ITS environmental monitoring and forecasting:

International trends and experiences

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International trends and experience

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An important note for the reader

Land Transport New Zealand is a Crown entity established under the Land Transport New Zealand Amendment Act 2004. The objective of Land Transport New Zealand is to allocate resources in a way that contributes to an integrated, safe, responsive and sustainable land transport system. Each year, Land Transport New Zealand invests a portion of its funds on research that contributes to this objective.

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Executive summary

The impacts of road transport on the environment are of growing concern in most developed countries. New Zealand is no exception with the primary areas of concern being the effects of vehicle emissions and noise.

The connections between traffic management and control and improvements in air pollution can range from short to long term; from immediate reactions to incidents to pre-emptive measures during periods of adverse weather conditions and to long-term strategies to reduce emissions.

Much of the current and past work on transport and air pollution has concentrated on long-term strategies related to decisions on car ownership, and vehicle choice and decisions related to land use. For these long-term strategies, their effects on air quality may be expressed efficiently through energy use and emissions, with air pollution being modelled separately, at a regional, national or perhaps even global scale.

For short- to medium-term controls the ability to reduce adverse environmental conditions through traffic management and control is limited, not least because of the difference in time scale of the reactions in the two systems.

As a result many current systems are designed to support control strategies targeted at optimising traffic conditions, leading to improvements in emissions and, therefore, air quality. This study examines the application of a range of environmental monitoring and forecasting systems to the management of urban transport facilities. It reviews the use overseas of environmental monitoring and forecasting systems as a component of wider integrated Intelligent Transport Systems (ITS) facilities, in particular those linked to traffic management and travel demand management (TDM), and considers the potential for the use of these systems in New Zealand.

The research provides direction from overseas best practice on the use of these systems to monitor and forecast adverse environmental effects of traffic and mitigate these through a range of measures, including links to integrated TDM planning, policy and transport strategy initiatives, and with more direct traffic management ITS facilities.

Through the evaluation of these systems the research provides some direction on the variety of objectives behind their development, the strong influence of national and regional transport policies on the types of systems used and technologies employed; and benefits that can be achieved through an improved ability to manage traffic on the basis of accurate and reliable environmental data. It also provides improved information on the adverse effects of traffic on the environment, leading to better targeted mitigation strategies (short and longer term).

Example systems covered in the research include facilities in Italy, specifically targeted at the protection of historic buildings from pollution; the USA, linked to real-time information delivery systems; Europe, linked to specific TDM evaluation; and Mexico, aimed at reducing the significant problems of poor air quality.

Intelligent Transport Systems – ITS

ITS in this context describes the integrated application of advanced information, electronic, communications and other technologies to the management and operation of surface transportation systems.

The International Standards Organisation (ISO) technical committee for ITS describes its field as:

The application of information technology, communications technology, and sensor technology, including the internet (both wired and wireless), to the general challenges and opportunities of surface transportation.

By applying the latest technological advancements to the transportation system, ITS can help meet increasing demand for transportation by improving the quality, safety and effective capacity of existing infrastructure.

Abstract

The purpose of this project was to review the use overseas of environmental monitoring and forecasting systems as a component of wider-integrated ITS facilities, in particular those linked to transport and traffic management, and to consider their potential for New Zealand. It also aimed to provide direction from overseas best practice on the use of these systems to monitor, forecast and manage the adverse environmental effects of New Zealand traffic.

Through evaluation of these systems this research intended to highlight the benefits that could be achieved through an improved ability to plan and manage traffic on the basis of accurate and reliable environmental data. It also planned to provide better information on the adverse effects of traffic on the environment, especially through air and noise pollution, leading to better targeted mitigation strategies (short and longer term).

1. Introduction

Air quality monitoring has identified vehicle emissions as a major source of pollution in the main urban centres, alongside domestic heating fires and industry, with national air quality guidelines and international standards regularly exceeded in some areas.

The domestic transport sector is also a significant contributor to greenhouse gas emissions, accounting for 45% percent of New Zealand's carbon dioxide emissions in 2002, with road transport responsible for 89% of all transport emissions.

Poor air quality is recognised as a significant cause of health problems, particularly for children and the elderly. A report from the National Institute of Water and Atmospheric Research Ltd (NIWA), commissioned by the Ministry of Transport and released in 2002, estimated that around 400 people die prematurely in New Zealand each year as a result of exposure to vehicle emissions.

Recent and programmed national initiatives aimed at addressing these issues include:

- the setting of national vehicle emissions standards through the Transport Vehicle Exhaust Emissions Rule (2003)
- emissions screening of imported used vehicles
- emissions screening of in-service vehicles as part of the warrant of fitness (WoF) or certificate of fitness (CoF)
- education programmes on the need for regular vehicle maintenance
- revised fuel specifications to reduce sulphur content in diesel fuels
- measures to address severe traffic congestion in key areas.

Noise is also a significant impact of road transport that has a detrimental effect on the environment, people and communities. As with air pollution, noise is a recognised contributor to health problems, linked mainly to stress-related disorders.

The New Zealand Transport Strategy (NZTS) (NZ Government 2002) sets out the government's vision for a transport system that is affordable, integrated, safe, responsive and sustainable. The strategy includes objectives to address the negative social and environmental impacts of transport, including protecting and promoting public health and ensuring environmental sustainability.

The effective management of land transport emissions and noise is, therefore, an important component of meeting the objectives of the NZTS.

Noise and the related effects of noise from road transport are increasing in New Zealand as a result of:

- increased vehicle use
- a greater number of vehicles and increasing traffic congestion
- increasing levels of population.

Overseas, transport authorities are monitoring these effects using a range of technologies and, combined with more advanced traffic management tools, providing integrated facilities able to regulate traffic levels and congestion to reduce adverse environmental impacts.

This study looked at a range of international projects, with a focus on five aspects:

Project drivers

- examining the drivers behind each project and the principal issues that led to their inception (eg meeting government monitoring requirements or complementing other related initiatives)

Specific purpose or role

- considering what each specific system was set up to measure or forecast, and the main purpose of the facility (eg measuring specific elements or providing information for a specific purpose)

Policies and legislation

- considering the policies and/or legislation related to the development and/or application of these systems (eg policies/legislation that led to a system being established or the use of a particular system in directing future policy)

Project benefits and outcomes

- defining the outcome of each of the projects examined by how well the projects performed against their original intentions and requirements

  Outcomes and benefits were investigated to determine what had been achieved in terms of models and future strategies. The research looked at the tools that had been developed to implement these measures, and the benefits perceived by members of the public. This included studying the benefits that had arisen as a result of the projects, comparing them with those originally envisaged and taking account of lessons learned.

Key areas of consideration

- considering the main issues highlighted by each example in the context of the study.

2. Purpose of the research

The purpose of this research project was to review the use overseas of environmental monitoring and forecasting systems as a component of wider-integrated ITS facilities, in particular those linked to traffic and transportation management systems, and to consider the potential for using these systems in New Zealand.

The research was planned around the following structure:

1 Research into overseas examples of environmental monitoring and forecasting, looking in particular at what was measured and the key links to management and planning of transportation.

2 Consideration of the key issues and processes in New Zealand.

3 Examination of the overseas findings for application in a New Zealand context.

4 A summary of all findings, structured in a way to assist future policy and systems development in New Zealand.

The research has also provided direction from overseas best practice on the use of these systems to monitor and forecast adverse environmental effects resulting from traffic and transport, and to mitigate these with a range of policy and management tools.

Through evaluation of these systems the research has provided direction on the benefits that can be achieved through an enhanced ability to:

- plan and manage traffic on the basis of accurate and reliable environmental data
- provide improved information on the adverse effects of traffic on the environment, leading to better targeted mitigation strategies (short and longer term).

The European examples studied use a range of environmental monitoring and forecasting systems to manage traffic, specifically targeted at reducing adverse environmental impacts. Several of these have been put in place following European Union (EU) legislation requiring local councils and authorities to monitor air quality and other environmental factors and manage the primary sources.

The European experience also demonstrated a close link between the reporting of specific measures against required targets, and the use of these results in the development of further policies, strategies and systems. This focus on policy through to systems management was a key area of the research.

It also looked closely at the use of ITS in environmental monitoring and forecasting. The research straddled the two separate but related fields of the environment and ITS, and in some areas focused more on the policy and strategic elements of the environmental effects of transport, while in others it focused more on the technical aspects of ITS.

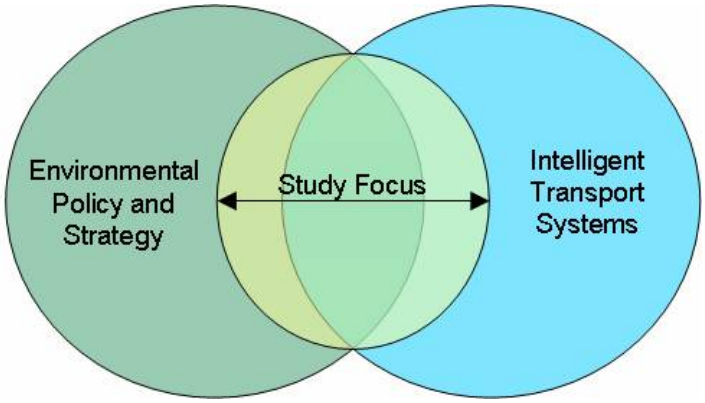

Figure 2.1 Study focus.

2.1 New Zealand context

In 1998, the Parliamentary Transport and Environment Committee undertook an inquiry into the environmental impacts of transport. Its interim report (NZ House of Representatives 1998) identified six environmental areas where land transport had a significant impact:

- air quality
- noise/vibration
- water/soil quality
- community impact, ie public health
- sustainable management of energy
- global climate change.

This list provided a useful summary of the key impact areas, but required some refinement to recognise the interrelationships and overlaps that existed and to set the right context for this study. Some refinement was also required to reflect impacts that were measurable and most directly related to the management of traffic and transport.

By combining and refining the list above to reflect these factors, the two key areas of focus for this study became:

1. air quality and climate change-related emissions
2. the effects of noise and vibration.

The figure overleaf illustrates these relationships.

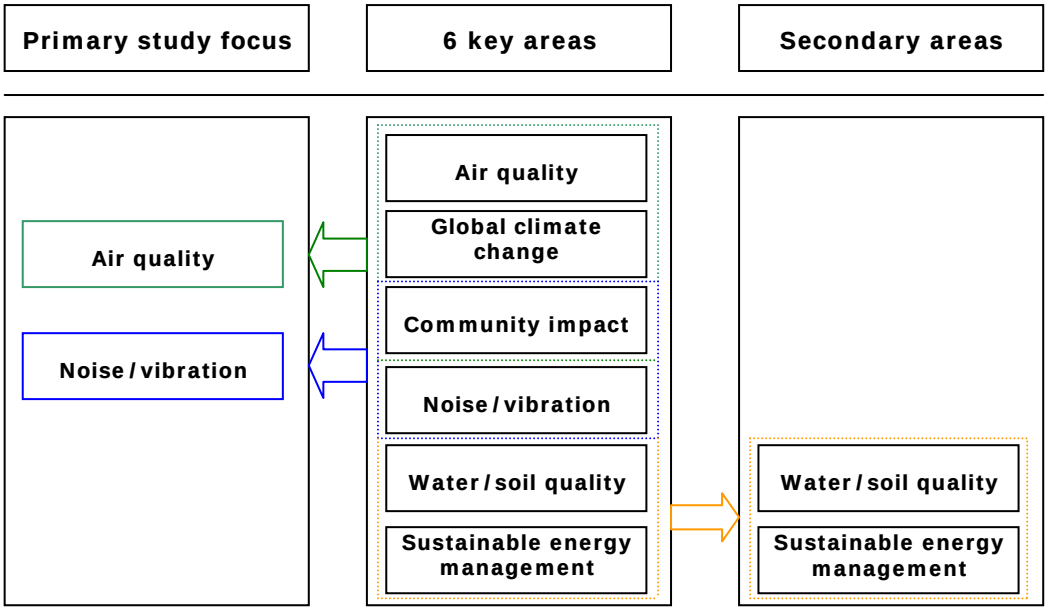

Figure 2.2 Environmental impacts.

Air quality and noise/vibration issues were selected as the primary focus areas as they were the most directly measurable impacts and had proportionally the greatest effect. They were also the primary factors contributing to community impacts and (depending on the type of air quality measures used) climate change.

The remaining two areas of impact (water/soil quality and sustainable management of energy) were considered to have a secondary impact in the context of this study.

Consultation with selected New Zealand industry organisations early in this research study (including the Ministry of Transport and Transit New Zealand) confirmed that air quality and noise/vibration were their primary areas of concern when developing and managing transport policy in this area.

2.2 Primary air quality focus

The evaluation of international environmental monitoring and forecasting systems shows the vast majority of systems focus on the measurement and modelling of air quality. Most target a common group of pollutants with known or suspected harmful effects on human health and the environment.

In most cases these pollutants are principally the products of combustion from heating, power generation or motor vehicles. They create problems both in the immediate vicinity of their source and over wider areas, in some cases reacting with the atmosphere to produce major secondary pollutants such as ozone.

In most developed countries, the major historic air pollution problem has typically been high levels of smoke and sulphur dioxide arising from the combustion of sulphur-containing fossil fuels such as coal for domestic and industrial purposes. Smog resulting

from the combined effects of black smoke, sulphate/acid aerosol and fog has been a problem throughout northern Europe for centuries.

This problem has diminished over recent decades as a result of changing fuel-use patterns, the increasing use of cleaner fuels such as natural gas and the implementation of effective smoke and emission control policies.

In developed countries, the major threat to clean air is now posed by traffic emissions. Petrol and diesel vehicles emit a wide variety of pollutants, principally carbon monoxide, oxides of nitrogen, volatile organic compounds and particulates, which have an increasing impact on urban air quality.

In addition, photochemical reactions resulting from the action of sunlight on nitrogen dioxide and volatile organic compounds from vehicles lead to the formation of ozone, a secondary long-range pollutant, which impacts across wide areas.

Traffic-related pollution problems are worsening world-wide, with particular problems in developing countries where vehicle fleets are increasing rapidly, often with older, higher-emission vehicles.

The following is a summary of the primary pollutants produced by industrial, domestic and traffic sources that are the main focus of international monitoring and forecasting systems.

2.2.1 Sulphur dioxide

Sulphur dioxide (SO2) is a corrosive acid gas which combines with water vapour in the atmosphere to produce acid rain. It causes damage to vegetation and soils, building materials and watercourses. SO2 in ambient air is also associated with asthma and chronic bronchitis.

The principal source of SO2 is burning fossil fuels which contain sulphur. Major SO2 problems now only tend to occur in cities where coal is still widely used for domestic heating, in industry and in power stations. SO2 emissions have diminished steadily over recent years and in most European countries are no longer considered to pose a significant threat to health.

Of particular concern in the past was the combination of SO2 and black smoke and particulate matter; current EC Directive Limit Values for SO2 are defined in terms of accompanying black smoke levels, although these are likely to change.

2.2.2 Particulates (PM10)

Airborne particulate matter varies widely in its physical and chemical composition, source and particle size. PM10 particles (the fraction of particulates in air of very small size (<10 µm)) are of major current concern, as they are small enough to penetrate deep into the lungs and so potentially pose significant health risks. Larger particles, meanwhile, are not readily inhaled and are removed relatively efficiently from the air by sedimentation. Particles are often classed as either primary (those emitted directly into the atmosphere) or secondary (those formed or modified in the atmosphere from condensation and growth).

A major source of fine primary particles is the combustion process, in particular diesel combustion, where transport of hot exhaust vapour into a cooler tailpipe or stack can lead to spontaneous nucleation of carbon particles before emission. Secondary particles are typically formed when low volatility products are generated in the atmosphere, for example the oxidation of sulphur dioxide to sulphuric acid. The atmospheric lifetime of particulate matter is strongly related to particle size, but may be as long as 10 days for particles of about one mm in diameter. The principal source of airborne PM10 matter in developed cities is road traffic emissions, particularly from diesel vehicles.

As well as creating dirt, odour and visibility problems, PM10 particles are associated with health effects including increased risk of heart and lung disease. In addition, they may carry surface-absorbed carcinogenic compounds into the lungs.

Concern about the potential health impacts of PM10 has increased very rapidly over recent years. Increasingly, attention has been turning towards monitoring both the smaller particle fraction PM2.5 which is capable of penetrating deepest into the lungs, and even smaller size fractions or total particle numbers.

2.2.3 Carbon monoxide

Carbon monoxide (CO) is a toxic gas which is emitted into the atmosphere as a result of combustion processes, and is also formed by the oxidation of hydrocarbons and other organic compounds. In most urban areas, CO is produced almost entirely (90%) from road traffic emissions. CO at levels found in ambient air may reduce the oxygen-carrying capacity of the blood. It survives in the atmosphere for a period of approximately one month but is eventually oxidised to carbon dioxide (CO2).

2.2.4 Nitrogen oxides

Nitrogen oxides are formed during high temperature combustion processes from the oxidation of nitrogen in the air or fuel. The principal source of nitrogen oxides – nitric oxide (NO) and nitrogen dioxide (NO2), collectively known as NOx – is road traffic, which is responsible for approximately half the emissions in Europe. NO and NO2 concentrations are, therefore, greatest in urban areas where traffic is heaviest.

Nitrogen oxides are released into the atmosphere mainly in the form of NO, which is then readily oxidised to NO2 by reaction with ozone. Elevated levels of NOx occur in urban environments under stable meteorological conditions, when the air mass is unable to disperse.

Nitrogen dioxide has a variety of environmental and health impacts. It is a respiratory irritant, may exacerbate asthma and possibly increase susceptibility to infections. In the presence of sunlight, it reacts with hydrocarbons to produce photochemical pollutants such as ozone. In addition, nitrogen oxides have a lifetime of approximately one day with respect to conversion to nitric acid. This nitric acid is in turn removed from the atmosphere by direct deposition to the ground or transfer to aqueous droplets (eg cloud or rainwater), thereby contributing to acid deposition.

2.2.5 Ozone

Ground-level ozone (O3) unlike other primary pollutants is not emitted directly into the atmosphere, but is a secondary pollutant produced by reaction between nitrogen dioxide (NO2), hydrocarbons and sunlight. Ozone can irritate the eyes and air passages causing breathing difficulties and may increase susceptibility to infection. It is a highly reactive chemical, capable of attacking surfaces, fabrics and rubber materials. Ozone is also toxic to some crops, vegetation and trees.

Sunlight provides the energy to initiate ozone formation, and high levels of ozone are generally observed during hot, still sunny weather in locations where the air mass has previously collected emissions of hydrocarbons and nitrogen oxides (eg urban areas with traffic). Because of the time required for chemical processing, ozone formation tends to be downwind of pollution centres. The resulting ozone pollution may persist for several days and be transported over long distances.

2.2.6 Other pollutants

In addition to these five primary pollutants a range of others are also monitored, including:

Benzene (C6H6) – a carcinogenic hydrocarbon found in the direct emissions from burning coal and oil, and from motor vehicle exhausts.

Volatile organic compounds (VOCs) – organic chemical compounds that have high enough vapour pressures under normal conditions to significantly vaporise and enter the atmosphere. A wide range of carbon-based molecules, such as aldehydes, ketones and hydrocarbons are VOCs. The term is often used in a legal or regulatory context to refer to any compound of carbon (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate) which participates in atmospheric photochemical reactions.

2.2.7 World Health Organisation and Ministry for the Environment guidelines

According to a World Health Organisation (WHO) assessment of the burden of disease due to air pollution, more than two million premature deaths each year can be attributed to the effects of urban outdoor and indoor air pollution.

The WHO air quality guidelines (AQGs) are designed to offer guidance in reducing the health impacts of air pollution. First produced in 1987 and updated in 1997, these AQGs are based on expert evaluation of current scientific evidence. They have been developed to support actions to achieve air quality that protects public health in different contexts.

WHO AQGs are based on extensive scientific evidence relating to air pollution and its consequences for health. Although this information base has gaps and uncertainties, it is considered to offer a strong foundation for the recommended guidelines, as in the following examples.

- Evidence for ozone (O3) and particulate matter (PM) indicates there are risks to health at concentrations currently found in many cities in developed countries.

Moreover, as research has not identified thresholds below which adverse effects do not occur, it must be stressed that the guideline values provided here cannot fully protect human health.

- An increasing range of adverse health effects has been linked to air pollution and at ever lower concentrations. This is especially true of airborne particulate matter. New studies use more refined methods and more subtle but sensitive indicators of effects, such as physiological measures.
- As understanding of the complexity of the air pollution mixture has improved, the limitations of controlling air pollution through guidelines for single pollutants have become increasingly apparent.

The WHO AQGs for PM, ozone, NO2 and SO2 are set out below along with a brief description of the basis for these levels. In some cases interim targets are given, which are intended as incremental steps in a progressive reduction of air pollution where pollution is high. Alongside each of the WHO levels are the current New Zealand Ministry for the Environment (MfE) levels for each pollutant.

Sulphur dioxide

WHO guideline values to protect health

In any 24-hour period, the average concentration of sulphur dioxide in air should not be more than 20 µg/m3.

The 10-minute mean of NO2 should not exceed 500 µg/m3.

MfE guideline values to protect health

In any one-hour period, the average concentration of sulphur dioxide in air should not be more than 350 µg/m3.

In any 24-hour period, the average concentration of sulphur dioxide in air should not be more than 120 µg/m3.

Ozone

WHO guideline values to protect health

The one-hour guideline has been removed as the eight-hour guideline should protect against short-term peak exposures of one hour. It was previously 150-200 µg/m3.

In any eight-hour period, the average concentration of sulphur dioxide in air should not be more than 100 µg/m3.

MfE guideline values to protect health

In any one-hour period, the average concentration of ozone in air should not be more than 150 µg/m3.

WHO guideline values to protect health

The one-hour guideline has been removed as the eight-hour guideline should protect against short-term peak exposures of one hour. It was previously 150–200 µg/m3.

In any eight-hour period, the average concentration of sulphur dioxide in air should not be more than 100 µg/m3.

MfE guideline values to protect health

In any one-hour period, the average concentration of ozone in air should not be more than 150 µg/m3.

In any eight-hour period, the average concentration of ozone in air should not be more than 100 µg/m3.

Nitrogen dioxide

WHO guideline values to protect health

In any one-hour period, the average concentration of sulphur dioxide in air should not be more than 200 µg/m3.

In any 24-hour period, the average concentration of sulphur dioxide in air should not be more than 150 µg/m3.

The average annual concentration of NO2 should not exceed 40 µg/m3.

MfE guideline values to protect health

In any one-hour period, the average concentration of nitrogen dioxide in the air should not be more than 200 µg/m3.

In any 24-hour period, the average concentration of nitrogen dioxide in the air should not be more than 100 µg/m3.

Carbon monoxide

WHO guideline values to protect health

In any eight-hour period, the average concentration of sulphur dioxide in air should not be more than 10 µg/m3.

MfE guideline values to protect health

In any one-hour period, the average concentration of carbon monoxide in air should not be more than 30 µg/m3.

In any eight-hour period, the average concentration of carbon monoxide in air should not be more than 10 µg/m3.

Particles (PM10)

MfE guideline values to protect health

In any 24-hour period, the average concentration of PM10 in the air should not be more than 50 µg/m3. The average annual concentration of PM10 should not exceed 20 µg/m3. There is no guideline value for PM2.5 yet.

WHO guideline values to protect health

In any 24-hour period, the average concentration of PM10 in the air should not be more than 50 µg/m3. The average annual concentration of PM10 should not exceed 20 µg/m3.

2.3 New Zealand conditions

Work in this area in New Zealand has mainly focused on the following pollutants:

- carbon monoxide (CO)
- nitrogen oxides (NOx)
- sulphur dioxide (SO2)
- ozone
- particulates (PM10)
- benzene (in some areas).

In most urban centres in New Zealand there are now emission inventories providing a reasonable picture of the main emission levels and sources, and showing that domestic fires and vehicles are the greatest contributors to these. Most of these inventories are currently estimates drawn from a range of sources. Although some of the inventories are not directly comparable due to the different methodologies used, they provide a reasonable indication of the nature and levels of the current problems, identifying sources and locations where actions are required to meet national environmental standards.

The following section provides a brief overview of the current proportions and contributors in the main urban centres of Auckland, Wellington and Christchurch.

2.3.1 Auckland

Carbon monoxide: Motor vehicles contribute the majority of CO emissions in Auckland, with a 1993 inventory indicating around 84% are likely to be attributable to this source. In any location, however, the relative contribution from different sources will depend on factors such as the proximity to roads.

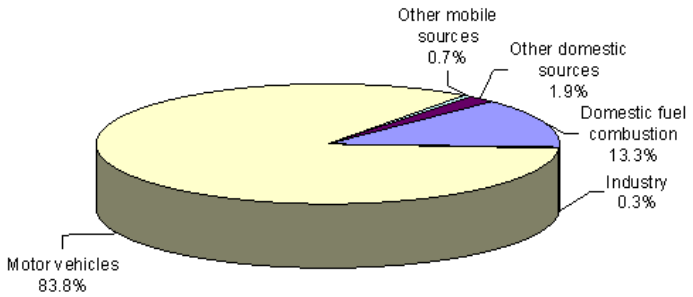

Figure 2.3 Auckland carbon monoxide sources.

Nitrogen oxides: Motor vehicles contribute 80% of NOx emissions in Auckland, with industry producing 12% and other mobile sources, domestic fuel combustion and other domestic sources contributing the remainder.

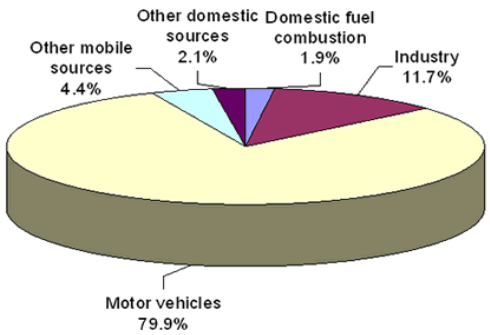

Figure 2.4 Auckland nitrogen oxide sources.

Sulphur dioxide: The main source of SO2 emissions in Auckland is industry, at 56%, compared with 14% from motor vehicles, 10% from other mobile sources and 20% from domestic sources.

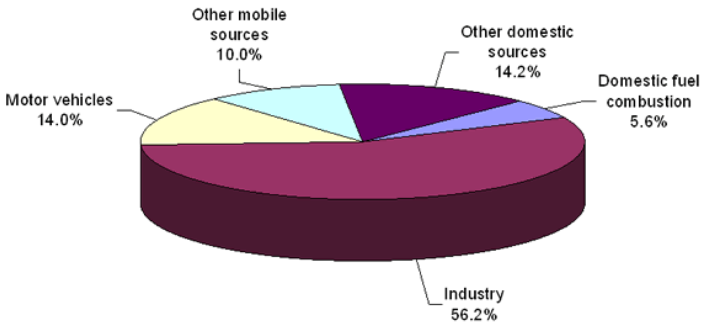

Figure 2.5 Auckland sulphur dioxide sources.

2.3.2 Wellington

Carbon monoxide: The main source of carbon monoxide in Wellington is also motor vehicle emissions, with a 1998 inventory indicating a contribution of around 64%; the other significant source being domestic and commercial combustion at 26%.

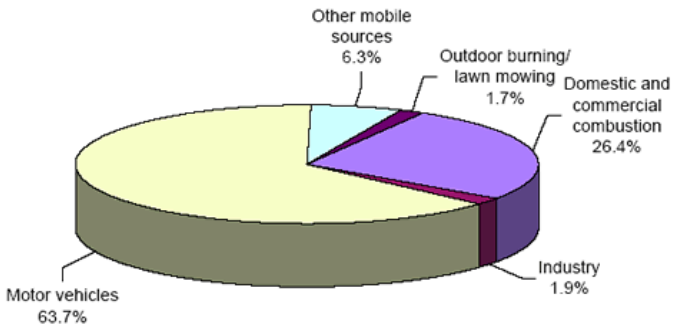

Figure 2.6 Wellington carbon monoxide sources.

Nitrogen oxides: The main source of NOx emissions in the Wellington region is again motor vehicles at 68%, with other mobile sources including aviation and commercial shipping contributing 28%.

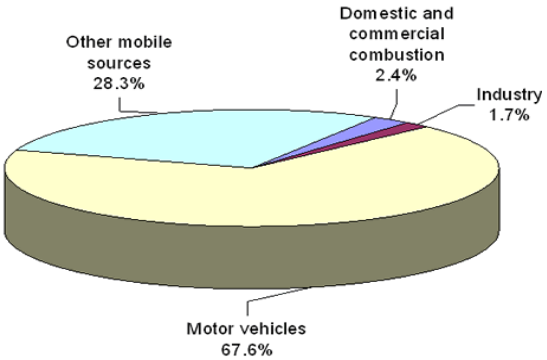

Figure 2.7 Wellington nitrogen oxide sources.

Sulphur dioxide: The main source of SO2 in the Wellington region is commercial shipping, which makes up 82% of this.

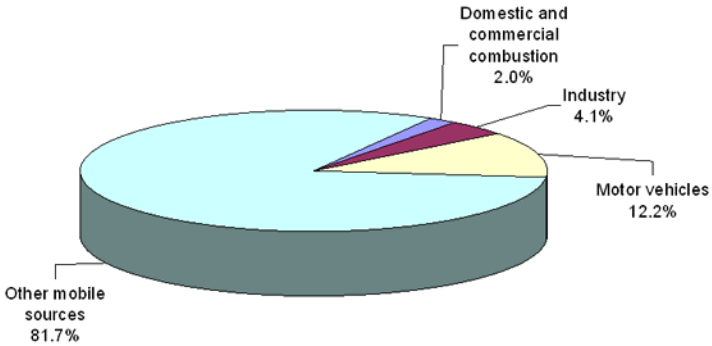

Figure 2.8 Wellington sulphur dioxide sources.

Ground level ozone / volatile organic compounds (VOC)

Ground level ozone, although not directly measured, has a close relationship to VOC emissions. In most areas of New Zealand, domestic home heating and motor vehicles are estimated to be the main contributors to these emissions.

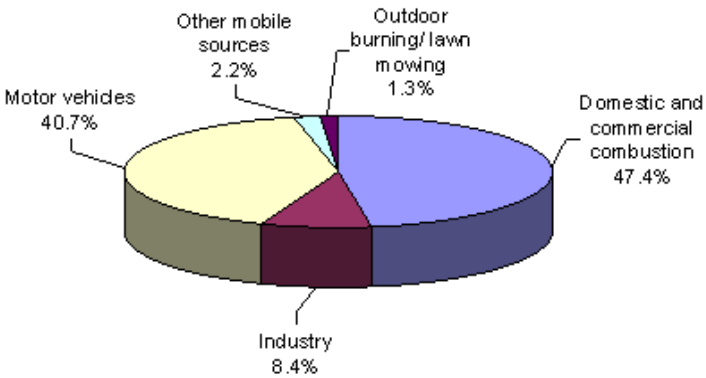

Figure 2.9 Wellington ground level ozone sources.

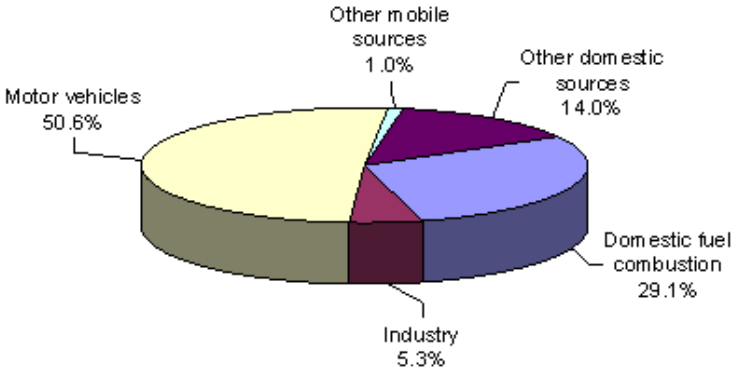

Figure 2.10 Auckland ground level ozone sources.

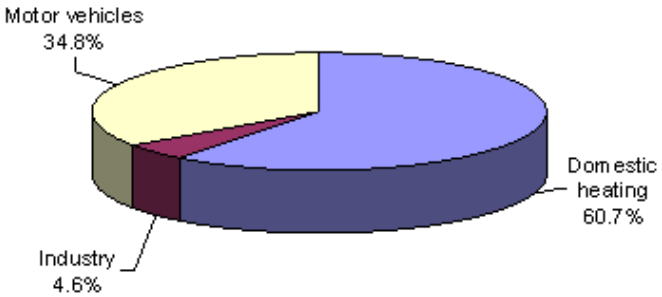

Figure 2.11 Christchurch ground level ozone sources.

PM10

The figure below illustrates the average annual PM10 levels in five major cities in New Zealand up to 2005.

Christchurch site levels are above the ambient guideline of 20 micrograms per cubic metre for all years from 1995 to 2005, while Auckland exceeded this guideline in 2004 and Wellington in 2003.

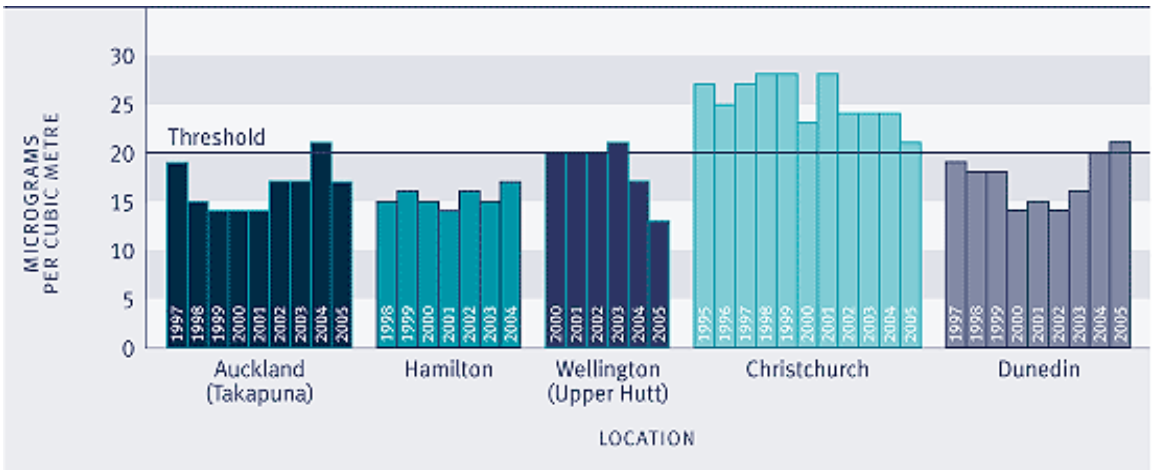

Figure 2.12 Average annual PM10 levels up to 2005.

2.3.3 Greenhouse gases

A review of New Zealand climate change policy was completed in November 2005 and has focused efforts on a 'whole of government' work programme for climate change covering communication and stakeholder engagement, a strategic framework, preparation for and adapting to climate change, forestry measures, transport measures, energy sector measures, agriculture and land use, development of a purchasing strategy for Kyoto compliant emission units, international engagement, alternatives to the carbon tax, cross-sector initiatives, and climate change research and technology investment priorities.

The focus of international engagements has been to work within the United Nations Framework Convention on Climate Change (UNFCCC) process to help ensure that the outcomes of the Montreal Climate Change Conference in December 2005 are aligned with New Zealand's views.

New Zealand is a party to both the UNFCCC and its Kyoto Protocol, and the government's climate change policy package is built on a foundation of existing policies and strategies – the New Zealand Energy Efficiency and Conservation Strategy, the New Zealand Transport Strategy, the New Zealand Waste Strategy, the Growth and Innovation Framework and the Sustainable Energy Work Programme within the Sustainable Development Programme of Action.

New Zealand has two greenhouse gas targets. One is an externally set target under the Kyoto Protocol, namely that by 2012 New Zealand will return its total net emissions to 1990 levels or take responsibility for any excess; and the other is an internally set goal, namely that New Zealand is set towards a permanent downward path for total gross emissions by 2012.

The 2004 New Zealand Greenhouse Gas Inventory was completed and submitted in April 2006, in line with the requirements of the UNFCCC. An overview of the significant categories in the 2004 profile is illustrated below:

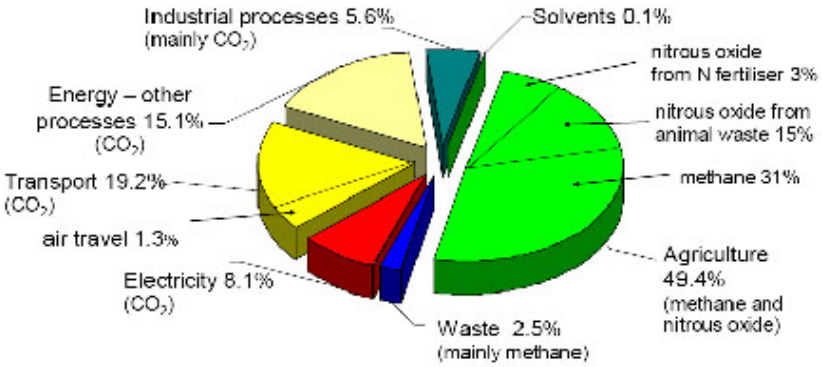

Figure 2.13 NZ greenhouse gas emissions in 2004 by sector (% of $MtCO_2$-e).

2.4 International comparison

Although ambient air quality is location-specific it is difficult to provide an effective comparison across countries. The following graphs have been drawn from an OECD study carried out in 1993 which provides an assessment of statistics for a range of OECD countries. The graphs also indicate WHO AQG levels and an assessment of current levels for Auckland, Wellington and Christchurch based on available data.

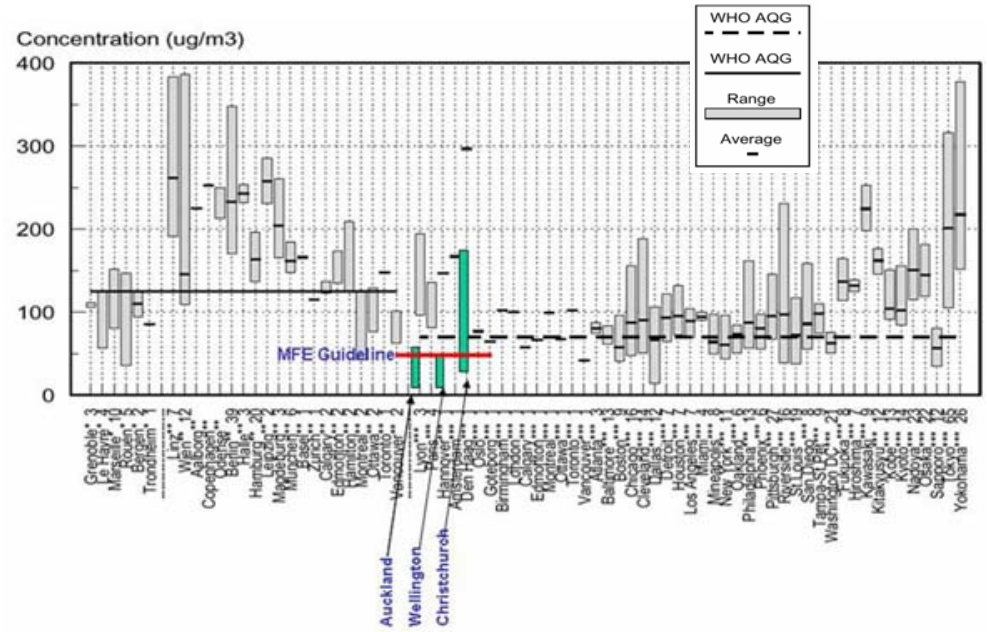

Figure 2.14 Urban peak statistics for suspended particulates (24-hour values) in 1993.

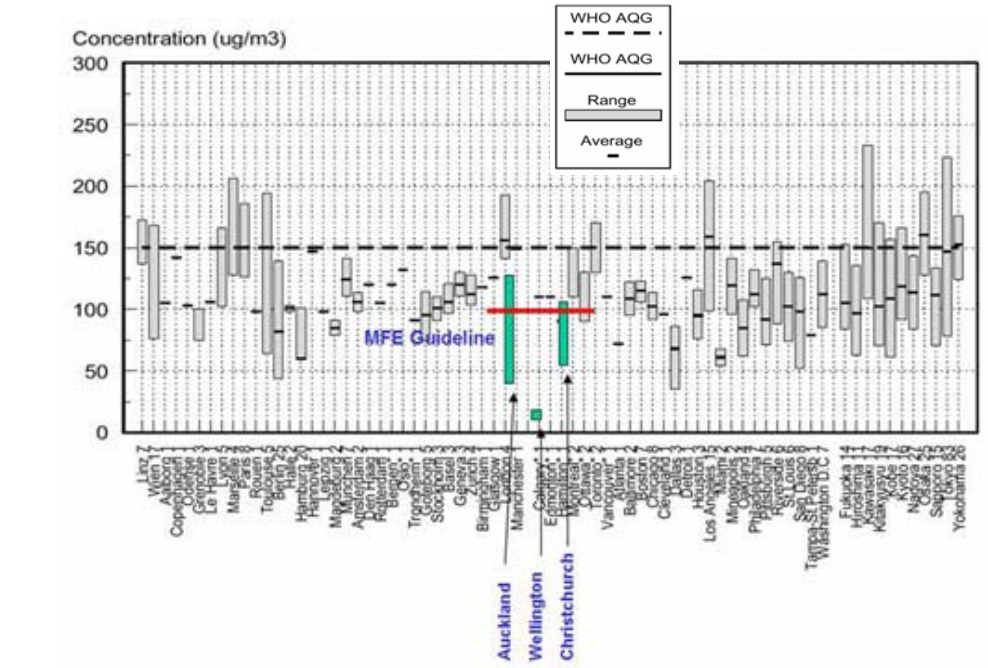

Figure 2.15 Urban peak statistics nitrogen dioxide (24-hour values) in 1993.

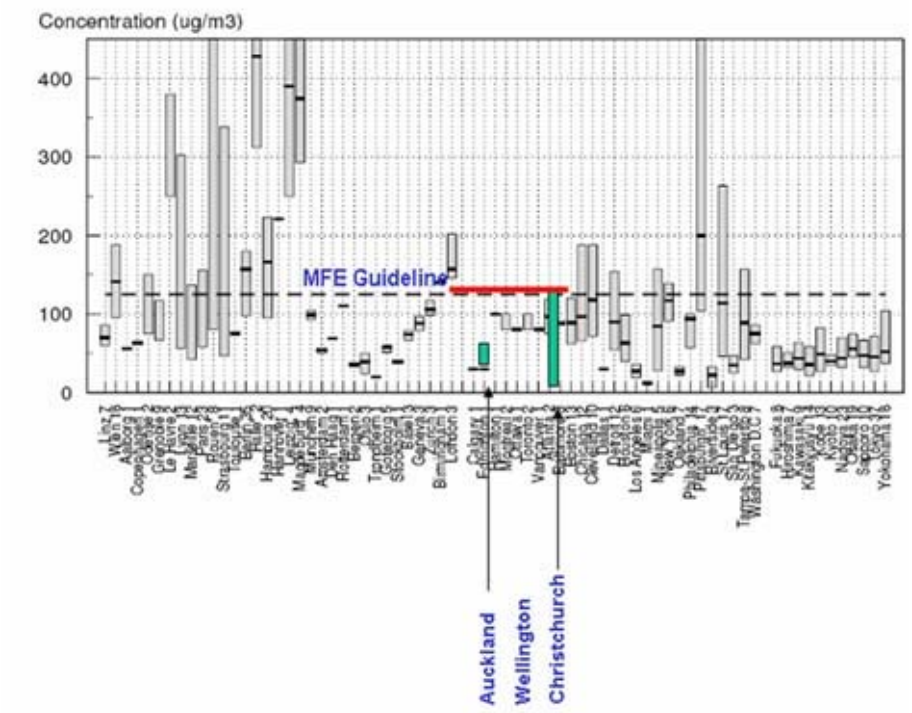

Figure 2.16 Urban peak statistics sulphur dioxide (24-hour values) in 1993.

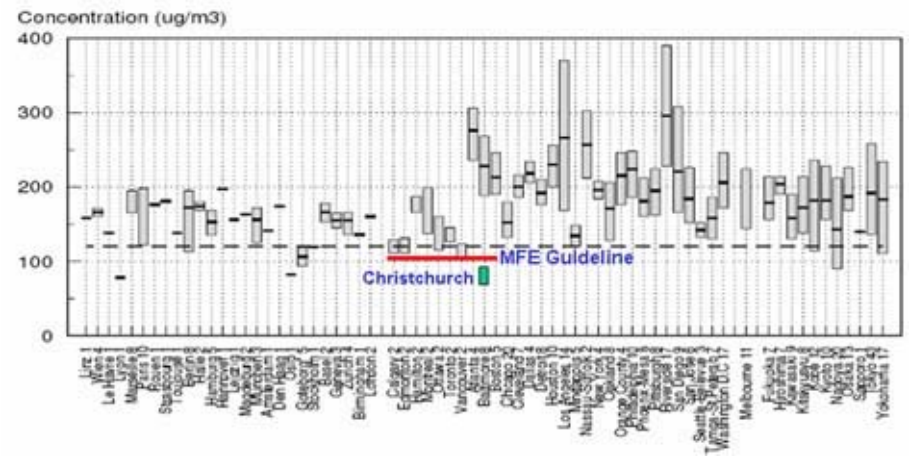

Figure 2.17 Urban peak statistics ozone (8-hour) in 1993.

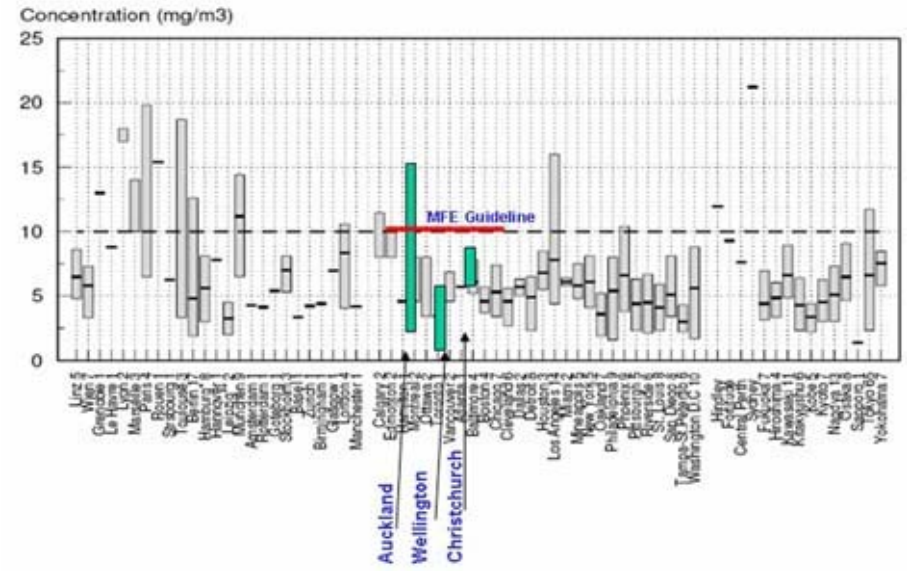

Figure 2.18 Urban peak statistics carbon monoxide (8-hour) in 1993.

2.5 Relevance to Land Transport New Zealand's outcomes and key topic areas

A key focus area of the *New Zealand Transport Strategy* (NZTS) is the need to reduce the impacts of transport on the environment, particularly where this affects public health.

The negative health impacts of road transport come from a wide range of emissions, contaminants, noise and accidents. The impacts from traffic in high-volume and congested areas are not only confined to exhaust emissions but include particles of worn tyre material, un-burnt fuel and road surface wear material. Vehicle emissions are also a major contributor to climate change, an area the government is committed to reducing.

The NZTS, released in December 2002, sets out the government's overall vision for transport.

> **By 2010 New Zealand will have an affordable, integrated, safe and sustainable transport system**

The principles of this approach are:

- sustainability
- integration
- safety
- responsiveness.

The NZTS also sets out a number of key objectives:

- economic development
- safety and personal security
- access and mobility

- public health
- environmental sustainability.

In support of the NZTS principles and objectives, the Land Transport Management Act 2003 (LTMA) states that Land Transport New Zealand must be satisfied that any programme it approves must contribute towards achieving the above objectives. A more detailed definition of these principles and objectives is set out below, in the context of the types of environmental monitoring being considered.

2.5.1 Principle 1: Sustainability

Sustainability in this context is defined as:

- focusing on improving the transport system in ways that enhance economic, social and environmental well-being and promote resilience and flexibility
- taking account of the needs of future generations
- being guided by medium- and long-term costs and benefits.

Environmental monitoring and forecasting systems support sustainability-based objectives through monitoring and proving compliance with policy directives, including improvement in localised air quality, reductions in noise pollution, protection of historic buildings, improving protection against the health affects of poor air quality, and meeting and measuring against greenhouse gas emissions targets.

The types of systems examined have the potential to improve the ability to monitor and analyse environmental data, leading to better targeting of these and other initiatives; to assist in targeting integrated measures to reduce emissions; and to improve targeting of transport demand policies.

2.5.2 Principle 2: Integration

Integration in this context is defined as:

- focusing on an efficient and integrated mix of transport modes and cooperation and collaboration between stakeholders
- ensuring the efficient use of existing and new public investment.

Environmental monitoring and forecasting systems support integration-based objectives, mainly through monitoring the impacts of transport on the environment. This proves the benefits of an efficient modal mix and provides data to assist in the optimisation of this mix.

These systems improve the ability to monitor and analyse environmental data, such as local air quality, noise, impacts on historic buildings, and health-related air and noise effects, leading to better targeting of transport integration initiatives.

2.5.3 Principle 3: Safety

Safety in this context is defined as:

- promoting high standards of health, safety and personal security for all people, including users, workers and operators
- ensuring a robust health and safety framework, complemented by an emphasis on individual and business responsibility.

Environmental monitoring and forecasting systems in this context support safety-based objectives, mainly through monitoring specific hazards such as air pollution and noise. The systems improve the ability to monitor and analyse these effects, leading to better targeting of initiatives and providing supporting information for future policy initiatives in these areas.

2.5.4 Principle 4: Responsiveness

Responsiveness in this context is defined as:

- recognising the diverse needs of urban and rural communities (those who use transport and those affected by it)
- promoting partnership between the Crown and Maori; between central and local government; and between government and citizens and communities, including business.

Environmental monitoring and forecasting systems have the potential to provide a variety of information to support policy and strategy initiatives to address localised problems with air quality, vehicle emissions and noise.

2.5.5 Objective 1: Economic development

This objective is targeted at:

- delivering a coherent and efficient transport system that contributes to quality of life and supports economic development goals, both nationally and within regions
- leading to improved flows of people, goods and services within and between urban and rural areas, and between New Zealand and overseas.

Environmental monitoring and forecasting systems support these objectives through monitoring and proving compliance with policy directives, including improvement in localised air quality, reductions in noise pollution, protection of historic buildings, improving protection against the health affects of poor air quality, and meeting and measuring against greenhouse gas emissions targets. These systems improve the ability to monitor and analyse environmental data, leading to better targeting of these and other initiatives.

2.5.6 Objective 2: Safety and personal security

This objective is targeted at:

- addressing safety and personal security concerns in order to improve quality of life and to promote modes such as walking, cycling and public transport
- strengthening current commitments to road safety education and enforcement for all road users.

Environmental monitoring and forecasting systems support safety-based objectives mainly through monitoring a specific hazard such as air pollution or noise. These systems improve the ability to monitor and analyse environmental data, such as local air quality and specific health-related aspects of air pollution and noise, leading to better targeting of initiatives to reduce specific effects, and providing supporting information for policy initiatives targeted in these areas.

2.5.7 Objective 3: Access and mobility

This objective is focused on:

- improving access and mobility for all New Zealanders through education, investment and infrastructure to improve local networks, communication and travel within and between regions.
- providing affordable and reliable transport services that will make a key contribution to better access and mobility through the promotion of the optimal use of different modes of transport in different settings and a range of measures including pricing and funding priorities.

Environmental monitoring and forecasting systems support access and mobility objectives mainly through monitoring the impacts of transport on the environment, and so proving the benefits of an efficient modal mix. These systems also support the promotion of the optimal use of different modes of transport in different settings.

Traffic congestion, either in the form of recurring peak delays or unplanned incidents and emergency works, has a major impact on access and mobility. Environmental monitoring and forecasting facilities provide support for a range of strategies that can assist with improving both the level and impact of congestion in urban areas.

Environmental monitoring and forecasting tools, linked to ITS, can provide advance warning of poor air quality by combining the information gathered with data from weather stations, thermal mapping and other forms of condition monitoring systems. This information can then be provided through the internet or through variable message signs (VMS) to enable travellers to make a choice about their mode of transport or route.

2.5.8 Objective 4: Public health

This objective is focused on:

- contributing to healthy communities and human interaction. Health outcomes will be improved through regulation, education, encouragement and investment
- promoting walking and cycling for short trips
- encouraging reduced dependence on private vehicles for mobility
- encouraging modal shifts that enhance air and water quality and reduce exposure to transport noise or other aspects of transport systems that can impinge on community and personal health.

Environmental monitoring and forecasting systems support public health objectives mainly through monitoring the impacts of transport on air quality and noise. These systems improve the ability to monitor and analyse environmental data, such as local air quality and specific health-related aspects of air pollution and noise, leading to better targeting of initiatives to reduce specific effects and providing supporting information for policy initiatives targeted to these areas.

2.5.9 Objective 5: Environmental sustainability

This objective is focused on:

- making transport more energy efficient and environmentally sustainable. Negative local and global environmental effects of transport will be reduced through education, regulation, technology and investment
- improving mobility for people, goods and services within New Zealand and between New Zealand and overseas, through creative responses that meet people's needs with minimal adverse effects on the environment
- improving the efficiency of existing road and rail networks, promoting alternatives to roads and reducing traffic growth will be key elements in minimising the adverse effects of land transport.

Environmental monitoring and forecasting systems support sustainability-based objectives through monitoring and proving compliance with policy directives, including improvement in localised air quality, reductions in noise pollution, protection of historic buildings, improving protection against the health affects of poor air quality, and meeting and measuring against greenhouse gas emissions targets.

These systems improve the ability to monitor and analyse environmental data, leading to better targeting of these and other initiatives, assist in targeting integrated measures to reduce greenhouse gases and improve the targeting of transport demand policies.

3. Sample projects selected

The purpose of this study was to review the use overseas of environmental monitoring and forecasting systems as a component of wider-integrated ITS facilities; in particular, those linked to active traffic management systems and related information systems, and to consider the potential for their use in New Zealand.

A range of international example systems were reviewed in order to select a suitable cross-section for more detailed consideration. Early discussions with industry organisations in New Zealand identified that the main focus for the study should be in the areas of air quality and noise.

The range of potential systems and initiatives reviewed at this stage included EU-funded initiatives linked to air quality and noise guidelines; systems targeted at major pollution problems in large cities; facilities targeted at forecasting and providing air quality information to the public; specifically targeted systems in city centres; and the development of integrated modelling tools.

From this process six projects or systems were selected to provide examples across a range of relevant issues, models and/or technologies. They were also at varying stages of development; some being completed studies and others developing systems.

The six systems selected were:

1. HEAVEN (Healthier environment through abatement of vehicle emission and noise) project – European Union
2. PROAIRE project – Mexico City
3. Paso del Norte Region Environmental Monitoring Project, Texas
4. Environmental monitoring and access control, Rome and Florence
5. Environmental monitoring system, York
6. Monitoring and simulation models – SIMTRAP

Each of these is described below.

3.1 HEAVEN project

The HEAVEN project was part of an EU-funded initiative, brought about by legislation requiring local councils to keep to air quality and noise guidelines. The project developed the use of existing and new modelling techniques to assist local councils and regions meet the requirements.

The primary purpose of this project was to develop and demonstrate a decision support system (DSS) to evaluate air quality and noise effects of TDM strategies in large urban areas, including both emissions and dispersion forecasting.

The main project objectives were to:

- improve the basis for decision-making through integrated and real-time information on key pollution factors
- inform key stakeholders (including the public) on the state of air and noise pollution levels and their effects on health
- investigate the data needs of health experts and the implementation of a valid data exchange platform with health authorities
- identify the key benefits of these measures for sustainable urban development and the quality of life in cities
- generate commercial value from the project
- draw conclusions for the implementation of local noise and air quality action plans.

To achieve these objectives the project was developed around an initial system concept and extensive user need analysis. This provided a sound foundation for the system development.

The HEAVEN DSS was then developed and a large-scale demonstration carried out on six project sites.

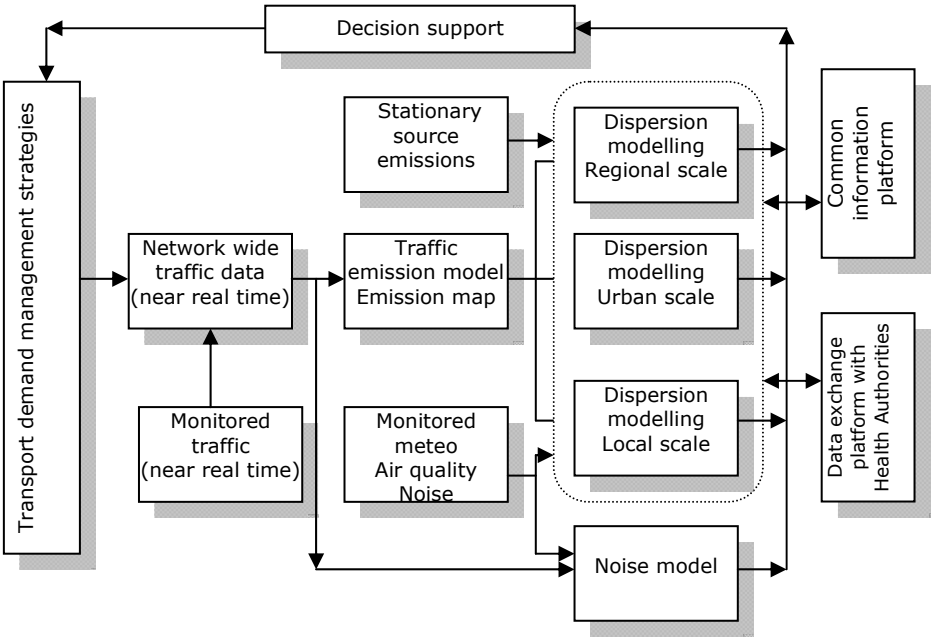

Figure 3.1 The HEAVEN DSS concept.

The HEAVEN DSS combined near real-time traffic flow information with emission and dispersion models to determine the contribution of mobile sources to air quality and noise.

In order to estimate emissions based on current traffic levels and on planned demand management scenarios, the system was developed to operate on-line, based on current traffic and environmental information, and off-line, based on planned traffic and environmental conditions and pre-defined TDM scenarios.

Where TDM measures were to be implemented, traffic was partially measured in near real time using a range of traffic detectors. These measurements then contributed to a traffic status estimation base on a network-wide traffic model. The output from this model was used as the input for the subsequent environmental models.

Emission models were used to calculate the traffic-related emissions for each link of the network for a number of primary pollutants, based on measured and modelled traffic characteristics. Specific air quality concentrations were then modelled using these emissions. A separate noise model made use of the same traffic inputs, combined with data on the road surface, topography and built environment.

The results of the emissions, air quality and noise modelling were fed into the decision-making process and, together with the traffic and environment monitoring data, contributed to the building of the common information platform of the HEAVEN system.

The architecture of the systems used within the HEAVEN package is illustrated below.

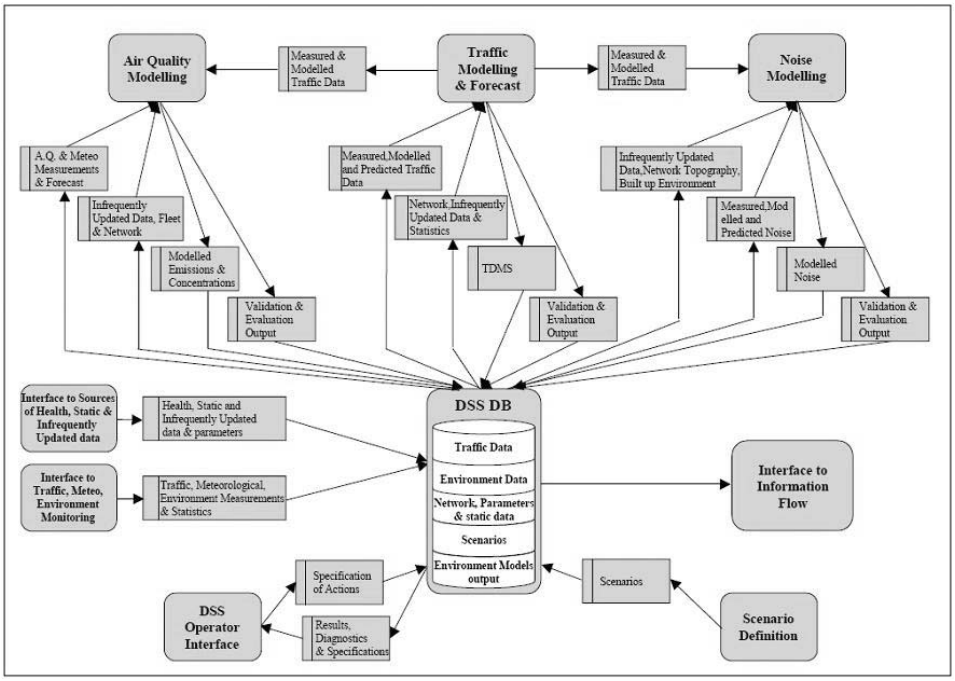

Figure 3.2 Example packages tested.

This illustrates how information is passed between and across the various models, drawing from and providing data to the central DSS databases.

Across the six trial areas a range of systems and scenarios were used, some testing the effects of actual improvements and others the potential impacts of planned improvements. The following is a summary of the six city trials.

3.1.1 Berlin

Local truck bans and 30 km/h speed-limits were implemented across the demonstration area during the trial and the HEAVEN system was used to calculate the likely effects these measures would have on air and noise pollution. These calculations showed that a

combined implementation of both measures would reduce PM10 by 13.1% and NO2 by 16.3%, while the noise levels would be reduced by 5,7 dB(A).

Two city-wide long-term scenarios were also assessed. The first assumed that all vehicles would fulfil the Euro III emission standards by 2005 and the second was based on full Euro IV standards by 2010.

For both scenarios, the expected traffic volumes and background concentrations were calculated and compared with the situation in 1998 as a reference case.

The analysis of the results showed the lower emissions would reduce PM10 pollution by 16 µg/m3; however, the PM10 concentration would still exceed EU limit values on a high number of street segments in Berlin. The predictions for NO2 were similar, with certain areas decreasing by more than 20 µg/m3, but remaining high in others.

3.1.2 Leicester

The HEAVEN system was applied in Leicester in December 2000 to support an air quality review and assessment, which designated several air quality management areas. The trial identified NO2 and PM10 as problem pollutants (ozone was not covered by the review, although it has also been identified as a problem for Leicester). A selection of TDM strategies included in the local transport plan was also analysed.

Annual NOx exposure results for winter and summer conditions were also assessed for park and ride proposals associated with a range of schemes for inter-authority negotiations and public consultation processes.

All results illustrated a reduction between winter and summer, as well as before and after the implementation of park and ride schemes. The AVTUNE (AirViro-based traffic and urban noise evaluator) noise emissions model was also deployed, identifying lower levels after implementation.

Twenty percent speed reduction and no heavy goods vehicle (HGV) scenarios were also tested, requiring a revised assessment of traffic flows. This resulted in peak-hour spreading together with re-routing which increased the overall exposure levels.

3.1.3 Paris

The city of Paris implemented bus lanes, physically separated from other traffic, during the summer of 2001. The use of the bus lanes was restricted to public transport, taxis, cyclists, police and emergency vehicles.

The HEAVEN system was applied to three streets:

- Rue de Rivoli (a section of 2.25 km)
- Boulevard de Sébastopol (1.28 km)
- Boulevard de Strasbourg (0.63 km).

The study compared data from three periods: October 2000 (before the implementation), October 2001 (just after the implementation) and October 2002 (one year after the

implementation). The evaluation included emissions of CO, NOx, PM10 and CO2 as well as air quality concentrations.

The results showed that emissions diminished by amounts between 3% and 19%. Depending on the street, the pollutant and on the period, the emissions were shown to increase or decrease due to variations observed in traffic volume.

The impact on air quality concentration was less pronounced than on the emissions. On the three sites, the results showed a decrease in the pollutant concentration levels of between 4% and 10% for CO, between 2% and 4% for NOx and between 1% and 2% for PM10. The decreases which were less than for emissions as background levels were added.

The HEAVEN DSS was also used to evaluate the impact of a car-free day on Sunday 22 September 2002 (six designated areas were restricted to public transport vehicles, taxis, bicycles, low-pollution vehicles (gas powered, electrical), vehicles on duty, and vehicles for disabled persons and residents (from 9 am to 7 pm).

The impacts identified were a 6% reduction in traffic overall and a 63% reduction in the restricted areas. Speed increased by 6% within the restricted areas.

During the restriction period emissions of NOx, CO, particulates, CO2 and VOC were reduced between 47% and 30%, depending on the pollutant, in the restricted area; while across the city an emission reduction between 15% and 10% was observed.

3.1.4 Prague

In Prague, a master plan scenario with a time horizon of 2010 which assumed major land-use changes and developments in the Prague road network, formed the basis of the main assessment. It proposed to re-route public transport (PT) traffic out of the city centre to a twofold ring road system on the north-west perimeter of the city. This was, however, a controversial plan as the proposed road would cross residential, shopping, leisure, office and light industry zones. Opponents proposed an alternative scenario of a longer ring road which would avoid residential areas.

The HEAVEN DSS was used to compare traffic loads, emissions and concentration levels on both routes. The calculations showed that the difference in traffic loads on the most affected inner-city roads was not great enough in either proposal to cause considerable changes in the average air quality. Both alternatives resulted in minor differences of about 1% for NOx, CO and PM10 for the whole city area. The main differences were in spatial distribution of emission sources, influencing their exposure to people.

A further scenario tested was based on the implementation of a range of traffic management measures aimed at reducing congestion and simplifying the overall traffic system. The HEAVEN assessment of the impacts of these measures demonstrated successful improvements to congestion; however, as the total amount of traffic crossing the modelled area remained similar, there were no significant effects in terms of air quality.

3.1.5 Rome

In recent years the municipality of Rome has introduced a number of measures aimed at reducing air pollution and traffic through the restriction of private vehicle traffic; including banning most polluting vehicles from the historic city centre.

HEAVEN was used to evaluate the environmental effects of these measures on a simulated scenario assuming a 100% catalysed fleet.

The analysis of the before and after scenarios showed that imposing restrictions on the fleet (assuming all vehicles were catalysed) had a positive impact on air pollution, with reductions of -35.5% for CO, -62.6% C6H6 and -50.7% for PM10.

The closure of Via Nomentana (the main traffic arterial located to the east of the demonstration area) was also tested to evaluate how a specific action on the traffic network might impact on traffic and pollution in the short term. As one of the main city links connecting the centre with many suburban towns this street regularly experienced high peak congestion. The analysis focused on CO, C6H6 and PM10 emissions and air quality concentrations across the whole area. The evaluation showed that, as a result of traffic redistribution and increased congestion, closing Via Nomentana would impact negatively on air pollution overall, with increased pollutant concentrations evaluated +28.9% for CO, +49.3% C6H6 and +18.7% for PM10.

3.1.6 Rotterdam

In Rotterdam, the main scenario tested was based on long-term measures aimed at improving air quality problems in the Overschie area. These included the construction of additional roads providing a connection between two highways (A16 – A13) and the extension of another (A4). The measures were mainly targeted at reducing traffic on the inner-city sections and eliminating heavy-duty traffic on the A13.

A simple approach was adopted with reductions in traffic densities from 150,000 to 90,000 and to 75,000 vehicles. The results showed that emissions of NO2 and Benzene would be reduced between 20% and 60% while PM10 indicated very low reductions.

A further assessment of an environmentally induced speed limit (from 100 to 80 km/h) in the Overschie demonstration area indicated a significant impact. During weekdays estimated NOx concentrations in the study period decreased by 14%.

3.1.7 Key areas of interest

The HEAVEN project provided a package of tools designed to allow cities to assess the impacts of traffic on air quality and noise pollution in near real time and to test the effects of actual and planned TDM measures.

The systems developed provided the ability to obtain near real-time data on traffic and environmental conditions in urban areas and to test a range of scenarios and TDM packages.

The systems also assisted in monitoring compliance with the EU directives associated with air and noise quality, and providing direction for a range of related policies.

Key areas of interest with this project, in the context of the research study, include:

- how the monitoring of environmental and forecast impacts can be connected to the policies and operational elements of TDM strategies
- how key areas of real-time inter-system operation have influenced the development of environmental monitoring initiatives and the control measures implemented.

3.2 PROAIRE project, Mexico City

The Federal District of Mexico City contains one of the largest cities in the world with a total district population of approximately 18 million people. Mexico City itself is well known for its major smog problems. In addition, the metropolitan region is also a significant contributor to greenhouse gas emissions, accounting for 20% of the country's total emissions.

In February 2002, the Mexican 'Metropolitan Environmental Commission' (Comisión Ambiental Metropolitana, or CAM) announced the third and current stage of the PROAIRE project — a programme to improve air quality in the metropolitan area of the valley of Mexico. The purpose of the entire PROAIRE project is to assist the government address urban air pollution problems faced by Mexico City, and to assist broader objectives related to global climate change. PROAIRE III is the third stage of the programme which is taking place from 2002 to 2010.

According to the Washington-based World Resources Institute, some 6,400 people die annually of particulate pollution in the Mexico City metropolitan area.

PROAIRE III requires $14.7 billion of approximately equal parts of public and private investment to achieve reductions of 18% in suspended particulates, 16% in sulphur dioxide, 26% in carbon monoxide, 43% in nitrogen dioxide and 17% in hydrocarbons.

Figure 3.3 Mexico City

The key steps to achieve the programme's objectives are:

- unifying existing information on the costs and emissions reductions associated with different control strategies – PROAIRE stages I and II and separate studies focused on greenhouse gas mitigation – into one harmonised database of options for analysing the joint management of urban air pollutants and greenhouse gases in Mexico City

- implementing decision-support tools – based on linear programming and goal programming – to analyse low-cost strategies for meeting multiple targets for multiple pollutants simultaneously. In addition to using these tools for analysing the relationship between controls on local air pollutants and greenhouse gases, the objective is to create user-friendly tools and train members of government offices in their use.

PROAIRE I and II were designed to build capacity in Mexico for addressing urban air pollution and associated greenhouse gas emissions in an integrated manner. These phases helped to unify air quality improvement measures with measures to reduce greenhouse gas emissions, thus creating one consistent body of possible control actions. This formed the base for the current third stage.

PROAIRE III is focused on the reduction of ozone and particulate matter and will eventually include more than 80 measures that affect transportation, industry, the service sector, natural resources, health and education, with a strong emphasis on public participation and environmental education.

The chosen measures fall into three broad categories:

- improvements in energy efficiency
- enhancement of public transport
- the protection of green space and forests.

The first stage of the PROAIRE project revealed that the primary source of emissions in Mexico City was the transport sector. A baseline emissions inventory completed in 2000 revealed that the city generated approximately 51 million tonnes of CO2 and that 37% of this came from the transport fleet. Consequently, many of the PROAIRE measures focused on vehicle and other transport improvements.

The wider programme contains 89 separate points and places an emphasis on citizen participation, including emissions inspections of many smaller industrial establishments, the promotion of alternative energy sources and the introduction of zero-emission vehicles for public transportation.

A review of four of the measures that have been evaluated provides an indication of the level and types of improvements expected, including vehicle fleet measures, PT service and fleet improvements and non-transport-related measures. The examples include:

- **Taxi fleet renovation**

  A major initiative focusing on the Mexico City taxi fleet identified that, of the 100,000 taxis operating in the city, more than half were over 10 years old and exempt from emissions regulation. The Federal District has since implemented a scheme to purchase 80,000 of the oldest vehicles, providing the owners with a deposit for a newer low-emissions vehicle. This scheme is estimated to have reduced daily emissions from taxis by approximately 31%. The target is to replace 80% of old taxis by 2010, improving fuel efficiency from 6.7 km/L to 9 km/L.

- **Metro expansion**

  Seventy-six km of new metro construction is planned by 2020 (five km between 2003 and 2010, 71 km from 2011 to 2020). Users are expected to come from current microbus services.

- **Hybrid buses**

  Diesel buses are to be replaced by 1,029 hybrid buses which will be brought into circulation by 2006.

- **LPG leaks**

  Stove maintenance is to be performed in one million households to eliminate leaks.

The following three tables set out the forecast benefits of these measures in terms of particular pollutants and their related health effects.

Table 3.1 Annualised emissions reductions (tons/year).

Control measure	PM10	SO2	CO	NOX	HC	CO2	CH6	N2O
Time horizon 2003–2010								
Taxi renovation	0	64	165,483	5,135	16,863	275,007	64	498
Metro expansion	1	4	3,518	155	324	19,567	5	1
Hybrid buses	73	14	566	-119	274	54,063	2	0
LPG leaks	0	0	0	0	2,480	7,475	0	0
Time horizon 2003–2020								
Taxi renovation	0	59	146,380	3,060	12,811	257,542	60	466
Metro expansion	9	65	28,835	1,271	2,653	160,368	39	9
Hybrid buses	82	16	635	-134	307	60,656	2	0
LPG leaks	0	0	0	0	1,954	5,888	0	0

Table 3.2 Annual particulate and maximum ozone exposure changes (ig/m3).

	Particulates (PM10)		Maximum daily O3	
	Mean	95% CI	Mean	95% CI
Time horizon 2003–2010				
Taxi renovation	0.36	(0.17:0.58)	5.13	(1.59:9.97)
Metro expansion	0.01	(0.01:0.02)	0.14	(0.04:0.28)
Hybrid buses	0.14	(0.06:0.23)	-0.07	(-0.14:-0.02)
LPG leaks	0.07	(0.02:0.28)	0.91	(0.14:1.76)
Time horizon 2003-2020				
Taxi renovation	0.24	(0.12:0.38)	3.02	(0.94:5.87)
Metro expansion	0.12	(0.07:0.18)	1.07	(0.33:2.08)
Hybrid buses	0.15	(0.07:0.25)	-0.07	(-0.14:-0.02)
LPG leaks	0.06	(0.02:0.12)	0.74	(0.23:1.43)

Table 3.3 Annual mean health impacts (cases/year): Time horizon 2003–2020.

	Taxi renovation	Metro expansion	Hybrid buses	LPG leaks	Cogeneration
Acute mortality					
Total mortality	36	15	10	9	1
Infant mortality	19	10	12	5	0
Chronic mortality					
Total	4	2	3	1	0
Cardio-respiratory	0	0	0	0	0
Lung cancer	4	2	3	1	0
Chronic bronchitis	295	152	184	76	6
Hospital admissions					
All respiratory	134	49	1	33	3
COPD	22	8	0	5	1
All cardiovascular	0	0	0	0	0
Congestive heart failure	0	0	0	0	0
Ischemic heart disease	0	0	0	0	0
Pneumonia	29	10	0	7	1
Asthma	12	5	1	3	0
Emergency room visits (ERVs)					
Respiratory causes	632	232	19	154	16
Asthma	583	215	15	144	15
Restricted activity days	8,908	4,584	5,575	2,320	176
Minor restricted activity days	*296,928*	*119,279*	*48,591*	*73,350*	*7,190*
School absenteeism	*132,439*	*52,346*	*18,814*	*32,756*	*3,174*

A major innovation of this scheme is its funding regime. Using a range of public-private partnerships, Mexico City has engaged the assistance of various organisations and stakeholders in the implementation and funding of these projects. Key participants include: water, public transport and electricity utilities, World Bank, Shell Foundation, the World Resources Institute, French Fund of the Environment, Chicago Climate Exchange and the International Council for Local Environmental Initiatives (ICLEI).

Due to rapid growth patterns Mexico City has not established an emissions reduction target. The Federal District's current objective is a lower rate of emissions growth, rather than an absolute reduction.

3.2.1 Key areas of interest

The PROAIRE project is primarily a long-term policy initiative with planned biannual reviews including a review of the resources allocated to each group of measures, and potentially adding additional measures and deleting existing measures, as more information becomes available.

Key areas of interest with this project, in the context of the research study include:

- the broad objectives of the project extending to incorporate transport and industry impacts, and developing improvements targeted at both the impacts of local air quality and greenhouse gas emissions
- the approach taken in the initial stages of PROAIRE to consolidate information from studies with different objectives to provide a common platform and to assist in achieving jointly desirable outcomes
- the relevance of the specific measures targeted at the transport sector and how the effectiveness of these is monitored
- how the decision-support tools were developed
- consideration of the measures chosen and how this has changed over the life of the project so far.

3.3 Paso del Norte Region Environmental Monitoring Project, Texas

The area included in the Paso del Norte Environmental Monitoring Project covers the border area between the United States and Mexico known as El Paso del Norte, and on the United States side includes parts of the states of New Mexico, Texas and the city of El Paso.

Figure 3.4 Paso Del Norte region.

The Paso del Norte Environmental Monitoring Project, also known as EMPACT, aims to improve air quality by providing the public with accurate, timely information on a range of environmental air quality indicators combined with traffic and weather information. The

purpose of the dissemination of this information is to give the public better information to allow them to make the most appropriate decisions about their transport choices. This approach is based on the collection, visualisation and communication of relevant information.

The City of El Paso is the lead agency for the project. Other partners include the University of Texas at El Paso (UTEP), the Texas Natural Resource Conservation Commission, the El Paso City County Health Management District, the New Mexico Environment Department and the Departamento de Ecología del Estado in Ciudad Juárez, Chihuahua, Mexico.

The primary objective of improving information available to the public has been addressed through a range of initiatives including:

- coordination among various agencies, institutions, organisations and broadcasters within the region
- development of standards for generating and sharing information and displaying this information to the public and decision-makers
- establishment of a communications infrastructure to support these systems
- public outreach programmes to improve local understanding of individual actions that can help improve the quality of the environment
- education of future generations by developing opportunities for students to conduct research and become involved in the improvement of the environment.

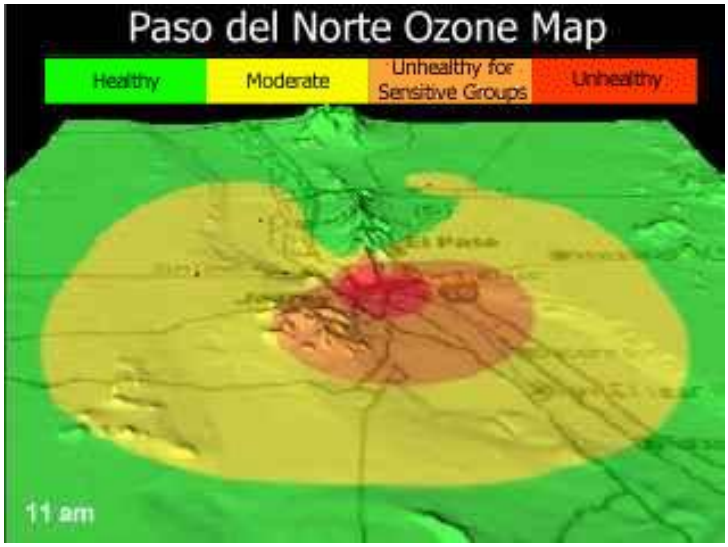

Figure 3.5 Paso Del Norte region pollution map.

The system is based on the collection of three types of environmental data: air quality, traffic and weather patterns. Twenty-five existing continuous air monitoring systems (CAMS) are used to collect the air quality data: 14 in Texas, six in New Mexico and five in Mexico. The data is collected every five minutes. CAMS in the Paso del Norte region are

operated by four separate government agencies serving three states in two countries, with the same or similar basic layout at each station.

The majority of the CAMS are based on a constant-speed vacuum pump system. Heavy particulate matter is collected in a trap while meteorological data (ie wind speed, wind direction and temperature) is collected at, or close to, the top of a tower. Data from the monitors is sent to a data logger and then retrieved via a modem.

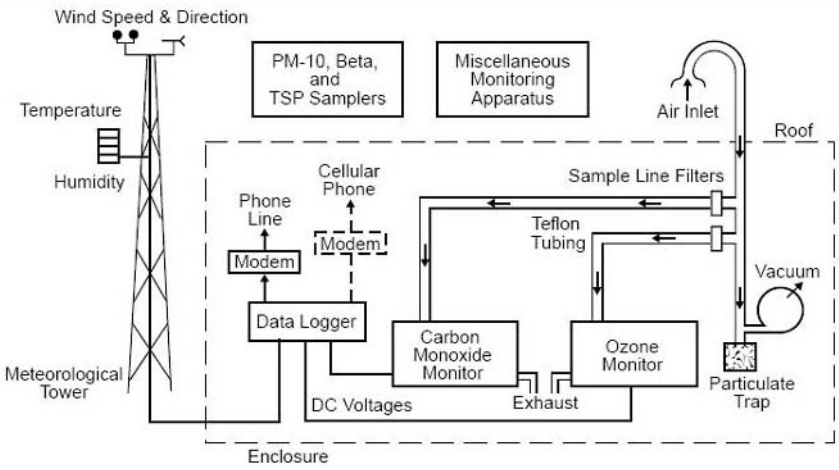

Figure 3.6 Typical CAMS.

Air quality data for ground level ozone, carbon monoxide and particulate matter is used to inform the public about levels of air pollution and potential health risks, targeted especially at those who suffer from respiratory illness.

Traffic information is obtained through roadway monitoring and is then used to inform the travelling public about congestion, accidents, road construction, maintenance delays and any other traffic problems.

In the El Paso metropolitan area, this information is generated by 600 existing traffic sensors which collect speed and volume data and by 34 existing cameras which provide video images. Traffic volume information and traffic video images are collected at five-minute intervals at fixed locations in El Paso and on some of the highways in the area. Volume and speed measurements are summarised on an hourly basis, and data sets and displays are refreshed on the project's website every 60 minutes.

The wind speed, wind direction and temperature data collected at the CAMS is transferred and processed with the air quality data. Other weather data from the National Weather Service (NWS) in Santa Teresa, New Mexico is retrieved at a server at UTEP. Visibility images from NWS satellite links and the UV index forecast from the Environmental Protection Agency's SunWise Program website are also transferred to UTEP.

The data is processed through a series of algorithms and re-displayed. Current temperature, UV intensity, relative humidity, wind speed and heat index readings appear in digital form on the Paso del Norte project website. Graphs showing changes in various weather parameters are also on the website.

TransCAD is used for transportation modelling and to develop emissions estimates. The input variables differ dramatically between El Paso and Mexico, particularly at peak travel times. There is also a dramatic difference in the emission factors for vehicles based in El Paso and Mexico, as Mexican vehicles are on average seven years older and not subject to the same inspection and maintenance programmes.

The project incorporates this traffic-related data into the air quality analyses, along with that from idling vehicles at border crossings (a major contributor to air quality problems in the region). Weather information is included both as helpful day-to-day information and as an air pollution indicator.

Air quality data, traffic volume data, traffic video images, weather data, and static and live images from a web cam are transferred from monitoring locations, hubs and websites run by multiple agencies. As with other aspects of the Paso del Norte project, communication between agencies is vital to processing the timely environmental data. UTEP collects and processes data from the different agencies to upload onto the project website. Data storage for the Paso del Norte project includes an ftp server and access via interactive searches and select features provided on the project's internet server. Queries can be performed in the air and on traffic databases to identify data sets of interest and can be downloaded using anonymous ftp file transfer.

In addition, digital readouts located in strategic areas are used to provide information on environmental and traffic conditions.

As well as providing data for the emissions models, traffic data from the system is also used to inform the public about delays, road construction and accidents. It can identify current and potential traffic congestion areas and alternative routes, and educate the public about the relationship between traffic and air pollution. This real-time data is also used by emergency services to respond to accidents and by border crossing agencies.

Core public education programmes targeting improvement actions provide static and live images of current conditions at various locations in the region.

3.3.1 Key areas of interest

Key areas of interest in this project, in the context of the research study include:

- the impact of a purely information/distribution-based project (compared with one that would make changes to the existing system)
- the relative importance of real-time information on the impact of the scheme
- the impact of including weather-forecasting
- managing the basic differences across several states and across the international border (eg the significantly older vehicle fleet in Mexico).

3.4 Environmental monitoring and access control, Rome and Florence

Increasing motor vehicle use in many Italian cities has resulted in a range of pollution-related problems, not least damage to many of the country's ancient buildings. Emissions from traffic congestion often cause a haze of air pollution in Italy's major cities, which affects both the country's economically important tourist industry and the respiratory health of locals and tourists.

In recent years, the Italian government has been a leader in the development of environmental monitoring regulations in the EU, mainly in response to the problems experienced in its major cities and growing public pressure to address these problems.

In the early 1990s, the Italian government held a referendum in major cities to determine public opinion on freeing historical districts from traffic congestion and poor air quality levels. Italian law now requires that cities with a population larger than 100,000 have a pollution monitoring network system.

These regulations have led to the implementation of numerous measures to mitigate growing air pollution problems. Most notably, access control schemes have been implemented in several cities (including Rome and Florence) in order to protect ancient buildings by limiting the number of vehicles entering the cities.

Many of the most affected areas and buildings are now monitored as part of a national programme.

Figure 3.7 Florence environmental monitoring.

A range of institutions are working together on a project to monitor the environmental impact of pollution on artworks and historic structures, involving *in situ* observations of the degradation process triggered by contaminated urban air. The process involves placing devices adjacent to important buildings and creating artificial models that simulate the deterioration of the original materials. At the same time physical (meteorological and microclimatic), chemical (gases and polluting dusts) and biological agents in the vicinity are monitored continuously.

These facilities are being applied extensively in both Florence and Rome, the results providing input to the planning and operation of the access control and charging facilities in the cities.

One of the key objectives in Rome and Florence is to improve understanding of the impacts of vehicle emissions on historic buildings and to provide direction and support for a range of traffic and access control initiatives. The charging and access control systems currently in operation have been introduced to reduce the number of vehicles entering central limited traffic zones (LTZ) to those strictly necessary and to promote public and alternative transport use.

The city transport administrations are targeting a range of problems created by excessive vehicle-related pollution with a range of sustainable mobility policies and ITS initiatives. These are aimed at reducing congestion, limiting the impact of air pollution, improving trip times and reliability and reducing current high transportation costs.

A key component in addressing these problems is the *Piano Generale del Traffico Urbano* (PGTU – Urban Traffic General Plan) in Rome. This plan has been developed to tackle the mounting problem of public transport, mobility and transport-related emissions. A key element of the PGTU is the definition of transport demand policies (ie controlled access zones and parking pricing).

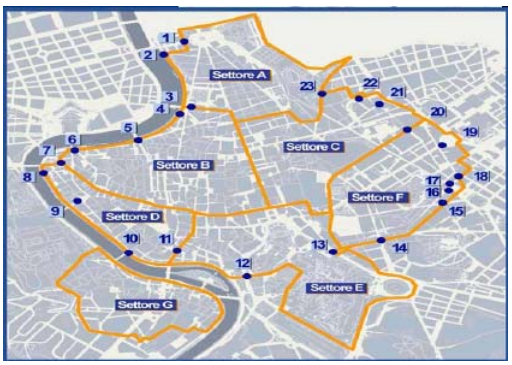

Figure 3.8 Rome access controls.

The PGTU divides the metropolitan area in zones consisting of a central area and three concentric rings. While residents within the zone can enter for free, non-residents must pay an amount equivalent to a 12-month public transport pass in order to obtain a permit for the access control area. In limited circumstances, non-residents may obtain permission to circulate and park in the LTZ area if they fall into certain categories, such as doctors with offices in the centre.

For other areas, the access conditions, exemptions and means of determining access rights vary significantly across the different municipalities. These are driven primarily by local political pressures and city-specific issues and problems, as well as local industries and traditions. An example of the latter is the temporary exemption provision in Florence for central city furniture craftsmen and their customers.

The need to develop and operate the access control systems in such a complex environment has provided an opportunity to adapt to other specific measures (such as EU

emissions categories) and the potential for closer links between monitored and forecast environmental conditions/impacts and the policies and operation of the PGTU.

3.4.1 Key areas of interest

Key areas of interest in this package, in the context of this research study include:

- how the monitoring of the environment and forecast impacts is connected to the policies and operation of the PGTU and, in particular, access control conditions
- how the operation of the PGTU influences the basis of the environmental monitoring initiatives
- the potential application of access control facilities to manage direct environmental impacts more closely.

3.5 Environmental monitoring system, York

The city of York has responded to recent EU directives and United Kingdom government restrictions on air quality by establishing an environmental monitoring system, aimed at measuring seven different air pollutants.

The monitoring system consists of nine sites spread across the city to collect data on these seven air pollutants. This information is then used to model and assess air pollution levels; to attempt to identify sources of pollution; and to assist with strategic transport planning. It will be used for the medium- to long-term forecasting of pollution levels to help develop future policy and strategy, and aid traffic management in the city of York.

The following air pollutants are measured:

- nitrogen dioxide
- sulphur dioxide
- particulate matter
- carbon monoxide
- lead
- benzene
- 1,3 butadiene.

To assess ongoing compliance with air quality objectives, the local authority reviews the outputs of the model, provided through a mapping package illustrated below. The shaded red areas indicate where the nitrogen dioxide annual objective may not be met. Air quality is monitored in the city using accurate real-time monitoring equipment giving pollutant concentrations on a minute-by-minute basis.

As with most similar systems, the level of monitoring provided is not sufficient to monitor air quality on all streets in the city, and an air pollution dispersion model is used to

predict how pollution moves around the city and how the weather and traffic flow influences this dispersion. In York a dispersion model called ADMS-Urban is used.

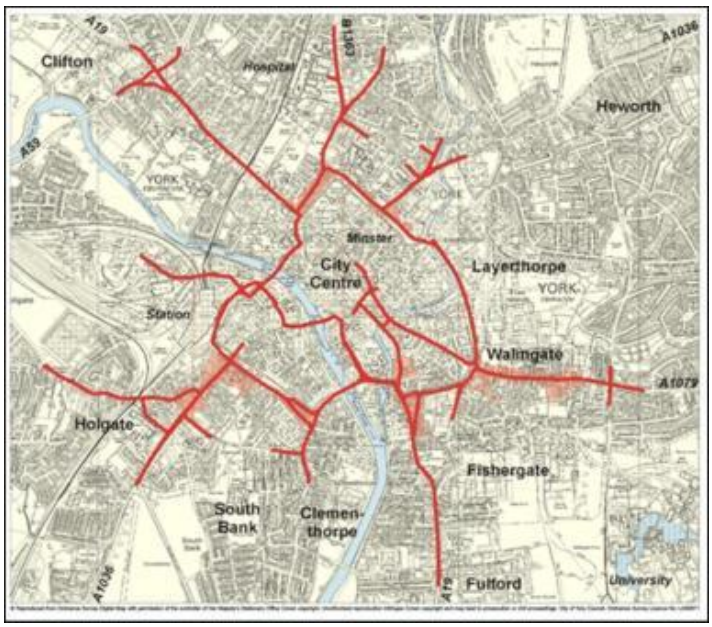

Figure 3.9 York emissions map.

ADMS-Urban is an air quality management system developed by Cambridge Environmental Research Consultants. This is a desktop GIS (geographic information system) based system and contains a direct link to the United Kingdom emissions inventory database. This provides for comparison with defined air quality limits, guidelines and objectives, and for the modelling of 'what if?' scenarios. The system is used for:

- traffic planning
- environmental impact assessment
- future projections
- emergency planning.

As part of this programme York has implemented urban traffic management and control (UTMC), with databases holding information about air quality across the city, on-going and planned roadworks, bus operations and road traffic incidents. Information collected from air quality monitoring equipment, traffic counters and car park monitors is fed to different departments at the council, the police, Radio York and the public.

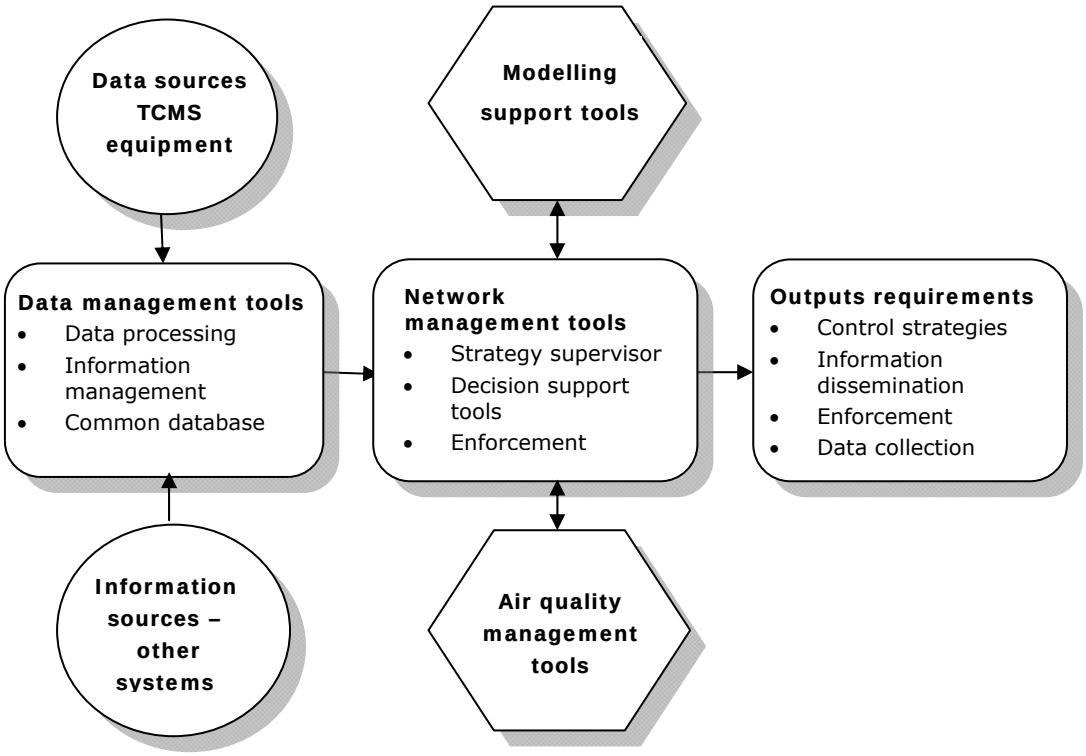

Figure 3.10 York system architecture

As part of this integrated package several trial projects are being examined, including altering traffic flows on a two-mile stretch of the A19 in north York using traffic and access controls in response to a build-up in vehicle emissions. If air quality is poor, information is posted on variable message signs and traffic is retained in a different location along the corridor, either by asking car users to use park and ride or informing them of delays.

The central UTMC-based database is used to feed information on current and profile pollution levels through a national web-based information service.

3.5.1 Key areas of interest

Key areas of interest in this project, in the context of the research study include:

- the original drivers behind the project from a city and EU perspective
- the relative importance of weather and traffic data in the model used
- use of the system to inform and direct other related initiatives.

3.6 Monitoring and simulation models – SIMTRAP

Effective modelling tools are essential when identifying management or control strategies to cope with increasing demands on the travel system and tightening environmental standards. Different countries and regions have developed different tools to quantify both

the transport-environment link in the medium to long term and the different levels of enforcement.

In the United States, since the publication of the Transport Conformity Rule in 1993, metropolitan planning organisations have had to extend their analyses regarding the environmental consequences of their transport plans. The required analyses are geared towards medium- to long-term planning (in the order of years) and must take place at two levels:

1. regional analyses, estimating emissions from road traffic and other sources, using large-scale traditional transport models
2. local analyses, concentrating on air quality impacts at emission hot-spots.

The analyses generally use standard emissions models (EMFAC and MOBILE), which are driven by total traffic volumes and average speed, and a standard fleet composition. Inputs are provided by static travel demand models, setting the demand for travel, spatial distribution and resulting road traffic conditions, now and in alternative future scenarios.

In the United Kingdom, the emphasis in modelling air quality impacts of transport is also on emissions, with the *Design manual for roads and bridges* (Vol 11) (United Kingdom Highways Agency 1998) prescribing an air quality screening method based on traffic flows, vehicle mix and fixed emission parameters. Simple empirical relations are used to convert these into air quality values.

Most current approaches used to quantify the link between transport and the environment are geared towards the long term. They are based on static models using aggregate outputs from large-scale demand modelling systems or generalisations of relationships established elsewhere, and concentrate on emissions rather than resulting air quality.

Although each of the individual components used in these approaches addresses a small number of all the interrelations that play in detail, the overall results cannot reflect all relevant dimensions in an integrated manner.

The SIMTRAP project recognises the need for a system that will be able to address all dimensions of the transport/environment link in an integrated manner, particularly in the medium term; developed through partnerships between European cities and targeted at managing and improving air quality.

Environmental decision support systems for urban areas are used to varying levels across Europe. Many large urban areas have networks of environmental measurement stations and databases, the level of deployment depending on the level of technological sophistication, the significance of environmental pollution and the level of environmental awareness in the respective areas.

These are normally confined to a single environmental domain or sub-domain (eg air, ground water and coastal water) and are incorporated in relatively simple management decision support systems.

The SIMTRAP system has been developed mainly to address medium-term planning requirements for detailed and integrated modelling of transport and air quality. It combines dynamic traffic simulation software, which can produce detailed emissions calculations and modelling, taking into account speed, acceleration, deceleration, engine size and temperature; and dynamic 3D air pollution modelling, accounting for the complex interactions between emissions, landscape and meteorological conditions.

Through the SIMTRAP system these have been combined with high-quality visualisation tools in 3D GIS, providing an integrated system for traffic flow simulation, air pollution modelling and decision support. The system effectively integrates two previously existing simulation packages and adds a GIS toolkit with built-in functionality for decision support to facilitate user interaction and analysis of the results. The models are run on different hardware platforms at different locations with additional models easily incorporated using defined standard interfaces.

The SIMTRAP system focuses mainly on addressing the relationship between traffic and ozone, since the effect on ozone concentration is often counter-intuitive and needs an objective decision basis.

Results are presented as maps of spatially and temporally resolved pollutant concentrations which can be compared for a range of scenarios such as industry, household and land-use patterns. Their potential for improving air pollution can be balanced against the influence of traffic.

SIMTRAP is a collaborative project co-funded by the European Commission, Directorate General III (Industry), under their ESPRIT Programme. It includes PTV Software and Consulting, GMD-FIRST, Hague Consulting Group, the consortium consisting of Environmental Software and Services (ESS) (Austria) and Unseld and Partner (Austria), and the Provincia di Milano (Italy). Smith System Engineering (United Kingdom) acts as sub-consultant, while the Berlin Senate and the city of Maastricht are involved in the demonstration projects.

The two base models used are DYNEMO (traffic simulation) and DYMOS (emissions dispersion and chemical transformation).

The DYNEMO model best reflects the profile of traffic-related emissions across an area large enough to provide an effective ozone base. Due to the nature of ozone processes and effects, the study area must be large enough to extend beyond boundary effects (between 100 x 100 km and 200 x 200 km).

DYNEMO is a simulation tool for both urban and rural road networks. It can deal with networks where about 100,000 vehicles move simultaneously and has been used to simulate a large part of the German motorway network.

The DYMOS model is a parallel implemented simulation system that analyses the generation, dispersion and chemical transformation of gaseous air pollutants and different aerosols. The model is well suited to reproduce the most frequent occurrences of smog situations; high concentrations of inert pollutants (eg SO2, NOx and dust) caused by high pressure weather situations; and high concentrations of ozone and other photochemical oxidants caused by strong insulation during high-pressure weather situations.

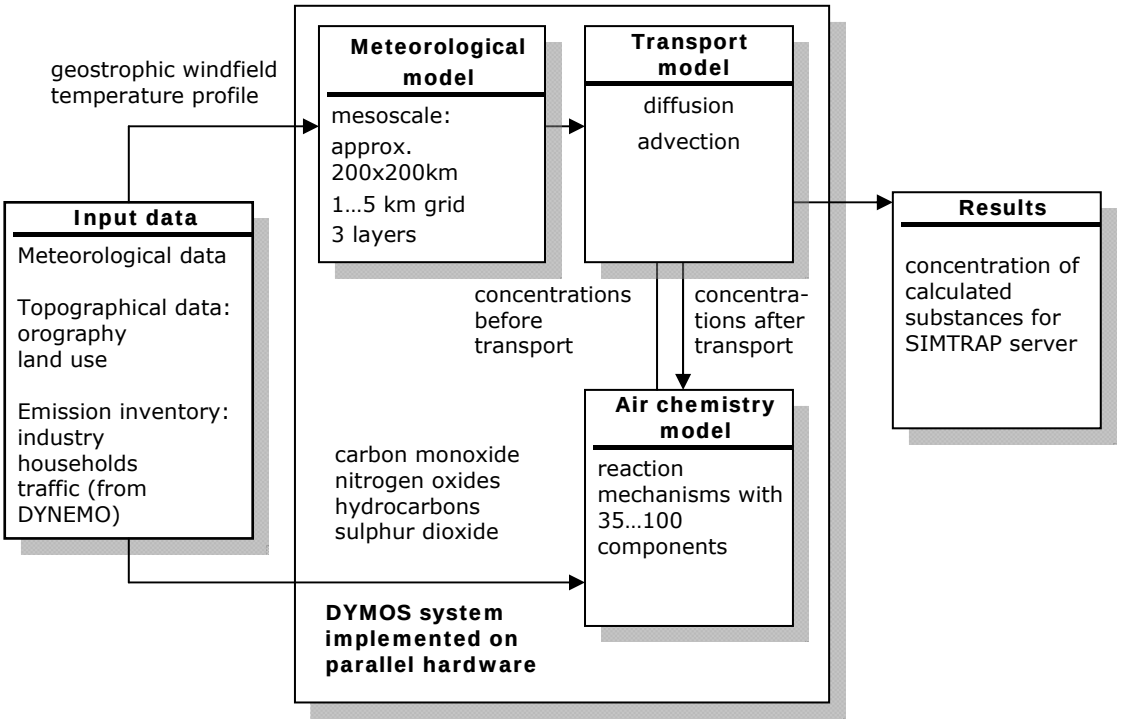

Figure 3.11 SIMTRAP model structure.

The system has been demonstrated in several European cities. In Milan, Italy the model was applied to the Milan municipal area, assessing the air quality of the province of Milan with 52 monitoring sites, 10 of them located in Milan city. In Berlin, Germany the network was used as a test site during the development and integration of the main system components, as well as in providing data for different control measures to assess different traffic scenarios. Among the scenarios studied were gating strategies for the city centre and the impact of proposed traffic management schemes, as well as general trends in emission technology.

The application of SIMTRAP in a strategic planning context includes four steps:

- capturing the model base data (transport network, topography, emission inventory)
- defining simulation scenarios
- running the simulation
- visualising and analysing the simulation results.

SIMTRAP, like other simulation packages, is designed to test 'what-if' scenarios, including such parameters as:

- weather situation (either one day from a database of historical data for the study area or a fictitious, extreme situation)
- changes to the emission inventory (households, industry and background)
- changes to traffic demand (both long-term trends and short-term fluctuations, eg due to events)
- changes to the transport network (eg additional or removed links)

- changes to the attributes of network links (eg blocked links/lanes, lower permitted speed or a new traffic light phasing scheme)
- changes to the fleet composition (eg more environmentally friendly vehicles).

The GIS functionality of the system provides a wide range of display facilities for spatial and linear (eg traffic density) data. In particular, traffic and pollutant data can be overlaid and difference plots allow data from several runs (corresponding to different traffic control options) to be compared graphically.

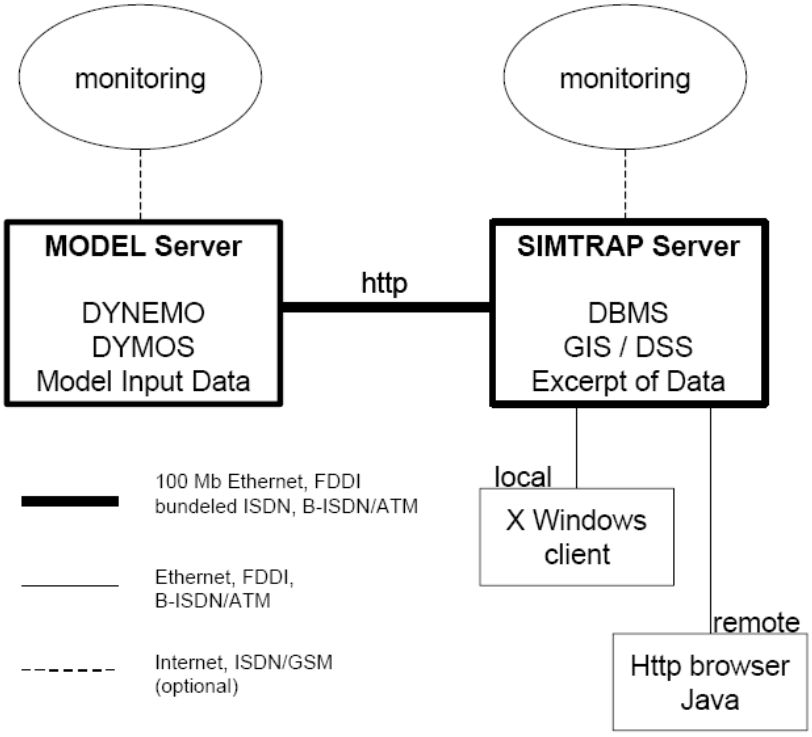

Figure 3.12 SIMTRAP architecture.

The following example is taken from the first SIMTRAP demonstrator which covers the Berlin–Brandenburg area. The transport network comprises all main roads within Berlin (ie all except residential streets) and the major roads in Brandenburg. The network consists of 1,020 zones, 5,282 nodes and 13,738 links. This network and the corresponding O/D matrix were developed by the Berlin Senate over several years and were the most detailed traffic model available for the area.

For use in SIMTRAP, the model of the central part of Berlin was further refined, including priority rules and traffic light phasing schemes for numerous intersections. Environmental and geographical data, including a history of meteorological measurements, were re-used from an earlier project aimed at ozone forecasts using static traffic assignment.

Figure 3.13 SIMTRAP output.

Data, traffic-control options and anticipated trends in traffic demand and technology can be evaluated for their environmental impact, using this model as a base.

One example tested was the impact of a large sporting event, such as the Berlin Marathon, which not only generates increased traffic demand following a particular pattern, but also requires the temporary closure of many streets. The test also examined the combination of this scenario with a critical weather situation.

SIMTRAP modelled this scenario by modifying the O/D matrix to account for the spectators. The links over which the marathon takes place were marked as closed in the traffic model. Data from the weather forecast for the day of the marathon (or a worst-case day from the meteorological history) was added and the scenario run. The results were analysed for concentration hot spots exceeding environmental standards or were compared with the base scenario without the marathon.

Figure 3.14 Berlin output.

In Vienna, Austria the system was applied to simulate the effect of different dynamic network control strategies (dynamic driver information or dynamic route guidance) on pollution. Accuracy of the component simulation models was validated several times before the start of the project.

3.6.1 Key areas of interest

Key areas of interest in this project, in the context of the research study include:

- the specific focus on ozone, the wider impact of this pollutant and its secondary link to transport-related pollution
- the development of a specific modelling package to address the specific issues
- the relative importance of weather and traffic data in the model used.

4. Areas of consideration

This chapter considers each of the example systems described in chapter 3 under four broad categories.

- **Project drivers** are the principal objectives, issues or problems that lead to the development of, and commitment of funding to, a specific project or programme.

  Examples of project drivers are the:

  - monitoring and proving of compliance with EU directives
  - improvement of localised air quality problems
  - reduction of noise pollution
  - provision of timely and accurate information to the public and development of information for this purpose
  - protection of historic buildings from the effects of air pollution and provision of continual analysis of data to ensure protection of historic buildings
  - achievement of government health-based air quality objectives and improvement of protection against the health effects of poor air quality
  - meeting and measurement against greenhouse gas emissions targets
  - proving of the level of environmental improvements achieved through TDM and other measures (eg parking systems)
  - addressing of effects on the economy specifically related to poor air quality
  - provision of advance warning of specific safety hazard.

- **Specific project purpose or role** is the reason why a specific system was set up and what it will measure or forecast. It will indicate the key measures to be used and how these relate to the broader project drivers.

  Examples of the project purpose or role are the**:**

  - decision support systems for the environmental effects of TDM at *day-to-day* management level and the development of information for this purpose
  - decision support systems for the environmental effects of TDM at the *strategic level* and the development of information for this purpose
  - monitoring and forecasting of localised air quality problems (eg smog)
  - development and provision of timely and accurate information to the public
  - monitoring and forecasting of pollution impacts on historic buildings
  - monitoring and forecasting of specific health-related aspects of air quality
  - identification of specific emissions (carbon monoxide; nitrogen dioxide; sulphur dioxide; PM10, benzene)
  - monitoring and management of transport network efficiency as a means of reducing air and noise impacts
  - provision of data for integrated emissions and noise dispersion models

- unification of existing information on costs and emissions reductions and integrated database management and user interfaces
- feeding of data to decision support systems linked to the environmental effects of TDM strategies
- monitoring and forecasting of ice on vulnerable sections of road.

- **Policy and legislation** can play an instigative and enforcement role and be a facilitator of other projects.

  Examples of policy and legislation are:

  - federal (EU) level directives on air quality and noise
  - government health-based requirements for local authorities
  - integrated municipal level policy and legislative development to address local issues and meet national and federal objectives
  - national level vehicle fleet controls (vehicle numbers and standards).

- **Project benefits and outcomes** are the specific benefits and outcomes sought, including the planned benefits gained from these projects and secondary benefits that were not original intentions of the project.

  Examples of project benefits and outcomes are the:

  - improved ability to monitor and analyse environmental data, leading to better targeting of other initiatives
  - integrated measures to reduce greenhouse gases
  - long- to medium-term analysis and profile of air quality in a region to assist in monitoring and tracking performance
  - development of improved targeting of transport demand policies
  - development and management of controlled access zones
  - provision of improved data for related studies into passenger transport use, mobility and wider ITS initiatives
  - specific improvements in related health problems
  - reduction in specific emissions
  - improved effect on the economy where a reputation for poor air quality has developed
  - improved safety in specific risk areas.

- **Summary of key issues and areas of consideration** is a summary of the main issues raised by each example in the context of the study and specific features which provide insights into particular issues relevant to New Zealand.

4.1 HEAVEN

4.1.1 Project drivers

The key driver behind the HEAVEN project was a requirement to:

- comply with EU directives on traffic-related air and noise pollution impacts and
- demonstrate the potential benefits of mitigation strategies to deal with these impacts.

In order to achieve this, the HEAVEN project was initiated to provide a basis for monitoring and to demonstrate a decision support system for evaluating the environmental effects of various TDM strategies on traffic pollution in large urban areas.

HEAVEN aimed to strengthen urban environment and transport management, based on better access to air and noise pollution information. It also improved cooperation among key environment, transport and health sectors and increased the transparency of city government practice through better citizen access to environmental information.

Traffic engineers, urban planners, and public and environmental health officials had often made independent efforts to address these problems. Each had approached the problems from their own slightly different perspective, often using new technologies within their individual field and sometimes identifying unique ways of moving forward. However, the different information sets used were often not interlinked and the results not shared in a useful way. The HEAVEN project brought together these information sets to develop a decision support system, providing integrated and near real-time information on air and noise pollution and giving a comprehensive overview of the current transport situation.

4.1.2 Specific purpose or role

The specific focus of the HEAVEN project was to develop and demonstrate a decision support system that integrated ITS-related monitoring and forecasting and evaluated the environmental effects of TDM strategies on traffic pollution in large urban areas.

The purpose was to enable the cities involved (Berlin, Leicester, Paris, Prague, Rome and Rotterdam) to identify compliance with EU directives and to prove the benefits of a range of planned and implemented measures.

The concept was to improve the basis for decision-making using integrated and real-time information and to assist in drawing conclusions for the implementation of local noise and air quality action plans.

4.1.3 Policy and legislation

The main policy/legislative factors behind the HEAVEN project were related to EU directives on the monitoring of air quality levels and the introduction of measures to meet defined targets. The EU has introduced a series of directives that provide targets for noise and air quality levels to which cities/towns/regional councils must conform.

European Council Directive 1996/62/EC on Air Quality Assessment and Management (Framework Directive) and the associated daughter directives address the regular assessment of air quality through monitoring and modelling in urban areas. The main directive also calls for action plans to improve air quality and requires authorities to supply more information to the public.

Further, European Council Directive 2002/49/EC addresses the assessment and management of environmental noise. In relation to noise from land transport, it requires larger cities to generate noise maps indicating the number of people exposed to certain noise levels. Using these maps, cities must develop action plans which aim to achieve specific noise limits in accordance with each member state's own level.

The HEAVEN project aimed to produce a DSS that would allow evaluation of air quality and noise, the development of longer-term strategies for decision making, and the drawing of conclusions on the effect of current legislation and resultant future policy.

4.1.4 Project benefits and outcomes

The HEAVEN project was an EU-driven venture involving a number of large European cities that were actively pursuing strategies to deal with poor air quality and noise impacts. It involved the development of emission, dispersion and noise models to enable the analysis of air quality and noise.

The key benefits of the project and system included:

- the development of a common information platform for display and analysis of air quality and noise data, leading to greater consistency in the consideration of impacts and solutions, and providing an improved basis for comparison across major European cities
- specific applications that provided a better description of the current urban environmental situation and enhanced environmental scenario analysis in most cases
- an ability to make better-informed traffic management decisions based on current and forecast environmental conditions
- improved access to, and quality of, environmental information
- improved institutional cooperation between transport, environment and health agencies in the trial cities
- improved and expanded environmental information to support wider strategic planning and decision making.

The HEAVEN project provided a framework of new concepts and tools designed to allow cities to assess the impacts of traffic on air quality and noise pollution in near real time, thus delivering a system that supported tactical and strategic decisions.

Through the application of the HEAVEN DSS, cities were able to:

- obtain a near real-time description of the traffic and environmental situation in urban areas
- assess the environmental efficiency of already implemented TDM strategies

- perform extensive scenario calculations and assess the environmental efficiency of TDM strategies prior to their costly implementation
- inform professional users and the public in near real time about the traffic and environmental situation
- assist in identifying compliance with the EU directives associated with air and noise quality review and assessment procedures
- assist decision makers in formulating policies with public participation.

In Berlin, analysis of potential improvement measures was successfully demonstrated, providing measures of expected reductions in PM10 pollution and NO2 at a localised and city-wide level.

In Leicester, the HEAVEN system successfully supported a detailed air quality review and assessment, providing measures of annual and seasonal NOx exposure and improvements attributable to park and ride proposals and other TDM measures that were based on inter-authority negotiations and public consultation processes.

In Paris, evaluations included CO, NOx, PM10 and CO2 reductions directly related to variations in traffic volume and congestion, as a result of planned improvement measures and trials including car-free days.

In Prague, the systems assisted in proving the benefits of a range of master plan scenarios, including land use and traffic and road developments, and a range of complex variations on these that helped to identify optimum packages of measures.

In Rome, the HEAVEN system was used successfully to evaluate the benefits of several TDM measures including access control, PT priority and combinations of measures including a percentage of the fleet being catalysed.

In Rotterdam, the system assisted in proving the benefits of long-term measures aimed at improving air quality in specific areas, including the construction of additional road capacity and speed-limit variations.

4.1.5 Summary of key issues and areas of consideration

The HEAVEN project provided a package of tools designed to allow cities to assess the impacts of traffic on air quality and noise pollution in near real time, and allowing them to test the effects of actual and planned TDM measures. The systems assisted in monitoring compliance with the EU directives associated with air and noise quality, and also provided direction for a range of related policies.

4.1.5.1 Implemented and planned measures

The systems developed provided the ability to obtain near real-time data on traffic and environmental conditions in urban areas, and to model and test a range of scenarios and TDM packages in actual operation as well as through simulation of planned packages.

4.1.5.2 Integration of transport and dispersion modelling

One of the most significant issues illustrated by this project was the recognition of the link between transport and other contributors to air and noise pollution, and the need to integrate the tools used to assess these impacts in order to effectively identify the benefits of specific measures. The HEAVEN systems successfully integrated dispersion models at regional, urban and local levels with traffic emissions models and a range of source data.

4.1.5.3 Role of EU directives

The main driver for the development of the HEAVEN system was the introduction of EU directives and measures, illustrating how such measures can lead to innovative developments to address air and noise pollution problems. The EU requirements led to a need to develop more effective monitoring and forecasting facilities, and to integrate related modelling tools. This in turn led to a requirement to demonstrate the benefits of various transport-related improvements and packages.

4.1.5.4 Providing assessment of project-specific benefits

A major objective of the system was to provide a means to separate the benefits of specific transport management projects from the wider environment, while also including adequate consideration of a range of other measures that might be implemented or planned.

4.1.5.5 Assessment of integrated transport and planning strategies

The use of the HEAVEN system in most of the trial cities has demonstrated the potential for this type of facility to assist in evaluating integrated transport and wider planning strategies as well as specific TDM measures. Although originally developed as a means to demonstrate the benefits of specific transport-related projects, the ability of the system to model a range of features and effects has led to its use as a wider planning tool. Examples of this include: Berlin – city-wide long-term scenarios including varying levels of Euro III and IV emission standards; Prague – master plan scenarios including major land-use planning changes and road network developments; Rotterdam – long-term scenarios including major changes to the transport network.

4.1.5.6 Model integration issues

In developing the system of monitoring and modelling tools, one of the key challenges for the project was the effective integration of multi-level dispersion models with the required traffic emissions inputs and monitoring devices. In the various cities included in the trial there were some significant differences in the levels of data available and in the priority problems (some localised short-term; some city-wide; and some focused more on long-term improvements). One of the recognised successes of the project was the ability of the systems to provide an effective assessment tool in all of these situations.

Different issues relating to the specific pollutants needed to be addressed to assess impacts at local, city-wide and regional levels. This led to the need for a complex modelling package to provide a credible assessment of the impacts and benefits.

4.1.5.7 Innovation in options assessed

A wide range of innovative measures and packages were tested in the various trial cities. Their solutions, the results achieved and their application provide a useful source of examples for potential improvement measures. These include:

- Berlin – localising truck-bans in problem areas
- Leicester – using scenario results as the basis for inter-authority negotiations and public consultation processes related to planned improvements
- Paris – assessing specific street-based improvements
- Prague – testing master plan scenarios and land-use planning options
- Rome – testing catalysed fleet scenarios and the closure of existing main traffic arterials to demonstrate the benefits of existing facilities
- Rotterdam – testing environmentally induced speed limits (from 100 to 80 km/h), proving the potential for significant reductions in NOx concentrations.

4.2 PROAIRE project, Mexico City

4.2.1 Project drivers

Mexico City is one of the most polluted cities in the world, presenting a significant hazard to the health of its citizens. The metropolitan area of Mexico City contributes 20% of the entire country's greenhouse gas emissions, presenting a serious threat to the environment.

The primary driver behind the PROAIRE project was a recognition at government level that it needed to target specific solutions at both these problems and that there were opportunities to do this.

The PROAIRE project was developed as a new initiative to integrate air quality and climate protection. The objective of the plan was to achieve significant reductions in both air pollution and greenhouse gas emissions. The project was targeted at developing measures based on their ability to cut emissions of both standard air pollutants such as nitrous and sulphur oxides, as well as greenhouse gases. The Metropolitan Environmental Commission invested US$12 billion in improvements identified through this initiative.

4.2.2 Specific purpose or role

The specific purpose of the PROAIRE project was to provide a framework for monitoring air pollution and to identify and facilitate actions to address the problems. Over 85 air pollution and greenhouse gas emissions reduction actions were identified for implementation during the eight-year period. These include energy efficiency improvements, protection of forests and green spaces and public transportation enhancements.

The stated objectives behind the PROAIRE project were to assist the government in addressing the problems of urban air pollution in Mexico City, looking towards the broader subject of global climate change. The steps identified to achieve these objectives were:

- unifying existing information on the costs and emissions reductions associated with different control strategies – PROAIRE and separate studies focused on greenhouse gas mitigation – into one harmonised database of options for analysing the joint management of urban air pollutants and greenhouse gases in Mexico City
- implementing decision-support tools, based on linear programming and goal programming, that could be used to analyse low-cost strategies for meeting multiple targets for multiple pollutants simultaneously. In addition to using these tools for analysing the relationship between controls on local air pollutants and greenhouse gases, the objective was to create user-friendly tools and train members of government offices in their use.

4.2.3 Policy and legislation

The primary legal mandate for air pollution prevention in Mexico is the General Law of Ecological Balance and Environmental Protection 1988, which assigns several responsibilities to the national government, including issuing standards for air quality and limiting emissions from vehicles.

The federal government has primary responsibility for enforcement, including a range of civil and criminal sanctions which can be delegated down to state and city governments. City and state governments have responsibility for monitoring air quality and regulating vehicle inspection and maintenance requirements.

Responsibilities for examining air quality issues in Mexico City cross city and state boundaries, as well as policy and political boundaries. City, state and federal governments have begun working together to reduce emissions and concentrations. The governments have set up a cross-governmental organisation called the Metropolitan Environment Commission (CAM), established in 1996, to coordinate activity between all three levels of government. Membership of CAM is made up of federal government ministries, major energy stakeholders and state government representatives.

4.2.4 Project benefits and outcomes

The key benefit from the PROAIRE project to date has been the unification of existing information on costs and emissions reductions and the incorporation of information from other studies on greenhouse gas mitigation into a common database to facilitate analysis and management.

The final outcome of PROAIRE III will not be known until further into the project's life cycle. This third phase of the project is due for completion in 2010.

So far, the main outcome has been the gathering and analysis of data to facilitate the development of future strategies and frameworks. One of the lessons that can be taken from the PROAIRE project is that even air quality management programmes that have an agreed scientific foundation will not have any impact without political support and

appropriate administrative mechanisms. Limits on the emission of particulates and ozone have been established in the past on the basis of scientific findings, yet have never been enforced.

The city's air quality problems are further exacerbated by the lack of coordination between the three levels of government – city, state and federal – each of which can be governed by a different political party. At the half-way stage of the project, however, the current aim is to further develop a framework and comprehensive plan for the control of air pollution and hence, greenhouse gases.

4.2.5 Summary of key issues and areas of consideration

The PROAIRE project is an initiative aimed at integrating air quality and climate protection. It is targeted at developing measures based on their ability to cut emissions contributing to standard air pollutants as well as greenhouse gases.

4.2.5.1 Coordinated approach to addressing local air quality and greenhouse gases

One of the most significant issues related to this project is its coordinated approach to targeting a range of air quality problems and the specific targeting of solutions that have the ability to improve city-level air quality, while at the same time reducing CO2 emissions.

4.2.5.2 Wider funding attraction

The combined approach has increased the profile of the project to potential external partner funding organisations to a greater degree than similar projects focused purely on localised pollution, and this has led to wider funding support.

4.2.5.3 Identification of sources and connections

Earlier phases of the PROAIRE project identified and measured urban air pollution and associated greenhouse gas emissions, indicating connections between these in order to assist in the subsequent selection of projects.

4.2.5.4 Transport sector a major contributor

These earlier stages revealed that the primary source of emissions in Mexico City was the transport sector.

4.2.5.5 Diverse transport measures

As the transport sector is the largest source of CO2 and air pollution, many measures focus on vehicle and other transport improvements, including improvements in energy efficiency and enhancement of public transport.

4.2.5.6 Large-scale measures

Several of the measures being implemented are of significant scale and are planned over extended periods. These include replacing 80,000 old taxis with newer low-emissions vehicles by 2010, a 71 km expansion of the city metro by 2020 and the replacement of over 1,000 buses with hybrid vehicles by 2006.

This indicates both the level of commitment to the project's objectives and the scale of the measures required to meet these objectives.

4.3 Paso Del Norte Environmental Monitoring Project, Texas

4.3.1 Project drivers

The region of Paso Del Norte is an area around the border of the United States, Texas and Mexico. The key driver for this environmental monitoring project was degrading air quality in the region, caused primarily by the location of the city of El Paso near the USA-Mexico border, making it a popular point for Americans to enter Mexico, and by the nature of the surrounding geography.

In the Paso Del Norte region, several individual communities across two states of the United States and one state of Mexico share an 'air basin' in the valley formed by the Rio Grande river between the Franklin Mountains and the Sierra de Juárez. This common air basin is subject to an inversion layer which traps air-borne pollutants in the cooler air on the valley floor during the morning. This weather phenomenon combined with the high level of idling traffic waiting to cross the border results in high levels of air pollutants and poor air quality.

4.3.2 Specific purpose or role

The Paso Del Norte Environmental Monitoring Project aimed to provide the public with timely and accurate information on air quality and pollution, and to improve the dissemination of information between the many agencies, institutions and broadcasters throughout the region.

The improved reliability of the information and its distribution through a wide range of media channels was designed to facilitate better-informed decision making by travellers and by the organisations responsible for managing traffic and transport in the region.

The project also required the development of standards for sharing information and displaying it to the public and decision makers in the region.

4.3.3 Policy and legislation

This project was not developed as part of any specific local legislation, but was brought about by a perceived need for a change in the way people approached their day-to-day lives based on the air quality within the region. However, it was in part developed to address the region's responsibilities under the Clean Air Act; a federal law that regulates air emissions in the United States.

The Clean Air Act requires the United States Environmental Protection Agency to set standards for six commonly occurring pollutants, including ground-level ozone, carbon monoxide and particulate matter, which are most commonly produced by land transport vehicles. These standards are known as National Ambient Air Quality Standards (NAAQS), and are national targets for acceptable air concentrations of each of the six pollutants. They are primarily targeted at protecting public health and secondarily at preventing damage to the environment and property.

Under the Clean Air Act, each state is required to develop a programme which describes how that state will maintain air quality that meets the NAAQS.

4.3.4 Project benefits and outcomes

One of the main benefits to the region and its inhabitants is the improved availability of information on air quality and pollution. The public can now go to the El Paso Del Norte website to check current and forecast climate conditions and use this information to make decisions on travel plans, as well as developing a better understanding of the impacts of these choices. Surveys have indicated that the facility has raised awareness of the scale and impact of transport-related emissions in the region and is having an effect on people's travel decisions.

A key to the success of the project has been the endorsement and support of the international committee which oversaw the project. The Joint Advisory Committee included representatives from local, state and federal governments, utilities, industry and educational institutions from both the United States and Mexico. This committee created a forum for assigning responsibilities and gave the project participants the authority to collect and process the information.

The project has led to improved communication between the various agencies involved to ensure the timely processing of all the data, and this has in turn led to improvements across other related systems and initiatives. As part of the wide system application, data is now stored to allow long- to medium-term analysis, as a way of checking the region's progress in improving air quality and pollution.

Emergency services in the Paso Del Norte region are using the near real-time data on environmental and meteorological information created by this project. This has led to the development of a secure intranet site to expand information access to remote emergency services offices and to other agencies which do not have access to the same systems.

New health research has also been initiated as a result of the geospatial data in the Paso Del Norte project. The Texas public hospital discharge database, which contains demographic and diagnostic information for individual hospitals by postal (ZIP) code, has been combined with the air quality data from the Paso Del Norte project for use in several epidemiological studies.

4.3.5 Summary of key issues and areas of consideration

4.3.5.1 Aim to provide information

This project was developed to integrate a range of environmental and transport-related data and to model current and forecast air quality, primarily to provide an information base. While other similar projects have been more directly focused on supporting and proving the benefits of specific improvement measures, this application seeks mainly to assist and educate the public in their transport choices and assist agencies in managing day-to-day transport emissions.

Results have indicated a clear improvement in awareness and some shift in transport choices across the region.

4.3.5.2 Ozone source monitoring

One of the main sources of concern in this region is the build-up of ozone, due to the high levels of sun and concentrations of emissions. The process by which ozone is produced from these emissions has also been a major factor in the scale of the area that the project covers. This has led to the need for modelling and monitoring facilities specifically designed for the purpose of monitoring ozone in areas where it is produced rather than in the locations of the contributing emissions.

4.3.5.3 Cross-border vehicle quality

Another specific feature of the region that has led to variations in monitoring and modelling applications is the variations in vehicle fleet age and levels of maintenance; vehicles on the Mexican side of the border being significantly older and more polluting than those in the United States. The emissions models used have, therefore, been developed to incorporate data on the home origins of vehicles in order to reflect their likely emissions contribution.

4.3.5.4 Static and congested traffic

Further modelling and emissions monitoring variations have been required to deal with the major impacts of congestion at the US/Mexico border crossings.

4.3.5.5 Education and awareness

A major objective of the project has been to improve the availability of public information on air quality and pollution, and to raise awareness of the problem sources and potential opportunities to reduce these through transport choices and management. The project has, therefore, focused significantly on coordinating the communication of base data and targeted information through a range of information channels, and developing and focusing key messages linked to the issues raised by the system.

4.3.5.6 Inter-agency cooperation

The project has led to improved communication between the various agencies involved to ensure the timely processing of all the data, and this has in turn led to improvements across other related systems and initiatives.

4.3.5.7 Developing systems architecture

To optimise the level of data sharing and inter-agency use of the systems developed, agreed industry standards were adopted and a common systems architecture developed at an early stage. This allowed multiple organisations and systems to contribute and improved the ability to address database problems and the potential for packaging information.

4.4 Environmental monitoring and access control, Rome and Florence

4.4.1 Project drivers

Smog and the effects of air pollution caused by vehicles have been a particular concern in many Italian cities for a long time. Numbers of ancient buildings are deteriorating as a direct result of the problem and this has been a primary driver behind legislation to

protect these areas. In the early 1990s, the Italian government took steps to improve its environmental laws in response to a series of public referenda and later in response to the country's obligations as a member of the EU. Many of these cities also rely on a large tourist industry that has been affected in some areas by the levels of pollution.

4.4.2 Specific purpose or role

The systems used in Rome and Florence incorporate a combination of access control projects restricting traffic in defined zones based on a range of access conditions, and targeted environmental monitoring at major historic buildings.

The monitoring systems provide continual assessments of the air quality levels as well as specific impacts on key buildings. The information developed from these systems is used to monitor the impact of the traffic and access control measures and provide direction for their ongoing adjustment.

In most of the systems developed internationally to address the monitoring and forecasting of environmental impacts, the primary issue is either the health impacts of pollutants or greenhouse gas emissions. The significant focus of these Italian systems on the detrimental effects on historic buildings is relatively unique and also introduces some particular variations in approach.

4.4.3 Policy and legislation

In the early 1990s, the Italian government held a referendum in major cities to determine opinion on freeing historic districts from traffic congestion and poor air quality levels. Italian law now requires that cities with a population larger than 100,000 have a pollution monitoring network system. These regulations have led to the implementation of numerous measures to mitigate growing air pollution problems.

Further requirements have subsequently been introduced at EU level, related to the monitoring of air quality levels and the introduction of measures to meet defined targets.

European Council Directive 1996/62/EC on Air Quality Assessment and Management (Framework Directive) and the associated daughter directives address the regular assessment of air quality through monitoring and modelling in urban areas. The main directive also calls for action plans to improve air quality and requires authorities to supply more information to the public.

Further, European Council Directive 2002/49/EC addresses the assessment and management of environmental noise. In relation to noise from land transport, it requires larger cities to generate noise maps indicating the number of people exposed to certain noise levels. Using these maps, cities must develop action plans which aim to achieve specific noise limits in accordance with each member state's own level.

4.4.4 Project benefits and outcomes

One of the key objectives in Rome and Florence has been to improve understanding of the impacts of vehicle emissions on historic buildings and to provide direction and support for a range of traffic and access control initiatives.

The access control systems, combined with other demand management initiatives, have successfully reduced the number of vehicles entering central zones and reduced overall emissions and impacts on the buildings monitored.

The need to develop and operate the access control systems in such a complex environment has also provided an opportunity to adapt to other specific measures (such as EU emissions categories) and to explore the potential for closer links between monitored and forecast environmental conditions/impacts and the policies and operation of the PGTU.

As the schemes have developed, the level of data collected by the various environmental monitoring facilities has become a key measure of the benefits achieved by the PGTU. This has also led to the more targeted application of monitoring facilities.

4.4.5 Summary of key issues and areas of consideration

4.4.5.1 Pollution impacts to buildings

In most of the systems developed internationally to address the monitoring and forecasting of environmental impacts, the primary issue is either the health impacts of pollutants or greenhouse gas emissions. The significant focus of the Italian systems on the detrimental effects on historic buildings is relatively unique and also introduces some particular variations in approach.

This has led to some specialised monitoring of effects and links to the application of targeted policy drivers.

4.4.5.2 Access control

The zone-based access control systems employed are a relatively unique solution, being driven in part by high demands, restricted local networks and current legislation. Local (municipal) level variations in policy have also led to the need for flexible and dynamic systems to address these requirements.

4.4.5.3 Tourist industry

Again an aspect relatively unique to the Italian systems is the focus on the importance of the tourist industry. The high tourist demand in the zones of concern has been a major contributor to, as well as an area of concern about, the impacts of adverse affects and some of the innovations developed as part of the access control solutions have been directly related to addressing these issues (eg rights of access for residents, and tourist hotels within zones having access to specific temporary exemptions for guests).

4.4.5.4 Required pollution monitoring

The legal requirement for air quality monitoring was introduced (for cities with >100k population) earlier than in most other European countries as a result of the referendum held in the early 1990s. This relatively strong requirement has been the catalyst for several innovations, including the introduction of earlier access control systems based on manual checks. It illustrates the effect that specific legislation can have on promoting the development of solutions.

4.4.5.5 Link between monitoring and controls

The links between the monitoring of air quality conditions and the management of traffic and transport has evolved through several stages as the various schemes have been developed. Some early trial systems (Rome in particular) included links between roadside air quality monitoring and the main traffic control system. This was found to be relatively ineffective, as controls in one area often resulted in greater problems in other areas.

Subsequent systems have focused on providing improved data on the impacts of particular measures, and using these to assist in directing adjustments of specific parameters around the application of these measures (eg the setting of access control regulations, time factors and the management of some exemption models). This has in turn led to more influential policy measures concerning the location and application of monitoring tools to improve information.

4.4.5.6 Opportunity to adapt

The need to meet the complex requirements of municipal authorities in particular, has resulted in the development of flexible systems that can address a wide range of other options. For example, the dynamic exemption systems developed to provide for a variety of special status users are now providing an opportunity to introduce more easily variable conditions for particular emissions category vehicles.

4.5 Environmental monitoring system, York

4.5.1 Project drivers

The key driver behind the York project was to respond to British government health-based air quality objectives by focusing on a range of air pollutants and protecting people sensitive to changes in air quality and pollution.

As part of the programme to pursue these objectives, county councils are required to measure air quality and report back measurements, to ensure conformity with United Kingdom and EU legislation.

York has also linked this initiative to the demonstration of a trial ITS initiative aimed at the integrated application of a range of monitoring and traffic management systems.

4.5.2 Specific purpose or role

The specific purpose of the York environmental monitoring system was to measure pollutants in order to assess whether the city of York met its statutory obligations, but its aim was subsequently extended to provide specific inputs to targeted traffic management facilities.

4.5.3 Policy and legislation

All United Kingdom local authorities have a duty to try to achieve health-based air quality objectives set by the government.

Under the requirements of the Environment Act 1995, Part IV, local authorities are required to periodically review and assess air quality in their areas against health-based objectives prescribed by the government. When it appears that the levels are unlikely to be met, local authorities must designate air quality management areas and draw up action plans for improving air quality in those areas.

The later United Kingdom Air Quality Strategy has revised air quality objectives and local authorities are now required to review and assess air quality in their areas against the current objectives set down in the Air Quality Regulations 2000.

4.5.4 Project benefits and outcomes

The benefits of the system in York at this stage are mainly restricted to the reporting of statutory measures and the distribution of information on the city's pollutant levels and profiles. However, the integration of these systems with the wider UTMC systems in the city have provided the potential for increased benefits through future operational links between these monitored factors and the management of traffic and transport.

The key beneficiaries from the monitoring and related controls are people with respiratory problems. These people can check real-time information to enable them to plan journeys and take action to avoid poor air quality areas. This information is now more readily available and is being collected over a long period of time to enable analysis and the development of future strategies.

The analysis of air quality and pollution also enables local authorities to implement medium- and long-term strategies and forecasting of pollution levels to aid those affected.

4.5.5 Summary of key issues and areas of consideration

4.5.5.1 Compliance with statutory monitoring requirements

The development of the initial system began with requirements imposed by central government, and the specific pollutants monitored were directly linked to those specified by central government. However, the target levels, while mainly driven by these government targets, have been varied in some cases to local conditions.

4.5.5.2 Integrated UTMC system trials

The facilities implemented to serve the initial monitoring functions have subsequently been integrated (and extended) as part of an integrated ITS trial, leading to the standardising of data forms, architecture and the development of some specific ITS applications using air quality monitoring as a primary input to traffic control.

4.5.5.3 Contribution to centralised database

The data generated by the various monitoring facilities has been linked through a centralised national system to provide real-time and profile information on the measured pollutants.

4.6 Monitoring and simulation model – SIMTRAP

4.6.1 Project drivers

The main driver behind SIMTRAP and other similar projects has been the need to support medium-term planning decisions around the development and implementation of measures to improve air quality in large urban areas. This in turn has been driven by increasing national and EU-level requirements for major cities to monitor and address air quality problems.

4.6.2 Specific purpose or role

The SIMTRAP system has been developed mainly to address medium-term planning requirements for detailed and integrated modelling of transport and air quality. It combines dynamic traffic simulation software, which can produce detailed emissions calculations and emissions modelling, taking into account speed, acceleration, deceleration, engine size and temperature; and dynamic 3D air pollution modelling, accounting for the complex interactions between emissions, landscape and meteorological conditions.

4.6.3 Policy and legislation

The SIMTRAP project was not directly associated with any specific legislation or policy, other than those of the EU that led to the development and funding of the project. Being an EU-funded project, the development of the system was influenced by the key EU directives on environmental monitoring and in part by the local legislation and policies of the trial cities.

Under the requirements of the Environment Act 1995, Part IV, all local authorities are required to periodically review and assess air quality in their areas against health-based objectives prescribed by the government. When it appears that the objective levels are unlikely to be met, local authorities must designate air quality management areas and draw up action plans for improving air quality in those areas.

4.6.4 Project benefits and outcomes

The integrated approach of the SIMTRAP project has been recognised as providing a more realistic picture of traffic-related air pollution than had previously been achieved by separate traffic and air pollution models.

While ozone pollutant formation is a slow process, variations in traffic still have a significant effect and static assignment tools fail to provide an effective means of modelling ozone concentration forecasts, or evaluating the effects of traffic-related measures such as restrictions at peak hours.

The combination of the DYNEMO and DYMOS models have provided this facility, permitting sufficiently large areas to be studied (a key capability for ozone). This in turn has led to improved evaluation of the impacts of control measures that previously were inconclusive (eg lower concentrations in one area being offset by higher concentrations elsewhere).

The integration of the transport and air pollution models was a major focus of the project, along with their interface with the graphics and the DSS. This led to the development of an effective tool and the potential for further developments, including:

- on-line monitoring of air quality monitoring sites using the detailed information obtained in modelling and decision support
- linking the DSS to traffic control centres to enable the automatic implementation of on-street control measures
- optimisation in the design of ameliorative measures, rather than pure decision support.

4.6.5 Summary of key issues and areas of consideration

4.6.5.1 Support for medium-term planning decisions

The SIMTRAP project and its various applications have been targeted specifically at the need for improved medium-term strategic planning tools that incorporate dynamic measures of key inputs. This has led to the development of a system that provides an effective tool to prove the benefits of medium-term improvements in the context of EU objectives, and assists in evaluating various scenarios and the combination of project and management strategies.

4.6.5.2 Combining traffic simulation and emissions modelling

The main focus of the SIMTRAP facility has been the critical issue of integration between a dynamic traffic model and an emissions model, taking account of the wide variety of other contributing factors. This is the principal component of the system and the issue that sets it apart from other approaches.

The SIMTRAP system was developed to provide an alternative to current static modelling approaches, recognising the limitation of these tools, through the application of an effective and credible model that could take account of a wide range of impacts and scenarios.

4.6.5.3 Ozone focus

The link between vehicle emissions and ground-level ozone pollution is well understood, but as the formation of ozone is a slow process, static assignment tools fail to provide an effective means of modelling ozone concentration forecasts, or evaluating the effects of traffic-related measures such as restrictions at peak hours.

A key focus of the SIMTRAP system was to provide a tool that could effectively model the impacts of traffic-related measures on ozone pollution, requiring a wider coverage area and a wider range of modelling elements than other traditional models.

5. Application to the New Zealand environment

New Zealand has relatively good air quality due to its low population density, close proximity to the sea and remoteness from other continents and sources of pollution. However, there are some areas (mostly urban) where concentrations of air pollution are quite high, especially during low-wind conditions, due to high-traffic density and homes heated mainly by open fires or wood burners.

Air quality monitoring throughout New Zealand indicates that concentrations of suspended particles (in particular PM10) in the air exceed the ambient air quality guideline values in many urban areas during the winter months.

Assessments to determine sources of PM10 emissions have been carried out since about 1995 for the main cities, as well as for some smaller towns. All of these have included an assessment of PM10. Other common contaminants measured have been carbon monoxide (CO), nitrogen oxides (NOx), sulphur oxides (SOx), volatile organic compounds (VOC) and carbon dioxide (CO2).

Results indicate that the main source of PM10 emissions in most areas during the winter months is solid fuel burning for domestic heating, although industrial contributions may also be significant in a number of locations. Domestic home heating is also responsible for the majority of the PM2.5 emissions, as most of the PM10 emissions from this source are the smaller PM2.5 size fraction. Motor vehicle emissions may also be a major source of PM10 and PM2.5 in Auckland, although further work is being carried out to assess this.

A report prepared by Environet Limited for the Ministry of the Environment (MfE) (2003) stated:

> Limited information is available on trends in sources of PM10 emissions in New Zealand, owing to the relatively recent nature of the use of emission inventories. Some data for Christchurch and Timaru suggest little change in emissions between the years 1996 and 2000. Estimated future trends in PM10 emissions are likely to be dominated by variations in home heating methods and growth in household numbers in most locations. Home heating methods are likely to be influenced by cost and availability of alternative sources such as electricity and gas, as well as any air quality management measures. Future trends in industrial PM10 emissions are likely to be location dependent, whereas a nationwide decrease in PM10 emissions from motor vehicles is predicted from 2001 to 2021.

5.1 National level

The main government body providing national direction on the environment is the MfE. The MfE has the role of advising the government minister on environmental matters. It also ensures administration of the Resource Management Act through national environmental standards and policy statements related to all forms of environmental concern, not just mobile pollutants such as motor vehicles.

The Ministry's clean air programme promotes the sustainable management of air in New Zealand by developing the best national policies and tools to maintain and, where necessary, improve air quality. These include:

- guidelines
- national environmental standards and regulations
- good-practice guidance
- education programmes
- research and reporting.

The MfE examines all aspects of air quality in New Zealand, including the health, environmental and economic impacts of local air quality throughout the country. It also works closely with other government departments to ensure their policies and strategies have a positive influence on air quality.

The Ministry's current programme includes the following transport-related initiatives:

- national environmental standards for air quality
- health and air pollution in New Zealand
- a new guide for dispersion modelling
- assessment and management of dust emissions
- reduction of vehicle emissions
- air quality indicators
- assistance with environmental education programmes.

5.2 Regional level

5.2.1 Auckland Regional Council

Greater Auckland includes Auckland, Manukau, Waitakere and North Shore Cities, and Rodney, Franklin and Papakura districts. Across all of these areas high-volume traffic corridors and vehicle emissions in poorly ventilated street canyons give rise to significant concentrations of PM10, CO and NOx/NO2.

At present, Auckland, including its surrounding regions, is the only area known or suspected to be widely affected by an urban plume. This phenomenon is largely photochemical (ozone) and is likely to be due to the high emissions and conducive meteorological conditions of the region. Effects may spread out several tens of kilometres, even possibly affecting parts of the Coromandel Peninsula.

Extensive monitoring of PM10, PM2.5, NO2 and CO has been undertaken in the Auckland region. This monitoring demonstrates that air quality is better in residential and rural areas than in industrial areas and at roadsides. This is reflected in the urban and rural air

quality targets, which recognise that it is desirable to achieve better air quality in areas where people sensitive to pollution are likely to be regularly exposed to it.

The targets are intended to provide a level to which air quality should be maintained (especially where it is already better than air quality targets) and enhanced where it does not meet the targets. They should apply wherever members of the public may be exposed for the relevant averaging period. For example, 'urban air quality management area targets' apply in areas that are representative of places where people live, or might regularly be exposed and may include worst-case exposure situations such as 10 metres from a busy roadway or in a residential valley subject to inversion conditions. These targets will not generally apply to roadsides (including kerbsides and footpaths) because people will only frequent these for relatively short periods of time. It would be unrealistic to expect acceptable air quality in these areas in the short term. Similarly, targets do not apply in areas not generally open to the public, such as within the boundaries of an industrial site.

The targets for 'all areas' (see below) have been set because the Auckland Regional Council (ARC) does not have adequate monitoring information to set targets lower than the MfE's *Ambient air quality guidelines* (2002) for those pollutants.

Air quality management area	Contaminant	Target	Averaging time
Urban and rural	Particles (PM10)	33 µg/m^3	24 hour
	Particles (PM10)	13 µg/m^3	Annual
	Particles (PM 2.5)	17 µg/m^3	24 hour
	Nitrogen dioxide (NO2)	132 µg/m^3	1 hour
	Nitrogen dioxide (NO2)	66 µg/m^3	24 hour
	Carbon monoxide (CO)	20 mg/m^3	1 hour
	Carbon monoxide (CO)	6 mg/m^3	8 hour
Industrial	Particles (PM2.5)	25 µg/m^3	24 hour
	Particles (PM10)	50 µg/m^3	24 hour
	Particles (PM10)	20 µg/m^3	Annual
	Nitrogen dioxide (NO2)	200 µg/m^3	1 hour
	Nitrogen dioxide (NO2)	100 µg/m^3	24 hour
	Carbon monoxide (CO)	30 mg/m^3	1 hour
	Carbon monoxide (CO)	10 mg/m^3	8 hour
All areas	Sulphur dioxide (SO2)	350 µg/m^3	1 hour
	Sulphur dioxide (SO2)	120 µg/m^3	24 hour
	Ozone	150 µg/m^3	1 hour
	Ozone	100 µg/m^3	8 hour
	Lead	0.2 µg/m^3	3 month moving average calculated monthly
	Benzene* (year 2002)	10 µg/m^3	Annual
	Benzene* (year 2002)	3.6 µg/m^3	Annual
	1,3-Butadiene	2.4 µg/m^3	Annual
	Formaldehyde	100 µg/m^3	30 minutes
	Acetaldehyde	30 µg/m^3	Annual
	Benzo(a)pyrene	0.0003 µg/m^3	Annual
	Mercury (inorganic)	0.33 µg/m^3	Annual
	Mercury (organic)	0.13 µg/m^3	Annual
	Chromium VI	0.0011 µg/m^3	Annual
	Chromium metal and Chromium III	0.11 µg/m^3	Annual
	Arsenic (inorganic)	0.0055 µg/m^3	Annual
	Arsine (arsine)	0.055 µg/m^3	Annual

Figure 5.1 Auckland regional air quality targets.

Ambient air quality monitoring results for 2000 are compared in the following table, to provide an indication of the reduction required to meet the targets.

Air quality management area	Pollutant	Target	Averaging time	EPI equivalent for the target	Maximum measured level (2000)	EPI equivalent for the measured level
Industrial	Particles (PM_{10})	50 µg/m^3	24 hour	Alert	57 µg/m^3	Action
	Particles (PM_{10})	20 µg/m^3	Annual	Alert	19 µg/m^3	Alert
	Particles ($PM_{2.5}$)	25 µg/m^3	24 hour	Alert	37.2 µg/m^3	Action
	Nitrogen dioxide (NO_2)	200 µg/m^3	1 hour	Alert	170 µg/m^3	Alert
	Nitrogen dioxide (NO_2)	100 µg/m^3	24 hour	Alert	57 µg/m^3	Acceptable
	Carbon monoxide (CO)	30 µg/m^3	1 hour	–	Not measured	–
	Carbon monoxide (CO)	10 µg/m^3	8 hour	–	Not measured	–
Urban and rural	Particles (PM_{10})	33 µg/m^3	24 hour	Acceptable	43.3 µg/m^3	Alert
	Particles (PM_{10})	13 µg/m^3	Annual	Acceptable	18.1 µg/m^3	Alert
	Particles ($PM_{2.5}$)	17 µg/m^3	24 hour	Acceptable	29.2 µg/m^3	Action
	Nitrogen dioxide (NO_2)	132 µg/m^3	1 hour	Acceptable	76.8 µg/m^3	Acceptable
	Nitrogen dioxide (NO_2)	66 µg/m^3	24 hour	Acceptable	42.2 µg/m^3	Acceptable
	Carbon monoxide (CO)	20 mg/m^3	1 hour	Acceptable	7.5 mg/m^3	Good
	Carbon monoxide (CO)	6 mg/m^3	8 hour	Acceptable	4.2 mg/m^3	Acceptable
	Ozone (O_3)	150 µg/m^3	1 hour	Alert	100 µg/m^3	Alert
	Ozone (O_3)	100 µg/m^3	8 hour	Alert	74.5 µg/m^3	Alert

Figure 5.2 Maximum measured air pollution levels 2000.

The above figures indicate that the main areas of concern are PM10 and 2.5 levels in some areas, NOx levels in industrial areas, and ozone across both urban and rural areas.

Parts of the Auckland region experience relatively frequent (46 days in 1999) breaches of acceptable ambient air quality levels for CO and N, close to busy roads. These breaches usually occur during periods of calm weather and vehicle congestion.

Breaches of acceptable levels for particulate matter have also been recorded at peak traffic sites, as well as sites further away from busy roads. Motor vehicle emissions are a significant contributor to these high particulate levels, along with domestic fires and industrial emissions.

Elevated ozone concentrations are measured downwind of central Auckland's urban areas. There is the potential for breaches of acceptable levels of ozone to occur in the Auckland region in certain weather conditions, particularly if vehicle emissions continue to increase.

Mobile sources, in particular motor vehicles, are the largest source of air pollution in the Auckland region. The Auckland Regional Emissions Inventory suggests that motor vehicles are responsible for 70–80% of total emissions discharged into the Auckland region's air.

Measures being implemented to address these problems include:

- a shift in land-use patterns toward a more compact urban form, which focuses growth along passenger transit corridors and main arterial roads
- passenger transport investment in bus, ferry and rail
- completion of major roading projects within the region's main transport corridor

- TDM measures to reduce the need for vehicle travel by influencing and changing travel behaviour.

5.2.1.1 Summary

- Auckland has high-volume traffic corridors and vehicle emissions in poorly ventilated street canyons.
- There are significant concentrations of PM10, CO and NOx/NO2.
- It is the only area which is known or suspected to be widely affected by an urban plume (ozone).
- Extensive monitoring of PM10, PM2.5, NO2 and CO has been undertaken.
- Monitoring demonstrates the air quality is better in residential and rural areas than in industrial areas and at roadsides.
- The main areas of concern are PM10 and PM2.5 levels in some areas, NOx levels in industrial areas and ozone across both urban and rural areas.
- Parts of the Auckland region experience relatively frequent breaches of acceptable ambient air quality levels for carbon monoxide and nitrogen dioxide close to busy roads (usually during calm weather and vehicle congestion).
- Breaches of acceptable levels for particulate matter occur at peak traffic sites.
- Elevated ozone concentrations are measured downwind of central Auckland's urban areas.
- Motor vehicles are responsible for 70–80% of total emissions.
- Measures include land-use planning, passenger transport investment, completion of major roading projects and TDM measures.

5.2.2 Wellington Regional Council

Greater Wellington includes Wellington, Porirua, Lower Hutt and Upper Hutt cities and Wainuiomata; an area with approximately 500,000 people, several high-traffic-volume corridors and complex topography.

The Wellington region is generally very well ventilated, lying in the windy area between the mountain chains of the North and South Islands, and has often been regarded as having minimal air quality problems. However, several areas within Greater Wellington warrant attention. Traffic-related emissions are significant on some days in city centre street canyons, and near the high-volume traffic corridors between the suburbs and city centre. Several areas in the Wellington region also experience high pollutant levels on a neighbourhood scale. For example, the Hutt Valley is bordered on both sides by 500 m ranges, and Wainuiomata lies in a basin surrounded by 350 m hills. This terrain and frequent winter inversions inhibit the dispersion of pollutants.

Wellington region's climatic conditions and weather processes are different from those of New Zealand as a whole. The region's weather is highly variable and the combination of its climate and topography contribute to air quality that is generally very good. However,

areas of poor air quality do occur in some situations, mainly due to localised variations in topography, climate and discharges.

In the Wellington region, there is generally good information available on climatic factors such as wind and rain, and while their influence on air quality is generally understood, the localised effects are not as well documented.

The objectives in Wellington's Regional Air Quality Management Plan are concerned with protecting and maintaining air quality where it is good, enhancing it where it is not as good, preventing further deterioration in all areas, and avoiding or reducing the effects of air pollution. Air quality in the region is generally assumed to be high, but data on air quality across the region is limited.

The targets for air quality adopted by the Greater Wellington Regional Council (GWRC) for the period 2006–2016 state that: 'There will be no recorded instances when air pollution reaches the alert level of the national air quality guidelines or 66% or greater of the national air quality standards.'

The region currently operates three fulltime monitoring facilities to provide data on the levels of these pollutants.

5.2.2.1 Vivian and Victoria Streets

The intersection of Vivian and Victoria Streets in central Wellington city has been identified as one of the main locations where air quality is under pressure from motor vehicle emissions. Located on a busy arterial route with traffic volumes of about 40,000 vehicles on weekdays and 30,000 during weekends, the 'canyoning' effect of the multi-storeyed buildings in this area contributes to a build up of pollutants.

This was the location of the GWRC's first permanent transport air quality monitoring station, established in February 2004. This site, being one of the most challenging locations in the city, provides an effective measure of traffic impacts. Data from this site reveals relatively low levels of CO and NOx, but a trend toward PM10 levels close to the 66% target.

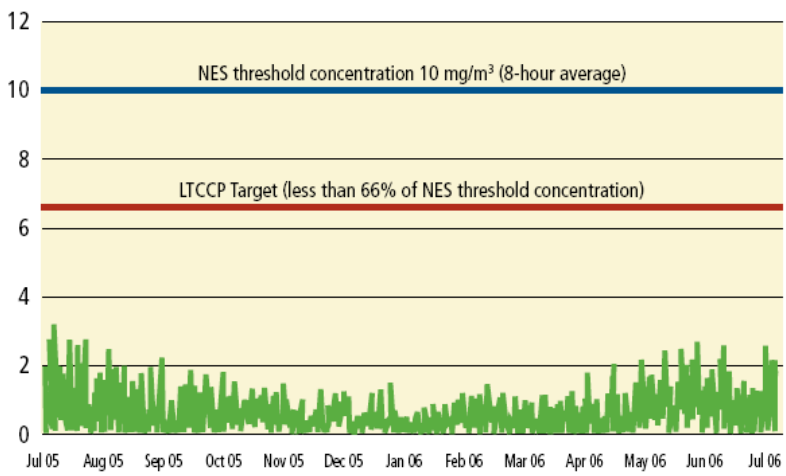

Figure 5.3 Eight-hour average CO. Source: GWRC

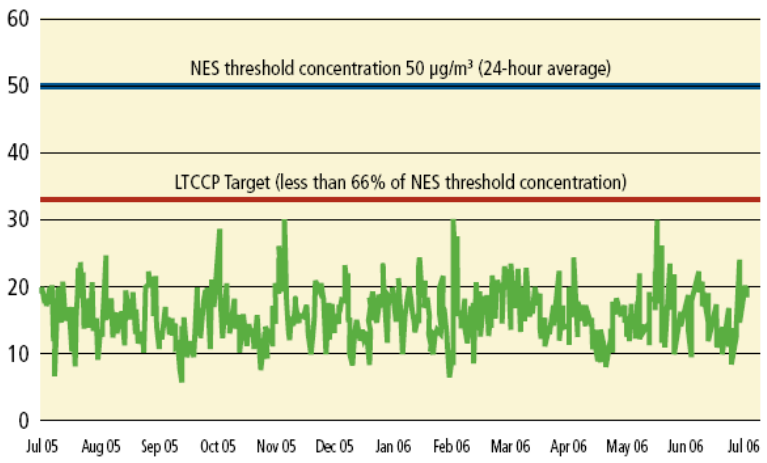

Figure 5.4 24-hour average PM10. Source: GWRC

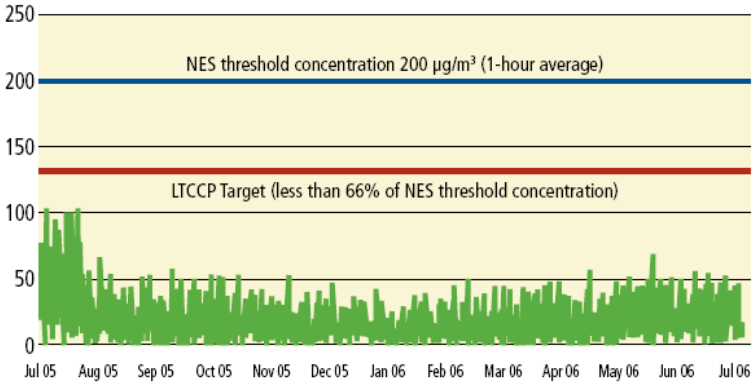

Figure 5.5 One-hour average NOx. Source: GWRC

5.2.2.2 Ngauranga Gorge

The first of two mobile stations has been located in Ngauranga Gorge. The station is adjacent to SH1 and monitors vehicle-generated pollutants from this busy section of the strategic network. Data from this site again reveals relatively low levels of CO and NOx, but also a trend toward PM10 levels close to the 66% target.

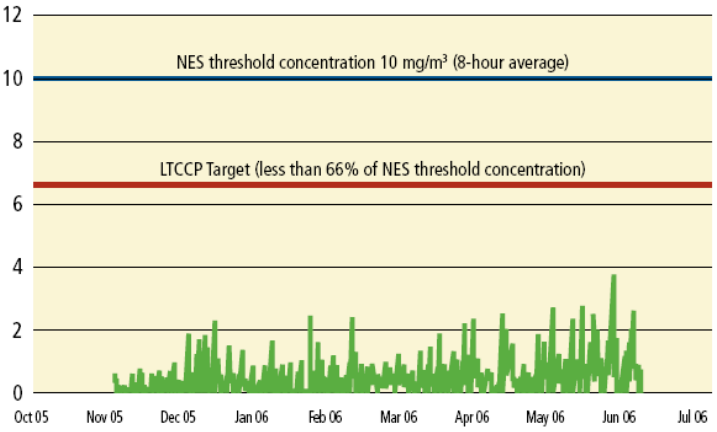

Figure 5.6 Eight-hour average CO. Source: GWRC

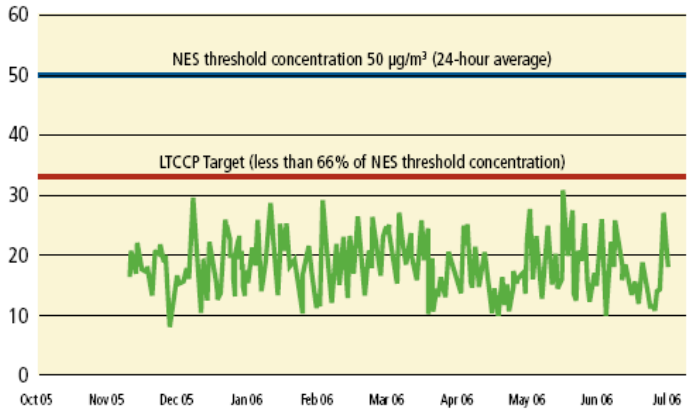

Figure 5.7 24-hour average PM10. Source: GWRC

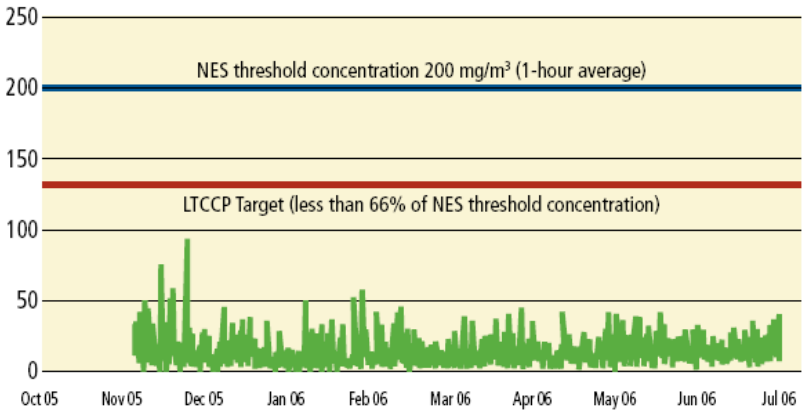

Figure 5.8 One-hour average NOx. Source: GWRC

The GWRC (2006a) reported that regional fuel consumption had grown by 9% over the past six years and carbon dioxide emissions resulting from land transport fuel combustion were calculated to have increased at the same rate; however, overall air pollution due to transport emissions continued to be less of a problem in Wellington than in other regions.

Fuel sales are likely to grow, with more private vehicle ownership and use, and this will in turn exert further pressure on the region's air quality. By 2016, CO2 emissions from transport in the Wellington region are forecast to increase by 22.5% from 2001 levels.

Reducing the need to travel and improving the efficiency of the transport network will contribute to a reduction in the amount of fuel consumed by vehicles and the associated CO2 produced. The GWRC's TDM policies, such as promoting the use of active modes and public transport, aim to reduce the impact of the transport sector on the environment.

Supporting and advocating integrated land-use and transport planning through district plans, the *Regional Policy Statement for the Wellington Region* (GWRC 1995) and the *Wellington Regional Strategy* (GWRC 2006b) will influence higher-density development around public transport infrastructure.

Encouraging a change in travel behaviour by increasing public awareness of alternative transport choices is a key objective of the *Wellington Regional Travel Demand Management Strategy* (GWRC 2005).

5.2.2.3 Summary

- Wellington has several high traffic volume corridors and complex topography.
- It is often regarded as having minimal air quality problems due to winds.
- Traffic-related emissions are significant on some days in city centre street canyons and near the high-volume traffic corridors.
- Hutt Valley and Wainuiomata are prone to inversions that inhibit the dispersion of pollutants.
- Most measures are within targets but PM10 is close to its target level.
- Measures include encouraging a change in travel behaviour and the use of alternative modes.

5.2.3 Environment Canterbury

Christchurch, a city with a population of 350,000, has some high-volume traffic corridors, a cool winter climate, extensive wood and coal heating activity and some significant meteorological factors affecting pollutant levels. Located adjacent to the 1,000 m high Banks Peninsula hills, the air above the city is not well ventilated in calm weather conditions. In winter, Christchurch is well known for its frequently occurring nocturnal inversions which severely inhibit the dispersion of pollutants.

Although efforts have been made to reduce the use of wood and coal for domestic heating, Christchurch experiences localised pollutant levels which are close to, or have exceeded guideline values. PM10, SO2, CO and NOx levels are monitored across the city, particularly close to high-volume traffic corridors.

In summer and early autumn, emissions and meteorological conditions are also favourable for the occurrence of photochemical pollution. Higher-level inversions created by a westerly airflow over the Southern Alps can be a factor in such events, which result in ozone build up.

Environment Canterbury's air quality monitoring network for 2004 consisted of eight ambient air quality monitoring sites in the Canterbury region. The main air quality monitoring site for Christchurch is located in St Albans, with other sites in Hornby, Ilam and the Christchurch Botanic Gardens.

The contaminants monitored in Canterbury included PM10, PM2.5, CO, SO2 and NOx. Meteorological conditions were also monitored at most sites by measuring wind speed, wind direction and temperature.

In 2004, seasonal variations were evident at most sites with higher concentrations of most contaminants during the autumn and winter months and generally low concentrations at other times.

The main contaminant of concern is PM10, as concentrations in breach of the National Environmental Standards (NES) occurred at all monitoring sites. Emissions from home heating fires, combined with meteorological conditions during winter, were key factors. The NES threshold for PM10 is 50 µg/m3 for a 24-hour average, with an annual allowance for one day greater than this threshold. In Christchurch, this threshold was exceeded on 33 days (from 9.00 am) and the maximum concentration measured with the filter dynamic measurement system (FDMS) was 160 µg/m3.

Adjusted PM10 data, to reflect NES methods, showed that in Timaru the NES threshold was exceeded on 40 days, with a maximum concentration of 102 µg/m3. In Kaiapoi the threshold was exceeded on 18 days, with a maximum concentration of 99 µg/m3. In Rangiora and Geraldine the threshold was exceeded on seven days and four days, with maximum concentrations of 75 µg/m3 and 61 µg/m3 respectively.

The NES threshold for CO is 10 mg/m3 for an eight-hour average, with an annual allowance of one period greater than this threshold. This was not breached at any monitoring sites in Canterbury during 2004; neither was the MfE's national ambient air quality one-hour average guideline concentration of 30 mg/m3. The highest eight-hour average concentration at Christchurch's St Albans monitoring site was 9.8 mg/m3.

At most other monitoring sites in the region the highest concentrations were within the MfE's acceptable air quality indicator category, at less than 66% of the guideline values, except in Geraldine where the highest concentrations were within the MfE's good air quality indicator category, at less than 33% of the guideline values.

The NES threshold for SO2 is 350 µg/m3 for a one-hour average, with an annual allowance of nine hours greater than this threshold. There is also a limit of 570 µg/m3 that is not to be exceeded at any time. These thresholds were not breached at any monitoring sites in Canterbury during 2004; neither was the MfE's national ambient air quality 24-hour average guideline concentration of 120 µg/m3. The highest concentrations, measured at Christchurch's Hornby monitoring site, were within the MfE's acceptable air quality indicator category, at less than 66% of the guideline values. Elsewhere, the highest concentrations did not exceed the MfE's good or excellent air quality indicator categories, at less than 33% or 10% of the guideline values respectively.

The NES threshold for NO2 is 200 µg/m3 for a one-hour average, with an annual allowance of nine hours greater than this threshold. The threshold was not breached in Christchurch during 2004. Neither was the MfE's national ambient air quality 24-hour average guideline concentration of 100 µg/m3. Concentrations of NO2 measured at the monitoring sites in Christchurch were within the MfE's acceptable category except for one day when the maximum hour average concentration measured at St Albans was in the MfE's alert category.

2003		24-hr PM_{10}*	24-hr $PM_{2.5}$ #	8-hr CO	1-hr CO	24-hr SO_2	1-hr SO_2	10-min SO_2	24-hr NO_2	1-hr NO_2
Christchurch	St Albans Coles Pl	Action		Alert	Acceptable	Excellent	Good	Good	Acceptable	Alert
	Hornby	–	-	-	-	Acceptable	Acceptable	Acceptable		
	Gardens	Action	-	Acceptable	Good	Good	Good	Good		
	Ilam	Action	-	Acceptable	Good	Good	Good	Good		
	Burnside			Acceptable	Good	Good	Excellent	Good	Acceptable	Acceptable
Kaiapoi		Action	-	Acceptable	Good	Excellent	Good	Good		
Rangiora		Action	-	Acceptable	Good	Excellent	Excellent	Excellent		
Geraldine		Action	-	Good	Good					
Timaru		Action	-	Acceptable	Good	Good	Good	Good		

Figure 5.9 Summary against MfE measures 2004.

The major contributing factor to air quality problems in Christchurch is domestic heating; however, the monitoring figures indicate that transport is also contributing significantly to specific problem areas.

Environment Canterbury is engaged in a range of measures to address these issues, including a strong focus on demand management, to make more efficient use of the existing land transport infrastructure. Initiatives include promoting personal travel behaviour change, introducing restraints through parking management and pricing mechanisms, and developing business travel plans to encourage greater use of walking, cycling, public transport and more efficient motor vehicle use, through measures like ride sharing or tele-working.

5.2.3.1 Summary

- Christchurch has some high-volume traffic corridors.
- It has a cool winter climate and extensive wood and coal heating activity.
- A large basin topography leads to air above the city not being well ventilated in calm weather.
- Localised pollutant levels are close to, or exceeding guideline values.
- Higher-level inversions result in ozone build up.
- The main contaminant of concern is PM10 with concentrations in breach of NES.
- The major contributing factor is domestic heating.
- Transport contributes significantly to specific problem areas.
- Measures include TDM, more efficient use of the existing land transport infrastructure, promoting personal travel behaviour change, introducing restraints through parking management and pricing mechanisms, and developing business travel plans.

5.3 National and regional air quality targets

As part of the local council monitoring of air quality, areas where air quality is known to be a problem have been identified regionally to provide a national picture of areas of poor air quality. These areas have been termed 'airsheds' or local air quality management areas (LAMAS). This provides a picture of industrial rather than transportation pollution.

Forty-two airsheds were identified in September 2005. These are areas where air quality is likely or known not to meet national air quality standards. A requirement is in place for air quality in these areas to improve steadily until 2013, after which time no further resource consents will be allowed for smoke or soot discharge. This requirement is aimed at industrial polluters and not at transportation, but increase in car use and travel leads to deterioration in air quality in these areas also and will need to be addressed.

Motor vehicles are the largest single source of air pollution in urban areas. There are, however, no real controls over vehicle emissions in New Zealand. They can affect public health, welfare and property and are a major factor in the smog that can sometimes cover the larger urban regions. This smog is implicated in global climate change and also contributes to water pollution. Although 'run off' into water supplies is not a significant pollution problem in the transport environment as yet, it will need continual monitoring. Motor vehicle emissions are not subject to resource consents under present legislation.

Vehicle emissions are a significant problem in Auckland due to the large suburbs surrounding the central business district and people's reliance on their cars to get into work and to go about their everyday lives. Depending on meteorological and atmospheric conditions, this can create very poor air quality over the city.

Figure 5.10 Auckland, showing a non-polluted day and a polluted day.

5.4 Effects on public health - evidence

A principal driver behind any future policies and decisions concerning poor air quality and other related environmental effects, will be the impacts on public health.

The Ministry of Transport commissioned a report from the National Institute of Water and Atmospheric Research (NIWA 2002) on the health effects of vehicle pollution in New Zealand. This report is widely accepted as a good first endeavour at portraying the health

effects of motor vehicle pollution, to which it attempts to attach a figure of premature mortality.

The study was based on methodologies established overseas, in particular a recent study in Europe, which showed that the number of premature deaths due to vehicle-related air pollution was greater than that due to road accidents.

The study focused on the health effects of fine particulates (PM10). Other contaminants from vehicles can also be a problem to health, but for consistency, PM10 was studied as an indicator of the health effects of vehicle pollution.

An analysis was made of the relevance of overseas research to New Zealand and it concluded that the overseas results were relevant and enabled a similar approach to be taken in New Zealand.

The study concentrated on population centres with a population of over 5,000 people.

The amount of monitoring and exposure data available for New Zealand at the time of the study was relatively small, particularly in comparison with Europe.

The report admits this and also clearly states that its assumptions were made in a best effort to derive objective results from the study.

The report states that:

> The most likely estimate of the number of people above 30 years of age who experience pre-mature mortality in New Zealand due to exposure to emissions of PM10 – 566 people). This compares with 970 people above age 30 experiencing pre-mature mortality due to particulate pollution from all sources (including burning for home heating), and with 502 people dying from road accidents (all ages).

Analysed on a regional basis, most of the increased mortality due to vehicle emissions (253 people, or 64% of the total) occurs in the greater Auckland region. Wellington and Christchurch experience somewhat lesser rates (56 and 41 people respectively, or 14% and 10%). Other New Zealand cities and towns larger than 5,000 people experience the remainder (46 people or 12%).

The results given in this study are consistent with the European studies that have been carried out and show that mortality due to vehicle-related air pollution is twice that of the road accident mortality figure.

The air quality figures used to predict the effects on public health and causes of mortality are for total pollution. Assumptions and data from the Auckland and Christchurch air shed models were used to calculate the proportion of this caused by motor vehicles.

New Zealand has nothing like the amount of pollution of Europe, but does suffer from a higher road accident mortality rate than European countries, so some adjustment of the figures may be required for this. The study does, however, conclude that the premature deaths caused by motor vehicle pollution are significant.

Items not addressed by this study include the higher rates of mortality due to diesel particulates and the effects of cleaner low sulphur fuels that are widely used in Europe, compared with the lower-quality fuel currently used in New Zealand.

It is emphasised that this is a preliminary study, but as a first attempt, this study holds good value as part of the future 'tool box' for developing policy on vehicle emissions in New Zealand.

5.5 Vehicle legislation

Current legislation in New Zealand is focused around the warrant of fitness (WoF) test in terms of emissions levels and exhaust noise.

Vehicles discharge many forms of emissions, including noise, exhaust emissions from the combustion of fuel in the engine post any subsequent exhaust system treatment, vapour emissions from the vaporisation of fuel and oil, oil from leaks and various dust particles from the wear of brakes, clutches and tyres.

The current rule concerns vehicle exhaust emissions – limiting those that affect air quality such as carbon monoxide, oxides of nitrogen, hydrocarbons and particulates. Other vehicle emissions such as noise and vapour are not regulated by current legislation.

A vehicle's exhaust emission performance at manufacture is determined by testing a sample of the same model produced during strictly controlled laboratory tests, as set by the relative emissions standard. Most international vehicle producers have to comply with exhaust emission standards at the time of vehicle manufacture.

In 1997, the New Zealand motor industry adopted a voluntary agreement requiring all new imported light petrol vehicles to comply with the emissions standards of their country of origin.

The current legislation essentially builds on this agreement, also taking other vehicle types into consideration. This will ensure all future new and used light and heavy vehicles coming into New Zealand are manufactured to international exhaust emissions standards, thus complying to the extent that our fuel quality allows.

The Land Transport Act 1998 provides for the Minister of Transport to produce Land Transport Rules which govern safety or licensing of vehicles.

Section 155(a) of that Act states that Rules may set out standards and requirements concerning vehicle emissions and environmental requirements. In developing Rules, the Minister must consider the risks to land transport safety, alignment with world best practice and benefits and costs.

The Ministry of Transport is currently developing a programme for reducing vehicle emissions. The initiatives being considered include in-service and border screening of vehicle emissions performance.

Specifying a minimum emission standard will bring about an improvement in the emissions performance of the fleet. The rule has also added benefit in allowing the development of the broader vehicle emissions programmes mentioned above, by ensuring the fleet has at least a minimum emissions performance capability.

The Ministry of Transport (2003) has stated that New Zealand-specific emissions standards are not warranted for the following reasons:

- Improvements in emission and engine technologies are being driven by overseas standards and environmental obligations. Where they apply, they deliver air quality improvements and will continue to do so.
- New Zealand is an importer of vehicle technology, and new vehicles entering the fleet increasingly reflect international emissions specifications.
- New Zealand is a very small market and adopting stringent standards here would have little impact on the speed of technological change from vehicle manufacturers to limit emissions. It could, however, have major impacts on whether or not vehicles are supplied to the New Zealand market, and on the cost of those vehicles.
- The overseas trend is towards a global standards regime based on European standards.

Low emission exhaust systems and some types of modern engine can be sensitive to higher amounts of sulphur in the fuel or other fuel specifications. New Zealand's fuel quality differs from fuel used in other countries. The low-sulphur fuels available in the United Kingdom and Europe are not available in New Zealand yet, and until they are, it is not reasonable to apply the same emissions standards to New Zealand vehicles.

6. Summary of key issues and application of findings to New Zealand

This report has looked into environmental monitoring and forecasting and related topics. The aim of the report has been to study international experience in the use of technology and policy matters surrounding the subject; to extract the key issues; and to consider potential applications to New Zealand.

Vehicle emissions are an increasing problem in New Zealand and they are one of the largest single contributors to poor air quality. Together with noise pollution they are becoming an ever-growing concern for Land Transport New Zealand due to a number of key factors:

- There is steady population growth in New Zealand.
- Most of this occurs in city centres and urban areas where air pollution problems are concentrated.
- In these areas there is an increase in the number of vehicles and a growth in their use, leading to increased traffic density.
- People are becoming more aware of the problems and health effects of poor air quality.

The following projects were studied identify aspects and concepts that could be applicable to New Zealand:

1. HEAVEN (Healthier environment through abatement of vehicle emission and noise) project – European Union
2. PROAIRE project – Mexico City
3. Paso del Norte Region Environmental Monitoring Project, Texas
4. Environmental monitoring and access control, Rome and Florence
5. Environmental monitoring system, York
6. Monitoring and simulation models – SIMTRAP.

These projects were selected because of the variety of models or technologies used. They provided a wide range of projects at varying stages of completion and offered various reasons for initiating a project. Special study was made of the factors driving each project to help develop policy options that do not currently exist in New Zealand for dealing with transportation pollution.

The figure below sets out the main issues identified through the evaluation of each project.

HEAVEN	PROAIRE	Paso Del Norte	Italy
> Testing implemented and planned measures	> Linked local air quality and greenhouse gases	> Aimed to provide information	> Pollution impacts on buildings
> Integration of transport and dispersion modelling	> Wider funding attraction	> Ozone source monitoring	> Tourist industry
> Role of EU directives	> Identification of sources and connections	> Cross border vehicle quality	> Access control
> Providing assessment of project specific benefits	> Transport sector a major contributor	> Transport sector a major contributor	> Building focused monitoring
> Assess integrated planning strategies	> Diverse transport measures	> Static and congested traffic	> Required pollution monitoring
> Model integration issues	> Large scale measures	> Education and awareness	> Link between monitoring and controls
> Innovation in options assessed		> Inter-agency cooperation and architecture	> Opportunity to adapt
	York	SIMTRAP	
	> Compliance with statutory monitoring requirements	> Support medium-term planning decisions	
	> Integrated UTMC system trials	> Combining traffic simulation and emissions modelling	
	> Contribution to centralised database	> Ozone focus	

Figure 6.1 Summary issues.

6.1 Identified initiatives and concepts

Set out below are 30 significant initiatives and concepts that were identified during the evaluation of the example systems. In section 6.2 they are considered in a New Zealand context.

1 Development of a **package of tools** to assess the impacts of traffic on air quality and noise in near real time and in a scenario-based context

2 Monitoring of compliance with, and providing direction for, **directives and policies** associated with air and noise quality

3 Ability to obtain near real-time data on traffic and environmental conditions in urban areas, and model and test a range of **real and simulated scenarios** and TDM packages through the same systems

4 Integration **of transport and dispersion modelling** to assess impacts and effectively identify benefits of specific measures

5 **The role of directives** and requirements leading to the development of facilities, and as catalysts or innovations

6 **Assessment of project specific benefits** and the ability to separate these benefits from the wider environment

7 **Assessment of integrated transport and land-use planning strategies,** including city-wide long-term scenarios, emission standards, master plan scenarios, land-use planning changes and road network developments

8 **Model integration issues** and the ability to address cities with different problems and environments, providing an effective tool while assisting in region-wide comparisons

9 **Application of innovations in the options assessed;** these include localised truck bans; use of data for inter-authority negotiations and public consultation; specific street-based improvements; land-use planning options; catalysed fleet scenarios; closure of existing arterials to demonstrate benefits of existing facilities; and environmentally induced speed limits

10 Coordinated approach to addressing local **air quality and greenhouse gases**

11 **Wider funding** attracted through broader focus

12 Identification of **sources and connections** between air quality and other factors (eg greenhouse gases, safety and economic benefits)

13 Wide and diverse **transport focus**

14 **Large-scale** fleet and infrastructure measures

15 **Aim to provide information,** integrating environmental and transport-related data to assist and educate the public in their transport choices, and assist agencies in managing day-to-day transport emissions.

16 **Ozone** source monitoring

17 **Vehicle quality** and modelling links

18 Targeted monitoring of **static and congested** traffic

19 Education and awareness through **communications strategies**

20 **Inter-agency cooperation and systems architecture** allowing multiple organisations and systems to contribute and benefit

21 Pollution impacts to **buildings**

22 **Access control** as a concept and management tool

23 **Tourist** industry focus as a benefit and contributor

24 **Required pollution monitoring,** including legal requirements

25 Link between **monitoring and controls** at several levels

26 **Flexibility** providing the opportunity to adapt in the future

27 **Integration** with wider ITS facilities

28 Contribution to **centralised databases**

29 Support for **medium-term planning** decisions

30 **Ozone-specific models** and integration.

6.2 Potential New Zealand application

The following discusses the potential application of the identified initiatives and concepts to New Zealand.

*Development of a **package of tools** to assess the impacts of traffic on air quality and noise in near real time and in a scenario-based context*

One of the main benefits of this approach, developed through the HEAVEN project, is the basis it provides for comparing the impacts of actual facilities, which will bring credibility to the forecasting of benefits from planned improvements.

Being able to prove the level of benefits achieved by specific management measures on specific pollutants would be particularly useful for New Zealand. It would assist in assigning limited funds to the most effective solutions, as well as assisting, developing and testing the most efficient packages and strategies.

In New Zealand, the problem areas of the main urban centres include a range of interrelated factors, but with significant differences in each centre resulting from their topography and principal pollutant sources. In these environments an integrated package of tools would effectively assess benefits and test scenarios.

The multi-city trials used for the HEAVEN project illustrate the flexibility of the systems developed. In any New Zealand application there would need to be a similar level of flexibility to operate effectively and deliver credible results in a range of environments. Ensuring flexibility would also help justify the costs of developing the system.

*Monitoring of compliance with, and providing direction for, **directives and policies** associated with air and noise quality*

Several of the example systems examined have been specifically developed to address requirements imposed by national and regional EU-level directives and policies for monitoring air quality and noise levels. Subsequently, some of these systems have themselves become significant contributors to the further development of policies.

From a New Zealand perspective, the main targets and directives are currently operated at a regional council level, with direction from the MfE. The measures that are being implemented to address identified problems are also constrained by the powers of these

authorities, which mainly include development controls and long-term transport planning measures.

In the more advanced international examples, the strength of the directives and development of systems to address identified problems is clearly greater than in New Zealand, reflecting in part the larger scale of the problems, but also the levels of investment committed.

The higher levels of funding for projects to monitor and meet the targets has also been a major factor in the development of several of the systems examined; particularly those targeted at providing decision support around the funding of major projects.

In a New Zealand context, to develop the same drivers would require a strengthening of current directives and an increase in funding for specifically targeted projects. This would lead to an increased need for effective decision support and proof of benefits.

Ability to obtain near real-time data on traffic and environmental conditions in urban areas, and model and test a range of ***real and simulated scenarios*** *and TDM packages through the same systems*

The use of near real-time data has assisted in providing systems that are capable of monitoring impacts of changes in the management of networks as they occur, adjusting traffic control systems and measuring the impacts on particular measures.

The application of systems to this level is influenced significantly by the scale of the system and the cost involved in deploying monitoring equipment. Examples of this type have included applications to small defined areas, but also across wider areas.

In a New Zealand context, this type of facility would have potential in some of the problem areas of Auckland, Wellington and Christchurch, as a management tool and as a longer-term planning input. PM10 measures, in particular, are linked to traffic controls in identified problem areas.

Integration of transport and dispersion modelling *to assess impacts and effectively identify benefits of specific measures*

This area of development is one that has been highlighted by several of the examples considered. The SIMTRAP example, in particular, included a significant focus on developing an effective interface between a dynamic traffic emissions model and broader dispersion modelling.

In a New Zealand context, the improved facility that these types of systems provide (particularly in areas where ground level ozone is a recognised problem) would assist in improving the monitoring and evaluation of traffic impacts on a range of problem pollutants.

However, these types of integrated models are complex and have been developed mainly for ozone modelling; an area that, while of concern in New Zealand, is not as significant an issue as PM10. In this context, priorities may limit the application of this type of system due to cost and the need for systems more aligned with addressing PM10 issues.

The role of directives *and requirements leading to the development of facilities and as catalysts or innovations*

The requirement to meet national and regional EU-level directives has been a significant factor in several of the innovations illustrated in the examples considered, such as the Italian access control and monitoring systems developed in response to strong government requirements to monitor and address pollution.

Currently in New Zealand, measures to address identified problems are in part constrained by the limited powers of the key authorities involved, and while cost is clearly a real and important constraint, stronger limits and consequences may lead to greater focus on solutions and so to a more innovative response.

In a New Zealand context, to develop the same drivers would require a strengthening of current directives and an increase in funding for specifically targeted projects.

Assessment of project-specific benefits *and the ability to separate these benefits from the wider environment*

One of the key issues highlighted in many of the systems considered is the need to effectively separate and identify the specific benefits of particular measures within an environment of multiple sources, influences and applications.

Being able to prove the benefits achieved by specific measures on specific pollutants would be particularly useful for New Zealand. It would assist in assigning limited funds to the most effective solutions, as well as assisting, developing and testing the most efficient packages and strategies.

Assessment of integrated transport and land-use planning strategies*, including city-wide long-term scenarios, emission standards, master-plan scenarios, land-use planning changes and road network developments*

Some of the more advanced systems examined have been developed and used to assess not only the benefits of particular individual measures, but also broader packages and strategies. These systems, through their ability to isolate and model the benefits of a range of individual measures, also provide the ability to test variations in packages and strategies.

Variations tested include emission standards, master-plan scenarios, land-use planning changes and road network developments.

This facility would be of particular interest in New Zealand to assist in developing coordinated strategies and packages of TDM and other measures; to evaluate the relative benefits of these in optimising outcomes; and to evaluate funding.

The integration of land-use planning measures and TDM in particular is a major focus area.

Model integration issues *and the ability to address cities with different problems and environments, providing an effective tool while assisting in region wide comparisons*

In New Zealand, the problem areas of the main urban centres include a range of interrelated factors, but with significant differences in each centre resulting from their topography and principal pollutant sources. An integrated package of tools suitable for application across different environments would effectively assess benefits and provide for broader national and regional assessments and comparisons.

The multi-city trials used in the HEAVEN project illustrate the flexibility of the types of systems that can be developed. In any New Zealand application there would need to be a similar level of flexibility to operate effectively and deliver credible results in a range of environments. Ensuring flexibility would also help justify the costs of developing the system.

Application of innovations in the options assessed *– these include localised truck bans; use of data for inter-authority negotiations and public consultation; specific street-based improvements; land-use planning options; catalysed fleet scenarios, closure of existing arterials to demonstrate benefits of existing facilities; and environmentally induced speed limits*

Throughout the example systems examined, there were references to improvement measures that have been either implemented or tested. Some examples are listed below with comment on potential New Zealand application.

- *Localised truck bans*

  These have been tested and implemented in some European scenarios. The banning of heavy vehicles from some areas of a city (either completely or by time of day) has been proved an effective measure for PM10 emissions in particular.

  Application in some parts of Auckland to address PM10 'hot spots' may be feasible, although most of these are on major arterials which may limit potential application.

- *Use of data for inter-authority negotiation and public consultation*

  Within several of the examples studied, the use and value of data to support consultation and negotiation processes has been identified as a major area of success.

  With inter-agency planning and public consultation being a major part of the development and infrastructure management process in New Zealand, this aspect of system application would have significant value here.

- *Testing of specific street-based improvement*

  The use of integrated modelling systems to test and quantify the benefits of specific localised improvements would be a useful tool within the New Zealand planning and project funding process, with many improvements being considered on a project-specific basis.

- *Catalysed fleet and emission category based scenario*

  With the adoption of emissions categories in Europe in particular, many of the systems studied have been used to evaluate scenarios that involve varying

applications and adoptions, and assumptions related to future levels of catalysed fleet.

While there are no immediate plans to introduce emissions categories in New Zealand, the ability to model and evaluate the potential benefits of scenarios that include such categories and associated influences, would assist in proving the benefits, and potentially improve support for these initiatives.

- *Closure of existing arterials to demonstrate benefits of existing facilities*

  The use of monitoring and forecasting systems to assess the impacts of major route closures has been limited, but includes the assessment of a closure for a major sporting event and an example designed to illustrate and quantify the benefits of a specific arterial route.

  Both of these examples would have relevance in New Zealand, in assessing the effects of planned closures and quantifying the potential impacts of major routes closed by serious slips or earthquakes, etc.

- *Environmentally induced speed limits*

  Examples of variable speed limits linked directly to environmental measures are limited, but have been trialled and scenarios tested in several European cities. The potential for these applications in New Zealand would be limited to major urban motorways, and the most likely drivers would be measures of congestion with environmental factors providing a secondary influence.

Coordinated approach to addressing local ***air quality and greenhouse gases***

A particular aspect of the Mexico City example studied was the strong connections made between air quality and greenhouse gas emissions and the targeting of improvements to both issues.

New Zealand is a party to both the UNFCCC and its Kyoto Protocol, with a government climate change policy package built on a range of existing policies.

The Mexico example provides some useful lessons in terms of coordinating responses to both problems. There are opportunities for New Zealand to apply some of the initiatives developed, highlighting the climate change benefits of measures developed primarily to assist in reducing congestion and reducing urban pollution. However, the scale of these two problem areas (and the resulting connections) in Mexico City is clearly significantly greater than in New Zealand and more relevant for the coordinated approach.

Wider funding *attraction through a broader focus*

A further aspect of the Mexico City example was the highlighting of connections between air quality and greenhouse gas emissions to support funding from a wider source base.

As with the previous issue, there are some limited opportunities for New Zealand to apply this approach, although the potential would be significantly reduced by the scale of benefits and available funding sources.

*Identification of **sources and connections** between air quality and other factors (eg greenhouse gases, safety and economic benefits)*

The Mexico City example and others have highlighted the need to consider not only the multiple environmental factors and benefits of proposed improvements, but also other related benefits including greenhouse gas reductions, safety and economic benefits.

Much of this multiple benefits assessment is already a feature of project evaluation in New Zealand, but has the potential to be improved and enhanced through the more advanced tools available to quantify and separate benefits of specific projects and strategies.

Most examples in this area are focused on the identification of the secondary environmental benefits of projects; but as more projects and management strategies are developed with a primarily environmental improvement focus, there is a need to ensure consideration of the more traditional benefits.

***Large-scale** fleet and infrastructure measures*

Several of the example systems studied have assessed and implemented large-scale fleet and infrastructure measures to assist in reducing air quality problems. The Mexico City example includes large-scale replacement of taxi and bus fleets and significant investment in passenger transport infrastructure.

From a New Zealand perspective, the evaluation of similar approaches would most likely be focused on Auckland, where major expansions and upgrades of PT infrastructure are planned and several recent campaigns have focused on addressing old and poorly maintained vehicles and their emissions.

***Aim to provide information** – integrating environmental and transport-related data to assist and educate the public in their transport choices, and assist agencies in managing day-to-day transport emissions.*

This form of application has been highlighted by the Paso Del Norte project in particular, but is also an important element of other systems. Through these applications the benefits of improving public awareness of the nature and scale of air quality problems has been illustrated, in particular their links to transport choices.

A key aspect of this type of facility is the need for a reliable and reasonably accurate source for data and currently in New Zealand these are limited. However, the proven benefits of such systems provide the potential to support initiatives to develop similar systems in New Zealand (particularly in the main centres).

Inter-agency cooperation and data sharing are also highlighted as significant benefits by the examples studied, and these have real potential for application in New Zealand.

***Ozone** source monitoring*

A major area of concern in many large cities is the build-up of ground-level ozone, produced through a combination of vehicle emissions and high levels of sunshine. The process by which ozone is produced is a major factor in the scale of the area covered by

some projects, and a particular focus is on monitoring both the base pollutants that contribute to ozone production and other meteorological factors that contribute to its production and dispersion.

In a New Zealand context, ozone has been identified as an occasional problem in the Auckland region and a potential problem in Christchurch. However, there are no major programmes currently focused on ozone sources or dispersion in these areas. Ozone pollution has not yet reached a stage where it is recognised as a major problem in these areas.

Vehicle quality *and modelling links*

An issue highlighted by the Paso Del Norte project in particular was the significant differences in emissions contributions from vehicles based in Mexico and the United States; primarily the higher contributions from older and less maintained vehicles on the Mexican side of the border, and the development of specific modelling applications to address these differences.

While New Zealand does not have any need to consider cross-border movements or fleet differences, the issue does highlight the need to examine fleet profiles when developing emission models, and the significant differences that can be experienced when these issues are included.

Targeted monitoring of ***static and congested*** *traffic*

A further issue highlighted by the Paso Del Norte project was the emissions contribution from vehicles queuing at border crossings and the development of specific modelling applications to address these factors.

While again New Zealand does not have any need to consider cross-border movements, this issue highlights the need to examine regular congestion and queuing locations when developing emission models, and the significant differences that can be experienced when these issues are included.

Education and awareness through a ***communications strategy***

The education and awareness focus of the Paso Del Norte project in particular, highlights the benefits that can be achieved by improving public awareness of the nature and scale of air quality problems and the links to transport choices.

A key aspect of this type of approach is the coordination of an effective communications strategy, targeting key messages and supporting these with data and information designed for public consumption.

The application of any similar strategies in New Zealand would need to address the specific issues in each of the main urban centres and to be coordinated with other related campaigns.

The benefits of inter-agency cooperation and data sharing are also highlighted in the examples studied and would need to be considered for any potential application in New Zealand.

Inter-agency cooperation and systems architecture, *allowing multiple organisations and systems to contribute and benefit*

The Paso Del Norte project highlighted the need for, and benefits from, working across a group of agencies to develop a coordinated system capable of sharing data for a range of initiatives. A significant factor in the success of this system was the cooperation between agencies from the earliest stages, which led to the early development of a systems architecture to deliver to a range of objectives.

A key aspect of this type of facility is the need for a reliable and reasonably accurate source of data and these are currently limited in New Zealand. However, the proven benefits of such systems provide the potential to support initiatives to develop similar systems in New Zealand (particularly in the main centres) and illustrate the benefits of a cross-agency approach and early planning for integrated systems.

Pollution impacts to ***buildings***

An issue highlighted by the Italian applications in particular was the impact of urban pollution on ancient buildings. Clearly a major issue in many Italian cities, this was a significant factor in developing monitoring and control policies and systems in many major cities.

The relevance of this issue to New Zealand is relatively limited, with no buildings of similar age and significance. However, the impact of pollutants on urban buildings of significance, whatever their age, is an area that needs to be considered.

Access control *as a concept and management tool*

Access control systems have been developed for several Italian cities as a means of addressing urban congestion and pollution. These systems are based on controlling access to defined areas of the city based on local access rights (residents, business owners etc) to limit traffic. Narrow constrained city centre layouts coupled with high tourist traffic demand have also been factors in the development of this approach.

As a demand management tool these systems have proved very effective in Italy, with improvements similar to those resulting from the London congestion charge.

From an emissions perspective, the Italian schemes also provide exemptions for zero emissions vehicles (electric vehicles represent a growing proportion of the Italian fleet).

Considering the concept in a New Zealand context, these systems have the potential to effectively manage demand in specific central areas and also to reduce trips on main access routes.

Tourist *industry focus as a benefit and contributor*

The Italian examples have included a particular focus on the tourist industry, both as a contributor (to congestion and emissions) and as an industry that is being adversely affected by increasing pollution.

The level of focus in this area is relatively unique to the Italian examples and highlights an area where a balance between protection and access has had to be accommodated. The flexibility of the Italian systems actually provides several features targeted at supporting the tourist industry, including temporary exemptions for hotel guests in some restricted zones.

From a New Zealand perspective, the tourist focus is significant as this industry comprises around 6% of GDP, and these examples provide some indication of the types of measures that can be provided and an approach to balancing tourist demand with impacts and access.

Required pollution monitoring, *including legal requirements*

Several of the example systems examined have been developed specifically to address requirements to monitor air quality imposed by national and regional EU-level directives. The level of monitoring required varies and examples illustrate some of the difficulties in providing a suitable level of monitoring and estimation to meet requirements (full network modelling being impractical).

From a New Zealand perspective, there are already requirements in place for local authorities to monitor particular aspects of pollution and in 2013 more defined measures and legal obligations are due to be introduced. At this stage there will be a need to adequately define how the measures are to be assessed.

In the York example, specific pollutants monitored were directly linked to those specified by central government, while in some cases target levels were adapted to local conditions.

Link between ***monitoring and controls*** *at several levels*

In several of the examples studied, links between environmental monitoring and controls at varying levels have been identified, from systems that serve to direct long- and medium-term policy, to those used to direct shorter-term variations in transport control policies, through to the more direct application of air-quality-driven variable speed limits.

From a New Zealand perspective, a key lesson here is the need to consider the effective matching of systems to perform specific functions.

Flexibility *providing the opportunity to adapt in future*

The development of the Italian access control facilities, and in particular the variety of local variations, has led to a system that while relatively complex, is also flexible.

This flexibility has more recently led to increased opportunities to introduce further variations to the schemes and introduce more flexible control measures targeted at groups including low-emission category vehicles.

This example illustrates the benefits of maintaining flexibility through a system designed to provide for broader applications in the future.

***Integration** with wider ITS facilities*

A notable feature of the York example was the subsequent integration of monitoring facilities into a wider ITS trial, leading to standardising of data forms, architecture and the development of some specific ITS applications using air quality monitoring as a primary input to traffic control.

From a New Zealand perspective, the potential for integration of any developed systems with wider ITS facilities needs to be considered early, ideally in the form of a future systems plan. This will assist in optimising future inter-operability and maximising the potential benefits from the system.

*Contribution to **centralised databases***

A feature of several examples studied has been the wider use of the data generated by various monitoring and modelling facilities, linked through centralised national or regional systems to provide real-time and profile information on measured pollutants.

Some examples included inter-agency sharing of data and the development of common databases, while others included national databases developed mainly for public information.

These applications highlight the need to identify current and future opportunities for the use of shared data and the benefits of planning data structures to improve the potential for this kind of coordination.

*Support for **medium-term planning** decisions*

The SIMTRAP example, in particular, has been targeted specifically at the need for improved medium-term strategic planning, highlighting a lack of available tools in this space (between the more generic long-term planning packages and micro-level local models).

A key feature of this type of system is the dynamic nature of the integrated models and the development of systems that provide an effective tool to prove the benefits of medium-term improvements.

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8. Abbreviations and acronyms

AQGs	Air quality guidelines
AVTUNE	AirViro-based traffic and urban noise evaluator
C6H6	Benzene
CAM	Comisión Ambiental Metropolitana
CAMS	Continuous air monitoring stations
CO	Carbon monoxide
CO2	Carbon dioxide
DSS	Decision support system
EMPACT	The Paso del Norte Environmental Monitoring Project
ERVs	Emergency room visits
EU	European Union
FDMS	Filter dynamic measurement system
GDP	Gross domestic product
GIS	Geographic information system
GWRC	Greater Wellington Regional Council
HEAVEN	Healthier environment through abatement of vehicle emissions and noise (EU)
HGVs	Heavy goods vehicles
ICLEI	International Council for Local Environmental Initiatives
ISO	International Standards Organisation
ITS	Intelligent transport systems
LAMAS	Local air quality management areas
LPG	Liquefied petroleum gas
LTMA	Land Transport Management Act 2003
LTZ	Limited traffic zone
MfE	Ministry for the Environment
MoT	Ministry of Transport
NAAQS	National ambient air quality standards
NES	National environmental standards
NIWA	National Institute of Water and Atmospheric Research Ltd

NO	Nitrogen oxide
NO2	Nitrogen dioxide
NOx	Oxides of nitrogen – (NO and NO2)
NZTS	New Zealand Transport Strategy
NWS	National Weather Service
OECD	Organisation for Economic Cooperation and Development
O3	Ozone
PGTU	Piano Generale del Traffico Urbano (Urban Traffic General Plan)
PM	Particulate matter
PM10	Particulate matter (size <10 µm)
PROAIRE	Programme to improve the air quality in the metropolitan area of the valley of Mexico
PT	Public transport
SIMTRAP	Simulation of traffic induced air pollution
SO2	Sulphur dioxide
TDM	Travel demand management
UNFCCC	United Nations Framework Convention on Climate Change
UTEP	University of Texas at El Paso
UTMC	Urban traffic management and control
UV	Ultraviolet (light)
VOCs	Volatile organic compounds
VMS	Variable message signs
WHO	World Health Organisation
WOF	Warrant of fitness
ZIP	Zone improvement plan