, reliability and efficiency. However, the review did not uncover any worthwhile examples in use internationally of a Network Operations Planning Framework that could be adapted for Australia.

The purpose of this report is to outline a possible Network Operations Planning Framework that could be applied by jurisdictions in managing road networks. The Framework builds on processes already underway by jurisdictions and by Austroads. It also incorporates elements of *National Guidelines for Transport System Management in Australia* (2006).

Austroads (2008) *Guide to Traffic Management (Part 4)* makes specific reference to Network Operations Planning and includes the framework developed by VicRoads (2008) as an example which emphasises the strong inter-relationship between build/maintain road infrastructure and manage/operate infrastructure. Other relevant Austroads publications that are complementary to the operations planning framework include: *National Performance Indicators for Network Operations* (Austroads 2007) and *Understanding Network Performance Information Provided to Road Users* (Austroads 2006).

2.4 Functions of Road Network Operations

The World Road Association Handbook (2003) identifies five major functions of Network Operations, as shown in Table 1.

Table 1: Functions of Road Network Operations

FIELD/SERVICE	EXPLANATION/SCOPE
Network monitoring	Network monitoring covers all measures, resources, and procedures that enable the operator to observe and find out the performance of the network and its use as quickly and completely as possible. Network monitoring mainly covers supervision of traffic conditions and supervision of external events (weather or other natural events) likely to affect its use. Network monitoring performs a key function in gathering prevailing road network operations information and providing support for other network operation missions. Quick response to incidents based on the monitored information enables road network operators to take appropriate actions to minimise the negative effects of incidents. The resulting impacts of these operations are again monitored and evaluated to take further actions.
Maintaining road serviceability and safety	Maintaining road serviceability covers, in the event of a disturbance, all field operations designed to maintain or restore conditions of road use that are as close as possible to the normal situation.
Traffic control	Traffic control covers all measures, in respect to predetermined objectives, aimed at distributing and controlling traffic flows in time and space, in order to avoid the onset of disturbances or to reduce their impacts. Traffic control is carried out in coordination with, and under the control of, the authorities in charge of traffic policing. Traffic management tasks make use of any opportunities to spread traffic across time periods or any existence of alternative routes. They can be pro-active, preventive or remedial. Examples include: ramp metering, speed control, tidal flow, adaptive traffic signal control, collective route guidance, individual route guidance, road pricing, and toll collection technology.
Travel aid and user information	Travel aid tasks are not specifically aimed at modifying traffic flows. However, when used for information purposes, they must be closely coordinated with traffic management measures as they may induce users to change their travel time, route or mode of transport. In this context, they may be integrated with broader strategies related to demand management. The common objective of all traveller information services is to provide high quality, real-time, detailed information on transportation system operational conditions, including weather, so that individual travellers can make informed decisions regarding whether to make a trip, when to make it, what mode to take, and what route to take. Real time traveller information should be available both before a traveller begins a trip, as well as while the trips are underway, so that adjustments can be made to reflect changing operational conditions.
Demand management	Demand management covers all the operational measures that aim to limit the consequences of a decreasing level of service on a route. This is carried out through actions related to the mobility policy such as improving traffic distribution through time or encouraging users to change modes. Operation tasks related to demand management are integrated into a global and multimodal mobility policy with the road being part of it. They complement some traffic management actions. One of the most frequently used measures of demand management is information provision.

It is important to recognise the some of the activities such as provision of traveller information provided within the above-mentioned functions may be provided by the private sector either in collaboration with public agencies or stand-alone. In most cases the services are provided on a commercial basis.

3 DEVELOPMENT OF A FRAMEWORK

3.1 Purpose of a Framework

The purpose of a framework for Network Operations is to assist network managers to monitor the performance of road networks, identify gaps in performance and service delivery, and determine which measures may best address those gaps most efficiently against the needs of a broad range of road users. The Framework is designed to facilitate the attainment of objectives for both the road agency and road users, while recognising that the needs of road agencies and road users may often conflict. The Framework also plays a key role in infrastructure planning by aiming to enhance the longer term efficiency with which we use our road infrastructure.

The approach adopted by Austroads to develop a planning framework for Network Operations reflects the philosophy that underpins *National Guidelines for Transport System Management in Australia* (2006) but takes it further by focusing on the non-infrastructure suite of initiatives to improve our approach to extracting maximum efficiency from the existing stock of road capital and new infrastructure projects. The current work underway by jurisdictions, particularly those by WA and Queensland, provides a sound basis on which to develop such a Framework.

The two approaches should be seen as complementary building blocks in the development of a framework for Network Operations which is essential to delivering a network that achieves overall functionality and best meets the needs of all stakeholders. For road agencies this raises six fundamental questions:

- What options exist to tackle bottle-necks on the road network where demand exceeds supply resulting in significant recurrent cost to society?
- What user driven services are to be delivered?
- Where on the road network should investment be made to add to the stock of road asset to address infrastructure constraints?
- In adding to the stock of capital, what road network operations (non-infrastructure) options are available to preserve the capacity of that asset to ensure long term efficiency benefits to society from that investment?
- How can that *efficiency dividend* be incorporated into and achieved from infrastructure planning and provision through the use of non-infrastructure measures?
- In managing the existing stock of capital, what road network operations (non-infrastructure) options are available to preserve the capacity of that asset to ensure long term efficiency benefits to society?

3.2 Overview of a Framework for Network Operations

Based on the guiding principles of *National Guidelines for Transport System Management in Australia* (2006), the Literature Review and consultation with State Road Authorities, the seven key steps that should be included in a Framework for Network Operations are:

- network operations objectives and scope
- network and services definition
- network performance
- management options for network operations
- development of network operation plans

- implementation of network operation plans
- evaluation of plans and network performance.

These steps constitute phases in the Framework and are summarised in Table 2. They are discussed in the following sections of the report.

It is suggested that Network Operation Plans be reviewed annually on a rolling five year time horizon.

Table 2: Phases of a Network Operations Planning Framework

Phase	Activity	Elements/Inputs	Outputs
1	Network Operations Objectives	▪ Government policies and objectives. ▪ Road user requirements ▪ Traffic and Road based transport productivity targets ▪ Performance of the network ▪ Identification of key transport partners, roles, priorities, operational strategies and inter-relationships across network elements	Identification of key objectives for Network Operations. Identification of key network Performance requirements.
2	Network and Services Definition	▪ Existing and future network including infrastructure plans. ▪ Existing and future road network functions. ▪ Priority multi-modal transport networks (i.e. public transport, pedestrian/cycle, freight etc ▪ Road user requirements. ▪ Existing road network operations services and their scope. ▪ Defining the hierarchy of road users across the network to address the competing demands for road space across commuters, freight, public transport, commercial/urban development.	Defined road network corridor/area. Defined road hierarchy/priorities. Defined “road user services” to be deployed across the network.
3	Network Performance	Development of processes, tools and techniques to enable road agencies to collect relevant road operation data and monitor the performance of road networks. Include consideration of future demand for planning time horizon. Identification and development of appropriate levels of service standards and infrastructure standards.	Set of Performance Measures and targets that reflect the needs of road agencies and road users in their access to information for improved decision-making. Identification of gaps in network performance. Defined service standards and infrastructure standards.
4	Management Options for Network Operations	Understanding of the broad range of network management, behavioural responses of road users to options available and their capacity to address performance gaps to address the needs of road agencies and road users. Understanding of inter-relationships between options to deliver network functions and desired outcomes to minimise unintended impacts of operations management.	Clear identifications of ‘best fit’ options that align with the major functions required of network operations.
5	Development of Network Operation Plans	Identification of key elements that should constitute an appraisal framework to determine the relative merits of management options. Assessment of wider network impacts of proposals, including scenario testing.	Development of an appraisal framework that allows road agencies to determine the cost-effectiveness of management options. Development of the network operation plans.

Phase	Activity	Elements/Inputs	Outputs
6	Implementation of Network Operation Plans	Identification of elements/trade-offs in the use of management options based on quantitative and qualitative information. Identification of priorities for a program to deploy initiatives across road networks, that takes account of budget and policy constraints. Mechanisms to undertake corridor, route and link planning for road network operations to identify candidate initiatives.	Program management guidelines for road network operations Development and implementation of a program for road network operations including operational adjustments
7	Evaluation of Plans and Network Performance	Development of a process to enable ex-post review of initiatives to determine whether or not they improved the efficiency of road network use and their effectiveness in meeting Government, road agency and user objectives. Annual review of network operations plans on a rolling five year time horizon.	Identification of factors that may have (not) contributed to the attainment of objectives. This may warrant a review of elements of the framework or of the framework itself.

The phases of the Framework are interconnected. The determination of road network objectives in Phase 1 provide the input to the identification of road network functions and hierarchy and the road user driven services (Phase2). Performance monitoring of the road network (Phase 3) facilitates the identification of management options to tackle gaps in network performance against agreed targets (Phase 4). The issue for decision-makers is that of identifying the *right* set of initiatives (Phase 5) that can be subjected to an objective appraisal process to develop Network Operation Plans. The next Phase centres on the determination of priorities and allocation of funding requirements for deploying those initiatives in a comprehensive program to improve network operations (Phase 6). Phase 6 involves an iterative process with the Corporate, Investment Planning and Program Development Process, which considers the overall infrastructure and non-infrastructure requirements to develop an annual delivery program and allocation of appropriate funding. Finally, the post evaluation of initiatives against objectives is essential to the evolution of a Framework that can contribute to the realisation of expected outcomes for road agencies and road users (Phase 7).

Future infrastructure plans are an essential input to Network Operations planning in Phase 2 in the definition of the network and desired services for assessment of network performance and the identification of gaps in performance (Phase 3). This emphasises the importance of feedback mechanisms that can achieve an integrated approach to the provision and management of the road network. Similarly, this relationship is re-emphasised in Phase 6 in the development and implementation of Network Operations plans and how those initiatives could impact infrastructure investment. The result could be minor construction activities to facilitate the deployment of network management initiatives and/or the incorporation of new management initiatives in broader road construction plans. Similarly, Network Operations has a role in assisting with the implementation of regulations which could also have implication for road investment decisions (e.g. expanding the network for higher productivity vehicles through the provision of Higher Mass Limits (HML)).

The iterative nature of the process is shown in Figure 2.

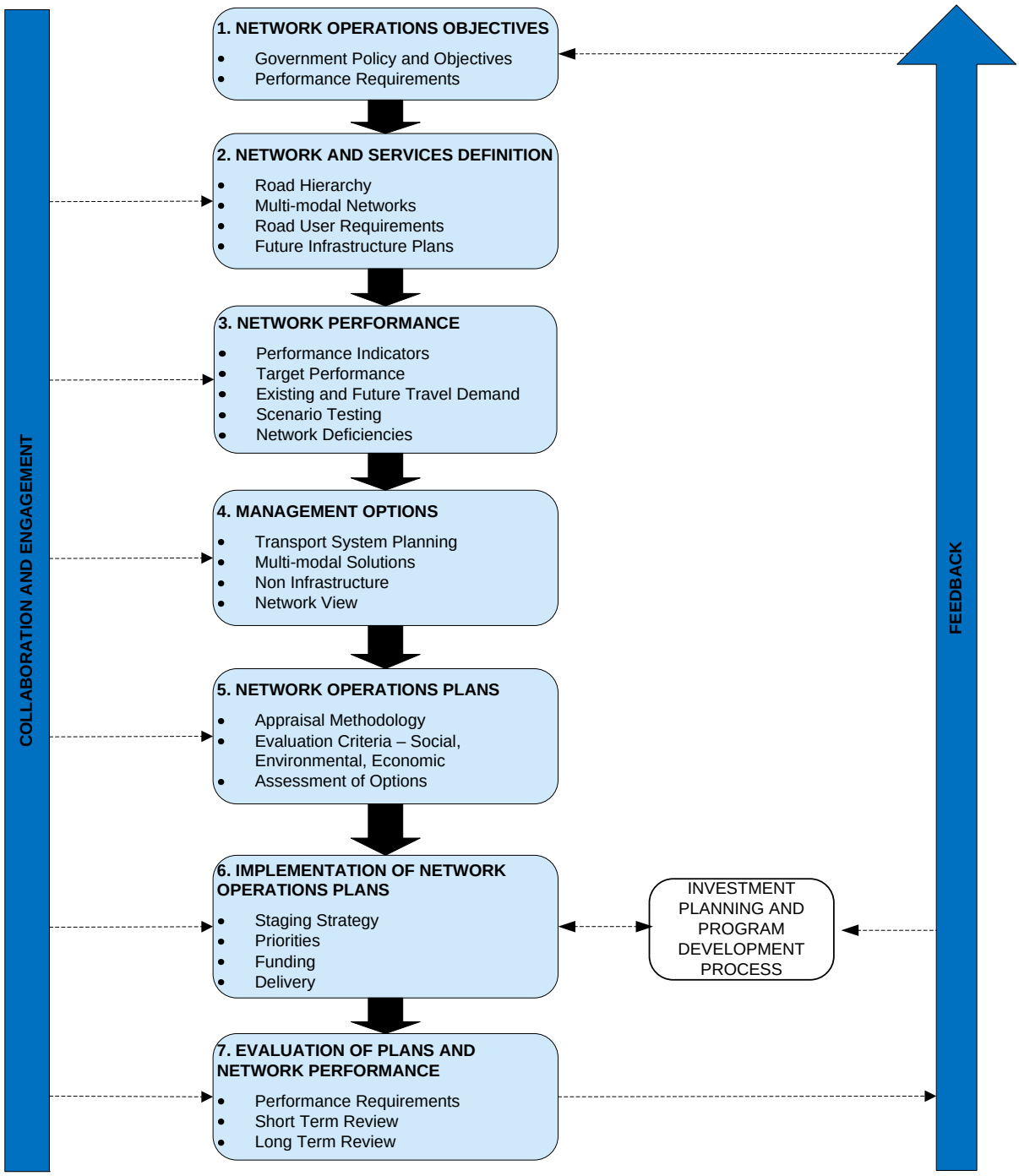

Figure 2: Network Operations Planning Framework

Phase 1: Network Operation Objectives

There is a broad range of objectives for network managers and road users that need to be incorporated into a planning framework.

Phase 1 requires the setting of clear objectives for Network Operations. In the case of WA, Main Roads has released a strategy for road Network Operations known as 'Smarter Roads Better Journeys' with the objective of 'providing user driven services to deliver reliable, safe and sustainable road access to the community' (MRWA 2006).

World Road Association (Handbook 2003) identified the objectives for Network Operations as:

- improving safety on the road network
- optimising traffic flow on arterial and freeway networks
- reducing congestion within and between cities
- co-ordinating agency traffic/transit operations
- managing incidents, reducing delays and adverse effects of incidents, weather, roadwork, special events, emergencies and disaster situations
- effectively managing maintenance and construction work to minimise the impact on safety and congestion
- informing travellers with timely and accurate information
- improving the interfaces between modes of transport for passengers and freight
- eliminating bottlenecks due to inadequate road geometry
- providing reliable and convenient public transport services.

The important issue here in developing a Framework for Network Operations is the clear line of sight through the deployment of initiatives to improve the efficient functioning and safety of a corridor to the attainment of objectives for improving the overall performance of road networks. Further, the MRWA objective for Network Operations places strong emphasis on meeting the needs of all users. Road users may be considered in terms of the business and non-business sectors. Further, the impact of transport on society needs to be part of the planning, development and management process. For example, Governments have recognised the following objectives for transport:

- providing public transport priority
- providing freight access and mobility
- managing traffic impacts on communities to preserve social amenity (e.g. strip shopping centres)
- encouraging better strategic land use and transport planning
- encouraging more sustainable transport options (e.g. cycling and walking).

This approach requires greater focus on service delivery by road agencies to meet the needs of road users and communities impacted by transport. It also means that the two components of road infrastructure and network operations are highly interconnected in their contribution in meeting the objectives set by governments for the road sector. The implication is that network operations is an integral component of planning and providing roads infrastructure. The incorporation of network operations is critical to the overall delivery of an integrated roads program that ensures:

- efficiency of infrastructure spending
- maintenance of long term productivity gain from road infrastructure
- attainment of road users needs both in the short term and long term.

Phase 2: Network and Services Definition

Definition of the geographic area, functional road hierarchy and configuration of the existing and planned road network to be analysed are defined in this phase. The desired approach should be to focus analysis on strategic corridors or areas and include arterial and regional roads, including higher order local roads.

The philosophy underpinning transport system planning is that *modal* planning should be preceded by *multi-modal* planning. Therefore, it is important to identify the priority land transport networks in consultation with transport partners. Examples include:

- transport and high activity corridors (e.g. freight access to key distribution centres)
- public transport networks (bus and rail)
- freight networks (road and rail)
- cycling/pedestrian networks (*on-road* and *off-road*).

This approach will assist in achieving more effective transport integration, consideration of key road user groups and influence the operational characteristics of the road network.

The preferred road user driven services to be delivered should also be defined at this Phase. Research of work undertaken by World Road Association indicate that the key road user driven services expected by stakeholders and the community include those outlined in Section 2.4 of this document and include, Network Monitoring, Maintaining Road Serviceability and Safety, Traffic Control, Demand Management, and Traveller Aid and User Information.

Based on an agreed road network ranking, or priority, the level of services to be deployed across the road network can be determined to best meet the needs of road user groups. The proposed ranking or priority for road use should typically be based on factors such as functional road hierarchy, traffic flow, needs of different road user groups, frequency of traffic disturbances and impact on traffic flow. The ranking could typically include freeways, major arterials and higher order local roads with the deployment of intelligent transport systems technology diminishing across this hierarchy.

Defining the hierarchy of road users across the road network is an important component of this Phase in attempting to achieve a more sustainable transport system in the longer term. To meet this objective, road managers need to address the competing demands for road space across commuters, freight operators, public transport operators, business travel, parking space provision and use. In this way, road managers can convey Government's strategic objectives into a more transparent message for road users, land use planners and the community.

Phase 3: Network Performance

This Phase deals with setting performance measures and standards linked to agreed objectives and monitoring the performance of road networks against the requirements of both road agencies and road users. This Phase will identify any gaps in performance. For this Phase, plans for infrastructure development represent an important input to the planning of Network Operations. This allows potential gaps in performance to be identified, and the role that Network Operations may play in complementing construction initiatives to address those gaps.

Road network monitoring or '*intelligence'* is fundamental to understand how the road network is operating and to assess performance. Therefore, road network operators must have continual access to quantitative and qualitative road network data, for use in *real time* or *non-real time* applications to assess current traffic demand and performance. Transport modelling is a valuable tool to help derive future traffic volume estimates, travel time, capacity etc. Typically, a planning time frame of ten years should be adopted for modelling purposes. Network monitoring comprises two essential elements:

- data collection, monitoring and modelling (to assess the impact of a proposed intervention/initiative)
- real time traffic monitoring.

Scenario testing is a very useful tool when considering alternative futures, which could influence future traffic demand. These include climate change, oil supply/fuel prices, percentage of travel by public transport, alternative modes (cycling and walking) and other demand management strategies. Scenario testing will assist in considering the flexibility of possible solutions in changing environments and also facilitate better risk management.

The indicators used to assess the performance of the road network should include a balance of economic, social and environmental factors, consistent with current approaches used by road agencies.

The Austroads (2007) National Performance Indicators (NPI) for network operations covers three categories, efficiency, reliability and productivity. To achieve a more holistic triple bottom line and sustainability assessment, three additional categories that should be considered for network operations planning include amenity (i.e. noise and vibration), safety and environmental (i.e. emissions/air quality). Austroads has developed measures for safety and there is an emerging focus on other indicators such as environment factors including climate change. The Austroads Indicators for network operations include the following measures:

Traveller Efficiency (Travel Speed) – this indicator monitors congestion in terms of speeds. It is derived from spot speeds on freeways measured directly using point sensors such as a pair of loops. On arterial roads, it can be derived from the inverse of travel times estimated from an Advanced Traffic Control system. This indicator does not use histograms for its reporting but uses a single number for each performance measurement period (all the other four indicators use histograms for performance reporting).

Traveller Efficiency (Variation from Posted Speeds) – this indicator monitors the proportions of a road network at various levels of deviations from posted speed limits on freeway or arterial road links.

Traveller Efficiency (Arterial Intersection Performance) – this indicator monitors the proportion of an arterial road network at various levels of congestion, which is defined in SCATS as the number of *Congested Minutes* in a measurement period. The relevant threshold values for identifying these congested minutes are based on stop-line detectors. For an Advanced Traffic Control system such as STREAMS with advance detectors, a different set of thresholds should be used.

Reliability (Travel Speed) – this indicator measures the variability of speeds by calculating the coefficient of variation in a manner similar to the Route Variability of Travel Time in the current NPI Program. It is displayed as the proportions of a road network at different levels of variability in a measurement time period.

Productivity (Speed and Flow) – this indicator is based on the product of speed and flow. High productivity is achieved if both speed and flow are maintained near maximum values, i.e. near free-flow speed and capacity flow. It is displayed as the proportion of a network at various levels of productivity in a measurement period.

Given that road networks have to meet the needs of different road user groups, the other issue relevant to public transport users of road networks (i.e. trams and buses) is that of modal choice, and the extension of performance indicators to cater for multi-modal journeys. This places emphasis on journey time rather than travel speed. This also has application to other non-road public transport trips (i.e. ferry and train) where vehicle access to/from public transport interchanges are part of the journey.

The importance of whole-of-journey time is an issue for policies that attempt to encourage modal shift. For example, in the case of park-and-ride initiatives, travel times as measured by travel speed on the road network would appear to be inadequate if consideration is not given to time spent (and energy wasted) searching for parking space and walking time from parking to a public transport service/interchange. For the users of public transport, modal use decisions could be influenced by inefficient changeover points between car and public transport and/or between modes of public transport. This also raises the need to have *seamless* information systems on travel across road networks and public transport networks.

This again links back to the attainment of broader government objectives such as environmental sustainability through emissions reduction and the liveability of urban areas.

Phase 4: Management Options for Network Operations

There is a wide range of options for network operations to better meet the needs of road users. The choice of specific measures in each function can vary with each agency. Some examples are listed below:

Traveller Aid and User information

- on-trip real time traffic information (e.g. congestion information, occurrence of incidents)
- pre-trip information (e.g. travel times, congestion) via internet, wireless devices, radio etc
- real time traffic monitoring/surveillance to control variable speeds, signal priority
- parking management (e.g. providing users with real time information regarding parking availability).

Maintaining Road Serviceability and Safety

- incident management, including surveillance, real time information to road users, priority access, emergency field response crews, towing contractors
- access management (e.g. emergency lanes) and road user rest facilities.

Traffic Control

- short term monitoring to provide real time response for traffic management
- ramp metering to improve motorway travel speeds
- adaptive signal control
- variable speed limits
- reversible flow lanes

- targeted minor infrastructure improvement solutions (improved merge/weaving, intersection upgrade
- automated speed enforcement.

Demand Management

- HOV facilities
- network access management (e.g. priority lanes, shoulder running, HOV lanes, freight lanes, emergency lanes)
- public transport priority traffic signal systems (i.e. PTIPS)
- parking restraints
- congestion charging
- an integrated extensive public transport system (e.g. bus priority measures, cycling facilities).

Other

- integrated transport and land use planning.

The central issue then is that of identifying and determining which initiatives should be implemented, when and where they should be implemented, how they should be packaged, and their cost effectiveness in delivering outcomes against agreed objectives. These concerns apply equally to the planning of new infrastructure and the need to incorporate network operations in the construction phase, as well as the need to improve the efficiency of use of existing infrastructure.

Phase 5: Development of Network Operation Plans

This Phase involves the assessment of Management Options identified in Phase 4 to develop Network Operation Plans. The options should be evaluated using social, environmental and economic criteria, linked to agreed objectives, in consultation with transport partners and key stakeholders. A hypothetical, simplified example to illustrate the application of the proposed Framework to develop a network operation plan is contained in Appendix A, Box 1.

The Network Operation Plans developed through this Phase of the Framework can include a wide range of network operation management measures, including minor road improvements, ITS infrastructure, new procedures and systems requirements, etc. The Network Operation Plans should be used as input to the separate road investment planning and program development process, which brings together the evaluation of infrastructure and non-infrastructure proposals and the allocation of available funding and resources.

The appraisal methodology for estimating benefits and costs, summarised in Figure 3, provides an effective methodology for Network Operations planning. The Strategic Merit Test (SMT) is designed to assess how well initiatives fit with the governments' objectives. The purpose of this Phase of the Framework is to assist decision-makers with determining the best set of options for Network Operation Plans to improve network management through the application of non-infrastructure initiatives.

The SMT identifies proposals that should proceed to the next stage of appraisal, proposals that require further scoping, and proposals that should be abandoned. Proposals subjected to the SMT should reflect jurisdictional objectives, policies and strategies. The SMT is an important first cut at assessing options to determine their strategic fit against key agency and user objectives. This step includes the use of an Objective Impact Table (OIT) to determine the relationships between options and objectives. (An example of a SMT, including an OIT is shown in Appendix A, Box 2.) This highlights the importance of seeking early advice on objectives for the transport sector, both from a provider/manager and user perspective. At a later stage if required, rapid and detailed Benefit-Cost Analysis (BCA) may be applied to assess the likely economic merits of preferred options following their successful adherence to the SMT.

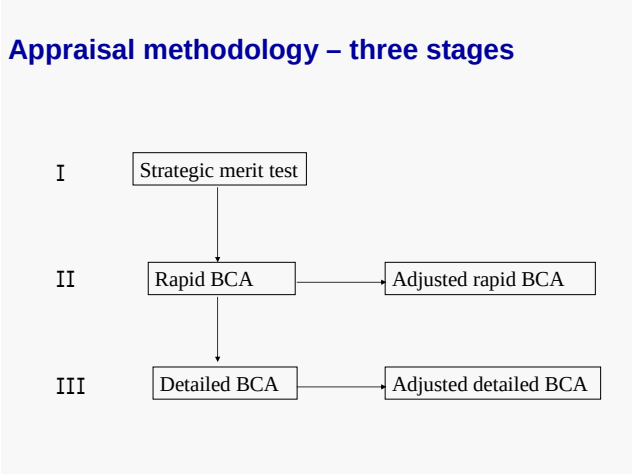

Figure 3: Approach to Estimating Benefits and Costs

Rapid BCA is intended to be a cost-effective way for decision-makers to gauge whether an initiative is likely to pass detailed scrutiny. The methodology for a rapid appraisal is the same as that for detailed appraisal, but with lower expectations about comprehensiveness and accuracy. It allows decision-makers to gain an initial feel for whether it would be worthwhile to proceed to the next phase of assessment. A key element of the BCA is the estimate of short to medium term demands for infrastructure by road users. It can also be used for the assessment of benefits to existing performance. This is essential to assessing the economic worth of an initiative in terms of its ability to generate savings in time, savings in crash costs, emissions reductions, savings in vehicle operating coats and productivity benefits from better management of existing infrastructure. (An illustration of the application of Benefit Cost Analysis is contained in Appendix A, Box 3.) For example, the Roads and Traffic Authority of NSW will generally be using road network operations to improve existing performance of the road network with a short to medium term planning horizon.

The adjusted BCA technique is an optional step and is a formal and transparent way to use a set of weightings of objectives that are different from the implicit weightings in standard BCA. Non-monetised benefits and costs can be presented to decision-makers for consideration alongside monetised (BCA) results using an Appraisal Summary Table (AST). The AST is a one page tabular summary which summarises information on the economic, environmental and social impact of an option, in monetised and non-monetised terms. An example of an AST is shown in Appendix A, Box 4. For small-scale initiatives, the detailed BCA step can be omitted.

The three-stage appraisal process can be viewed as a series of filters, as shown in Figure 4. Initiatives are fed in at the top of the process. Each filter removes some initiatives. The initiatives that pass through all filters demonstrate strategic merit and fit, and perform well in detailed appraisal.

Filter 1 – Strategic Merit Test (SMT): This is a largely qualitative assessment of the 'strategic fit' of each initiative. The SMT asks a series of questions to identify:

- how well the initiative contributes to transport system objectives, policies and strategies
- any barriers to the initiative (e.g. risk, dependence on other initiatives)
- likely sources of funding for the initiative (i.e. is a Public-Private Partnership possible?)
- whether other initiatives have been assessed in the broader context of the initiative.

Filter 2 – Rapid appraisal: Rapid appraisal (e.g. rapid benefit-cost analysis) screens initiatives that pass the SMT, but may not pass more detailed appraisal. It incorporates an indicative assessment of the main benefits and costs, without a high level of accuracy. Rapid appraisal complements, and can occur in parallel with the SMT, helping to identify information required for detailed appraisal. The Guidelines suggest that rapid BCA is applicable to all initiatives but may be sufficient for initiatives up to $10 million without proceeding to the next step of detailed BCA.

Filter 3 – Detailed appraisal: Detailed appraisal is a comprehensive analysis of the impacts and merit of an initiative. This step usually involves detailed BCA, a financial or budget assessment, and specific impact analyses and impact statements (e.g. environmental, social, regional, employment, and equity). All relevant monetised and non-monetised impacts need to be assessed. Perceived limitations of BCA have led to the development of other complementary approaches, including use of an Appraisal Summary Table (AST), and an optional approach to BCA, referred to as adjusted BCA. For most network management initiatives, it would appear that the Strategic Merit Test and Rapid Appraisal Analysis may be sufficient as it is unlikely that a Detailed Appraisal Analysis would be warranted for many management initiatives given the likely cost involved.

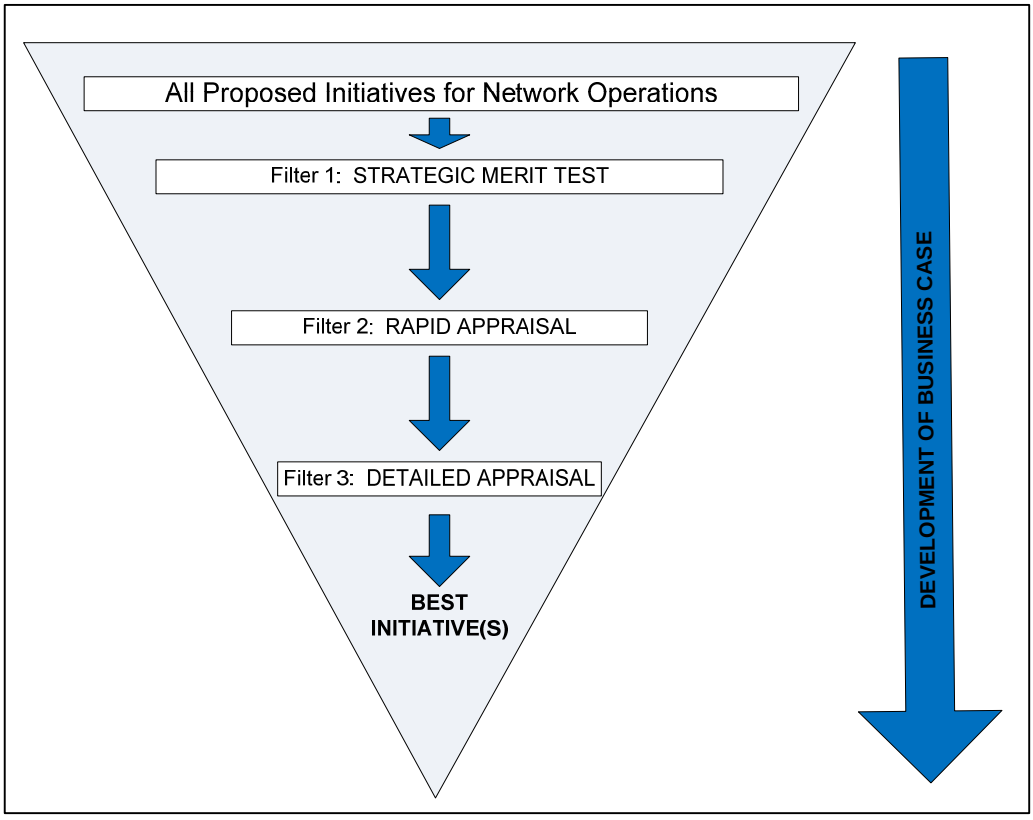

Figure 4: Filters Used to Assess Initiatives

Source: Adapted from ATC 2006.

Both quantitative and qualitative data and assessment play an important role in the assessment process. Where quantitative data are available, it can greatly assist decision-making. On the other hand, some important considerations can only be described in qualitative terms and these also need to be incorporated into the decision-making process.

The three step approach represents a process of attempting to arrive at interventions which are cost effective and meet agency and user objectives. It formalises the approach that many road agencies currently work through in assessing and implementing measures to better manage road networks. The first two steps have particular relevance in this regard. The detailed assessment of initiatives is a more rigorous part of the overall process, and requires greater alignment with approaches currently used by road agencies. However, there is an important distinction that needs to be made in terms of the respective starting points. The proposed Framework commences with a top-down approach which places initial emphasis on the network and through the use of corridor studies seeks to identify constraints to the efficient functioning of the network. In contrast, the application of traffic management systems is often location specific, i.e. there is recurrent congestion on part of the network which needs to be addressed. The critical link that needs to be established in a Network Operations sense is that between easing congestion at a specific location/link through an intervention and its impact on the broader network. The added complexity of the latter is forecasting behavioural responses by urban road users which make the assessment process more difficult than the assessment of a road upgrade in an interurban corridor. In the urban setting, road users have greater choice in their travel decisions across a network, including mode choice and route choice.

This approach can be translated and used for assessment of initiatives at corridor, route and link levels.

Phase 6: Implementation of Network Operation Plans

The aim of the appraisal framework above (Phase 5) is to assess the cost-effectiveness of initiatives in meeting the desired outcomes for road agencies and road users to develop a network operation plan. It can also be applied at corridor, route and link levels. At these levels it is designed to assist decision-makers develop corridor operating plans to improve the management of infrastructure against budget and policy constraints.

Development of network operation plans should focus on the interactions between initiatives, on-corridor (and to a lesser extent, off-corridor impacts), the need to review and potentially make operational adjustments to existing means of managing traffic flows, such as traffic signals, interactions between relevant government agencies and the potential responses by users, including mode shift (e.g. the introduction of a dedicated priority bus lane). These considerations are relevant to the development of a program of activity in terms of:

- ordering of priorities
- timing or roll-out of initiatives.

The development of a program for roll-out of the corridor operation plans based on priorities should be based on funding availability. The development of these programs is an iterative process with feedback loops as it interacts with the corporate Investment Planning and Program Development process, as shown in Figure 2. The Investment Planning and Program Development Process involves the assessment and integration of the network operation plan requirements with major capital investment proposals to develop an annual delivery program and allocation of appropriate funding. Annual programs need to consider the potential longer term impacts of changes in priorities that could result in unintended outcomes where consequential impacts are not countered by implementing planned interventions. This indicates the need for a rolling program of activities to ensure overall improvement in the operational performance of networks. Further, the outputs from an effective Network Operations Planning Framework are important elements in the development of infrastructure plans. All potential funding sources should be considered such as inter-agency and private sector sources, particularly in projects where private sector has a commercial interest (and consequently foresees opportunities for profits).

For example, in the above case of ramp metering, there could be a series of installations that need to be undertaken along a corridor to avoid the occurrence of unintended outcomes on other parts of the network. In this case, priority setting for a Network Operations program may have several dimensions:

- setting of priorities for the installation of ramp metering
- relationship between the installation of ramp metering and other ITS initiatives to improve management of the network
- relationship between network operations plans and infrastructure planning at the network and corridor levels.

This highlights the importance of a package approach that blends infrastructure and non-infrastructure solutions, as well as the packaging of non-infrastructure initiatives. In this way the benefits/impacts of individual measures are considered as part of an integrated package which helps to highlight the inter-relationships across measures. For example, improvement to traffic flow on one arterial route can provide an opportunity to improve public transport on a parallel route if they are implemented simultaneously. It is not only the blending of infrastructure and non-infrastructure initiatives that is important, but also the integration of road management initiatives that can boost the overall benefits for each mode (e.g. provision of real time information on bus movements coupled with information on availability of lockers for bicycles to encourage cycling to bus interchanges for public transport use).

Phase 7: Evaluation of Plans and Network Performance

The Framework is an iterative process – the review of outcomes requires the clear identification of objectives and performance requirements against which to assess the effectiveness of interventions deployed to improve the operational performance of road networks. This requires:

- collecting data and assembling information to continually monitor the performance of the network following the deployment of interventions (on-going activity)
- reviewing the cost-effectiveness of interventions in improving network performance (six months to two years depending on the initiatives); and
- assessing the extent to which initiatives have contributed to meeting objectives set for the network.

The purpose of the post network performance evaluation of initiatives is to establish whether or not expected outcomes were realised. This evaluation of initiatives should probably take place two years following implementation to allow broader network, or ripple effects flowing from changes in road user behaviour to settle down. This information from the evaluation of specific initiatives would then feed into the periodic review of network operations plans. A sample of initiatives should be selected for the review activity, spanning the five functional areas of Phase 3. There are two possible outcomes:

- systematic departure between expected and realised outcomes
- '*one-off*' departures.

Any significant departure between the realised and expected outcomes for a given initiative should lead to a review of the elements included in the appraisal process, such as forecast levels of demand based on expected behavioural responses or the costs of implementation. Beyond this, systematic departure across all initiatives may warrant a review of processes feeding into the appraisal phase; for example, were the needs of all road user groups properly understood on which decisions were based? It would be worthwhile to review the process after three years to accommodate changes in policies, methodologies and approaches to road system management.

This highlights feed-back loops in the Framework and the need to have a review mechanism in place that ensures delivery of network operations that meet the needs of both road agencies and road users. In the earlier example of ramp metering, an ex-post assessment may indicate a realised BCR of 20. There may be several reasons to account for this outcome:

- estimated productivity gain and time savings may have been higher than expected through an extended period of application than initially configured – after initial trialling it was realised that ramp metering should be extended beyond peak periods to cover am/pm shoulders and the inter-peak period
- while there was some expectation that private road users may change their travel patterns to avoid the location, there was an increase in use of the on-ramp as users realised time savings through improved traffic flow
- there was a greater reduction in the number of incidents following the installation of ramp metering than initially estimated resulting in additional productivity gain to the freeway, time savings and lower crash costs.

Further, the comparison of realised outcome against expected outcome provides feedback to managers on the relative merits of options for Network Operations, and subsequent deployment of initiatives. It also provides on-going information on any change in network performance as a result of new initiatives, with such initiatives adding to the stock of information for current and future management options. Changes in network performance are important to measure in order to assess the cost-effectiveness of initiatives in improving the productivity of road infrastructure. Finally, the post evaluation should provide insight on the extent to which an initiative contributed to the attainment of other objectives set for Network Operations, such as safety and environment, as well as efficiency benefits to users.

Following deployment of agreed solutions, State Road Authorities continue to monitor, review and adjust the operation of the road network on a regular, on-going basis, through Traffic Operation Centres and Customer Service Centres to assist in achieving the desired outcomes.

4 DATA AND INFORMATION

Many of the initiatives for improving the operational efficiency of road networks have the capacity to generate feed-back data to road agencies on network performance. The roll-out of network plans should provide road users, managers and operators with an improved information base with which to make more informed investment decisions. Such information should encompass road network performance information (e.g. travel times, incidents), availability of parking spaces, bus/tram schedules for multi-modal journeys (e.g. park and ride), etc. This could be integrated with information on other forms of public transport, such as rail. For example, for the traveller who has several options for journey to/from work, such information in real time could be useful in shaping travel behaviour and use of the road system: drive to work, drive to a railway station for park-and-ride, or walk/bus.

Further, such information could assist in modelling road use patterns to improve our understanding of road user behaviour. These could provide important information for our assessment of initiatives for improved management of road networks as part of the longer term development of network and corridor plans.

New sources of data and new technologies are providing Network Operations managers with options for developing measures to improve the operational efficiency of networks and to examine the relative benefits of options to reduce congestion. Specifically advances allow:

- estimates of door to door journey time based on travel times on local roads as well as main highways – this is important for developing competitive public transport options
- accurate estimation of reliability based on large sets of data together with the opportunity to estimate the influence of a variety of factors such as wet weather on journey time reliability
- estimation of the impacts of congestion on driver behaviour and vice versa for use in developing measures to improve management of the road network
- estimation of the impacts of congestion information on driver behaviour: Will the drivers change routes and if all drivers change routes what effects will that have on congestion elsewhere?

The importance of data/information to Network Operations is stated clearly by Main Roads WA (2008):

> *A critical element of network performance phase is the availability of current, accurate, reliable and 'real time' network operation data and information. Road data collection and analysis should be driven by the agreed performance indicators. The road data needs can typically include traffic volumes, travel speed, travel time, vehicle classification, crashes, incidents, flooding, system faults (i.e. traffic signals), freight tonnage, customer satisfaction surveys, environmental (air quality and noise). Access to, and use of appropriate and reliable systems, databases and analysis tools is essential to undertake these tasks.*

Analysis of future traffic demand is also important. Scenario testing is a very useful tool when considering alternative futures which could influence future traffic demand. These include climate change, oil supply/fuel prices, percentage of travel by public transport, alternative modes (cycling and walking) and other demand management strategies. Scenario testing will assist in considering the flexibility of possible solutions in changing environments and also facilitate better risk management.

5 CONCLUSIONS

This report has sought to develop a national approach to a Network Operations Planning Framework. Processes in place by jurisdictions and by Austroads have been taken on board in preparing this Framework. The Austroads National Performance Indicators and the congestion performance measures currently being developed for the Australian Transport Council could form the elements necessary to monitor the health of urban road networks. These could be used to assist the decision-making on initiatives for network operations by road agencies.

The Network Operations Planning Framework is applicable to both urban and non-urban sub-networks. For example, for inter-urban/regional travel, applications could include traveller information, remote flood monitoring facilities, advice on the provision of rest areas for fatigue management, information on major incidents, and monitoring of heavy vehicle movements with higher mass limits for asset management.

The Framework has also attempted to show the importance of the inter-relationship between infrastructure plans for the construction of new road projects and the role of network operations in that planning and implementation process. In some cases, the deployment of non-infrastructure options to improve the productivity of road links may allow construction to be deferred until an optimal point is reached in capacity utilisation beyond which part of the network is saturated, and construction is then warranted. This is an iterative process over time and space combining infrastructure and non-infrastructure solutions.

The Framework provides road network managers, planners and operators with sufficient guidance, without being too prescriptive, to facilitate '*best practice'* and a consistent approach to planning for road Network Operations to achieve desired outcomes. However, there appears to be limited examples of comprehensive Network Operations Plans. Therefore, it is suggested that through ongoing collaboration of State Road Agencies and application of the Network Operations Planning Framework a more detailed outline for a Network Operation Plan could be developed to achieve a more consistent and national approach. Further research could be directed toward the development of corridor operating plans which could cascade from the Framework.

APPENDIX A

Box 1: Development of Network Plans

Issue: Access by heavy vehicles to freeways from key distribution centres in urban areas. Development of long queues for heavy vehicles onto freeways from distribution centres contributing to high vehicle operating costs, increased emissions and reduction in safety.

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Phase 1 – Identify Government's Objectives: i.e. Improve the efficient movement of goods; Provide a safe transport system; Promote transport sustainability.

- Performance of the network not meeting Government's objectives or expectations of road users
- Key target group identified as road transport operators.

Phase 2 – Key access routes identified, including freeways, major arterial road and heavy vehicle routes as well as principal road user group, and agreed service levels for time of day.

Phase 3 – Performance measures developed and applied to assess performance gap for key access routes

Phase 4 – Management options identified, including consultation on plans to upgrade infrastructure at key locations on the network, improved freeway access control, improved traffic signal control on arterial roads and improved traveller information. Consultation on options to determine best fit of measures to address the problem. Consultation with road transport operators and shippers on plans to expand capacity and number of key distribution centres.

Phase 5 – Assessment of options to determine which initiative or package of initiatives is cost effective in meeting objectives.

Phase 6 – Identification of priorities for implementing initiatives across the network based on gaps in performance, volumes of freight flows, dollars required to roll-out program over agreed time period.

Phase 7 – Assessment of impact of initiative in meeting objectives, and efficiency of process.

Box 2: Application of the Strategic Merit Test

Issue: Access by heavy vehicles (HV's) to urban freeway during peak periods.

Problem: Access ramps convey significant flow of heavy vehicle traffic to/from important urban distribution centres. HV's (including B-doubles) transport inputs and outputs to/from the centres across the network. The high volume of HV traffic entering freeways has resulted in major bottlenecks along access roads due to banking up of traffic entering freeways and long delays to road users.

Options: The road agency responsible has proposed the installation of ramp meters to manage traffic flow onto freeways following internal consultation on the cost of extending merging lanes. Local councils have opposed the proposal and intend to impose restricted access regimes on heavy vehicles using local roads to non-peak times. This will cause serious disruption to industry dependent on those freight movements. The three options (and estimated costs for each location) to address the problem are:

- Restricted hours of access (signage cost of $25 000)
- Ramp metering to manage traffic flows (installation and monitoring cost of $600 000)
- Extension of the merging lane for traffic entering the freeway (construction cost of $200 000).

Does the proposal have strategic merit? A comparison of the three options against Government's objectives is summarised in the following Objective Impact Table.

Strategic Objective	***Restricted Access***	***Ramp Metering***	***Extended Merging Lane***
Economic efficiency	--	++	+
Safety	+	++	+
Social amenity	++	+	+
Environment	+/-	+	+
Industry productivity	-	+	+

[Scoring: --/++: highly negative/positive; -/+: negative/positive; 0: no discernible impact.]

On this basis, the management of traffic flows through ramp metering would appear to have the highest strategic merit in its contribution to government's objectives for the road network.

In terms of other aspects of the SMT:
- Have other options been considered to address the problem?: YES
- Is there potential for private funding?: NO
- Is the access issue of strategic importance to the local/state economy?: YES

Conclusion: The proposal to implement ramp metering to address the access problem for HV entering freeways has strategic merit, and should be taken to the next step of rapid BCA.

Box 3: Application of Rapid Benefit Cost Analysis

Issue: Access by heavy vehicles to urban freeways during peak periods.

Option: Installation of ramp metering to facilitate access by heavy vehicles entering urban freeways during peak periods.

Estimated Cost: The road agency responsible has estimated the cost of installation at $600 000 and the total annual operating cost at $45 000 for the first year of operation for each location (10% on the IT component of $300 000 and 5% on the road infrastructure component of $300 000).

Estimated benefits: The key variables relevant to the estimation of benefits include: time savings and road network productivity gain, reduction in crash costs, reduction in vehicle operating costs, and reduction in the cost of emissions. From Australian and international experience the estimation of the annual benefits is summarised in the following Table.

Source of Benefit	***Method of Estimation***	***Estimated benefit ($m)***	***Contribution to total benefits (%)***
Time Savings and Productivity Gains	▪ Current and forecast traffic volumes using the link ▪ Savings in time delays experienced by road users and cost of time by type of road user (i.e. business $40/hr; private $13/hr) – Austroads 2008 ▪ Estimate savings on infrastructure expenditure resulting from additional link capacity (i.e. lane equivalent traffic throughput)	8.03	83
Safety	▪ Crash rates by type (fatal, serious, minor, PDO) using *National Guidelines* (2006)	0.58	6
VOC Savings	▪ Reduction in fuel usage and other vehicle costs using *National Guidelines* (2006)	0.68	7
Environment	▪ Reduced fuel contributes less emissions using *National Guidelines* (2006)	0.39	4
TOTAL		9.68	100

The estimated average ***Benefit Cost Ratio*** per location from the initiative to install a ramp metering system on the access ramp to urban freeway network averages around 15 (= 9.680/0.645) . The high return from the investment would justify its installation. While single year analysis was used here, the time horizon for ITS investment is usually about ten years by which time advances in ITS technology warrant replacement.

Box 4: Appraisal Summary Table

Name of Initiative: Access by heavy vehicles to urban freeways during peak periods.

Description: Installation of ramp metering to facilitate access by heavy vehicles entering urban freeways during peak periods. The road agency responsible has estimated the average cost of installation at $600 000 and the total annual operating cost at $45 000 for the first year of operation (10% on the IT component of $300 000 and 5% on the road infrastructure component of $300 000).

Base Case: Access ramps convey significant flow of heavy vehicle traffic to/from an important city industrial centre. Heavy vehicles (including B-doubles) transport inputs and outputs to/from the centres. The high volume of HV traffic entering freeways has resulted in major bottlenecks along access roads due to banking up of traffic entering freeways servicing key distribution centres and long delays to road users.

Other Options: The options (and average estimated costs for each location) to address the problem are:

- Restricted hours of access (signage cost of $25 000)
- Ramp metering to manage traffic flows (installation and monitoring cost of $600 000)
- Extension of the merging lane for traffic entering the freeway (construction cost of $200 000).

Strategic Plan Objectives	***Impacts***	***Qualitative Description***	***Quantitative Assessment ($m)***	***Qualitative Assessment***	***Confidence***
	Capital costs	Construction and installation	0.600		High
		Operating costs per year	0.045		High
Economic Efficiency, Industry productivity and Reliability	Journey times	Current and forecast traffic volumes using the link	8.03		Medium
		Savings in time delays experienced by road users and cost of time by type of road user (i.e. business $40/hr; private $13/hr)			Medium
	Infrastructure funding	Estimate savings on infrastructure expenditure resulting from additional link capacity		Positive	High
	VOC's	Reduction in fuel usage	0.68		High
Social		Crash types by fatal, serious, minor, PDO	0.58		Medium
Environmental		Reduced fuel contributes l4 less emissions	0.39		High

RECOMMENDATION: Initiative contributes to meeting Government's economic, social and environmental objectives. It has strategic merit. High BCR (average 15). Complements road infrastructure plans and other management initiatives. **Implement initiative.**

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Key Words

Road Network Operations, Infrastructure, Infrastructure Management, Framework, Transport Planning, Performance Indicators

Abstract

The increase in the demand for transport services which is forecast to continue into the foreseeable future has placed greater focus on infrastructure and non-infrastructure solutions to meet that demand. Further, there is growing recognition of the importance of incorporating non-infrastructure solutions into the planning of new infrastructure in order to preserve productivity gains into the longer term through better management of the supply of and the demand for infrastructure. The purpose of this paper is to develop a high level reference document as a Framework to assist Network Operations planning.

The purpose of a framework for Network Operations is to assist network managers to monitor the performance of road networks, identify gaps in performance and service delivery, and determine which measures may best address those gaps most efficiently against the needs of a broad range of road users. The Framework is designed to facilitate the attainment of objectives for both the road agency and road users, while recognising that the needs of road agencies and road users may often conflict. The Framework also plays a key role in infrastructure planning by aiming to enhance the longer term efficiency with which we use our road infrastructure.

The seven key steps, outlined in this paper, that should be included in a Framework for Network Operations are:

- network operations objectives and scope
- network and services definition
- network performance
- management options for network operations
- development of network operation plans
- implementation of network operation plans
- evaluation of plans and network performance.