Compendium on Good Practices of the Efficient Operation of the Road Network

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on behalf of REAAA Technical Committee

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REAAA is the Road Engineering Association of Asia and Australasia. The association promotes the science and practice of road engineering and related professions in the Asia Pacific region through the development of professional and commercial links within and between countries in the region.

REAAA was set up in June 1973 with a permanent secretariat in Malaysia. It has more than 1,500 members in 37 countries. It holds regular events including an annual heads of road authorities (HORA) meeting, a triennial international conference, technical visits and study tours, trade exhibitions, seminars, forums and workshops. It also publishes a Journal twice a year and a regular Newsletter.

Local REAAA Chapters have been set up in Australia, Brunei, Korea, Malaysia, New Zealand and the Philippines. REAAA is also active in Indonesia, Japan, Papua New Guinea, the Pacific Islands, Singapore, Taiwan, Thailand and Vietnam.

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SUMMARY

Attaining congestion-free and smooth road traffic supporting a vital and environmentally-friendly society is a common challenge among the REAAA member countries. From the viewpoint of making the most out of a limited budget and human resources, the efficient operation of existing road networks fully utilizing ITS and other innovations is expected to become increasingly important.

This Compendium presents 21 examples of good practices addressing the challenges that member counties face in terms of the efficient operation of the road network, the measures taken, and the effects or outcome of the measures. In particular, the Compendium highlights how ITS and other innovations have been effective in optimizing traffic flow and in increasing capacity at roundabouts, ramps and toll plazas, thereby alleviating congestion.

Through the various good practices contained in this Compendium, it is clear that the greatest challenge the Asian and Australasian countries have in common is the achievement of optimum traffic flow on road networks that achieve mobility of the road users.

It is also clear that each country has taken various measures to address this challenge, taking into consideration unique environment and operation conditions. Some common measures have been implemented, however, which have demonstrated significant effects in terms of smoothing traffic flow. These measures include:

- enabling drivers to make better travel choices by providing traffic information (Australia, Japan, and Singapore)
- controlling traffic flow by toll incentives (i.e. road pricing) (Japan and Singapore)
- optimizing traffic flow using traffic signals adjusted to real-time traffic demand (Australia, Brunei, Korea, New Zealand, and Singapore)
- improving traffic flow at toll plazas through the ETC system (Japan and Malaysia)
- enhancing road networking effects through the development of road structures (Indonesia, Japan, Malaysia, The Philippines, Sri Lanka, and Thailand).

Although some countries noted that the rapid increase in traffic has been hindering the effective management of traffic flow, only one country (Singapore) has introduced a drastic measure to cope with this matter. Vehicle ownership in Singapore is managed by a vehicle quota system that has kept the net increase in the number of vehicles at 3% (per year) for many years since its inception in 1990. It has recently been revised to 1.5% per year, for 3 years, from 2009.

In terms of the efficient operation of the road network, road traffic policies and measures are implemented with various objectives such as reducing travel time and associated road user costs, improving safety, and improving the environment. Among these objectives, it is suggested that measures be taken to pursue the optimization of traffic flow because optimum traffic flow will also lead to the solution to all the issues. Furthermore, it should be noted that there is no single, simple solution toward achieving optimum traffic flow and that a range of measures may need to be implemented to further enhance the effects.

As the technology for road development and traffic operation is rapidly progressing, a framework needs to be established which enables member countries to share information on the latest technology created, implemented into practice, and to develop the most effective measures derived from this information.
It is recommended that a web-based database be developed which contains examples of good practice that each member country believes can be utilized as a basis for the development of good policy related to road development projects or traffic operation in the future. Examples of good practice will be listed along with details of the person who countries can contact for further details.

The REAAA Secretariat would maintain the database and ask member countries to update their existing good practices and add new ones periodically (i.e. each year).
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1 INTRODUCTION

Attaining congestion-free and smooth road traffic supporting a vital and environmentally-friendly society is a common challenge among the REAAA member countries. From the viewpoint of making the most out of a limited budget and human resources, the efficient operation of existing road networks fully utilizing ITS and other innovations is expected to become increasingly important.

The topic Efficient Operation of Road Networks was discussed at the 7th Heads of Road Authorities (HORA) meeting in Tokyo in June 2008. Twelve member countries reported good practices relating to the theme and measures taken to address them.

This compendium contains 21 case studies, categorized under the following four topics:

- improvement of existing road structures
- smoothing traffic flow utilizing ITS
- transportation demand management
- the development of road networks.

Material has been prepared by authors from Australia, Brunei, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore, Sri Lanka and Thailand.

The material contained in this Compendium serves as guides when considering policies and measures relating to the efficient operation of road networks throughout the region. In terms of outcomes, the Compendium is promoting, as a number of the infrastructure management studies have addressed, many aspects of efficiency, e.g. shorter journey times and associated road user costs, safety, asset preservation and vehicle operating costs.

It is hoped that this Compendium will trigger and promote the active exchange of information regarding each country’s efforts toward achieving efficient operation of their road networks, and that it will assist countries in the Asian and Australasian region to address their challenges in a more efficient and effective manner.
2 IMPROVING EXISTING ROADS

2.1 Brunei: Easing Traffic Congestion and Improving Environment by Road Network Operation

2.1.1 Peak hour congestion at roundabout

Brunei has a population of about 360,000 and a car ownership of 210,000. The proportion of car ownership is therefore relatively high, at 0.6 cars per capita (2008). This reflects the local culture of using private cars for daily transportation. Though traffic congestion is currently restricted to peak hour periods only, there are certain at-grade intersections (roundabouts) that require modification to ease peak hour congestion. One such location is the Beribi Roundabout, which is situated on the outskirts of the main town and capital centre. Morning congestion occurs due to traffic from residential towns travelling to the centre to attend schools and workplaces. The evening peak corresponds with people returning home.

Initial observations suggested that the Beribi Roundabout was operating at or above its practical capacity. The variation in traffic flow was also complex with unbalanced approach flows; it was operating efficiently under priority control outside the peak periods but not during the peak periods. Peak periods were morning (06:15-08:15), midday (11:30-14:30) and evening (16:15-18:15).

2.1.2 Measures taken to address this problem

Using control selection criteria for assessing various options to alleviate congestion, a signalised roundabout was proposed as shown in Figure 2-1. A base micro-simulation model was developed using S-Paramics software (Figure 2-2) to cover the three peak periods. The model was calibrated for turning counts, queues and delays or journey times. It also considered driver behaviour to ensure that the model approximated reality. The calibrated base model identified a set of optimised signal timings (Figure 2-3). As a result, two of the three arms were given simultaneous green times for short periods. The green time and the build-up of vehicles within the circulating carriageway needed to be balanced.

Figure 2-1: Signalised roundabout option
2.1.3 Effects of introducing signalisation at the roundabout

As a result of the refined adjustment to signal timings on the north arm during the morning peak, vehicular queues have been drastically reduced. The introduction of the fixed time signal timings resulted in an improvement in the performance of the roundabout. With the addition of vehicle actuation or SCATS and appropriate logic algorithms, performance should be even better. Additional measures to enhance performance and safety include revised geometry to increase storage areas, and dedicated bypass lanes. One such bypass (Figure 2-4) was constructed on the north arm and this resulted in reduced congestion on the approach to the signalised intersection.
2.2 Indonesia: Flyover Construction for Grade Separation at Railway Crossing/Congested Urban Area

2.2.1 Background

The current serious traffic congestion issues in Indonesia are related to increasing traffic volumes, the presence of railroad crossings, and the conflict with business and similar activities at the roadside.

Presidential Order No. 13 and Ministerial Order No. 53 require grade separation when highways cross railways. In line with these orders, there was a need to upgrade the North Java Corridor into a more efficient thoroughfare. Out of eight flyovers candidates, six were selected as high priority options.

2.2.2 Alleviation of traffic congestion by grade separation

Flyovers are generally constructed above busy intersections or railway lines. They are often used in Indonesia when roads cross railway lines. Frequent accidents at railway crossing and serious traffic congestion are national issues, and the provision of flyovers is an efficient countermeasure. Taking into account the rapidly increasing traffic volumes and the number of train movements, grade separation at railway crossing is needed at more locations, especially in Java Island.

2.2.3 Seismic design concept of flyover

Indonesia is located in a seismic-prone area and flyovers located in urban areas must be earthquake-proof structures. This requires:

- the provision of a highly ductile flyover structure:
  - increase structural ductility capacity to improve seismic response behaviour
  - geometrical considerations (effects of foundation flexibility, structural displacement ductility factor)
- improvement to the transverse confinement system, e.g. the provision of a steel-concrete composite column
- the provision of an integrated flyover structural system:
  - ensure that substructures and superstructure are fully integrated
  - the entire flyover system should be integral, not the simply-supported type
  - any local damage of substructure should not cause the bridge to collapse.

The planning and design of a flyover in urban areas must be made with the following priority requirements:

- fast construction and minimum disturbance during construction
- seismically strong and sustainable system
- aesthetically designed concept
- environmentally sensitive (less excavation, less noise, etc.)
- simple foundation construction in urban areas
- avoid large excavation areas for the pile cap.
The design of the bored pile is depending on sub-soil conditions. If the soil is soft, then stabilising the soil with cement soil should be considered. Various foundation types are shown in Figure 2-5.

2.2.4 Conclusion

More than 100 railway lines which intersect with roads are soon to be grade separated in Java Island. Several new concepts will be applied to flyovers to be installed in North Java. There should be a medium/long term program to implement grade separation at railway crossing to improve traffic flow at critical areas, with the aim being to have no accidents at railway crossings. Flyovers in urban areas or at railway crossings should be designed with sufficient earthquake-proof provision. New flyover concepts will be further developed based on the North Java Flyover Project.

2.3 Japan: Road Space Re-Allocation for a Safe Cycling Environment

2.3.1 Increasing bicycle-related accidents

In general, modal share of bicycles is higher in Japanese cities than in Western cities. However, when designing a road structure, bicycle traffic is rarely taken into consideration, being treated as pedestrian traffic on sidewalks. Many roadways do not have adequate space for cyclists to ride safely. This causes cyclists to ride on sidewalks for their own safety, thereby increasing conflicts with pedestrians as well as causing pedestrians to complain that they cannot walk safely. This is supported by the fact that the number of accidents involving cyclists and pedestrians has increased five-fold compared with the number of accidents ten years ago (Figure 2-6). Bicycle-related accidents are now one of Japan’s main social issues.
2.3.2 Measures taken to address this issue

An example of a ‘hard’ measure is shown on the left-hand side of Figure 2-7. Pavement markings that read ‘keep left’ and show bicycle rider symbols are placed on a roadway to clarify where to ride a bicycle. This measure also has the effect of making drivers more alert of cyclists riding in the same lane.

Measures to improve cyclists’ manners are also necessary. An example of a ‘soft’ measure is shown on the right-hand side of Figure 2-7. Police officers, in cooperation with local residents, instruct cyclists where to ride.

The implementation of both types of measures is expected to reduce the number of accidents.
2.3.3 Survey of pedestrians and cyclists

Cyclists and pedestrians were surveyed before and after the bicycle lane was provided. The results clearly showed that the measures had an effect on pedestrians’ and cyclists’ sense of safety when either walking on the sidewalk or riding on the roadway. The percentage of pedestrians who felt ‘very safe’ or ‘safe’ increased from 15% to 70% after the implementation of the measures. The percentage of cyclists who felt ‘very safe’ or ‘safe’ riding in the roadway also increased, from 21% to 36%.

Simple measures such as the re-allocation of existing road space can improve the road environment for both pedestrians and cyclists.

2.4 Japan: Introducing Smart Interchanges

In many urban areas in Japan there are situations where a road is heavily congested while a parallel expressway is not. This means that the road network is not operating effectively. In addition to tolls, limited accessibility discourages drivers from using expressways. In Japan, expressway interchanges are, on average, located at 15 km intervals, which is twice the distance typical of Western countries. Drivers are less likely to go out of their way to use a distant interchange, preferring to drive on congested general roads. While the provision of additional interchanges would enhance accessibility to expressways, additional interchanges have not been constructed as their construction involves large costs and land acquisition.

Recently, a less costly measure to construct additional interchanges has been developed. As shown in Figure 2-8, a so-called ‘smart interchange’ is constructed at an existing rest area with an approach road that links it to general roads. Tolls are collected at an electronic toll collection (ETC) gate, which permits only vehicles equipped with an ETC unit to pass through. The construction of a smart interchange does not require large facilities or personnel to collect tolls. As a result, smart interchanges can be introduced and operated at a much reduced cost compared with conventional interchanges. By June 2008, 31 smart interchanges had been introduced, with a total of 200 to be constructed over the next ten years.

2.4.1 Effects of introducing smart interchanges

Figure 2-9 illustrates a case in which the introduction of a smart interchange helped alleviate congestion on a general road. After the introduction of the smart interchange, the queue length at an intersection located near an existing interchange decreased by 60% during the morning peak hours. This indicates that drivers who previously used the existing interchange now use the smart interchange, thus helping disperse traffic and mitigate congestion.
Smart interchanges also have the effect of revitalizing the local economy in the local area, as drivers are likely to shop and dine there.

![Queue length on a general road near an existing interchange]

Figure 2-9: Queue length on a general road near an existing interchange

2.5 Korea: Capacity Improvement Using Shoulder Lanes on Expressways

2.5.1 Introduction

Congestion is a common problem on Korean Expressways. Approximately 10% of the 3,000 km length of expressway in Korea experiences continual congestion. It is estimated that this congestion costs approximately US$2.3 billion per year, which represents 10% of the total congestion costs in Korea. As the total length of highways and streets in Korea was about 103,000 km in 2007, it can be said that the cost of congestion associated with 300 km of expressway is equivalent to 10% of the congestion cost associated with 103,000 km of highways and streets.

Most of the congestion is associated with lane closures or ramp merges. A lane closure can cause a bottleneck phenomenon which changes the characteristic of approaching traffic. When the mainline traffic volume approaches lane capacity, and the geometry of the ramp does not allow for smooth merging manoeuvres for vehicles entering the mainline, the ramp merge usually becomes a congestion point.

Common approaches to addressing such situations include lane control, ramp metering and widening of the freeway line. These might cause disturbance to the highway network as well as involving large resources, being time consuming, and inducing high costs. Another option is to utilize the shoulder’s line, which can be the most cost-effective among those alternatives.

The principle of shoulder-lane utilization is simple. It extends the length of the merging lane to make it possible for drivers to manoeuvre smoothly when they are entering the mainline. It reduces the bottleneck associated with the merging and provides adequate time for the merging traffic to adjust their speed to the downstream-mainline traffic. Higher speeds when merging also lead to an increase in the capacity of the ramp. Generally, the merging point of a ramp with a relatively high longitudinal slope has a severe capacity reduction problem. If the merging point is moved to a flat section of the shoulder lane, then the problem can be eliminated.
The general characteristics of shoulder lane use in Korean expressways are shown in Figure 2-10. The lane control system (LCS) is showing an ‘X’, meaning the vehicle is not allowed to pass. An sign enforcement camera is installed on the top of the sign. The older pavement, which was supposed to be an area for emergency vehicles, was replaced with mainline-type pavement.

Characteristics:
- merging point shift (speed/volume increase)
- lane control system (LCS) with signal
- enforcement camera
- pavement reinforcement

2.5.2 Application of shoulder lane utilization in Korean expressways

Shoulder lane utilization has been applied in two freeways in Korea: 4 km from Singal IC to Jukjun SA (Figure 2-11) and 5.6 km from Yoju IC to Yoju JCT. There was increase of one lane because of the addition of the shoulder lane. The merging point shifted 4 km downstream of the existing merging point.

The incorporation of shoulder lanes has resulted in an increase in the capacity of the expressway, considerably reduced queue lengths of the merging vehicles and improved through speeds on the expressway. Even though the increase in maximum capacity is not clear it can increase the sustainability of expressway capacity. Statistical analysis of the application of shoulder lane utilization in both cases showed that the queue length decreased by half and the throughput speed increased from 45 km/h to 64 km/h (Figure 2-12).
2.5.3 Future plans

Two pilot projects of shoulder lane use have been successful. Ten more sections of freeways were equipped with a similar system in 2008. Important lessons have been learned from the implementation of shoulder lane utilization including:

- an advanced and detailed engineering study is required before implementation
- as enforcement signals are important for controlling the shoulder lane use, cooperation and enforcement from the police is needed
- expansion and improvement works should be planned following the implementation of the system.

2.6 Malaysia: Improvement of Existing Road Structure – SMART Interchange

Founded in the late 19th century, Kuala Lumpur is Malaysia’s largest, fastest growing and most important city. Most of the area has been built-up into townships, residential estates and industrial parks. Because of the intensity of development, the impact of flooding is increasing each year, as the city’s drainage system is unable to cope with frequent flash flooding. There are also severe traffic jams on the main southern gateway to the city centre from the south (KL Seremban Highway) and west (Federal Highway) during peak hour.

To overcome the flooding and congestion problems, a double-decked motorway bypass tunnel, approximately 3 km long, was constructed. It commences near the Kg. Pandan roundabout and ends near the Jalan Istana Interchange at the Kuala Lumpur-Seremban Highway. The motorway is connected to existing road networks by ingress and egress connection links to Jalan Tun Razak, Jalan Sultan Ismail and Kuala Lumpur Seremban Highway. The SMART tunnel will work on the following three-mode system.

- Mode 1: normal conditions – when there is low rainfall and no storm; the motorway is open to traffic
- Mode 2: moderate storm - the SMART system is activated and flood water is diverted into the bypass tunnel in the lower channel of the motorway tunnel; the upper channel is still open to traffic
• Mode 3: storm - the tunnel is closed to motorists; once all vehicles have vacated the tunnel, automatic water-tight gates are opened to allow flood water to pass through.

2.6.1 Outcome of SMART interchange

The SMART tunnel provides an alternative route for motorists from the Southern Gateway entering and exiting the city centre and reduces traffic congestion in the city, especially along Jalan Sg. Besi. The results of a study conducted by the Highway Planning Unit (HPU) of the Ministry of Works to quantify the benefits of the project are summarised in Table 2.1. It was found that the SMART tunnel led to a reduction in the average travel time from the Southern Gateway entering and exiting the city centre by 2 minutes. The SMART system was also shown to be successful after it managed to divert up to 500,000 cubic meters of floodwater from the Klang River to the holding pond in September 2007. This saved the city from another flash flood. It has also led to a reduction in the level of flood waters at the Jalan Tun Perak Bridge, preventing spill-over during heavy downpour.

2.7 New Zealand: Ramp Signalisation on the Auckland Motorway Network

2.7.1 Increasing traffic issues on the Auckland motorway network

The Auckland motorway network comprises 195 km of roading infrastructure. It carries nearly 50% of all road journeys and caters for major trucking and freight traffic. Traffic on Auckland motorways is invariably growing, resulting in significant congestion, higher emissions and road user costs and increasing traffic safety issues. Action is needed to effectively operate and manage the traffic on the motorway network as this is vital to the overall performance of the network. Existing adverse traffic conditions, especially during peak periods on the motorway network in Auckland City, clearly show a need for better travel demand management of the traffic on the Motorway.

2.7.2 Auckland motorway ramp signalling project

In 2004, the New Zealand Transport Agency (NZTA), in association with the several road controlling authorities in Auckland, investigated how to use advanced traffic management, traveller information and access control (ramp signalling) as tools to provide optimum travel demand management. As a result of the findings of this study the NZTA launched a project examining the construction of ramp signals on all the on-ramps on the Auckland Motorway network. A photograph of a new ramp signal system is shown in Figure 2-13, while the extent of the ramp signalling project is shown in Figure 2-14.
This fully collaborative project has led to improved network management to better deal with congestion, the creation of consistent travel times, reductions in costs and emissions and easier and safer travel for road users. The implementation of ramp signalisation has allowed the effective use of the existing motorway infrastructure by controlling the flow of traffic entering the motorway network; a queue which can be controlled to achieve optimum flow and capacity on the network.
The system enables the smoother entry of vehicles onto the motorway by spacing incoming vehicles evenly, thus increasing merge efficiency. Selected priority bypass lanes have been incorporated into the system to enable high occupancy vehicles and heavy commercial vehicles to merge safely and efficiently.

The system is designed to be alive and dynamic as it only operates when it is useful; it is turned off when not required. This is achieved by feeding traffic information by continuous measurement of all wait times and queue lengths using specific detectors and cameras at the on-ramps and the network as a whole. As a result, the system is equipped to micro-manage all coordination and timings through the use of an automated controlling algorithm which balances motorway throughput and operating speed against the real time traffic information it receives.

For example, if a queue length is growing on a particular on-ramp, the algorithm automatically increases the discharge rate to compensate for this. It will also adjust the flow on other nearby ramps to assist in dissipating the queue whilst maintaining maximum flow and capacity of traffic on the motorway network.

2.7.3 Project outcomes and performance

The introduction of ramp signalling has had a significant positive impact on the performance of the Auckland motorway network. To date, 26 ramp signals have been commissioned and are operating successfully. Data gathered has shown the following results since these portions of the system were commissioned:

- 18% increased throughput
- 22% shorter overall journey time
- 14% rise in travel speeds
- 91% better reliability
- 24% fewer accidents
- 6% reduction in fuel use
- 17% less CO emissions
- 13% reduction in hydrocarbons.

In the busiest sections of the Southern Motorway, where ramp signals have been commissioned in the southbound direction between the central city and the Ellerslie-Panmure, Mt Wellington and East Tamaki Interchanges, peak period traffic flows have been significantly improved with shortened periods of congestion. The motorway is carrying significantly more traffic during peak periods than before and speeds have increased.

Figure 2-15 illustrates a case of how ramp signalling has been effective in increasing capacity and reducing the travel time of commuters travelling south between Hobson and Market Rd. This is the heaviest loaded section of the motorway compared to the rest of the network. This section has increased its throughput by 400-600 veh/hour (+13%) and improved travel speeds by 10 km/h (+16%). Individual ramp volumes have also increased by approximately 100 veh/hour, resulting in homeward evening commuter traffic being cleared 20-30 minutes earlier than before the ramps were installed.
Figure 2-15: Ramp signals off (left); ramp signals on (right)
3 SMOOTHING TRAFFIC FLOW UTILIZING INFORMATION TECHNOLOGY

3.1 Japan: Electronic Toll Collection (ETC) System

Although the motorization of society has brought affulence, traffic congestion on expressways has become a serious problem. To address this issue, a new highway network has been constructed in Japan and highways have been widened.

Recent research revealed that approximately 30% of the congestion on expressways occurred near toll gates and that the main reason for this congestion was insufficient toll plaza capacity (Figure 3-1). It was therefore decided to introduce the ETC (Electronic Toll Collection) system.

The ETC system enables speedy toll collection because tolls are collected without vehicles having to stop, thereby reducing congestion. The ETC service commenced in Japan in March 2001. As shown in Figure 3-2, the number of vehicles using ETC had rapidly increased to approximately 5.37 million vehicles a day by June 2008, or about 74.2% of all vehicles that use toll expressways. Vehicles on the Tokyo Metropolitan Expressway have an especially high rate of ETC usage; 81.1% as of June 2008.
As expected, ETC has significantly contributed to a decrease in traffic congestion. The relationship between the ETC utilization rate and congestion on 18 toll barriers on the main lines of the Tokyo Metropolitan Expressway is shown in Figure 3-3. The percentage of ETC-equipped vehicles at those barriers increased from approximately 6% to 73% between 2003 and 2007 and this trend is continuing. ETC has led to a dramatic decrease in congestion and assisted the smooth flow of vehicles through toll barriers.

![Figure 3-3: Effects of ETC promulgation in solving traffic congestion](image)

### 3.2 Japan: Vehicle Information and Communication System

The provision of accurate road traffic information to drivers, and encouraging them to select a more appropriate route or change the time of day when they drive, is one of the most powerful measures in solving severe traffic congestion in urban areas. The construction of missing links and the improvement of poor existing links are essential. However, this work generally takes a long time to complete. Information provision is a much faster way to address these problems.

VICS (Vehicle Information and Communication System) is a digital data communication system that promptly provides the latest necessary road traffic information to drivers via a car navigation system. The service commenced in Tokyo in April 1996. In 2004, the service finally covered the entire country.

By March 2007, approximately 18.7 million VICS units, which are to be installed in the car navigation system, have been shipped since the service commenced (Figure 3-4). In 2006, a record 3.16 million units were shipped. Over 70% of all car navigation systems shipped in the past six years have come equipped with built-in VICS units. VICS units are now installed as a standard feature in car navigation systems.
year

Figure 3-4: Volume of shipments of VICS receivers and car navigation units (cumulative total)

The results of a user questionnaire conducted in 2004 (Figure 3-5) showed that, when asked about specific areas where VICS is effective, approximately 80% of respondents answered that it “gives peace of mind”, “helps me to understand road conditions en route to my destination” and “can find routes to avoid congestion”.

Figure 3-5: Results of a questionnaire on specific areas where VICS is effective

3.3 Malaysia: Smoothening Traffic Flow Utilizing Information Technology

Initially, tolls on expressways in Malaysia were collected manually. The operating capacity was 400 vehicles/hour. However, during the 1990s, various types of ETC systems were introduced on many expressways in Malaysia. They are an effective payment transaction medium, convenient for users and more capable of managing the increasing number of vehicles travelling on expressway. However, the various types of non-integrated ETC systems being used created confusion, especially to road the users (Figure 3-6).
3.3.1 Standardization of ETC systems at expressways

In early July 2004, the ETC system was standardized. This requires road users to have only one prepaid card, known as the Touch N’ Go, for the implemented electronic payment transaction (Figure 3-7). In addition, the Smart Tag facility is also being introduced. This enables users to pay the toll using the drive-through method (Figure 3-8). This has resulted in a major increase in capacity, up to 1200 vehicles/hour, compared with 400 vehicles/hour with the manual method.
3.3.2 Increase in ETC system usage on expressways
A total of 4.5 million prepaid Touch N’ Go cards and 700,000 Smart Tags have now been sold. The usage level of the ETC system is greatest on expressways: 44% of the total payment transaction in 2007 compared with 28% in 2003. With this technology, traffic flow, which is normally congested at toll plazas, especially during peak hours, has been increased for the benefit of the user.

3.4 Singapore: Smoothening Traffic Flow Utilising Information Technology

Singapore is a city-state measuring 23 km by 42 km, with a land area of about 700 km². It is home to about 4.8 million people, and accommodates more than 880,000 vehicles on a road network about 3,300 km long.

The number of daily journeys are expected to increase from 8.9 million in 2008 to 14.3 million in 2020, an increase of more than 50%. As there is a limit to which this increase can be accommodated (with private transport), there is a strong push to make public transport a more viable mode choice. Whilst the road network capacity will be expanded where possible, more emphasis has to be placed on optimizing and regulating road usage.

3.4.1 Optimizing road usage

Optimizing road usage is achieved using various technologies and intelligent transport systems (ITS). They can be categorized according to the use of traffic systems, their influence on driver behaviour and the use of vehicle systems.

Traffic Systems

One of the first traffic systems to be enhanced with technology were traffic lights. From the mid-1980s, all the traffic lights in Singapore were progressively linked and controlled by an integrated computerized system, known locally as GLIDE.

GLIDE optimizes traffic flow through its ability to adjust the traffic light timings based on actual traffic demand. It links adjacent traffic lights on roads so that vehicles can travel through traffic lights as they travel on the road network. Faults can be quickly repaired since they are detected instantaneously by the computerized system.

In the early 1990s, all aspects of the traffic lights were converted, with LEDs replacing incandescent bulbs. These not only save energy but also are longer-lasting and fail gradually instead of abruptly, as is the case with bulbs. This increases the reliability of traffic lights and reduces the number of times that traffic lights fail and cause traffic chaos at busy junctions.

Driver/User Behaviour

An improved knowledge of traffic conditions on the road network will enable motorists to make diversions about how to avoid long delays and therefore result in a more efficient road network. To facilitate this, an elaborate expressway monitoring and advisory system (EMAS) was implemented to cover the complete 150 km expressway network that carries much of the daily traffic. Incidents and traffic congestion are detected quickly by detection cameras and verified by surveillance cameras at the centralized Traffic Control Centre. Traffic information on these incidents, and the extent of traffic congestion, is then sent to the radio stations for on-air broadcast. Incident messages are also displayed on electronic message boards or VMSs along the expressways and on entrances to the expressway network.
Knowledge of incidents also allows the traffic authorities to dispatch tow-trucks and/or emergency vehicles to the scene of incidents so that traffic can be quickly cleared. This means that delays to all other motorists on the expressways are kept to as short a period as possible, resulting in a more efficient road network.

Traffic conditions on expressways and major arterial roads are also determined with the use of a GPS-based system installed on several thousand taxis. The traffic information sent by taxis or probe vehicles is analysed and traffic conditions made available via the Internet, using colour-coded roads to identify the different traffic conditions.

**Vehicle Systems**

Optimisation of the road network can also be achieved with more intelligent vehicle systems such as adaptive cruise control systems, collision avoidance systems and intelligent speed adaptive systems. These systems make journeys safer and cut down the occurrence of accidents, resulting in less disruption to traffic, thereby optimizing the use of the road network.

### 3.4.2 Regulating road usage

While the optimization of available road capacity is necessary, it is also important that user demand is regulated. This has been successfully achieved with the use of technology.

Vehicle ownership in Singapore is managed by a vehicle quota system that has kept the net increase in the number of vehicles at 3% (per year) for many years since its inception in 1990. It has recently been revised to 1.5% per year, for three years, from 2009.

Regulating road use through the Area Licensing Scheme from 1975, and then the Electronic Road Pricing System from 1998, is another element in Singapore’s multi-prong strategy to manage road use. Based on the use of electronic tags (in-vehicle unit) and smart-cards, with dedicated short-range communications (DSRC) technology, this has served Singapore well over the years and kept traffic conditions on the road network manageable.

### 3.4.3 Conclusion

Optimizing the road network through the use of technology and ITS has been successful in Singapore. However, emphasis now has to be placed on the promotion and encouragement of public transport as a choice mode to meet the increasing travel demand in the years ahead.
4 TRANSPORTATION DEMAND MANAGEMENT

4.1 Australia: A Network Operating Plan for Melbourne

4.1.1 The congestion challenge

A dynamic, affordable, liveable and attractive urban city will never be free of congestion. However, it must be managed to reduce its economic, social and environmental impacts. While some congestion is unavoidable, there is a level at which it starts to detract from liveability, reduces the reliability of travel, increases transport costs and has the potential to adversely affect the economy.

Road congestion not only impacts on people in cars, it also affects the reliability of on-road public transport services and the capacity of businesses to move freight. Unconstrained growth in road travel is unsustainable and the provision of attractive and well-patronised public transport alternatives is critical to future liveability in an urban environment. An example of competing demands in Melbourne is shown in Figure 4-1.

If no action is taken, many of Melbourne’s major roads will be at or over capacity by 2020 or sooner. The current economic costs of congestion amount up to A$2.6 billion per year\(^1\). This figure could at least double within the next 15 years if measures to manage congestion are not put in place.

The demand for travel across Melbourne is growing through:

- strong population growth
- economic growth
- increasing freight movement.

At the same time pressures are increasing on the capacity of the road network to respond to that demand, including:

- reduced budgets
- competing demands for road space
- liveability and the environment

\(^1\) A$1 \approx US$0.92 (March 2010).
more stakeholders (commuters, freight, trams, buses, bicycles, pedestrians, parking and abutting land use).

Historically, road authorities have managed traffic demand by building new infrastructure and maintaining existing roads to defined standards. However, maintaining the road quality and adding capacity by building new roads is reaching the limits of affordability, practicability and political acceptability.

There is no single, simple solution to managing congestion. Sustainable management of congestion will require an integrated approach involving infrastructure provision, farsighted land use planning, and changes in behaviour by individuals, businesses and governments.

A new approach is required, in which optimisation of the use of the existing infrastructure and the provision of improved services to the road users is the primary objective. The road authority’s role, therefore, becomes more complex, with a reduced focus on new infrastructure and a greater level of attention paid to the needs of the customer. Network operations encompasses these evolving responsibilities of network management and operations as illustrated in Figure 4-2.

4.1.2 Strategies to manage congestion

Fully eradicating congestion is neither an affordable, nor a feasible goal in economically dynamic urban cities. However, much can be done to reduce its occurrence and to lessen its impacts on users. While there are many possible measures that can be deployed to 'treat' or mitigate congestion, there is no single perfect solution. The effective management of congestion requires an integrated strategy that goes beyond the visible incidence of congestion ‘on the road’ and extends to land use planning and behavioural change.

The key strategies for effectively managing congestion are as follows:

Strategy 1 – Ensure that land use planning, and the community objectives it embodies, is co-ordinated with transport management policies.

Strategy 2 – Employ a combination of access, parking and road pricing measures to lock in the benefits from operational and infrastructure measures aimed at mitigating traffic congestion.

Strategy 3 – Support and encourage higher occupancy travel modes, such as trams, buses, cycling and walking in higher-density activity centres through the allocation of road space, traffic signal priority and information for road users to make better travel choices.
Strategy 4 – Facilitate access and mobility for freight on appropriate freight routes, particularly at
times of the day that least impact on communities.

Strategy 5 – Reduce the ‘misery’ on road users of unreliable and variable travel times by targeting
travel time variability and the most extreme congestion incidents with better management and
response to incidents.

Strategy 6 – Infrastructure expansion should be a ‘last resort’ option for managing congestion.

4.1.3 A smarter way to operate roads

These strategies require far more from the existing road network than simply ‘moving traffic’. A
smarter and proactive approach to road network operations is required, which balances the
competing demands for limited road space and supports wider urban goals.

Specifically, the road network needs to:

- support activity centres as places to live and work
- improve the operation of buses and trams
- encourage more cycling and walking
- facilitate appropriate freight access and mobility
- better manage access to the road network
- provide reliable journeys.

Into the future, Melbourne’s road network cannot hope to cope with ever increasing demands from
a wider range of road users. A more active approach to allocating priority is needed that
separates, where possible, many of the conflicts by route, place and time-of-day (Figure 4-3).

Using a set of guiding principles, each major road in Melbourne has been assigned a priority road
use. This task was completed separately for each of the 31 Local Government areas with the
involvement of local council traffic and planning officers, VicRoads and Department of Transport
officers.
Guiding Principles for Each Transport Mode

Pedestrians:
- encouraged in activity centres at times of high activity
- greater encouragement at more times for more important activity centres

Bicycles:
- encourage separation from other modes

Trams and buses:
- encourage at all times on key public transport routes
- strongly encourage during peak commuting periods

Freight:
- encourage on important freight routes
- encourage outside of commuting peak

Cars:
- encourage on preferred traffic routes, which avoid conflict with activity centres

A key aspect of these principles is the way activity centres are handled. Figure 4-4 illustrates a typical strip shopping centre along a major arterial road. Generally, pedestrians will be a priority mode within the activity centre, with public transport and bicycle priority routes connecting into the centre. To encourage through traffic away from the centre, a preferred traffic route is defined, which provides priority for general traffic and freight. Actions can then be identified for each mode on specific routes to support these priorities.
The end result is a road use hierarchy map of Melbourne, showing the priority modes on each major road (refer Figure 4-5).

![Road use hierarchy map for Melbourne's roads](image)

This map provides the basis for determining the relative priority of each transport mode at any point on the network and at any time of the day. The following simple four-level priority assignment is used:

- **strongly encourage movement**
- **encourage movement**
- **no specific priority**
- **discourage movement**.

By default each mode gets ‘no specific priority’ unless certain criteria are met. For example, Figure 4-6 shows how pedestrian priority is assigned based on whether it is a priority mode from the map, the place through which the road passes, and the time of day.

<table>
<thead>
<tr>
<th>Time-of-day</th>
<th>Outside of Activity Centres</th>
<th>Strip Shopping Centres</th>
<th>Major Activity Centres</th>
<th>Principal Activity Centres</th>
<th>Central Activity Districts</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMP</td>
<td>←</td>
<td>←</td>
<td>←</td>
<td>←</td>
<td>←</td>
</tr>
<tr>
<td>HOP</td>
<td>←</td>
<td>←</td>
<td>←</td>
<td>←</td>
<td>←</td>
</tr>
<tr>
<td>PMP</td>
<td>←</td>
<td>←</td>
<td>←</td>
<td>←</td>
<td>←</td>
</tr>
<tr>
<td>OP</td>
<td>←</td>
<td>←</td>
<td>←</td>
<td>←</td>
<td>←</td>
</tr>
</tbody>
</table>

![Pedestrian priority assignment](image)
Each mode has its own assignment table. The resulting priorities can also be viewed, for each priority mode from the road use hierarchy map, for a specific time period as shown in Figure 4-7.

<table>
<thead>
<tr>
<th>Priority mode</th>
<th>Relative Priority (High Off-Peak)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strongly encourage</td>
</tr>
<tr>
<td>Tram</td>
<td></td>
</tr>
<tr>
<td>Bus</td>
<td>🌟</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>🌟</td>
</tr>
<tr>
<td>Bicycle</td>
<td>🌟</td>
</tr>
<tr>
<td>Preferred traffic</td>
<td>🌟</td>
</tr>
<tr>
<td>Other traffic</td>
<td>🌟</td>
</tr>
</tbody>
</table>

Figure 4-7: Relative priorities

Priorities can then be put into operation at an intersection level to provide a Network Operating Plan. Figure 4-8 shows a typical plan for a local network during the middle of the day.

4.1.4 Using the Plan to make smarter decisions

Network operating plans are a key planning tool to encourage smarter decisions about how the network is managed by ensuring that local operational decisions consider the strategic and wider network objectives. Specifically, network operating plans are used to:

- design how traffic signals operate to support:
  - smarter trams and buses
  - less delays for pedestrians where it is needed:
    - improved traffic signal linking where and when it is needed
- integrate and balance the freeway and arterial networks
integrate transport with land use planning by supporting the development of activity centres
identify the critical locations, modes and times where the network operation needs to be improved
determine the relative trade-offs when reallocating road space between modes
informing and guiding all decisions that impact on the operational of the roads.

4.1.5 Smarter technology

The emergence of smarter technologies to manage traffic is a significant enabler for network operating plans. The ability to track trams, buses and freight in real-time, and to link this information to the operation of the traffic signal system, allows far more control over the operation of the road network than previously. The greater availability of real-time data on the operation of the road network can also provide road users with information to make better travel choices. An example showing freeway ramp metering is shown in (Figure 4-9. The soon-to-be completed freeway management system on the M1 corridor will provide the technology to better manage incidents and ensure that freeway traffic flow can nearly always be maintained at an optimal level.

4.1.6 What does the Plan mean for road users?

The network operating plan for Melbourne sets out a long term plan for how the road network will be managed into the future. Every decision that is made that supports the plan brings a sustainable transport future one step closer. Road users may notice local incremental changes in how roads operate but over time more significant changes will emerge. Overall, road users should expect to see:

- greater priority being given to trams and buses
- more support for cycling and walking
- improvements to the operation of roads that provide better alternatives for through traffic and freight around activity centres
- greater differences in the way roads operate across the day.
Ultimately, for the network operating plan to work to provide a sustainable transport future, State and Local Government authorities must work to ensure land use planning and transport decisions support the plan and road users are subsequently encouraged to make better transport choices.

4.2 Japan: Environmental Road Pricing Program for Heavy Vehicles

Traffic congestion due to the over-concentration of population, industry and traffic in urban areas is a major cause for increased NO₂, SPM and noise pollution. Japan produces approximately 5% of the global volume of CO₂ emissions, 19% of which is related to automobile traffic. It is necessary to reduce wastage of fuel during traffic congestion in order to cut CO₂ emissions.

4.2.1 Environmental road pricing program for heavy vehicles

One example at the Hanshin expressway is shown in Figure 4-10. There are two large cities in western Japan: Osaka and Kobe. Because of huge traffic demand between the two cities, two urban expressway routes are available – the Kobe Line and the Bayshore Line. Both are administered by the Hanshin Expressway Corporation. The Kobe line passes through a densely populated inland area and commercial zone, while the Bayshore line passes through an industrial area that is comparatively less densely populated. Previously, an equal toll was charged for both routes.

In order to mitigate environmental issues along the densely populated area and divert heavy vehicles to the Bayshore line, the ‘Environmental Road Pricing Program for Heavy Vehicles’ was introduced in 2001. Through this program, the Kobe line’s toll remained at ¥1,000, whilst the Bayshore line’s toll was discounted to ¥800. In addition, the discount rate was experimentally raised to 40% in February 2004, making the toll ¥600 during this period.

![Figure 4-10: Outline of environmental road pricing program](image)

4.2.2 Effect of introducing the environmental road pricing program

Following the reduction in the toll on the Bayshore line in February 2004, traffic increased by more than 300 vehicles/day. A total of 220 of these vehicles were diverted from the Kobe line, 80 vehicles were diverted from urban streets, with the rest coming from other sources (Figure 4-11).

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2 ¥1,000 ≈ US$11.10 (March 2010).
Vehicles are required to be equipped with ETC on-board-units as a condition of participating in the program. Since the ETC usage rate was not very high when the program commenced in the early 2000s, the number of vehicles that participated was only 1,200 per month. However, the number of participating vehicles has now grown to 12,000 per day.

4.3 Japan: Toll Discount Program Exclusively for ETC Users

4.3.1 Necessity of converting from urban streets to expressways

As the Japanese active-type ETC system can easily identify the usage history of each vehicle, a meticulous toll policy can be introduced to satisfy user needs. For example, when there is a lesser volume of traffic on an expressway that runs alongside congested general roads, traffic on the general roads can be shifted to the expressway via an ETC toll discount, resulting in mitigation of congestion on the general road. As ETC becomes significantly more widespread and its usage expands accordingly, it becomes possible to employ varied and flexible toll setting, as well as various other measures for utilizing road stock (Figure 4-12).

Example: Toll Fee Rates in Suburban Areas on Weekdays

![Example: Toll Fee Rates in Suburban Areas on Weekdays](image)

**Figure 4-12: Discount program for ETC users**
4.3.2 Measures taken to address this issue

One experiment was conducted in the Hitachi area. This city, which is famous for being one of the strongholds of the electronics giant, Hitachi Ltd., is sandwiched between hills and the ocean. Therefore, the area is long and narrow, with no arterial roads other than two ordinary national highways and one expressway. Traffic always tends to concentrate in the two national highways, thus making the city’s notorious for traffic congestion all day long.

The toll discount program was planned to divert this traffic to the expressway and help ease the traffic congestion problem in the greater urban area.

4.3.3 Effects of introducing a toll discount program exclusively for ETC users

The results of the program for 2005 are shown in Figure 4-13. For ordinary vehicles, the previous toll ranged from ¥350 to ¥1,100, with differences due to the distance between interchanges. The discounted rate was approximately 50% of the original toll. The survey revealed that traffic volumes on the national highway decreased by 3% during the commuter discount hours. Additionally, travel speed on the national highway increased by 4.2 km/h in the evening.

![Figure 4-13: Transition of traffic volume due to the toll discount program for expressway commuters (direction: inbound; Hitachi Area, Ibaraki Prefecture)](attachment:figure413.png)
5 DEVELOPMENT OF ROAD NETWORKS

5.1 Australia: Use of City Bypasses to Alleviate Traffic Congestion

5.1.1 Toowoomba Bypass

The city of Toowoomba is located about 125 km west of Brisbane. It is a focal point for both interstate and intrastate freight movement, as the Warrego, New England and Gore Highways converge in Toowoomba en route to and from the east. As a result, Toowoomba’s streets carry a heavy concentration of commercial/heavy vehicles. At least 25% of the heavy vehicle trips pass directly through the city of Toowoomba.

Increasing traffic volumes are putting pressure on the highway network that passes through Toowoomba and over the Toowoomba Range. Investigations undertaken by Queensland Department of Transport and Main Roads (QTMR) and Toowoomba City Council suggested that the city’s existing freight network would come under increasing pressure requiring significant improvements, as traffic volumes on roads in and around the city grow significantly.

Most of the existing range crossing has a 10% grade and tight horizontal curves (Figure 5-1). This results in high levels of congestion and a very poor accident record. Coupled with the section through urban Toowoomba City the existing route fell well short of specified national highway levels of service.

Recent road investment has focused on improved safety and traffic management through Toowoomba. There is limited scope for further cost-effective improvements on the existing route because widening to improve capacity and safety on the range would not improve the steep grade, provide only short term relief, and be very expensive. In addition, as the route would continue to use Toowoomba streets there would be a loss of urban amenity and continued freight inefficiency.

As a result, QTMR identified the need for a bypass that took highway traffic around Toowoomba rather than through it. This is a 42 km long road corridor that runs to the north of Toowoomba. The new corridor rises 450 metres from the start to the top of the range with maximum grades of 6.5% (almost half as steep as the existing crossing). The design speed is 110 km/h as opposed to the existing range crossing which is suitable for speeds of only 60-80 km/h.

The Federal Government has so far committed a total of A$33.25 million for the planning activities and land acquisitions. The bypass as planned includes:

![Figure 5-1: Existing Toowoomba range](image-url)
- 28 km of four-lane roadway on the Warrego Highway between Helidon Spa and Charlton
- 14 km of two-lane roadway between Charlton and the Gore Highway near Westbrook Creek
- A 735 m long twin-tube tunnel at the top of the range
- five grade-separated interchanges
- a 200 m long viaduct bridge east of the tunnel
- 22 other bridge structures.

**Private Public Partnership (PPP) Business Case Development Study**

The Federal Government provided A$10 million to progress a Private Public Partnership Business Case development study. This was completed by the end of April 2008. QTMR is currently leading the Toowoomba Bypass PPP Business Case Development Study (Stage 3). This study seeks to: determine the project priority and affordability, and clarify the project delivery options most likely to provide the best value for money outcome. The study includes the identification of: up-to-date estimate of the project cost, potential toll revenues, and the potential benefits arising from a PPP.

**Toowoomba Bypass Pilot Tunnel**

In late 2006, QTMR commissioned the design of a pilot tunnel 2.4 m wide, 3 m high and 525 m long. The pilot tunnel (about 90 m below the New England Highway) has been drilled through an area about 1 km north of the Toowoomba urban fringe. The pilot tunnel was completed in January 2008. General views of the tunnel are shown in Figure 5-2.

Excavation of the pilot tunnel involved drilling and blasting through the basalt rock. QTMR closely monitored environmental conditions throughout the project to ensure any side effects were properly managed. Work on the pilot tunnel was designed to ensure noise, vibrations or disruptions to nearby residents were limited to acceptable community standards.

The tunnel will help to better assess the geology and hydrology in the range escarpment. QTMR and its contractors will then have a more accurate picture of what conditions to expect if the planned twin three-lane tunnels are built as part of the full bypass. Being able to manage the risks and uncertainty inherent in tunnelling work will also allow QTMR to determine more accurate cost estimates.
5.1.2 **Tugun Bypass project**

The Tugun Bypass provides a high-standard road link between the southern Gold Coast in Queensland and northern New South Wales. The bypass is expected to take 55% of traffic off the existing Gold Coast Highway by 2017 and reduce travel time between Currumbin and Tweed Heads West to 5 minutes. Without the bypass, delays of up to 30 minutes on the Gold Coast Highway would be common by 2017.

The construction of the bypass cost A$543 million including A$423 million provided by the State Government and $120 million provided by the Federal Government. Key features of the bypass include:

- four lanes, with the provision to be upgraded to six lanes
- two grade-separated interchanges
- a 334 m long tunnel underneath the Gold Coast airport's runway extension
- twin bridges over Hidden Valley
- preserved rail corridor allowing for a future rail line from Robina to the Gold Coast airport
- of bulk earthworks of 800,000 m³
- pavement construction including 160,000 m³ of concrete and 90,000 tonne of asphalt.

Over 600 jobs were created during the peak of construction in October 2006. The new Tugun Bypass was opened to traffic in June 2008, six months ahead of the scheduled completion date (Figure 5-3). The bypass is expected to carry between 35,000 and 40,000 vehicles a day, with daily traffic projected to rise to 60,000 vehicles by 2017.

![Figure 5-3: Aerial view of Tugun bypass](image)

**Management of groundwater**

Dewatering at the Tugun Bypass tunnel site was only required during the construction of the tunnel. Once construction was complete natural groundwater flows have resumed over, under and around the tunnel. Twenty-three bores were installed to monitor water levels and chemical properties during and after construction.

An Environmental Reference Group (ERG), comprising state, local and commonwealth environmental representatives, met numerous times on site to discuss the project's environmental management and performance. They indicated that they were confident the site was suitably
managed, that there were no current effects on wetlands, and that there was minimal risk of any long term effects.

Some small areas of flora die-back were inspected by the ERG and independent experts. The die-back was attributed the combination of effects impacting on groundwater levels and localized frosts. Substantial regrowth was subsequently observed following rains in these areas. The trees that were trimmed by the Gold Coast Airport immediately adjacent to the tunnel, to comply with flight path height restrictions, also showed substantial regrowth.

5.2 Japan: Alleviation of Traffic Congestion by Developing Ring Roads

Chronic traffic congestion occurs in Japanese metropolitan areas. The central area of Tokyo is particularly heavily congested, with 460,000 vehicles per day. Of this, 60% is through traffic which could be bypassed by ring roads to alleviate congestion in the central area. However, road networks in Japan have been developed with a greater emphasis on radial roads, thus leaving the ring road completion rate as low as 40% in Tokyo, as opposed to 84% in Paris and 92% in Beijing.

Three ring roads are being given high priority for development in the Tokyo metropolitan area; 90% of the total length of the ring roads is scheduled to be completed within ten years.

The Central Circular Expressway is the innermost ring road with a total length of 47 km and a radius of 8 km. The Shinjuku section of the Central Circular Expressway was completed in December 2007. This 6.4 km long section lies in a highly developed area, so most of it was constructed underground using a shield tunnelling method.

With the completion of the Shinjuku section, approximately 70% of the Central Circular Expressway is now in service. This allows vehicles from the Chuo Expressway to travel to other radial expressways and vice versa without going through the inner routes, which are notorious for severe chronic congestion (Figure 5-4). Through networking effects, it is estimated that the total queue length during peak times will be reduced by 22%, and that the economic benefits will be ¥93 billion per year. Additionally, CO₂, NOₓ, and SPM emissions are expected to decrease by 60,000 tonne, 70 tonne, and 4 tonne respectively.

![Figure 5-4: Effect of new ring road on traffic flow](image-url)
5.3 Malaysia: Shortened Route from Sayong Village to Kuala Kangsar Town – Sultan Abdul Jalil Shah Bridge (Jambatan Sayong)

Sayong Village and Kuala Kangsar lie on the river bank of Sg. Perak, the second longest river in West Malaysia. The road connecting these two locations is about 14 km long and travels via Jambatan Iskandar, which is 7 km upstream from the town of Kuala Kangsar. The shortest route between Sayong Village and Kuala Kangsar or vice versa involves the use of small boats which cross the 200 metres wide Sg. Perak. Following the completion of the North-South Expressway in February 1994, Kuala Kangsar suffered a large reduction in traffic flow and, as a result, efforts had to be made to retain the town’s original profile and also to beautify this Royal Town of Perak.

5.3.1 Measures taken

A study of the feasibility of constructing Jambatan Sayong was conducted by the Highway Planning Unit, Ministry of Works (MoW), Malaysia in December 1998. The final report stressed the importance of building the Jambatan Sayong in the study area. Construction works for the new bridge commenced in January 2001 and were completed in March 2003.

Also known as Sultan Abdul, Jalil Shah Bridge is composed of concrete and located near the outskirts of the town of Kuala Kangsar. The 330 metre span bridge was officially opened by the Sultan of Perak, Sultan Azlan Shah in June 2002. The provision of the bridge is expected to make travel between Sayong Village to and from Kuala Kangsar much easier and faster.

5.3.2 Benefits of completed bridge

A study was conducted by the MoW to quantify the benefits of the project after it was opened to the public. A summary of the results is presented in Table 5.1. It can be seen that, following the opening of this bridge, the distance between Kuala Kangsar and Sayong was significantly reduced. Similarly, a 75% reduction in travel time and vehicle operating costs was recorded, resulting in a 36% increase in traffic volume. The implementation of the bridge also resulted in a 3.6% per annum increase in economic development in the region.

![Table 5.1: Results of Study of Effect of Opening the New Bridge](image)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Without Bridge (do nothing)</th>
<th>With Bridge (do something)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (km)</td>
<td>17</td>
<td>3</td>
<td>PWD</td>
</tr>
<tr>
<td>Travel time (minutes)</td>
<td>20</td>
<td>5</td>
<td>District</td>
</tr>
<tr>
<td>vehicle operating costs (VOC)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. car</td>
<td>RM 7.31(^3)</td>
<td>RM 1.29</td>
<td>Final report of feasibility study</td>
</tr>
<tr>
<td>b. motorcycle</td>
<td>RM 3.23</td>
<td>RM 0.57</td>
<td></td>
</tr>
<tr>
<td>c. bus</td>
<td>RM 15.47</td>
<td>RM 2.73</td>
<td></td>
</tr>
<tr>
<td>d. lorry</td>
<td>RM 5.44</td>
<td>RM 0.96</td>
<td></td>
</tr>
<tr>
<td>Traffic volume</td>
<td>11,235 veh/day</td>
<td>15,298 veh/day</td>
<td>PWD</td>
</tr>
<tr>
<td>Road accidents</td>
<td>14 cases</td>
<td>1 case</td>
<td>District</td>
</tr>
</tbody>
</table>

\(^3\) Malaysian Ringgit (RM)1 ≈ US$0.30.
5.4 Philippines: Best Practices for the Improvement of the Philippine Road Network

The Philippines is composed of 7,100 islands. The greatest length of the archipelago from north to south is 1,851 km, whilst the greatest breadth from east to west is 1,107 km. As of July 2007, the Philippine National road network had an overall length of 201,136 km and a road density of 0.671 km/km² of land area. The ratio of paved roads is only 0.23; this is related to the huge inventory of barangay roads or farm-to-village roads.

5.4.1 Infrastructure policies and strategies

One of the key elements of the road infrastructure plan for the Philippines is to improve traffic flow at main corridors in major urban centres through the use of effective traffic engineering and management strategies, including inter-modal integration, and the provision of flyovers and bypasses at selected locations.

The aim of the 2005-2010 Medium-Term Development Plan is to improve the public's access to activities, goods and services through the preservation, improvement and expansion of the national road network in a cost-effective and environment-friendly manner, and to enhance its operation, safety, efficiency and international connections.

One of the key elements of this Plan is the prioritisation of roads, including improving congestion in Metro Manila. This involves the completion of expressway projects and similar projects to speed the movement of traffic in and out of Metro Manila (Figure 5-5). Another key component is to address critical transport bottlenecks in urban areas through widening, traffic management and intersection improvements. In rural areas, the main strategy is to pave many roads and improve arterial road links between regional centres and production areas (Figure 5-6).

Figure 5-5: Typical expressway projects to ease congestion in urban areas

Figure 5-6: Improving arterial road links in rural areas
Infrastructure funds are being allocated according to the following order of priority:

- preservation and maintenance (especially of national roads)
- rehabilitation
- improvements to meet needs and traffic demand
- new construction to ease traffic congestion, shorten travel time and provide alternate route.

Some examples of recent projects are shown in Figure 5-7.

![Figure 5-7: Recent projects in Metro Manila to ease traffic congestion](image)

### 5.4.2 Use of public private partnerships (PPP)

In the late 1980s the Philippine Government was forced to consider innovative and expedient ways to finance new infrastructure projects. The Build-Operate-Transfer (BOT) scheme offered an attractive option because it effectively addressed:

- the need to address increasing supply bottlenecks during periods of fiscal constraints
- technological deficiencies which, although clearly identified, were not within the capacity of agencies to correct
- the need to improve the delivery of basic public services where capacity was over-extended
- the desire to seek private sector participation in order to effect market-based efficiencies in the management and operation of projects and the competitive pricing of public services.

The BOT modality:

- mobilizes private sector resources to increase capital stock for infrastructure development
- moves commercially viable undertakings to the private sector, thereby increasing the capacity of the Government to undertake other vital development activities
- encourages the private sector to optimize efficiencies in financing, management and operation of facilities.

Some recent project completed using PPP are shown in Table 5.2. Examples of recently completed projects are shown in Figure 5-8, Figure 5-9 and Figure 5-10.
### Table 5.2: Recent Projects Completed using PPP in the Philippines

<table>
<thead>
<tr>
<th>Project</th>
<th>Length (km)</th>
<th>Cost (PHP) (million)</th>
<th>Implementation Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-lane, elevated, Bicutan to Buendia</td>
<td>9.37</td>
<td>11,170</td>
<td>May 1996-December 1999 (Figure 5-8)</td>
</tr>
<tr>
<td>Rehabilitation of SLEX (Magallanes to Alabang)</td>
<td>13.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R1 Expressway, 6 lanes, Seaside Drive to Zapote</td>
<td>6.6</td>
<td>1,001</td>
<td>May 1996-May 1998</td>
</tr>
<tr>
<td>Stage 1, 4 lanes, Sto. Tomas-Lipa City</td>
<td>22.16</td>
<td>1,100</td>
<td>March 1993-May 2000 (Figure 5-9)</td>
</tr>
<tr>
<td>Subic-Clark Expressway: Stage 1</td>
<td>50.5</td>
<td>12,698</td>
<td>2005-2008 (Figure 5-10)</td>
</tr>
<tr>
<td>Subic-Clark Expressway: Stage 2</td>
<td>43.27</td>
<td>8,271</td>
<td></td>
</tr>
</tbody>
</table>

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4 100 Philippine Peso (PHP) ≈ US$2.20 (March 2010).

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**Figure 5-8: Makati CBD and Buendia exits**

**Figure 5-9: Sto. Tomas, Batangas to Lipa City, Batangas**
5.5 Sri Lanka: Easing Traffic Congestion – the Road Network Plan Approach

The road network density in Sri Lanka is 1.5 km/km², the highest in the region; 98% of goods (freight) transport and 94% of passenger transport takes place on roads.

Congestion in urban centres is a major problem. The average speed of long distance travel is 38 km/h, whilst in urban areas it can be as low as 15-25 km/h. This is mainly due to uncontrolled roadside development and also the fact that the road geometry requires significant improvement (Figure 5-11). The condition of carriageways also require attention.

Any improvements to mobility (speed) and a reduction in congestion requires a holistic approach. In order to address this problem, the Road Development Authority (RDA), the premier road construction and maintenance organization in Sri Lanka, prepared a Master Plan in 2007. The planning horizon for the first phase is 10 years (2007-2017). This exercise is now complete and in various stages of implementation.
The RDA is responsible for trunk and main roads (A & B class roads). In order to prepare the Master Plan, a core road network was identified after several trials. This core road network was modelled using JAICA STRADA V3.0 transport planning software, which assisted in the prediction of future traffic growth and the identification of the likely impact of new links and road improvements on congestion. It was predicted that the average network speed could be expected to increase from 38 km/h to 49 km/h during the planned period. In addition, maintenance and improvement needs for the road network were identified using HDM-4 V3.1 after extensive data collection and processing.

The most congested junctions were addressed separately using traffic data generated by simulation for different scenarios. Possible treatments to improve the performance of the junctions ranged from retrofitting, improvement to the layout geometry, signalizing, the provision of overpasses, etc. This work was also included in the National Road Master Plan.

Localized congestion due to the presence of cross-roads and roadside development, especially on trunk roads running through townships, was identified as candidates for short lengths of bypass. This was to avoid time-consuming and expensive land acquisition and resettlement costs. These options were also included in the National Road Master Plan.

The breakdown of investments in the National Road Master Plan is shown in Figure 5-12. The National Road Master Plan (2007-2017) includes:

- construction of expressways 594 km
- converting existing roads to six lanes 23 km
- converting existing roads to four lanes 482 km
- road improvements (two lanes) 2381 km.

![Figure 5-12: Breakdown of investments in the National Road Master Plan](image)

Improvements to junctions include:

- construction of flyovers and grade separate interchanges 21 junctions
- improvements to junctions 33 locations
- signalization 38 locations
- ring roads and bypasses of cities and towns 25 locations
- bridge reconstruction 170 locations
Examples of recent expressways include:

1. Colombo Katunayake Expressway 25.1 km
2. Southern Highway 130 km
3. Outer Circular Highway 28 km
4. Colombo Kandy Express Highway 98 km
5. Colombo Jaffna Highway 213 km
6. Extension of Southern Highway 100 km

The implementation of this holistic program is under way and comprehensive road condition and traffic surveys are being conducted in a programmed manner. This will continue until the desired outcome is achieved.

5.6 Thailand: The Industrial Ring Road Project

His Majesty the King suggested that an Industrial Ring Road be constructed to link the industrial areas in Samut Prakarn, the province adjacent to the southern part of Bangkok and the Port of Bangkok. This would alleviate traffic congestion and ensure that heavy trucks did not enter the town and cause traffic problems. Typical examples of traffic congestion in Bangkok are shown in Figure 5-13, whilst Figure 5-14 shows the Industrial Ring Road project connecting Phrapradaeng and Poo Chao Saming Phrai industrial zones with the Port of Bangkok.

The Department of Rural Roads carried out a project feasibility study, including economic and engineering aspects as well as an environmental impact assessment. Consecutively, the detailed designs for construction were developed and the design works were completed in July 1997. The project was funded by the Thai government (40%) and the Japan Bank for International Cooperation (60%).

Figure 5-13: Traffic congestion in Bangkok
5.6.1 Project highlights

The construction of the Industrial Ring Road bridge was a major undertaking, taking more than a decade to complete. As the purpose of the project was to connect the industrial zones and the port of Bangkok, and to prevent heavy trucks from passing through the city centre, engineering, economic, social and environmental considerations were taken into account in the selection of the route and the most appropriate means of crossing the river. The project faced formidable challenges imposed by the topography of the Chaophraya River, which is narrow and meandering.

After a rigorous study of relevant factors, options were narrowed down to two methods: a tunnel or cable-stayed bridges. Tunnelling is a modern construction technology that does not obstruct waterway traffic and navigation. It is safe and does not mar the landscape. Cable-stayed bridges, however, not only provide similar advantages from its long span but also take less time to construct. It was eventually decided that the cable-stayed bridge was the best option because it met the general requirements and worked best within various constraints. The construction of the bridges was a historic milestone for the engineering profession in Thailand, with the need to facilitate waterway traffic during construction without obstruction, to adapt to the physical topography and the short construction period being noteworthy features. Moreover, its graceful appearance created an attractive new landmark in Bangkok.

The Industrial Ring Road project consists of two cable-stayed bridges over the Chaophraya River, with spans of 398 metres and 326 meters for the south and north bridges respectively. Both bridges have seven traffic lanes. An additional lane is provided on the climbing lane for slow and heavy traffic. The bridge decks are approximately 58 meters above the river, thus complying with legal navigational channel requirements.

The bridge pylons were designed in a diamond shape, with the pinnacle representing the traditional Thai configuration, inspired by the crest of a pagoda or coronet (Figure 5-15). They also stand symbolically for diamonds given to the Thai people by the royal kindness of His Majesty the King. The area under the central interchange, which is located between the south and north bridges, was developed as a public park, including recreation areas and a museum (Figure 5-16).
5.6.2 Project benefits

Following the completion of the Industrial Ring Road project, traffic congestion problems have been relieved. This is because heavy trucks are no longer passing through the city centre. The Industrial Ring Road is also helping to reduce travel time from the Phochoa Saming Phrai industrial zones to the Port of Bangkok. Previously it took approximately 3 hours to travel from the industrial zone to the Port of Bangkok as the trucks had to cross the river twice by ferry and via an existing bridge. The trucks also had to pass through the city centre before arriving at the port.

As a result of the completion of the project, heavy trucks can now travel from Poo Chao Saming Phrai industrial zone to the port of Bangkok through the Industrial Ring Road project. They no longer have to enter the city centre; this saves approximately 2 hours and 20 minutes in travel time.

In addition to resolving the traffic congestion issue, the Industrial Ring Road has also provided nearby residents with recreation facilities such as parks, sport fields and a museum which exhibits bridge construction technology and neighbourhood lifestyles. The Department of Rural Roads aims not only to improve and maintain transportation facilities to the best condition, but also to provide a better quality of living to people.

5.6.3 Conclusion

The Department of Rural Roads takes great pride in the development of the Industrial Ring Road which connects two urban areas of Bangkok and Samut Prakarn Province. Obviously, the Industrial Ring Road has led to economic growth and a balance between the modern and traditional ways of life. The Department is also proud to state that, in the case of the Industrial Ring Road project, the successful development has been well blended with community cultural preservation in line with the Department’s ultimate goal.
5.7 Thailand: Development of Outer Bangkok Ring Road

5.7.1 Problems/objectives

Bangkok Metropolitan is the capital city of Thailand. Since Bangkok has grown very quickly, the area around Bangkok has also expanded. Basic data pertaining to the Bangkok Metropolitan and vicinity area, and a comparison with the whole of Thailand, is presented in Table 5.3.

<table>
<thead>
<tr>
<th></th>
<th>Thailand</th>
<th>Bangkok Metropolitan &amp; Vicinity Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (km²)</td>
<td>513,115</td>
<td>7,762</td>
</tr>
<tr>
<td>Population (million)</td>
<td>62.83</td>
<td>9.95</td>
</tr>
<tr>
<td>Vehicle registrations (million)</td>
<td>24.81</td>
<td>5.42</td>
</tr>
<tr>
<td>GDP per capita (US$)</td>
<td>3,000 (approx.)</td>
<td>8,000 (approx.)</td>
</tr>
<tr>
<td>Population/area (people/km²)</td>
<td>122</td>
<td>1,282</td>
</tr>
<tr>
<td>Population/vehicle registration (people/vehicle)</td>
<td>2.53</td>
<td>1.84</td>
</tr>
</tbody>
</table>

From this Table, it can be seen that the GDP/capita, and the population/area in Bangkok and its vicinity, are significantly higher than for Thailand as a whole. This is because the Bangkok metropolitan and vicinity area has been growing very quickly, not only in the economic sense but also the number of new cities and the population.

5.7.2 Practice

To address this traffic/transport problem, there has been a plan to construct the Outer Bangkok Ring Road for about 30 years. The feasibility study was conducted in 1978. The total length of the project is 177 km divided into three sections: west, east and south, 78.5 km, 70 km and 22.5 km long respectively. The south section was the last to be constructed, being opened to traffic in December 2007.

5.7.3 Outcomes/suggestions

The provision of the network has resulted in more efficient traffic flow on the Outer Bangkok Ring Road. However, it took a long time to complete the network because there were many factors that effected the project. The economic situation was one of the problems because, when the economic situation of the country declined, the project had to be postponed. Other problems were associated with land acquisition and environmental issues.

Governments need to be aware of these problems when considering the funding of major projects. Whilst some problems can be solved or controlled, and some cannot, good planning will assist in the successful completion of a project.
6 CONCLUSIONS AND RECOMMENDATIONS

This Compendium has presented 21 examples of good practices addressing the challenges that member counties face in terms of the efficient operation of the road network, the measures taken, and the effects or outcome of the measures. In particular, the Compendium highlights how ITS and other innovations have been effective in optimizing traffic flow and increasing capacity at roundabouts, ramps and toll plazas, thereby alleviating congestion.

Through the various good practices contained in this Compendium, it is clear that the greatest challenge the Asian and Australasian countries have in common is the achievement of optimum traffic flow on road networks that achieve mobility of the road users.

It is also clear that each country has taken various measures to address this challenge, taking into consideration unique environment and operation conditions. Some common measures have been implemented, however, which have demonstrated significant effects in terms of smoothing traffic flow. These measures include:

- enabling drivers to make better travel choices by providing traffic information (Australia, Japan, and Singapore)
- controlling traffic flow by toll incentives (i.e. road pricing) (Japan and Singapore)
- optimizing traffic flow using traffic signals adjusted to real-time traffic demand (Australia, Brunei, Korea, New Zealand, and Singapore)
- improving traffic flow at toll plazas through the ETC system (Japan and Malaysia)
- enhancing road networking effects through the development of road structures (Indonesia, Japan, Malaysia, The Philippines, Sri Lanka, and Thailand).

Although some countries noted that the rapid increase in traffic has been hindering the effective management of traffic flow, only one country (Singapore) has introduced a drastic measure to cope with this matter. Vehicle ownership in Singapore is managed by a vehicle quota system that has kept the net increase in the number of vehicles at 3% (per year) for many years since its inception in 1990. It has recently been revised to 1.5% per year, for 3 years from 2009.

In terms of the efficient operation of the road network, road traffic policies and measures are implemented with various objectives such as reducing travel time and associated road user costs, improving safety, and improving the environment. Among these objectives, it is suggested that measures be taken to pursue the optimization of traffic flow because optimum traffic flow will also lead to the solution to all the issues. Furthermore, it should be noted that there is no single, simple solution toward achieving optimum traffic flow and that a range of measures may need to be implemented to further enhance the effects.

As the technology for road development and traffic operation is rapidly progressing, a framework needs to be established which enables member countries to share information on the latest technology created, or implemented into practice, and to develop the most effective measures derived from this information.

It is recommended that a web-based database be developed which contains examples of good practice that each member country believes can be utilized as a basis for the development of good policy related to road development projects or traffic operation in the future. Examples of good practice will be listed along with details of the person who countries can contact for further details.

The REAAA Secretariat will maintain the database and ask member countries to update their existing good practices and add new ones periodically (i.e. each year).
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<thead>
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<th>Keywords:</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>compendium / congestion / road network / REAAA / natural disasters / ITS / operation / traffic management / case studies</td>
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</tr>
</tbody>
</table>

**Abstract:**

This Compendium presents 21 examples of good practices addressing the challenges that member counties face in terms of the efficient operation of the road network, the measures taken, and the effects or outcome of the measures. In particular, the Compendium highlights how ITS and other innovations have been effective in optimizing traffic flow and in increasing capacity at roundabouts, ramps and toll plazas, thereby alleviating congestion.

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