M50 Demand Management

Report

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NRA
An tÚdarás um Bóithre Náisiúnta
National Roads Authority

dlr
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Dublin City Council
Comhairle Cathrach Bhaile Átha Cliath

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Report prepared by AECOM on behalf of the Steering Group

GLOSSARY

DPT	Dublin Port Tunnel
EIS	Environmental Impact Assessment
ESRI	Economic and Social Research Institute
GNP	Gross National Product
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HGV	Heavy Goods Vehicle
ICT	Information & Communication Technology
ITB	Influencing Travel Behaviour
ITS	Intelligent Transport Systems
LAM	Local Area Model
MIDAS	Motorway Incident Detection and Automatic Signaling
NRA	National Roads Authority
NTCC	National Traffic Control Centre
NTA	National Transport Authority
NTpM	National Transport Model
PAG	Project Appraisal Guidelines
PCU	Passenger Car Unit
VMS	Variable Messaging Signs
VSL	Variable Speed Limits

M50 Demand Management

Report

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Executive Summary

Background

The M50 is the most heavily trafficked road in the country with in excess of 130,000 vehicles per day using several sections. The road was originally envisaged as a bypass route for strategic traffic around Dublin, however following the economic growth that took place during its construction, the M50 is now located within the suburbs of Dublin and provides a range of functions over and above that expected of a strategic corridor. A proposal to widen the carriageway and upgrade the junctions over most of the M50 received permission to proceed by An Bord Pleanála in 2005.

The traffic analysis undertaken for the upgrade scheme suggested that increasing demand would result in traffic flows that would exceed the capacity of the upgraded M50 significantly within its design life. As such it was recognised that future demand would need to be managed if the benefits of the upgrade were to be fully realised.

In acknowledging this, one of the conditions of the planning permission was to include the development of a scheme of demand management measures; with the condition stating the following:

> ***Condition 7**: A scheme of specific demand management measures for the M50 motorway corridor shall be published by the relevant road authorities not later than three years after the M50 Motorway Upgrade Scheme has been completed.*

In order to discharge this planning requirement the NRA convened a Steering Group (comprising the NRA, Dublin City Council, Dún Laoghaire Rathdown, Fingal and South Dublin County Councils) with a view to undertaking a study to identify a scheme of indicative Demand Management Measures for the M50. This report provides a summary of the work undertaken and describes the indicative scheme of measures identified.

However it must be stressed that no decision to implement these measures has been taken; such a decision is a matter for Government. The implementation of any scheme at a future date will be dependent on Government policy and decision, as well as being subject to the relevant statutory processes and legislation.

Traffic and Congestion on the M50

Traffic flows on the M50 have continued to grow since moving to free-flow tolling in August 2008 and the completion of the upgrade in stages between 2008 and 2010 with increases of up to 25% experienced on some sections of the M50 since 2010. As a result congestion has started to occur on sections of the M50. (This increase has occurred against a background of decreasing traffic elsewhere, with a 5% reduction in traffic on other National Primary Roads over the same period.)

Research has been carried out which shows that congestion will start to occur once hourly traffic flow in an individual motorway lane exceeds a certain level. This level of traffic flow is termed the safe operational capacity of an individual lane. Traffic data shows that in January 2010 all lanes in all sections of the M50 (northbound and southbound) were operating within this safe operating capacity even during peak periods. However, by November 2011 some 12% of the sections of the M50 were experiencing traffic flows in the busiest lane at peak times that exceeded this level.

The congestion has started to occur within the last two years reflects this and has in turn resulted in more frequent incidents and collisions. In the absence of the introduction of demand management it is forecast that by 2023 some 50% of sections of the M50 will experience traffic flows in the busiest lanes that exceed the safe operating capacity, primarily during peak times, but also at other times of the day.

In summary, the assessment of existing conditions has found that a number of key sections of the M50 are already beginning to experience some form of congestion and that by 2023, much of the M50 will be operating in excess of its safe operating capacity, with congestion commonplace.

As a result demand management measures are required to:

- Address the strong levels of growth in transport demand, predominantly through managing growth in the level of discretionary traffic, such that the strategic function of the M50 can be protected;
- Manage and mitigate the safety and reliability impacts that result from congested conditions, and which also threaten the strategic function of the M50; and
- Ensure flows in excess of the safe operating capacity are not sustained on a section for any period.

In essence, these three requirements relate to the need to influence demand that may be attracted to the M50, and subsequently manage the traffic that nevertheless has chosen to use the M50. This suggests two very different forms of management, one based on giving a price signal to users which influences the generation of demand and the other based on controlling traffic flow which materialises, a distinction that has been recognised throughout the study.

Extensive work was undertaken as part of this study in investigating, developing and testing various measures aimed at managing demand on the M50 in a way that will protect its capacity over its design life. The impacts and benefits that would arise from these measures have also been identified as part of this study.

Indicative Scheme of Demand Management Measures

The study has culminated in the identification of an indicative package of demand management measures of five different types;

- Fiscal Measures
- Intelligent Transport Systems/Traffic Control
- Information
- Smarter Travel
- Network Control

Fiscal Measures: Variable Distance-based Tolling by Vehicle Type on the M50

The study has concluded that the current single point tolling system, under which only 39% of

M50 users are subjected to a toll, should be replaced with a variable distance-based system. This would result in between 80% and 100% of users being subjected to a toll depending on the type of system implemented. Toll amounts would vary for different vehicle types, as is the case with the current single eFlow toll, and would vary for different times of the day to reflect the varying level of demand throughout the day.

A pure distance-based closed system, which captures 100% of users via toll points at all entry and exit points, would align best with the objective of demand management. However, with current technology the collection costs for a closed system would be higher compared to a multi point system, which could lead to tolls having to be higher to cover the cost. Therefore an indicative scheme which provides for an open system with five toll points (including the existing eFlow toll location where the toll rate would be reduced) has been put forward at this time, see Figure 1 on page iv).

The indicative scheme includes variable toll rates for different periods of the day, as shown in the Table 1 below.

Table 1 - Indicative Range of Variable Toll Rates at Individual Toll Points

Toll Type	Peak Periods (07:00-09:30 & 16:00-18:30)		Inter-peak Periods (06:00-07:00-, 09:30-16:00 & 18:30-19:30)		Off-peak Period (19:30-06:00)	
	Car	HGV >10t	Car	HGV >10t	Car	HGV >10t
Registered	€1.20-1.40	€3.60-3.90	€0.90-1.10	€2.90-3.20	€0.40-0.60	€1.00-1.20
Unregistered	€2.20-2.40	€4.60-4.90	€1.90-2.10	€3.90-4.20	€1.40-1.60	€2.00-2.20

NB: Toll rates ranges are shown at 2013 levels. At time of implementation appropriate indexation will be applied to these rates.

Under such a system a registered car user travelling the full length of the M50 would pay a total of €6.00 to€7.00 at peak times, €4.50 to€5.50 in the inter-peak period and €2.00 to €3.00 at off-peak times, compared to a single toll of €2.10 to €2.60 at present (€2.60 for video registered car users).

The study has confirmed that an indicative scheme of variable multipoint tolling, as an expansion of the M50 eFlow system using free-flow technology, is viable and will lead to an increase in the toll capture rate of M50 users which will provide better equality for all users. Such a scheme will ensure that the demand management measures are effective in protecting the full length of the M50.

Intelligent Transport Systems/Traffic Control: Variable Speed Limits

The study has examined the practicality and effectiveness of Variable Speed Limits (VSL) along the M50. The feasibility studies have identified that the section of the M50 between Junction 3 (M1) and Junction 14 (Sandyford) is most suited to the implementation of VSL, with the potential to extend it to the full length of the M50 in the future as demand on other sections increases. This would be expected to have a notable impact on journey time reliability and safety as the M50 experiences periods of near-congestion.

Intelligent Transport Systems/Traffic Control: Incident Detection

The study has included the provision of Incident Detection as a key strategy for managing demand along the M50. An appropriate incident management desk will be provided within the existing Traffic Control Centre, and lines of communication will be established between the incident room, key media outlets and the emergency services.

Information: Internet

The provision of Variable Speed Limits, Incident Detection, and tolling schemes will require a large amount of roadside detection and monitoring equipment, the data from which will be collated and monitored through the Traffic Control Centre. This information will be provided to road users via the internet, either through posting on web pages, social media or news feeds. During times of congestion, this information can be used to actively encourage potential road users to make alternative travel arrangements, and in this context will be an effective demand management tool.

Information: Roadside Information

Similarly this information will be provided to road users via Variable Message Signs, which are currently provided throughout the Dublin Area, with approximately 35 signs provided along the M50. This will provide information that is fully up to date to road users during their journey.

Smarter Travel: Area-Based Travel Planning

The study investigated the potential for Area-Based Travel Planning in order to manage demand on the M50 and concluded that, whilst travel planning can have a significant local impact in terms of reduced traffic demand, the impact on the M50 corridor itself would be limited (1-2% demand reduction). A number of locations have been proposed:

- Sandyford/Stillorgan;
- Park West;
- City West; and
- Cherrywood;

The implementation of Area Based Travel Planning can effectively be delivered by the Local Authorities as part of their integrated land-use and transportation planning.

Network Control: National Control Centre

The Intelligent Transport Systems measures set out earlier are all based on the provision of a Traffic Control Centre to monitor road conditions, respond to incidents and provide relevant information to road users. The existing Control Centre located at the Dublin Port Tunnel toll plaza is insufficient in its current layout to meet the requirements of an increased level of management, and an expansion of that facility is currently being examined. It is envisaged that a single control centre would manage all the operational functions of the national roads network.

The indicative package of demand management measures is shown in Figure 1 below.

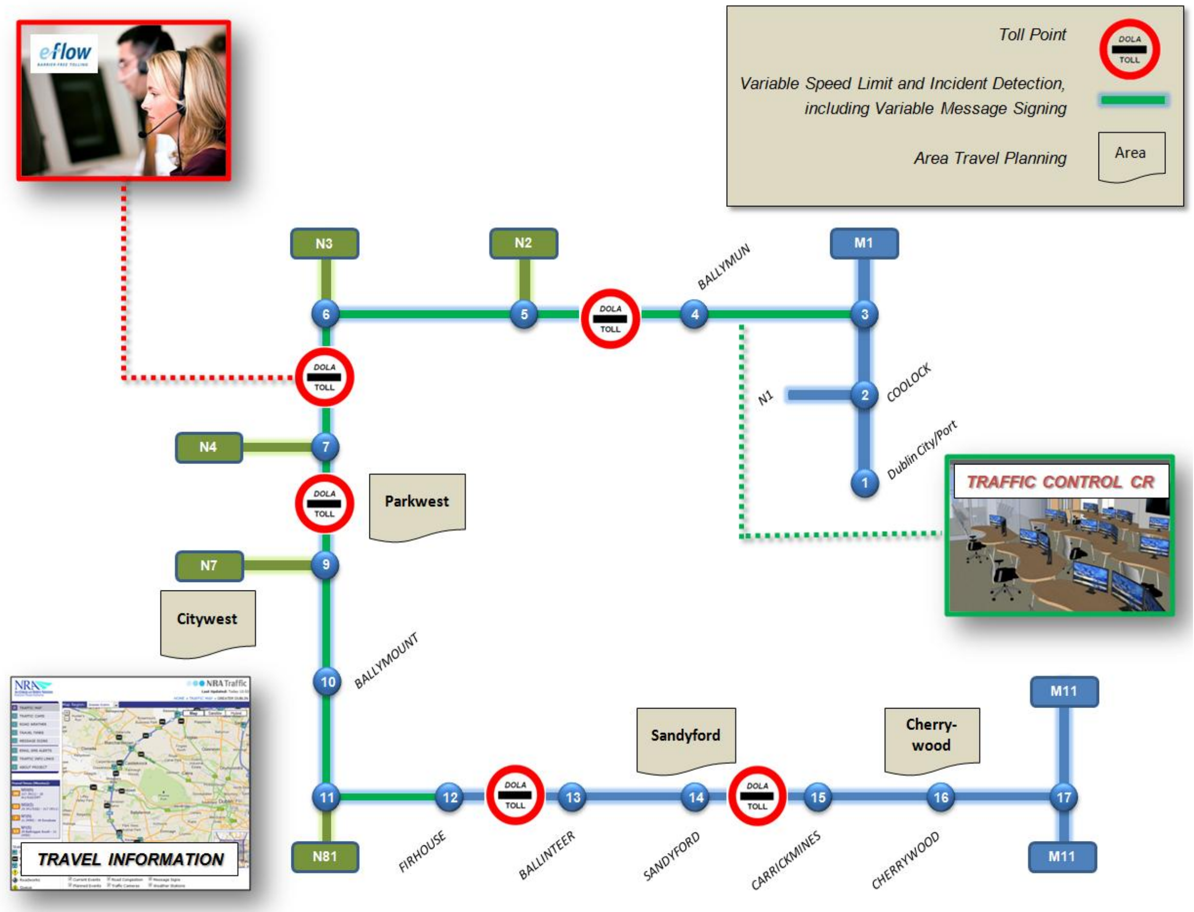

Figure 1 - Indicative Package of M50 Demand Management Measures

Benefits of the Indicative Scheme of Demand Management Measures

Fiscal: Variable Distance-based Tolling by Vehicle Type

The introduction of variable distance-based tolls will deliver considerable benefits to traffic on the M50 as a result of three key changes in traffic behaviour.

- **Reassignment**, where M50 users change their routing to avoid tolls. For such users, the perceived additional travel cost associated with using longer routes is less than the cost of the toll;
- **Mode switching**, where M50 users change to an alternative mode of travel mode due to the increased cost associated with travelling by private car. Such changes include switching to bus or rail for longer trips, or to walking or cycling for shorter trips;
- **Demand changes**, which describe decisions to travel to alternative (lower travel cost) destinations, to link trips together in order to reduce overall travel costs, or decisions not to make a trip at all.

As a result of these changes in travel behaviour the transport model developed for the study forecast a reduction in traffic flows along the M50 of the order of 20%. Approximately half of this reduction is as a result of mode switching and demand changes, with the other half arising from reassignment / re-routing onto the non-motorway road network.

The traffic modelling also shows that the increase in traffic on other roads as a result of reassignment of traffic from the M50 is relatively diluted and could be managed through supporting measures such as traffic management measures, online improvements and junction improvements.

With this level of reduction in demand by 2023 only 20% of the sections of the M50 will experience traffic flows in the busiest lanes that exceed the safe operating capacity during peak times, whereas 50% of the sections will experience congestion without the measures. This will lead to traffic flows and conditions similar to the conditions experienced in 2011, with a significant reduction in the number of incidents, better journey times, as well as an increase in the reliability of journey times compared to the do-nothing scenario.

To address the remaining sections on which flows still exceed the safe operating capacity, control measures, in particular Variable Speed Limits, will assist in managing the traffic by reducing the likelihood of incidents occurring and improving the level of service provided by the M50. The inclusion of control measures in the Demand Management Strategy reduces the reliance on fiscal measures and avoids the need for higher toll rates on these sections to manage demand. In addition, the business benefits to commercial traffic would be significant, with a reduction in journey time variability and greater ability for just-in-time haulage, in addition to reductions in journey times during peak periods.

In summary the assessment demonstrates that the impact of the M50 variable distance-based toll scheme will be positive in terms of reducing demand, congestion and incidents, and thus improving reliability and safety, on the M50. The consequential increases in traffic on other roads will require the consideration of some targeted traffic management measures in the final scheme to mitigate these impacts. Such measures would seek to reduce toll avoidance through sensitive areas, or improve safety and/or capacity on those roads which receive additional traffic.

Intelligent Transport Systems/Traffic Control: Incident Detection

The detection and management of incidents will reduce the safety risks associated with knock-on incidents following a collision, and provide ample warning to other road users of potential disruption so that they can take this into account when planning journeys. This will lead to improvements in journey time reliability. The introduction of Variable Speed Limits has been shown to reduce total annual incidents and the benefits derived from this reduction accrue from monetary saving associated with reducing the number of fatal or serious injuries, as well as time savings experienced by other road users who would otherwise be delayed by incidents, whether these are collisions or mechanical breakdowns.

Information: Internet Travel Information and Roadside Information (Variable Message Signs)

The existing Variable Message Signs on the M50 would be used as part of the measures and would be complimented by broader web-based information tools. The concept is that users will be able to develop a knowledge of historic and current network conditions either:

- Pre-trip, through the use of the travel information website;
- Pre-trip through the dissemination of travel bulletins using SMS or Twitter alerts; or
- In-trip, using the Variable Message Signs.

Variable Message signs are a safe means of providing in-trip information to road users, who will have restrictions on their access to web-based information whilst driving. It is noted that this infrastructure is already in place throughout much of the M50 and the main approach roads. The result of the measures proposed here will be that road users will have full information on the condition of the M50, and can plan their trip accordingly.

Smarter Travel: Area Based Travel Planning

Analysis of similar schemes elsewhere highlight that significant impacts are observed particularly in the increase of car sharing against single occupant car trips, and in journey time reductions. The key qualitative successes of similar schemes have included;

- Launching car sharing websites and incentivising these using travel vouchers and financial rewards;
- Increased cycling and public transport use promoted via travel plan bulletins, posters, websites and other local media outlets;
- Designation of car-sharing bays at workplaces;
- The setting up of new travel related forums for businesses and interested parties at locations around the country to discuss and tackle common travel issues using a co-ordinated approach with shared risks and benefits; and
- Improved bus services at many sites brought about by direct contact with public transport operators and improved communication between parties.

Network Control: Traffic Control Centre

The Intelligent Transport Systems measures set out earlier are all based on the provision of an expanded traffic control centre facility that would manage all the operational functions of the national roads network. The incident management and response function of the Traffic Control Centre will deal with live incidents on the M50.

Key Stakeholders

During the study the Steering Group discussed the study with the Department of Transport, Tourism and Sport (DTTAS), the National Transport Authority (NTA) and the Strategic Policy Committee (SPC) of the four Local Authorities. The purpose of the discussions was as follows:

- To provide information on the work being undertaken and the measures that were emerging from the studies;
- To ensure that the work was fully compatible with other policies and plans being developed at government level; and
- To identify the legal and institutional framework that would be necessary to implement the measures included in the emerging proposals.

Specifically presentations of the emerging package of measures, followed by questions and answer sessions, were made to the SPC's on the following dates:

- 11th June 2013, Dún Laoghaire Rathdown County Council;
- 12th June 2013, Dublin City Council;
- 1st July 2013, Fingal County Council; and
- 5th September 2013, South Dublin County Council

In general, with the exception of some specific local issues, there was a lot of commonality in the questions asked and the views expressed by the SPC members. The key issues raised / comments made were:

- A degree of acceptance that the problem would occur in the future, but not that it was occurring yet;
- Strong opposition to the proposed fiscal measures (tolling), with little or no support for increased tolls along the M50, particularly in view of the current economic climate;
- Objection to the imposition of fixed toll rate throughout the day;
- It was felt that the proposed tolling was being taken as a way of generating revenue rather than managing demand;
- Concern about the impact of traffic diverting onto the local road network;
- Some acceptance that it would be fairer for more users to be tolled, although the current eFlow toll was still viewed as a toll for using the bridge across the Liffey rather than a toll for using the M50;
- Recognition that a lot of valuable work had been undertaken in the study;
- Almost unanimous support for all the non-fiscal measures.

Discussions with DTTAS suggested that some modifications to the existing traffic signage regulations would be necessary for the implementation of the Variable Speed Limits, although this could be incorporated into an ongoing exercise to review the existing regulations.

Of particular note was that the SPC consultations raised the potential for a distributed pricing scheme with tolls varying across the day based on the traffic demand. The study team took time to consider the feedback from the various consultations and as a consequence reviewed the fiscal proposals. As a result a significant change was made to the proposed measures, with variable tolls for different times of the day being introduced to reflect the varying level of demand.

Implementation

The timescale for the implementation of the scheme of indicative measures, subject to various governmental approval and statutory procedures, is outlined below.

Table 2 - Planning and Implementation Period from Decision to Proceed with any of the Measures

Measure	Year 1	Year 2	Year 3	Year 4	Year 5
Variable Speed Limits	Planning	Implementation			
Incident Management System			Implementation		
Distance Based Tolling	Planning	Implementation			
Smarter Travel Planning	Planning		Implementation		

It is estimated that a period of 12-15 months would be sufficient to progress the necessary preliminary works and statutory procedures outlined above. Following this, and given the limited infrastructure requirement, the construction and testing stage is expected to take a further 12-15 months.

If at a future date a decision is taken to implement a distance-based toll scheme, a further more detailed study would be needed to determine whether to implement an open multi-point tolling system similar to this indicative scheme or to adopt a closed tolling system which would charge for distance of the M50 used based on entry and exit points.

Any future toll scheme would draw on the information prepared as part of this study, and would require a period of approximately three years for consultation (including an approval process from the necessary bodies, namely, the Minister for Transport, Tourism and Sport, the NTA and the European Commission) and implementation. The scheme would be also subject to the statutory process set out in the Roads Act which requires approval by the NRA Board. The scheme would also consider the mitigation of impacts that would be necessary on local roads that might result from the tolling proposals.

Conclusions

This study has been undertaken by the Steering Group to comply with the conditions imposed by An Bord Pleanála as set out below.

> ***Condition 7:*** *A scheme of specific demand management measures for the M50 motorway corridor shall be published by the relevant road authorities not later than three years after the M50 Motorway Upgrade Scheme has been completed.*
>
> ***Reason:*** *To protect the traffic capacity provided by the M50 Motorway Upgrade Scheme over its design life.*

In response the Steering Group investigated a wide range of possible alternatives and developed an indicative scheme of specific demand management measures for the M50, covering the M50 between Junction 3 (M1) and Junction 17 (M11). The various elements of the indicative scheme are set out in Table 3 below;

Table 3 - Summary of Elements of Indicative Scheme of Demand Management Measures

Category	Measures Taken Forward
Fiscal Measures	Distance-Based Tolling Variable tolling Tolling by Vehicle Type
Intelligent Transport Systems/Traffic Control	Variable Speed Limits Incident Detection
Information	Internet Roadside Information
Smarter Travel	Area-Based Travel Planning
Control	National Traffic Control Centre

The assessment of the fiscal measures has been based on an indicative five toll point open system, which provides a coverage rate of greater than 80% of trips. This has been derived to demonstrate the benefits and impacts of such a solution as a proxy for a pure distance based closed charging system, which would capture 100% of users via toll points at all entry and exit points.

With current technology the collection costs associated with a closed system would be higher compared to a five point system, which could lead to tolls having to be higher to cover the cost. Therefore, the five toll point open system has been put forward at this time.

However, it is worth noting that the cost of closed system tolling is anticipated to reduce as technology develops and improves in the future and as large-volume transaction systems become more cost-effective. As such any future development of a variable distance-based toll system on the M50 should consider the option of implementing a closed system or of providing a higher number of toll points in an open system. Ultimately any multi-point tolling scheme will have the potential to evolve to a closed system which would be able to better protect the traffic capacity of the M50 in the longer term.

The study showed clearly that fiscal measures had by far the most significant impact on managing future demand on the M50. In this regard it is important to note that in the absence of the introduction of the fiscal measures identified (i.e. variable distance-based tolling) it is unlikely to be possible to protect the traffic capacity provided by the M50 Motorway Upgrade Scheme over its design life.

This study demonstrates the feasibility of the indicative demand management measures which can provide a basis for the development of a detailed scheme for implementation.

1.0 Introduction and Study Objective

1.1 Background

The M50 is the most heavily trafficked road in the country with in excess of 130,000 vehicles per day using several sections. The road was originally envisaged as a bypass route for strategic traffic around Dublin, however over the prolonged construction period and the economic growth that took place during this period, the M50 ended up being located within the suburbs of Dublin and provides a range of functions over and above that expected of a strategic corridor. As such the M50 operates as the hub of the National Roads network and as an orbital of the largest population and business region in the country.

After the M50 was first opened traffic grew considerably in response to the increase in accessibility between population, employment and retail centres around the city fringes. This led to frequent traffic congestion, with long delays at junctions and at the former Westlink Toll Plaza.

A proposal to widen the carriageway and upgrade the junctions over most of the M50 was prepared and the proposal received permission to proceed by An Bord Pleanála in 2005. The proposal was defined as follows:

> *The scheme comprises the addition of a third lane in each direction on the M50 over a distance of 31 kilometres between the M1 and Sandyford together with the provision of auxiliary weaving lanes between the M1 and Scholarstown, generally within the existing motorway boundaries. Modifications to ten junctions will provide full or partial free flow for the principal turning movements and the Westlink toll plaza will be upgraded to a fully electronic free flow facility.*

The traffic analysis undertaken as part of the Environmental Impact Statement (EIS) for the widening scheme suggested that by 2023 many sections would have traffic demand in excess of 200,000 vehicles per day. In recognising the potential for additional induced traffic demand on the new upgraded M50, one of the conditions of the planning permission was to include the development of a scheme of Demand Management Measures; with the relevant condition stating the following:

> ***Condition 7**: A scheme of specific demand management measures for the M50 motorway corridor shall be published by the relevant road authorities not later than three years after the M50 Motorway Upgrade Scheme has been completed.*
>
> ***Reason:** To protect the traffic capacity provided by the M50 Motorway Upgrade Scheme over its design life.*

Widening works were completed on a phased basis over a number of years, as follows:

- Liffey Valley Bridge to Ballymount-Firhouse Link; completion March 2009;
- J3 to J6 and Ballymount-Firhouse Link to Sandyford; completion September 2010;
- J6 to Liffey Valley Bridge; completion March 2008;
- Toll Plaza Removal and implementation of eFlow free-flow tolling system; eFlow go live August 2008.

As such, to comply with the conditions imposed by An Bord Pleanála it will be necessary for the relevant road authorities to publish a scheme of specific demand management measures for the M50 in 2013, covering the M50 between Junction 3 (M1) and Junction 17 (M11).

In order to discharge this planning requirement the NRA convened a Steering Group (comprising the NRA, Dublin City Council, Dún Laoghaire Rathdown, Fingal and South Dublin County Councils) with a view to undertaking a study to identify a scheme of indicative Demand Management Measures for the M50. This report provides a summary of the work undertaken and describes the indicative scheme of measures identified. It is intended to discharge the condition of the An Bord Pleanála decision.

However it must be stressed that no decision to implement these measures has been taken; such a decision is a matter for Government. The implementation of any scheme at a future date will be dependent on Government policy and decision, as well as being subject to the relevant statutory processes and legislation.

1.2 Study Objective

In order to discharge this planning requirement the NRA convened a Steering Group, comprising Dublin City Council, Dún Laoghaire Rathdown, Fingal and South Dublin County Councils and the NRA, together deemed to be the "relevant road authorities", with the following objective:

> ***Study Objective**: developing a scheme of specific Demand Management Measures for the M50 motorway corridor that will protect the traffic capacity provided by the M50 upgrade scheme.*

1.3 Structure of this Report

The current study has explored alternatives, with a view to developing an indicative set of Demand Management Measures for the M50 which addresses the above requirement.

Section 2 of this report explains the recent growth in traffic on the M50 which has led to the existing traffic patterns. It also considers how this demand might change in future years and defines what is meant by capacity in respect of managing demand on the M50.

Section 3 describes the process by which potential demand management measures are assessed by setting a number of specific objectives for such measures.

Section 4 then presents research into available measures internationally, and their applicability in Ireland and sets out the development of a series of analysis tools to allow the impacts of alternative solutions to be quantified and monetised providing a quantitative assessment of alternatives against the specific objectives.

Finally Section 5 describes the indicative scheme of specific demand management measures that has been established through the above tasks, together with details of the benefits and impacts that will arise from the measures.

2.0 Current Conditions and Assessment of Future Demand

2.1 Recent Traffic Growth Following M50 Upgrade

Recent historic traffic data has been examined to understand growth drivers for the M50. Figure 2.1 shows the relative growth of M50 traffic, population and GNP over recent years. The data shows that M50 traffic has increased substantially since 2006, with a sustained period of growth between 2007 and 2011. This occurred against the background of a slight increase in population and a declining GNP.

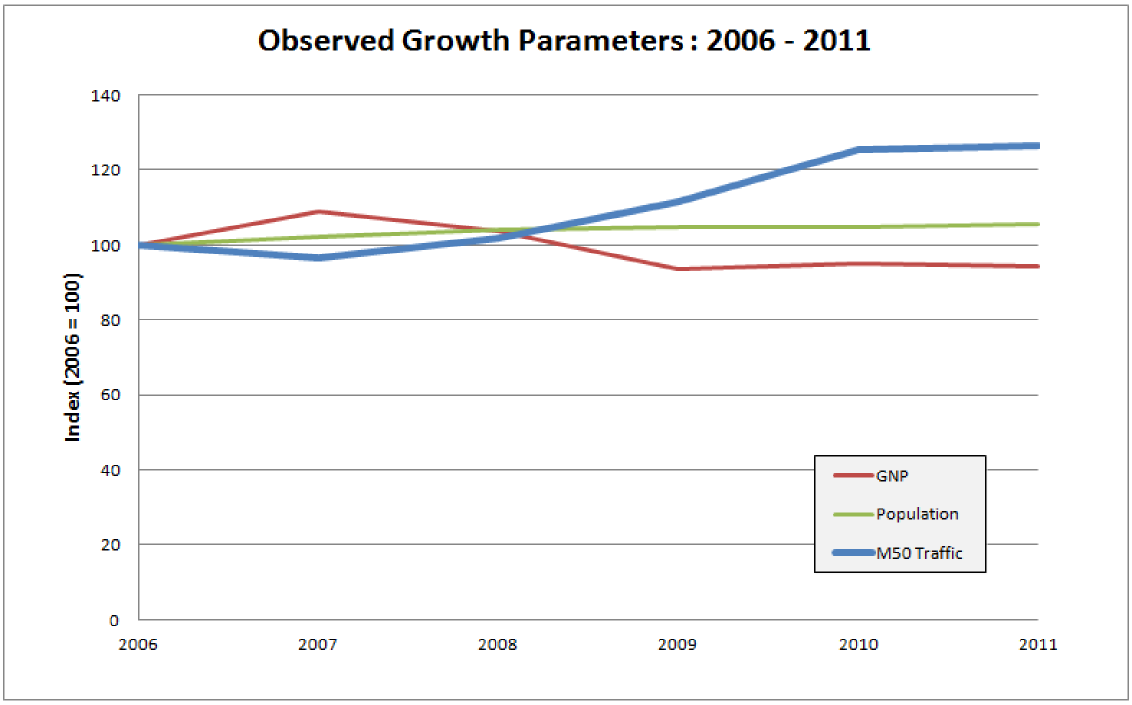

Figure 2.1 - Growth Drivers on the M50: (Traffic flows relate to traffic through M50 eFlow Toll)

It is worth noting that this on-going growth in traffic flows on the M50 has occurred during the time that free-flow tolling was introduced (August 2008) and following the completion of the upgrade scheme in September 2010.

The Figure 2.2 below shows the increase in Annual Average Daily Traffic (AADT) flows between 2009 and 2012 at the existing eFlow toll location on the M50. It is important to note that this increase has occurred against a background of decreasing traffic elsewhere, with a 5% reduction in traffic experienced on other National Primary Roads over the same period.

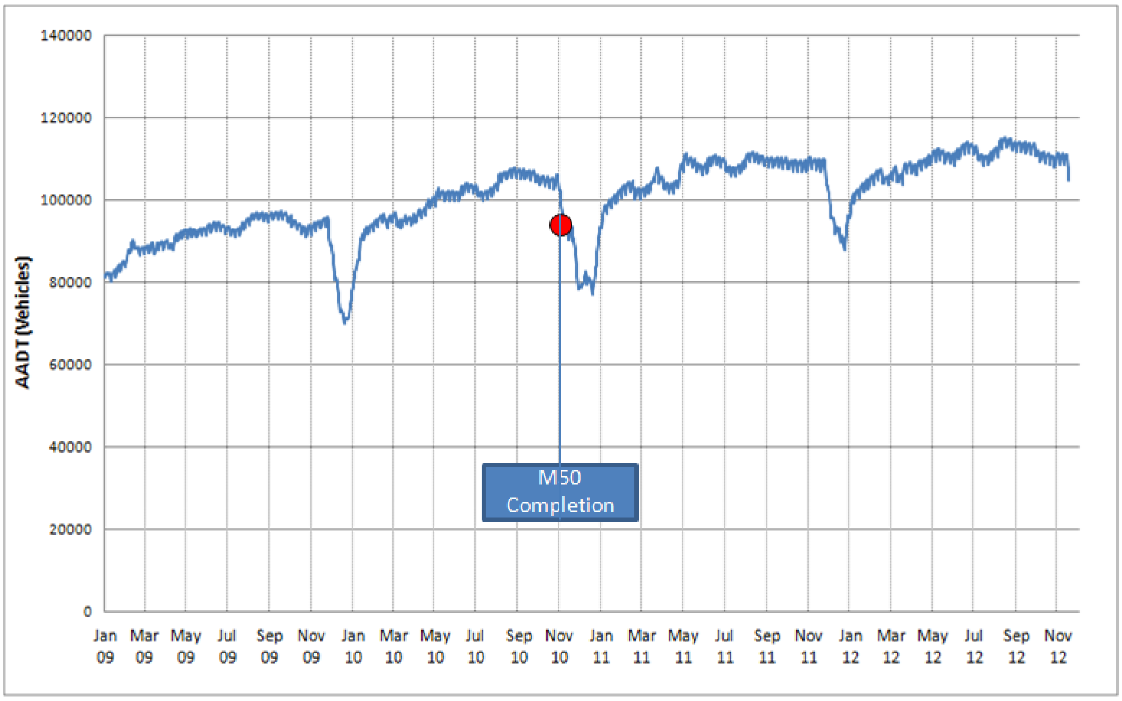

Figure 2.2 - AADT on the M50 at eFlow Toll Location 2009 - 2012

Another good indicator of recent M50 trends is to compare the data collated in January 2010 (prior to the completion of the M50 Upgrade), with the data that is now available through the newly operational Traffic Monitoring Units. A comparison of traffic flows showing Weekday Average Daily Traffic (WADT) and Weekday Average AM Peak Hour for January 2010[1] and February 2013 is presented in Figures 2.3 and 2.4 below.

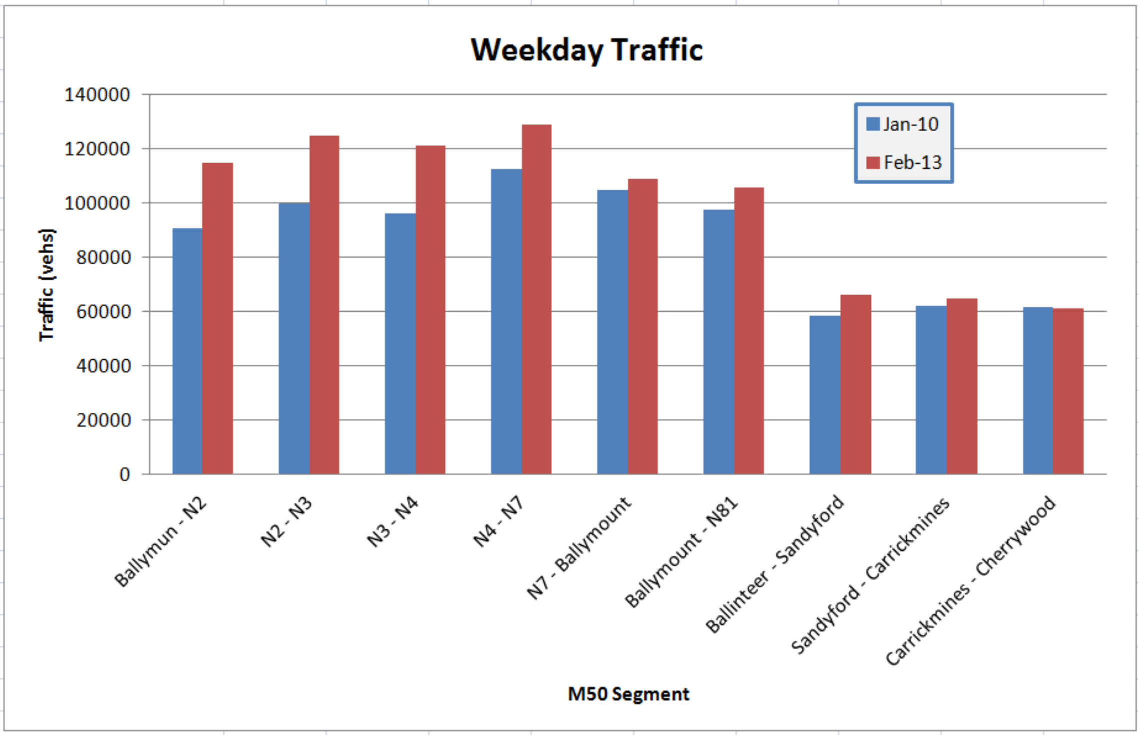

Figure 2.3 - Recent Growth on the M50: Monthly Average Weekday Traffic

[1] *Disruptive snowfall occurred during early January 2011 – this period was excluded from the assessment.*

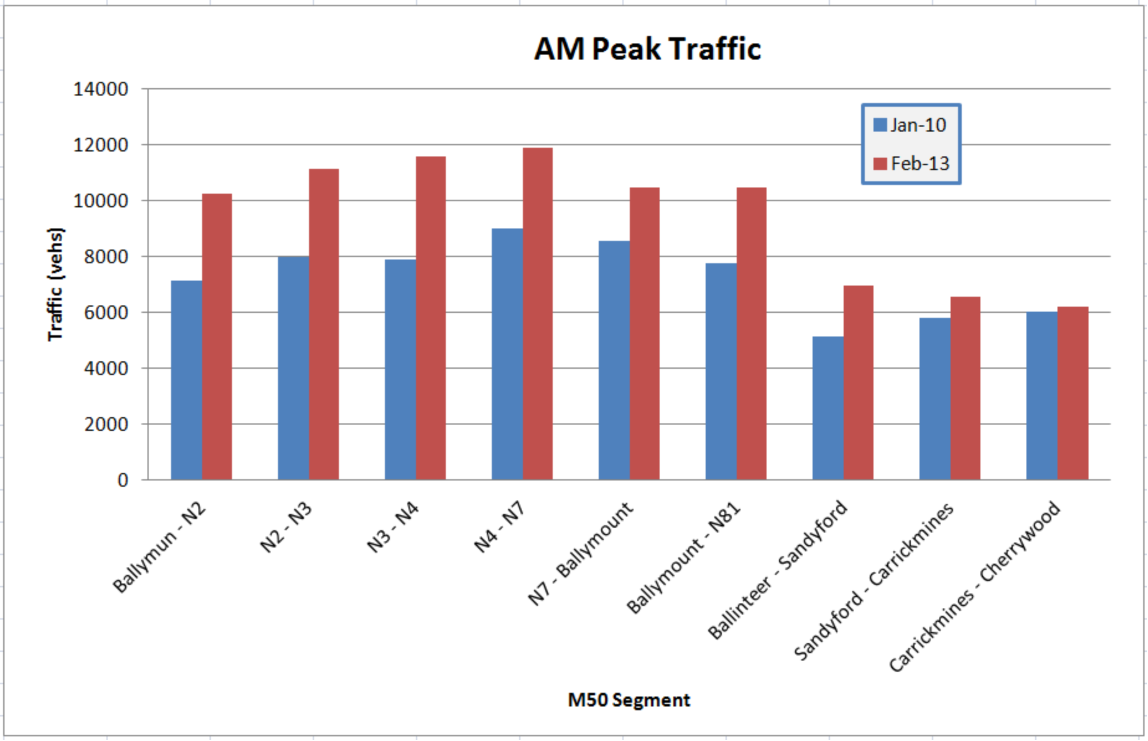

Figure 2.4 - Recent Growth on the M50: Monthly Average Weekday AM Peak (8:00 – 9:00)

In summary there is a clear trend of increasing traffic across the M50 during that time, with the most notable increases in daily traffic volumes occurring on the northern and western sections where increases of approximately 25% are recorded. The increases during the AM Peak are stronger, with increases of up to 40% in hourly traffic volumes on the northern and western sections, and along the southern section between Ballinteer and Sandyford.

The data shows very clearly that, as anticipated at the planning stage, there has been a significant increase in traffic flows as a result of the additional capacity and improved reliability provided by the M50 upgrade, and also a notable focus of demand increases during the peak periods. These increases are as a result of variable demand responses, in addition to the traditional reassignment responses, as described below.

- **Variable Demand:** Mode switching, where people have switched to the private car from bus or rail for longer trips, or from walking or cycling for shorter trips;
- **Variable Demand:** Demand changes, which describe decisions to travel to alternative destinations or decisions to make additional trips;
- **Reassignment**: where road users change their routing onto the M50 from other routes.

2.2 Current Conditions

2.2.1 Overview

A more detailed understanding of the existing conditions on the M50 was established through a series of traffic surveys undertaken during 2011 and 2012 along the full corridor. These surveys are supported by more recent data that is available through the M50 Toll and through the permanent traffic monitoring units that are in place along the M50 since February 2013. The following information is available:

- Link count surveys along the M50: January 2010
- Origin- Destination surveys at M50 Junctions: October 2011
- Link count surveys along the M50: March 2012
- Link Count surveys along the M50: Continuous collection since February 2013
- Journey Time Surveys: Continuous collection since September 2010
- Incident Monitoring: Continuous collection since September 2010
- M50 Toll Traffic: Continuous collection of data since 1990

2.2.2 Key Information

The M50 mainline carriageway caters for approximately 322,000 vehicle trips during each weekday. The average distance travelled along the M50 mainline is 12km, which equates to between one and two junctions. This confirms the short-distance nature of much of the demand using the M50 although a proportion of trips, which use the M50 to connect between radials, are significantly longer. At present, some 39% of all M50 users travel through the eFlow Toll.

The existing traffic volumes around the M50, showing total vehicles is presented below in Figure 2.5 below. The data shows the N4 to N7 section of the M50 to be the most heavily trafficked, at nearly 130,000 vehicles per day, with the south-eastern sections of the M50 carrying the lowest volumes.

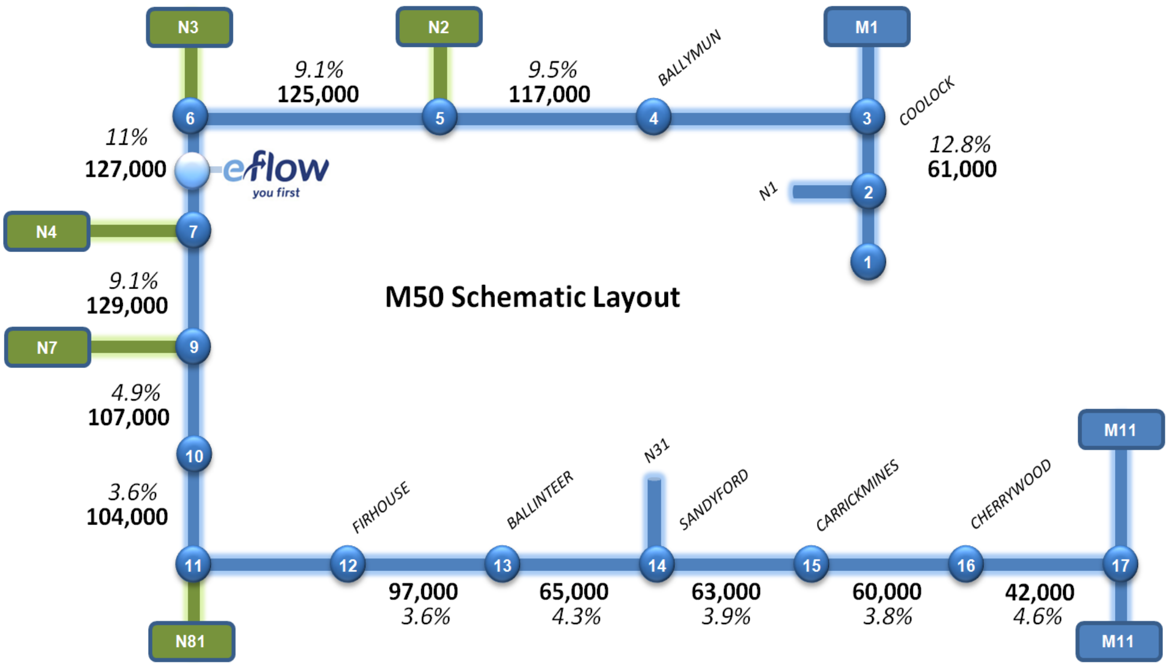

Figure 2.5 - Existing Weekday AADT Traffic Flows (% HGV) on the M50: 2013

A further analysis looks at AM Peak Hour flows (08:00 – 09:00), and is presented in Figure 2.6. The data shows AM Peak Hour flows at almost 12,000 vehicles per hour, with the existing tolled section (Junction 7, N4 to Junction 6, N3) being one of the sections carrying the highest flows.

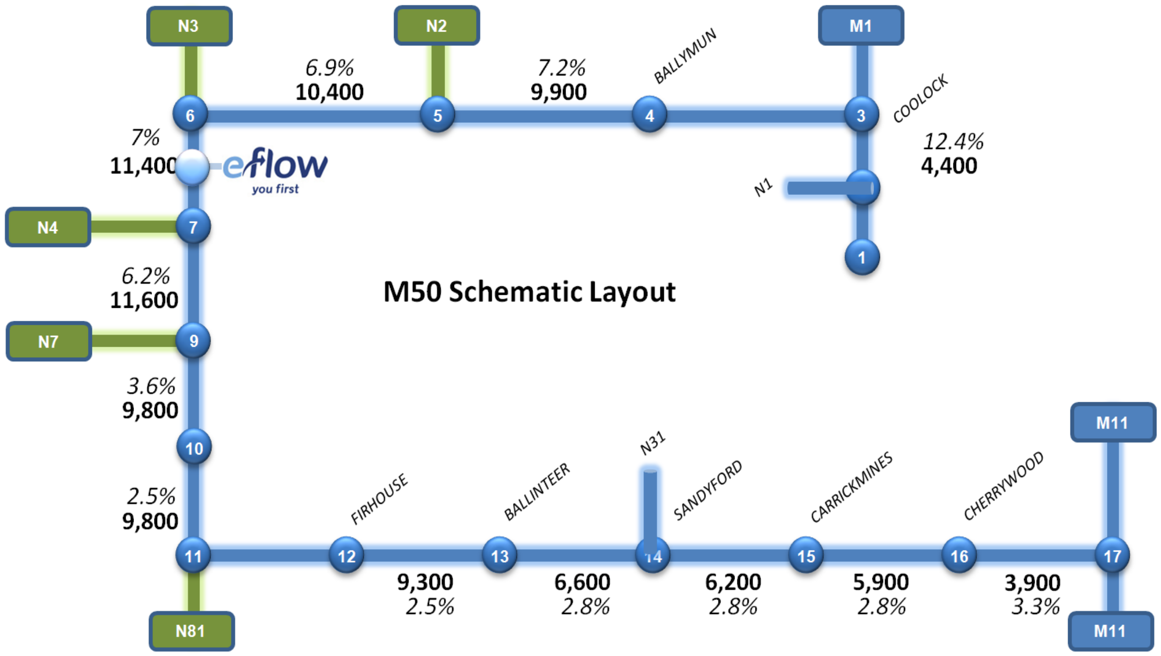

Figure 2.6 - Existing AM Peak Traffic Flows on the M50 (% HGV): 2013

It is worth noting from the Figures above that the proportion of daily traffic accounted for by peak hour activity is highest between Junction 13 and Junction 17 where it is around 10%, highlighting the dominance of commuting activity along this section.

2.2.3 Traffic Patterns

Using Bluetooth Origin - Destination Matching Data, an origin-destination matrix of junction to junction movements has been developed for the M50, and is reproduced in Figure 2.7 below. The data shows movements along the M50 between Junction 3 and Junction 17, with busier movements in darker shading. The following key points are relevant:

- Quite high levels of traffic demand associated with Junctions 3 (M1), Junction 7 (N4), Junction 9 (N7) and Junction 13 (Ballinteer). Comparatively low levels of demand through Junction 4 (Ballymun), Junction 15 (Carrickmines) and Junction 16 (Cherrywood);
- Strong demand between Junction 3 (M1) and Junctions 7/9 to the west. These are the dominant longer distance type movements along the M50, and incorporate much of the strategic freight activity associated with the Dublin Port Tunnel; and
- The low level of end-to-end traffic activity, in the region of 4,500 movements per day between the M1 and M11 – this represents about 1.5% of total demand on the M50.

FROM \ TO													
Junction No.	3	4	5	6	7	9	10	11	13	15	16	17	
3		2597	4625	6959	7475	9926	1655	1845	2101	269	449	1652	39555
4	3455		1592	2408	2163	2111	557	324	615	43	159	393	13819
5	4529	1527		3415	2881	3726	848	756	1024	116	206	617	19644
6	7770	2381	3173		4295	7410	1942	2036	3064	277	676	1679	34705
7	9937	2009	3453	4530		7553	3800	4737	6154	563	1159	2318	46213
9	10357	1563	3301	4516	5435		3481	3697	6077	604	1188	2274	42492
10	1491	285	760	1147	2720	3174		2155	1806	217	412	825	14992
11	1857	485	739	1565	3969	3722	1485		3938	550	864	1765	20939
13	2502	376	1050	2241	5631	6267	1780	4346		2112	1902	4556	32764
15	486	133	182	415	778	1057	373	911	2937		1140	1639	10050
16	598	117	229	541	1132	1469	486	1137	2787	1441		961	10899
17	3328	557	1110	1848	3716	4387	1508	3402	9894	2947	3387		36085
	46310	12030	20216	29584	40197	50801	17915	25346	40396	9140	11543	18679	322158

Figure 2.7 - Weekday Origin-Destination Matrix for the M50 (February 2013)

A good representation of key desire lines can be provided using bandwidth diagrams, showing key movements to/from a number of major junctions. Figure 2-8 shows desire lines represented as bandwidths for traffic using the M50 mainline from the M1, N4, N7 and Sandyford junctions. Again, this shows the strong levels of movement between the M1 and the N4/N7, and the low level of end to end activity. The plots also show the strong levels of activity attracted into the Sandyford junction from the N4/N7 and the M11.

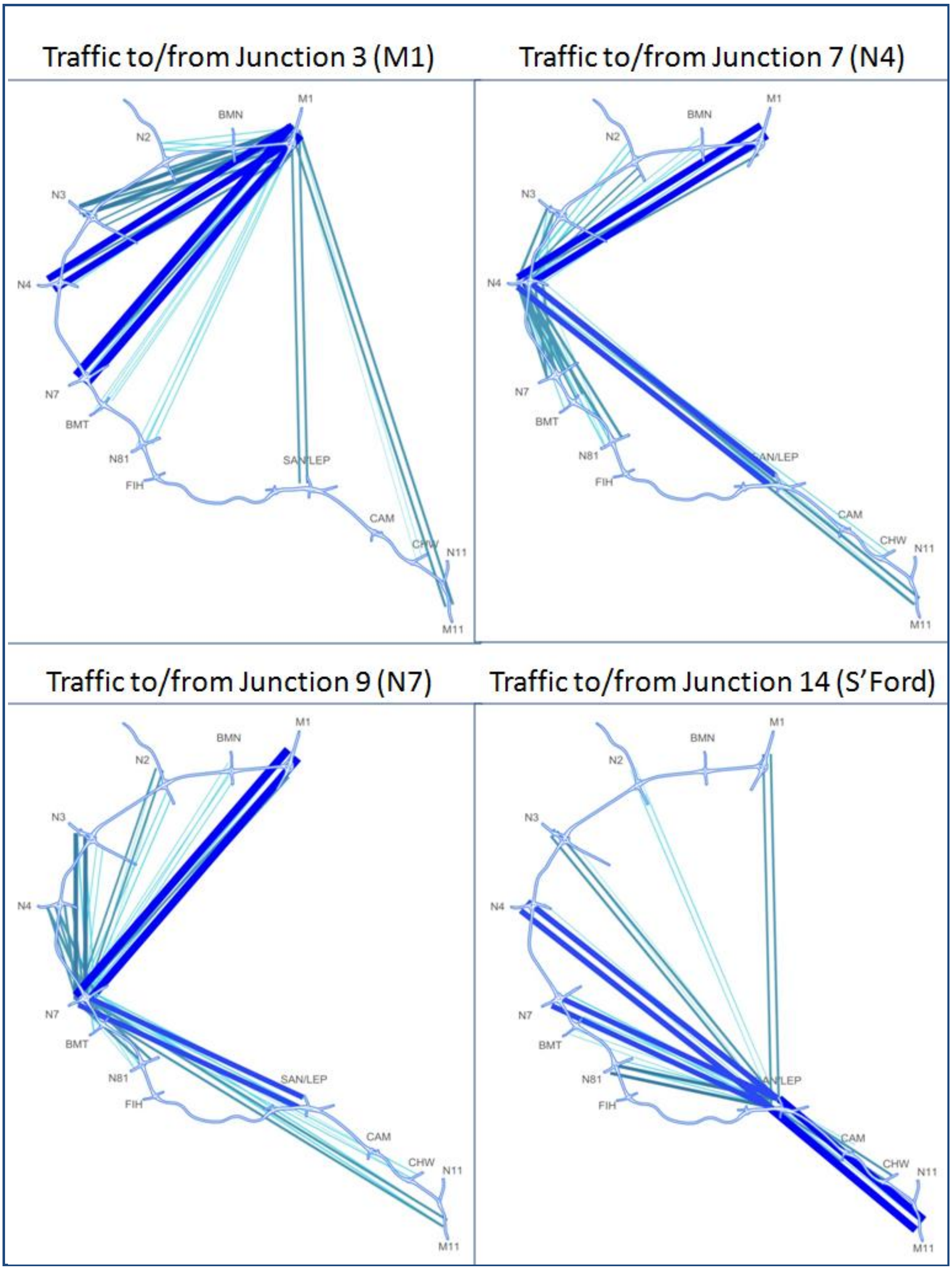

Figure 2.8 - Origin-Destination Patterns on the M50 (November 2011)

2.2.4 Journey Times

Journey times on the M50 are currently captured through the Automatic Number Plate Recognition (ANPR) cameras which match vehicles to estimate average journey times. This information is available for the full length of the M50 from March to September 2013 as presented below. The dataset shows the significant increase in average monthly journey times and the average standard deviation of journey times in the period March to October 2013, in particular the month of September when school traffic returned to the roads. The data suggests that the significant congestion issues are occurring on the M50 in particular the southbound direction during the AM period.

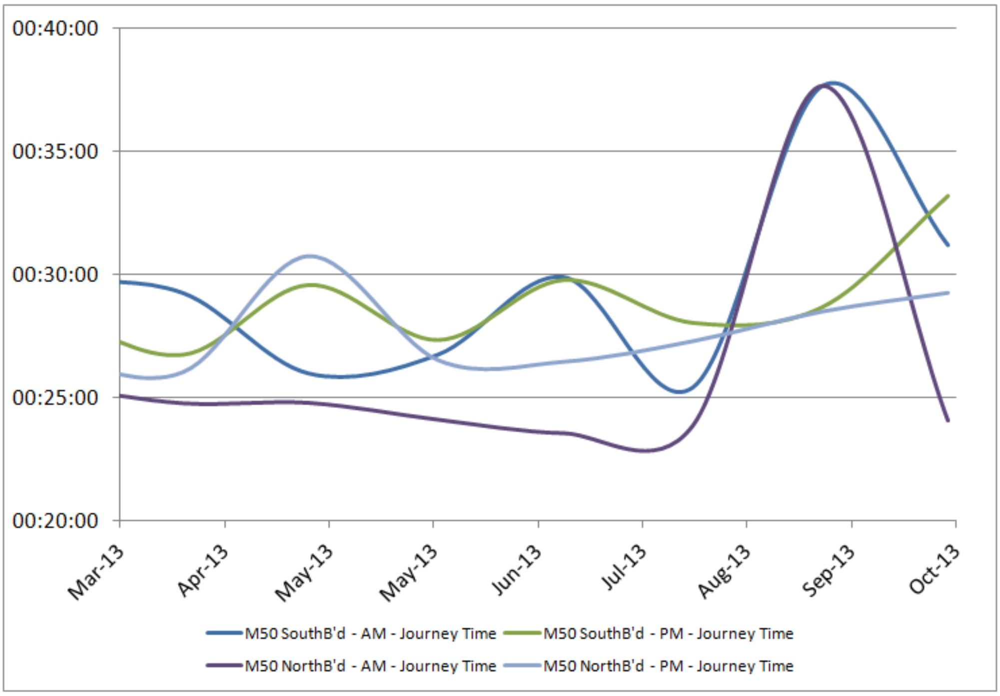

Figure 2.9 – AM and PM Peak Periods – Average Monthly Journey Time

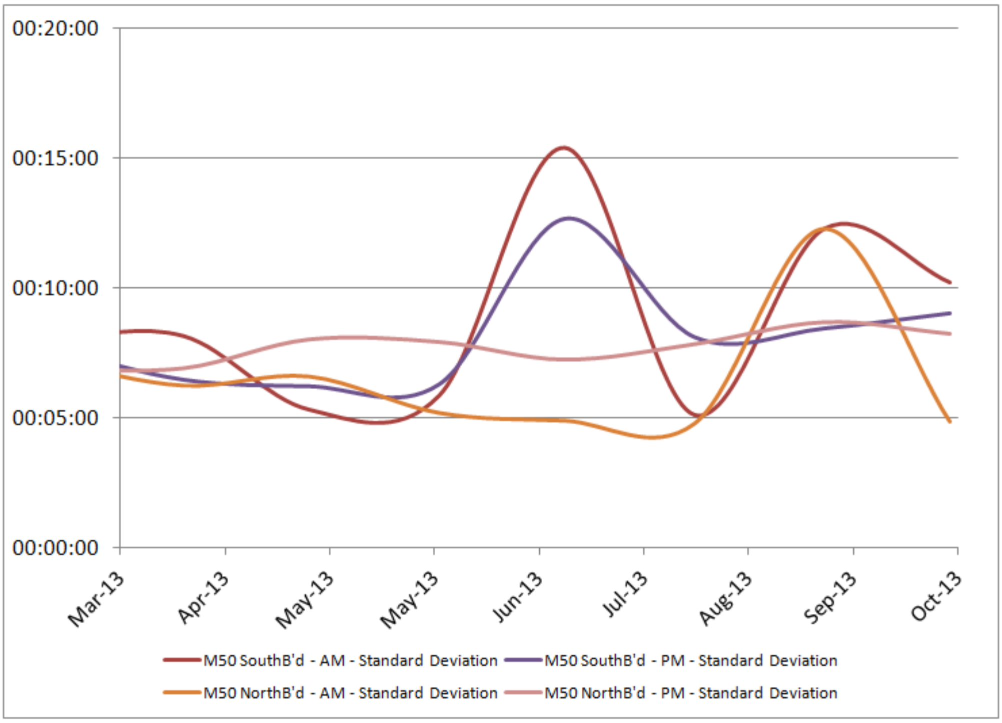

Figure 2.10 - AM and PM Peak Periods – Average Monthly Standard Deviation

Information taken from Dublin City Council cameras on the M50 during October 2013 shows frequent congestion along some sections of the M50 particularly from vehicles travelling southbound along the Ballymun – Firhouse section during the AM peak period.

Photo 2.1 – M50 Firhouse – PM

Photo 2.2 – M50 Ballymun – AM

Photo 2.3 – South Finglas – A

In order to establish a longer history of conditions on the M50, quarterly data, for the section of the M50 between Ballymount and the N4, between October 2011 and February 2013 has been extracted from this dataset.

This data has been compiled and is presented in Figures 2.11 – 2.14 below. It shows that journey times have been steadily increasing along this section during both the AM and PM peak periods showing an average increase of over 5% during this period.

The data suggests that journey times on the M50 are beginning to be significantly impacted upon by traffic increases. As traffic flows and congestion continue to increase the resultant impact on journey times will also increase.

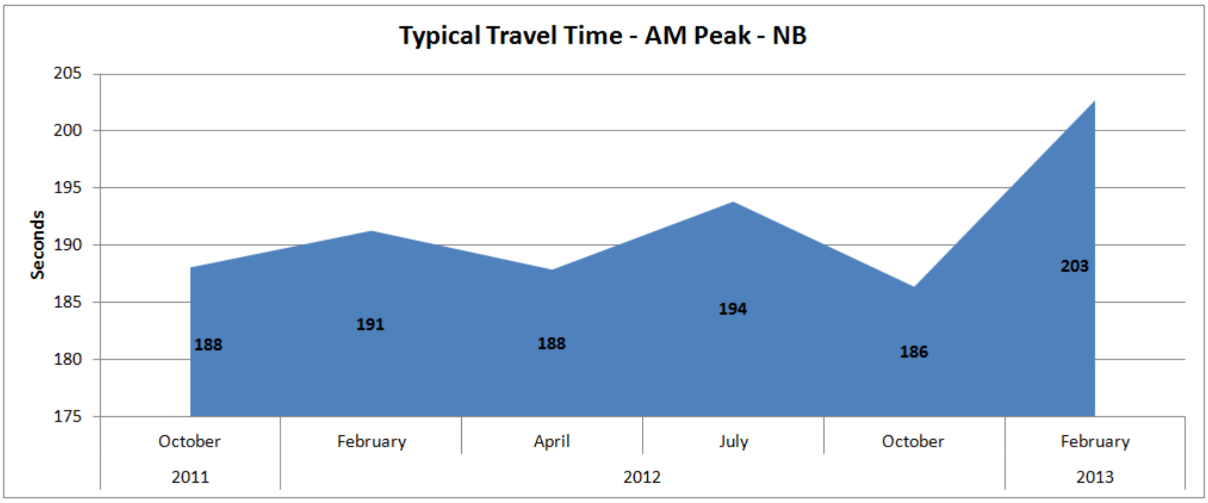

Figure 2.11 - AM Journey Time Monitoring on the M50: Ballymount - N4

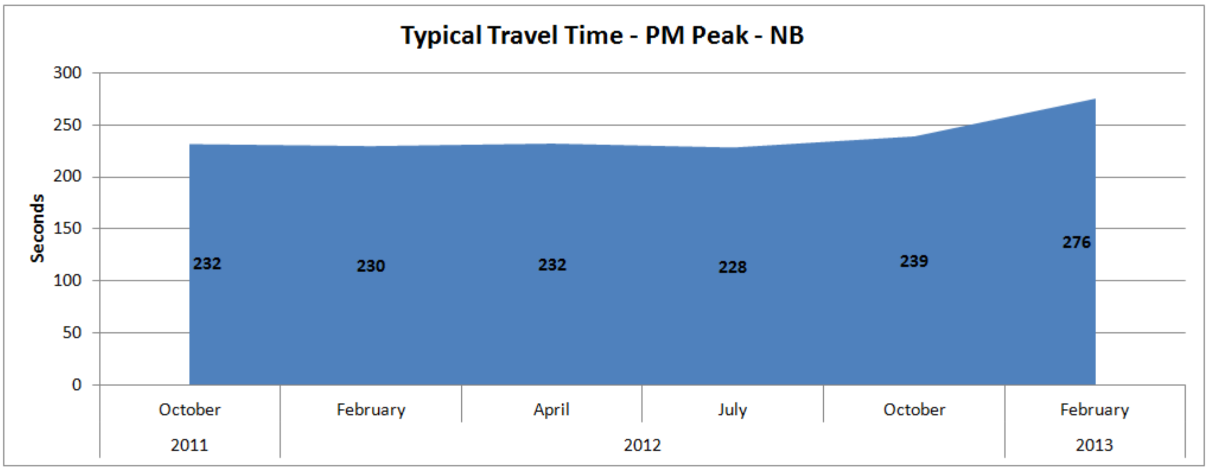

Figure 2.12 - PM Journey Time Monitoring on the M50: Ballymount - N4

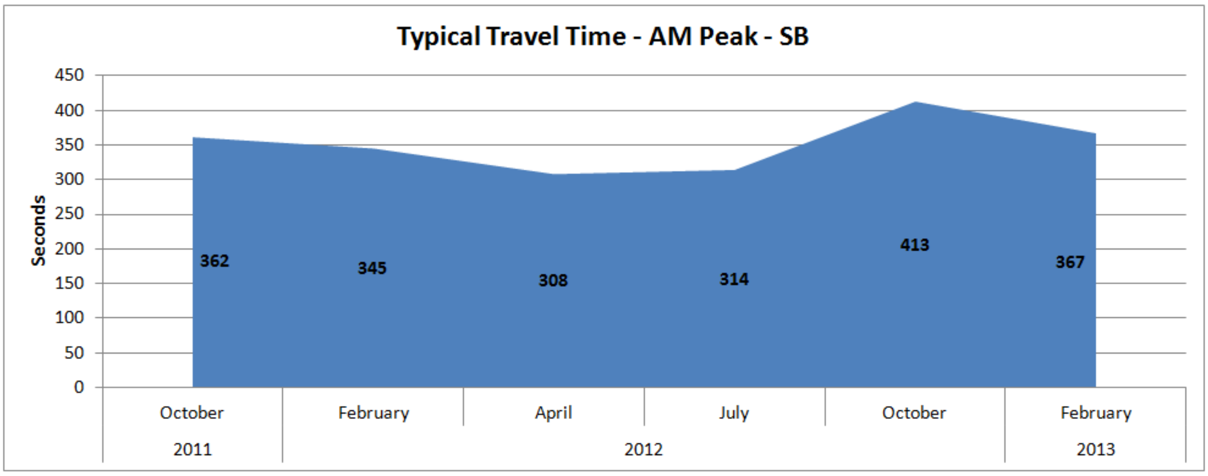

Figure 2.13 - AM Journey Time Monitoring on the M50: N4 – Ballymount

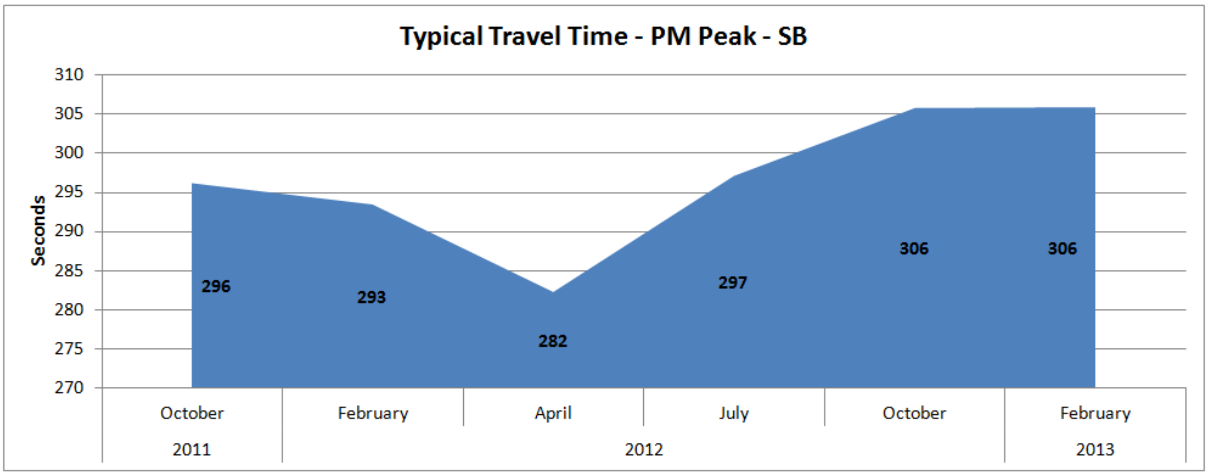

Figure 2.14 - PM Journey Time Monitoring on the M50: N4 – Ballymount

2.2.5 Incident Monitoring

Detailed incident data has been collected on the M50, between the M1 and M11, since early 2012 by the M50 PPP Operator. The last 6 months of data are shown in Figure 2.15 below which shows a comparison of incidents/month against average AM peak weekday flow for each month

(December data has been excluded).

The data has all been baselined to an August 2012 value of 100 for comparison purposes. The incident records include all types of incidents including collisions and breakdowns. The data shows that the occurrence of incidents on the M50 has been increasing on the M50 over recent months especially during the peak hours where the increase is more profound.

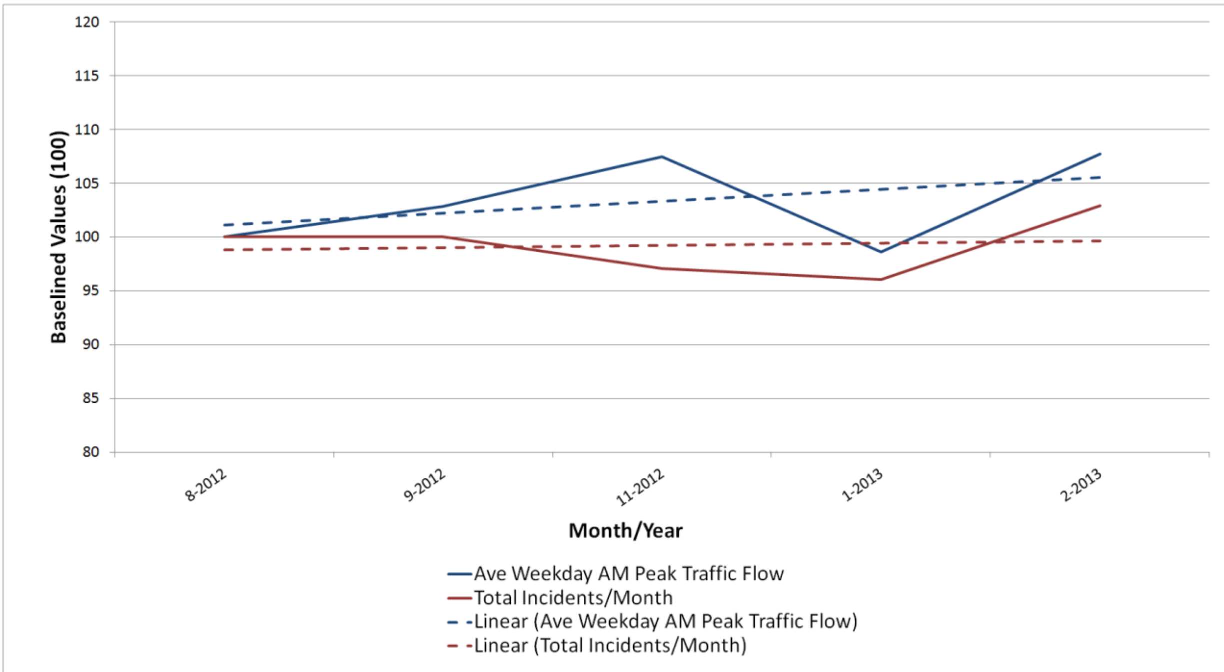

Figure 2.15 - Incident Monitoring on the M50

The incident data was interrogated to assess the occurrence of incidents resulting in lane closures. The data showed that lane closures currently occur on the M50 every 1.6 days for an average duration of 41 minutes on each occasion. This significantly impacts upon the perceived reliability of journey times on the M50 corridor.

2.2.6 Summary

The busiest sections of the M50 are currently carrying nearly 130,000 vehs/day whilst peak period flows of up to 12,000 veh/hour are travelling along the N4-N7 section. An analysis of historical journey time and incident data has shown that the increase in demand over recent years has led to increases in M50 journey times and incidents which will continue to increase into the future as demand continues to grow. The analysis confirms that a scheme of demand management measures are required to protect the role of the M50 as the hub of the National Roads network and maintain its strategic role.

As such it is important that the level of likely future traffic growth on the M50 is understood. This understanding is required to ensure that the core function of the infrastructure is retained for its design life by actively influencing the decision making of existing and future users through demand management measures.

2.3 Future Growth Drivers

In forecasting future growth in traffic a number of elements have been considered which will drive increases in demand on the M50 as follows;

- **Population Growth:** NRA Forecasts (driven by population) were developed for Low, Medium and High growth scenarios. Growth scenarios were based on projections from CSO, fed through a proprietary demographic model to produce forecasts of population, jobs and car ownership. A standard methodology for the implementation of the forecasts is given in the NRA's Project Appraisal Guidelines (PAG). It is noted that the 2011 Census of Population reported that population was broadly in line with those forecast in the Regional Planning Guidelines for 2011. This suggests that although economic activity has declined, there remains a strong potential workforce in place for the economic recovery.

- **Economic Recovery:** In its 2011 report "Recovery Scenarios for Ireland", the ESRI projected that the current economic position would gradually recover over the period from 2012 to 2020. During that time workforce participation would recover to pre-recession levels. Even since the publication of that report, the rate of recovery appears to be (initially at least) slower than expected. For the purpose of this study it was assumed that this recovery will take place during the period 2012 to 2025.

- **Variable Demand:** It has already been noted that, as expected, the M50 upgrade has generated increases in traffic as a result of variable demand responses, in addition to the traditional reassignment responses. This study seeks to understand the scale of that response and to develop an understanding of whether this response has fully occurred. As described below, this study has utilised detailed traffic models which are based on fixed future projections of population and employment distribution.

2.4 Assessment of Future Growth

Future growth is defined by projecting population and GNP, which yields a network-wide traffic demand. The resulting increase in demand on the M50 and the future pattern of traffic is then assessed using the network models, namely the NRA's National Transport Model and the Dublin Area Model. The Dublin Area Model was developed specifically for this project based on 2011 traffic data and derived from the NTA's Greater Dublin Area SATURN Model with particular focus on the M50 Corridor.

The forecasting exercise has referenced the growth drivers outlined above. In undertaking the forecasting the Base Year has been chosen as 2011, which reflects the period of the data collection for the current studies. The projection of this traffic demand therefore incorporates assumptions on population and GNP growth. No additional variable demand response or 'induced demand' is assumed in the analysis, as it is considered that such effects may have largely run their course over the period from 2008 – 2011, i.e. a period of three years encompassing the delivery of major capacity enhancement of the M50 and the removal (in 2008) of the "Westlink" barrier toll plaza between Junctions 6 and 7.

The resulting growth pattern is presented graphically in Figure 2.16 below. This is based on NRA Medium Growth for the purposes of illustration, although results for Low, Medium and High growth scenarios have been undertaken. The diagram shows the 27% increase in M50 demand that occurred between 2006 and 2011 as a result of the upgrade, against the background of decreasing traffic volumes elsewhere throughout the national road network. The M50 demand is then projected forward based on Medium Growth Rates to NRA future years of 2025 and 2040. The effect of GNP recovery generates a further 9% uplift in traffic volumes. Under the medium growth forecast, traffic volumes in 2025 are expected to be 47% above 2006 levels, or 14% above 2013 levels.

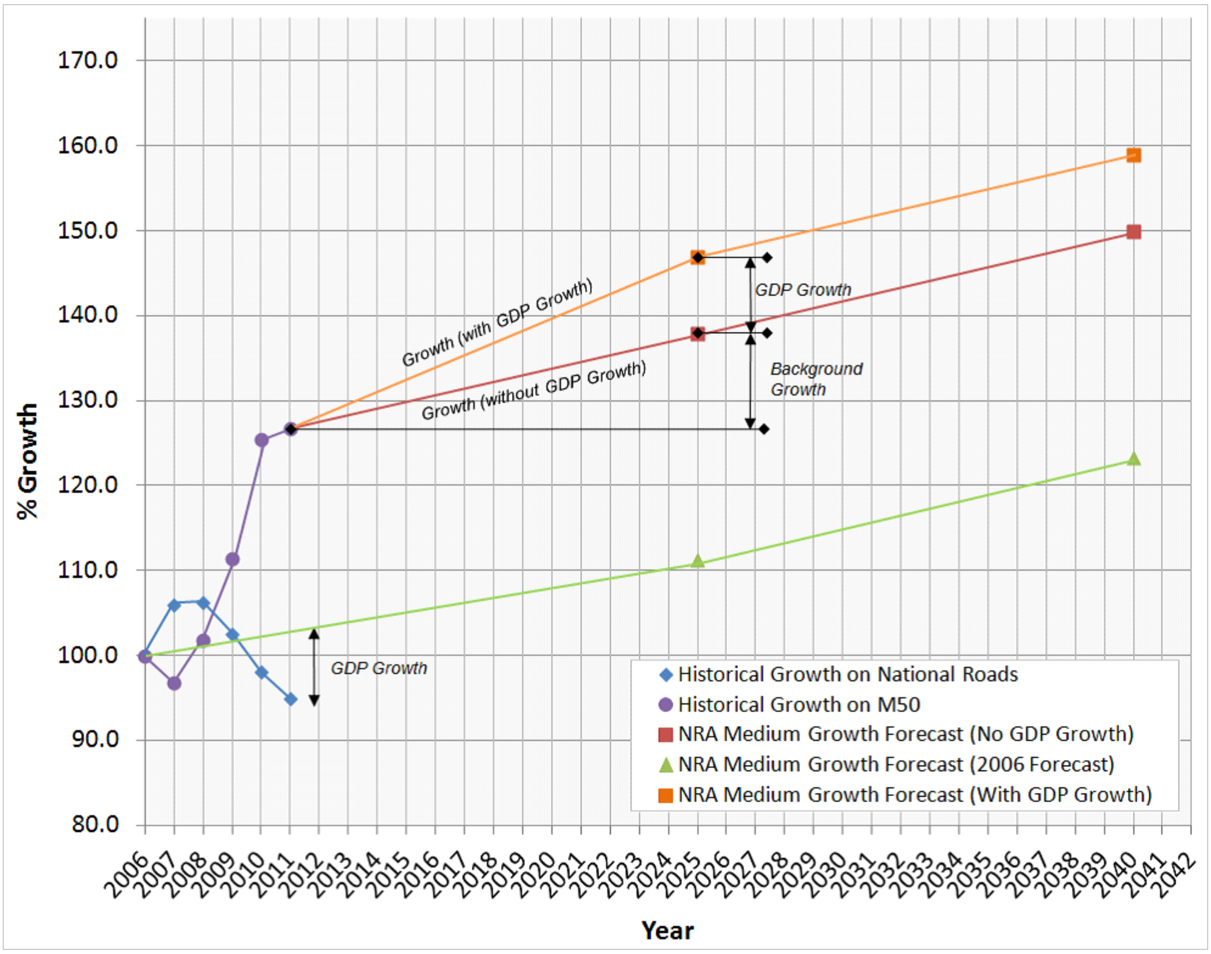

Figure 2.16 - Future Growth – Medium Growth Forecast showing GDP Uplift

The An Bord Pleanála reason for Condition 7 of its approval of the M50 Upgrade is that demand management measures are required on the M50 Motorway corridor to protect its capacity over its design life. In accordance with standard appraisal guidance, the design year for traffic capacity is taken as fifteen years from opening, with the forecast year for evaluation of benefits and costs taken as thirty years after opening.

The M50 Upgrade was completed in sections between 2008 and 2010 with major mainline capacity improvements substantially completed by the end of 2008. Accordingly, for the purposes of considering the benefits of demand management measures in this study a design year of 2023 has been adopted. Forecast traffic flows in 2023 (expressed as AADT and AM peak hour) for the M50 are presented in Figures 2.17 and 2.18 below, with flows expressed as vehicles.

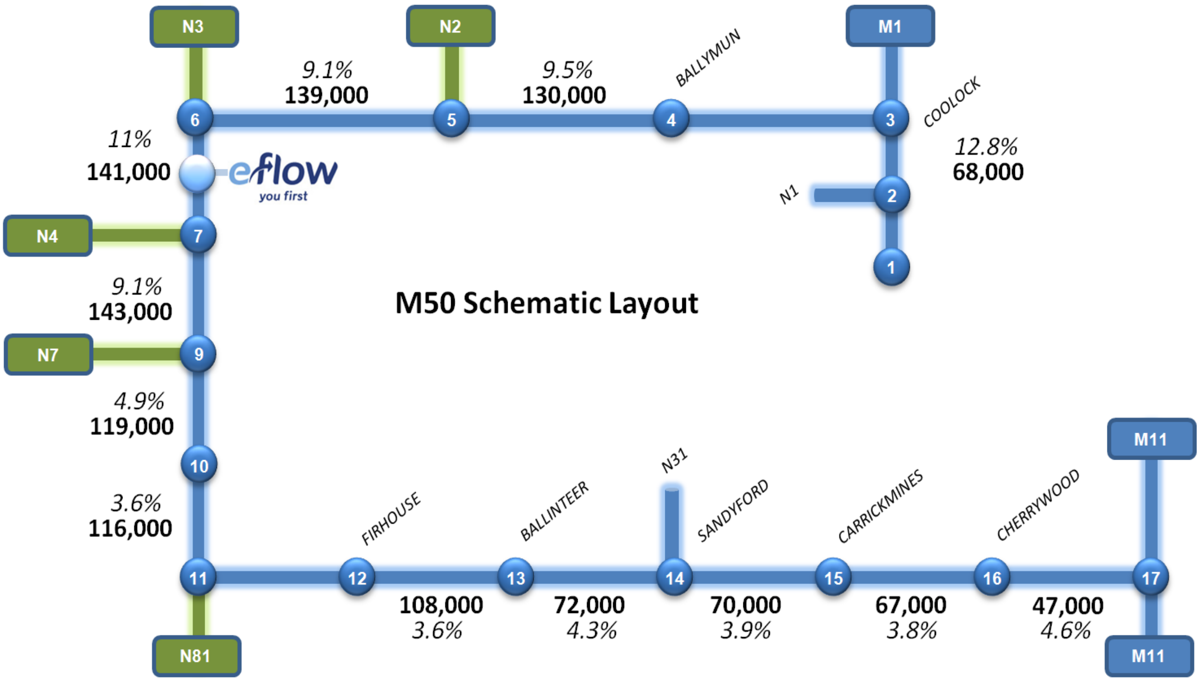

Figure 2.17 - Forecast M50 Traffic Flows AADT: 2023 Medium Growth (including GDP Uplift) (HGV%)
**Based on 2013 flows factored to 2023 volumes based on Figure 2.16 above*

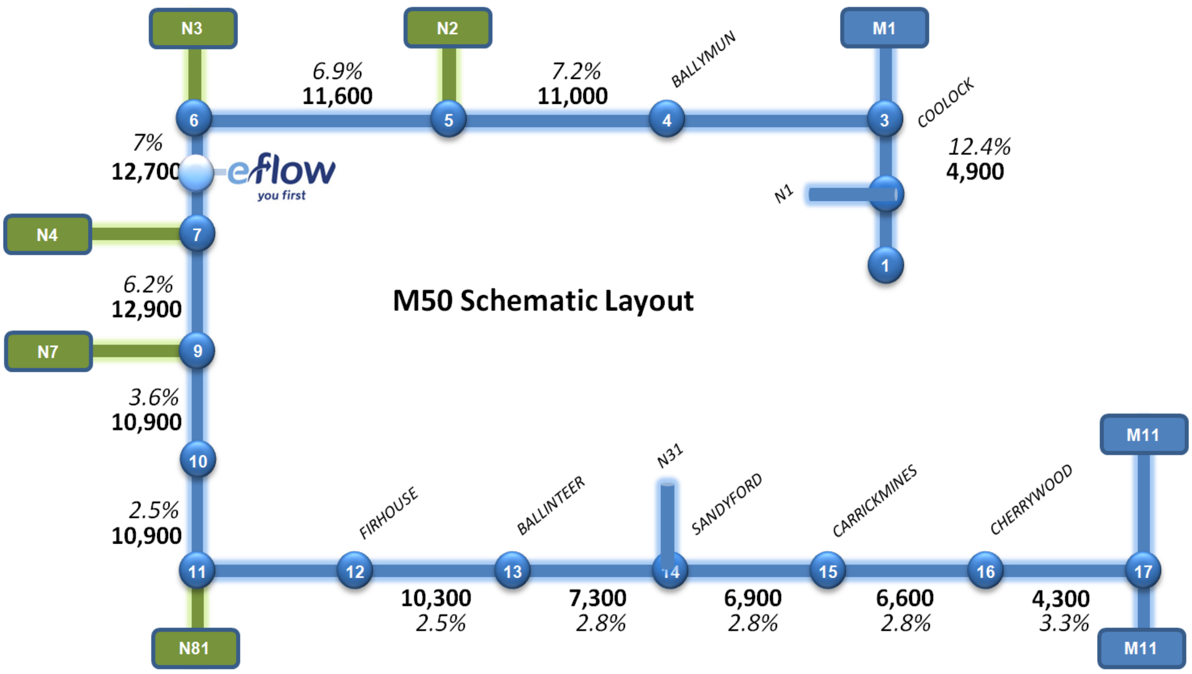

Figure 2.18 - Forecast M50 Traffic Flows AM Peak: 2023 Medium Growth (incl GDP Uplift) (HGV%)
**Based on 2013 flows factored to 2023 volumes based on Figure 2.16 above*

2.5 Defining M50 Capacity

As highlighted previously the objective of this study is to protect the capacity of the M50 over its design life. In order to identify demand management measures that could achieve this it is necessary to understand what is meant by the term "capacity" of the M50 in the context of this study.

Previous research by the NRA[2] has found that the Practical Capacity of an unmanaged lane in a traffic stream can be defined at between 1,800 and 1,850 Passenger Car Unit's (PCU) per lane per hour (equates to approximately 1,700 vehicles/lane/hour for the M50). The research showed that once traffic flow in a motorway lane exceeds 1,850 passenger car units (PCU) per lane per hour congestion, and more frequent incidents and collisions, will start to occur. As such this value of 1,850 PCU/lane/hour is taken to be the safe operating capacity of an individual running lane on the M50.

Analysis of traffic flows across a full day on the M50 shows that traffic demand is not evenly distributed across all lanes on the carriageway. During the peak periods, approximately 32% of the mainline flow is carried by the outside lane, with less than 20% accommodated by the auxiliary lane. Using this information, it has been possible to estimate the flow on the busiest lane of the M50 as a function of total traffic flow, see Figure 2.19 below.

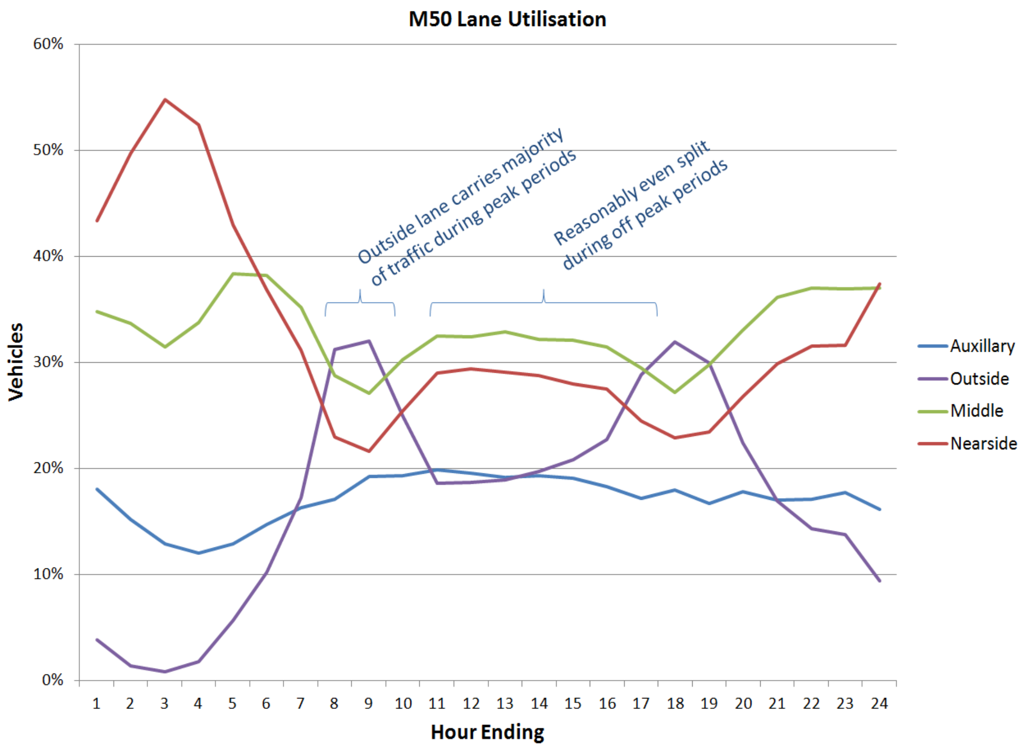

Figure 2.19 - Allocation of Traffic Demand into Lanes: M50, Dublin

It is clear therefore that the capacity of the M50 in the context of this study is determined by the flow on the busiest lane relative to the safe operating capacity of that lane. When the safe operating capacity is exceeded the resulting congestion and turbulence (start-stop driving) in that lane will lead to an increase in the level of lane changing/weaving as drivers seek adjacent lanes

[2] *A Study of Lane Capacity in the Greater Dublin Area: NRA: February 2012*

with spare capacity. This leads to turbulence in the adjacent lane, and the onset of congestion in that lane.

Using this information, an analysis of traffic flow and safe operating capacity on the M50 has been undertaken for January 2010, November 2011 and the design year of 2023 (assuming medium growth), see Figures 2.20 – 2.22. The plots show those sections (in red) where demand on the busiest lane will exceed the 1,850 PCU/lane/hour safe operating capacity in the AM peak hour.

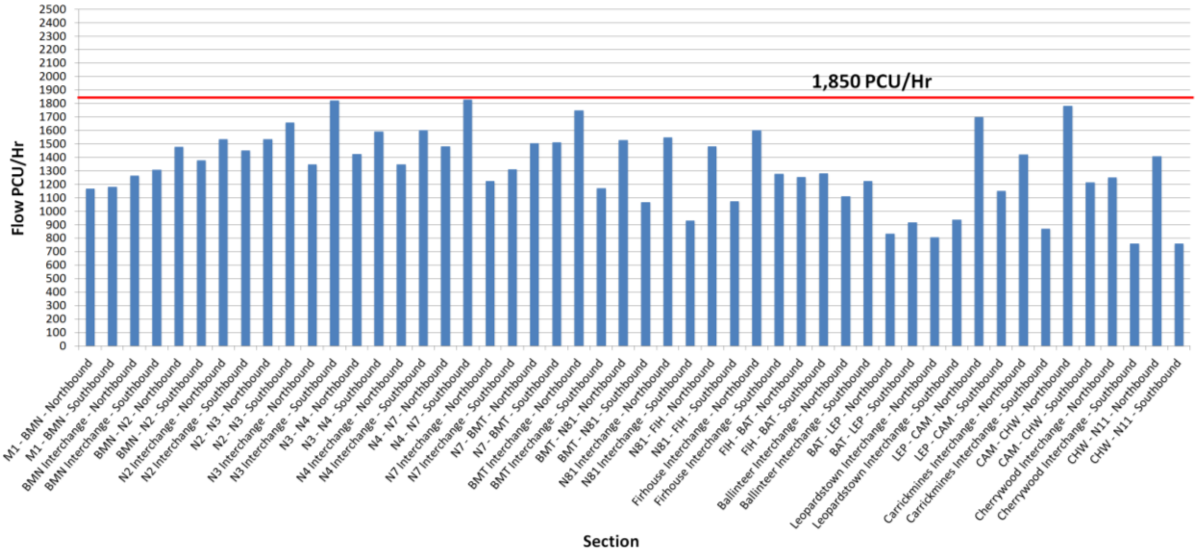

Figure 2.20 - Analysis of Demand and Capacity for January 2010

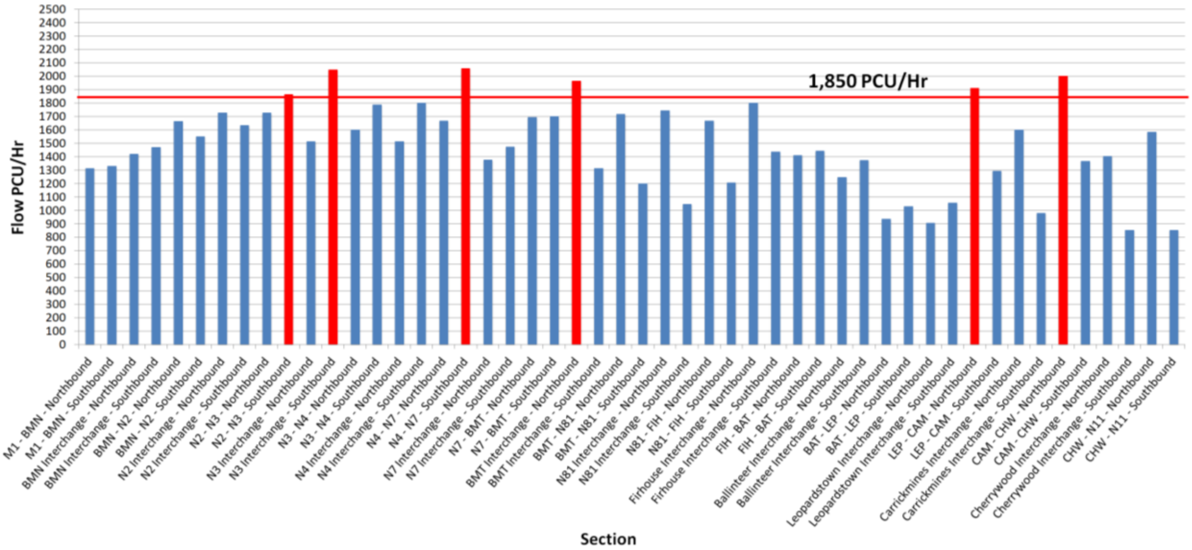

Figure 2.21 - Analysis of Demand and Capacity for November 2011

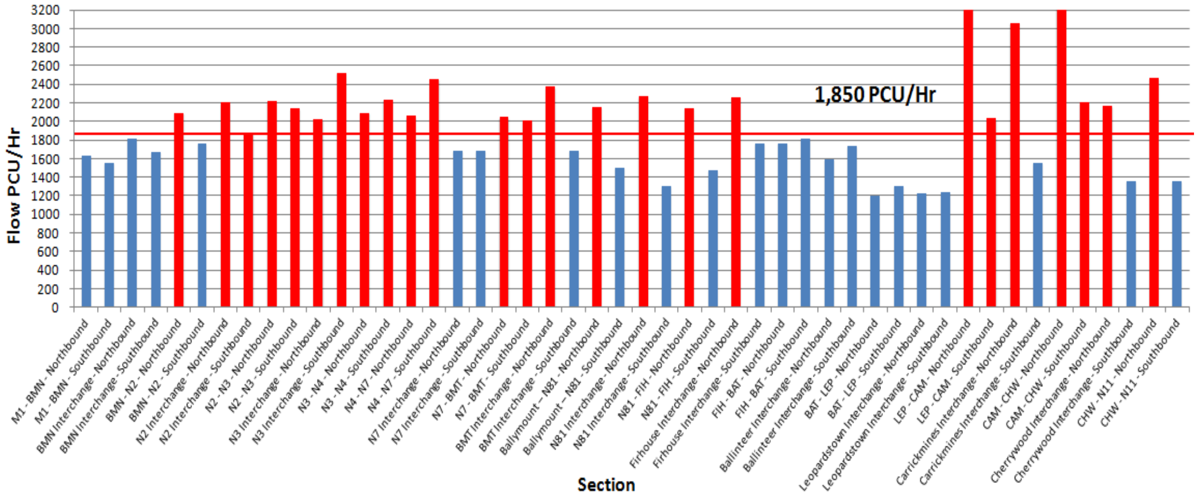

Figure 2.22 – Forecast of Demand and Capacity for 2023 (including GDP Uplift)

The analysis above clearly show that while demand was below safe operating capacity at the start of 2010, this capacity is now being exceeded at a small number of locations (on approximately 12% of the sections), and that, without intervention, demand will continue to rise such that by 2023 demand will exceed safe operating capacity on over 50% of sections of the M50.

Research by Kim and Elefteriadou[3] looked at the probability of congestion (traffic flow breakdown) occurring at different levels of traffic flow. They concluded that if a traffic flow of 1,850 vehs/lane/hr (equivalent to 2,000 PCU/lane/hr) is maintained for 1 minute the probability of congestion is very low. However if it is maintained for 5 to 15 minutes the probability increases to 19 - 47%. They developed a probability function of flow breakdown (congestion) occurring as a function of the average flow in each lane. This relationship is reproduced in Figure 2.23 below.

[3] *Kim and Elefteriadou, Transportation Research Board paper "Capacity Estimation for Two Lane Two-Way Highways using Simulation", 2007.*

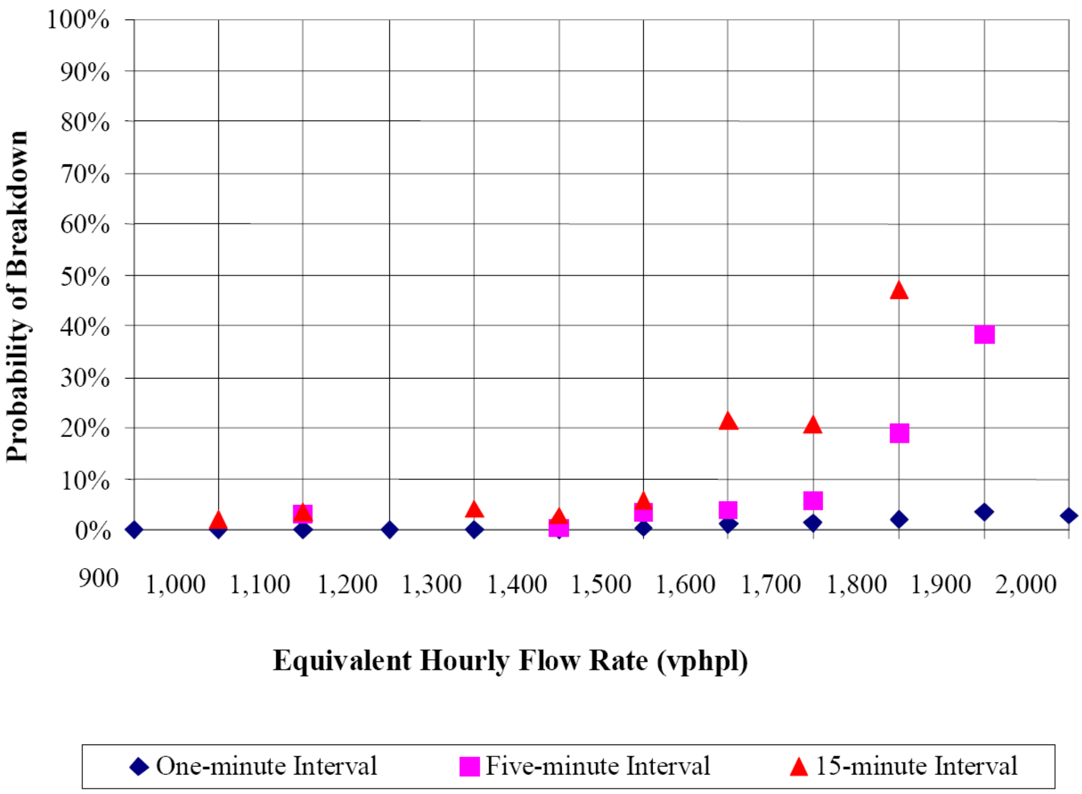

Figure 2.23 - Probability of flow breakdown (congestion) at different traffic flow rates

The safe operating capacity of a lane on the M50 has been determined to be 1,850 PCU/lane/hr (equivalent to 1,700 veh/hlane/hr). Reference to Figure 2.23 above shows that at this level of traffic flow, the probability of congestion occurring in any 5 minute period is approximately 5%, or one event in every 100 minutes. However, as flows increase above this the probability of congestion starts to rise rapidly.

Reference to Figure 2.22 above shows that by 2023, it is forecast for the medium growth scenario that the busiest lane flow on some sections of the M50 will increase to more than 2,400 PCU/lane/hr (equivalent to 2,250 veh/lane/hr), with the probability of traffic flow breakdown occurring increasing significantly to more than 40%. This is an 8-fold increase in the probability of congestion occurring in each 5-minute segment, and suggests multiple events, or sustained congestion, during the peak hour.

2.6 External Impact of M50 Conditions

2.6.1 Journey Times

As the number of vehicles using the national road network increases, the level of service for all vehicles will decrease. In other words, adding additional vehicles to the national road network increases journey times for all users. As traffic increases in the future, the impact of minor incidents will worsen resulting in increased journey times and congestion.

This imposes a real cost on road users and the economy as a whole. The marginal external cost of congestion (MECC) is defined as the difference between the marginal social cost and the trip maker's own costs where the marginal social cost reflects the cost that is imposed on road users and society at large by an additional trip. Charging road users an amount equal to the MECC is an effective means of influencing the demand for the road.

2.6.2 Journey Time Reliability

Journey time reliability is heavily influenced by the stability of the traffic stream, with congestion leading to temporary bottlenecks and resulting delay to all road users. As congestion increases, journey times increase and the predictability of journey times decreases resulting in an additional cost to road users and the economy as a whole. As traffic flows on the M50 increase, the influence of road space capacity will become more evident, in particular along sections downstream of egress/access points where capacity is constrained.

2.6.3 Road Safety

Whilst the number of collisions on any section of road is a function of the number of vehicles using that road, it is also a function of the traffic behaviour on the road. On high capacity roads such as the M50, the number of collisions is expected to increase as a result of higher levels of lane switching/weaving that may take place during those periods when the carriageway is approaching congestion. This activity leads to stop-start driving as the demand within individual lanes fluctuates, which can lead to significant safety risks on roads operating at high speed. An increase in incidents as a result of increased demand is already evident over the last six months as shown in Section 2.2.5 above.

2.6.4 Environmental Impacts

A further external cost of road use is the environmental damage from operating motor vehicles. These costs are imposed on the environment as a whole as opposed to the operator of the vehicle. Increased incidents and congestion leads to more turbulent traffic conditions which increases fuel usage and emissions.

2.6.5 Junction Impacts

In order to understand any potential issues with the M50 junctions in the future it is important to understand existing issues. The existing layout of the M50 junctions is set out in Figure 2.24 below.

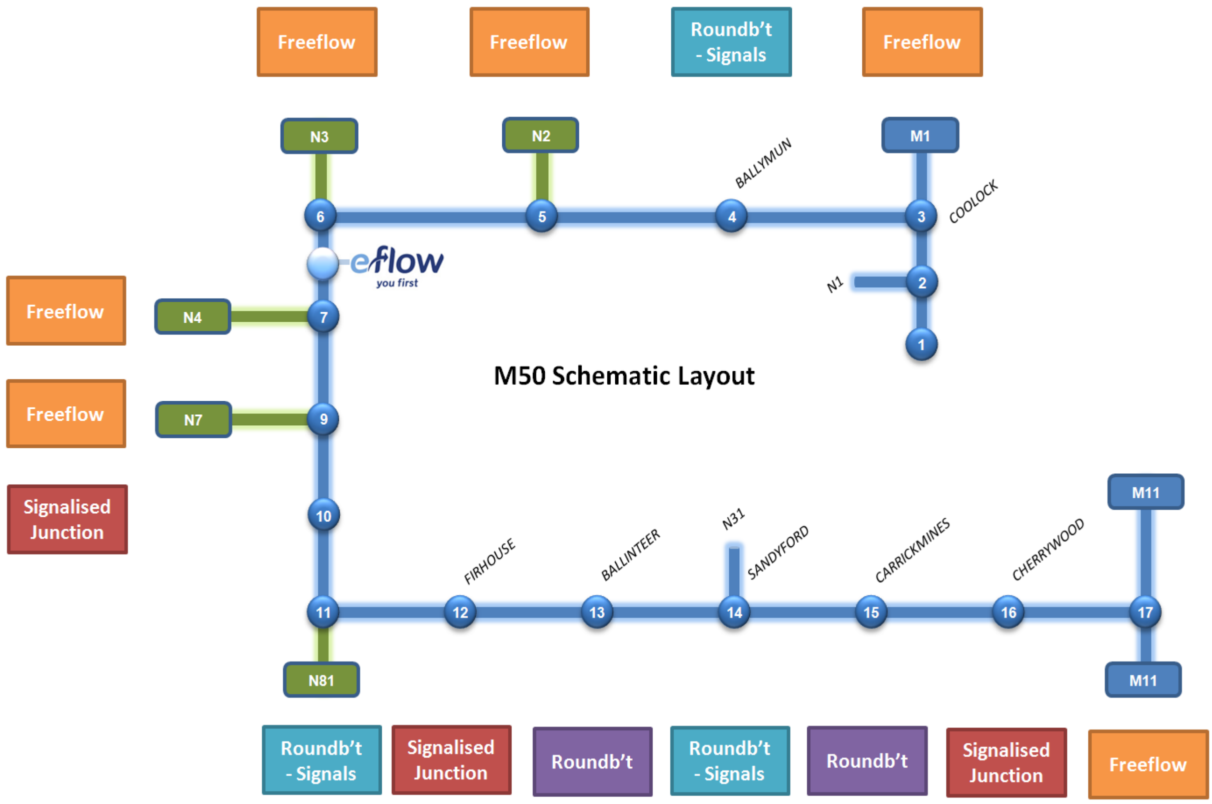

Figure 2.24 - Existing layout of M50 junctions

In this regard a number of site visits were undertaken, together with M50 maintenance contractor data, to identify existing issues at junctions. The junctions which experience consistent congestion/delays, and impact upon the operation of the M50, are outlined in Tables 2.1 and 2.2 below;

Table 2.1 - M50 Northbound Issues

Period	Location	Potential Reasons for Issues
AM	M1 Exit to M1 roundabout to N32	Intermittent queuing back to M50 Northbound
	Ballymun Exit to roundabout	Citybound traffic queues back on the auxiliary lane
	N2 Exit to city	Queuing from the signals at Joe Duffy and Charlestown junction
	Ballymount Exit to Industrial Estate	Intermittent queuing to the Ballymount Industrial Estate
	N81 Exit to roundabout	Intermittent queuing onto the auxiliary lane
PM	N7 Exit to N7 outbound	Queuing back from Newlands Cross
	N4 Exit to N4 outbound	Queuing from merge onto N4 outbound back into M50 NB Auxiliary Lane
	N2 Exit to city	Intermittent queuing

Table 2.2 - M50 Southbound Issues

Period	Location	Potential Reasons for Issues
AM	N7 Exit to city and N7 outbound	Congestion at merge points
	Ballymount Exit to Ballymount Industrial Estate	Problem since the M50 upgrade was complete in 2009. Traffic backs out from the Industrial Estate. Solution currently with SDCC to place a mini roundabout at one internal junction in the Industrial Estate
	Dundrum/Ballinteer) Exit	Back up from roundabout at bottom of slip
	Sandyford Exit (Leopardstown Rd)	Traffic backs up from within the Sandyford Business Estate. In 2012 changes were implemented to the ESB/Leopardstown Road Roundabout in 2012 which relieved the queuing, however queuing has since returned but not as prevalent
PM	N7 Exit to N7 outbound	Queuing back from Newland Cross

In addition to the above there are a two slip roads, listed below, that experience some queuing during the peaks but as yet the queues do not encroach on the M50. In the future, as demand increases, these queues may extend back to the M50 and cause issues for mainline traffic.

- J12 (Firhouse) Northbound Off Slip;
- J6 (M3) Southbound Off Slip.

With the exception of junctions with planned upgrades e.g. N7 at Newlands, it is envisaged the majority of the issues set out above will worsen as traffic flows increase in the future.

2.7 The Role of Demand Management

In summary, the assessment of existing conditions has found that a number of key sections of the M50 are already beginning to experience some form of congestion and that by 2023, about 50% of the M50 will be operating in excess of its safe operating capacity, with congestion commonplace.

On the basis of the discussion set out above, the requirements of demand management measures are as follows:

- Address the strong levels of growth in transport demand, predominantly through managing growth in the level of discretionary traffic, such that the strategic function of the M50 can be protected;
- Manage and mitigate the safety and reliability impacts that result from congested conditions, and which also threaten the strategic function of the M50; and
- To ensure flows in excess of the safe operating capacity are avoided on any section of the M50 for any sustained period.

In essence, these three requirements relate to the need to influence demand that may be attracted to the M50, and subsequently manage the traffic that nevertheless has chosen to use the M50. This suggests two very different forms of management, one based on giving a price signal to consumers which influences the generation of demand and the other based on controlling traffic flow which materialises, a distinction that has been recognised throughout the study.

3.0 Assessment of Potential Demand Management Measures

3.1 The Problem

The Identification of Need is one of the key requirements for the preparation of Business Cases, as referenced in the DTTAS Guidelines[4]. In essence, the need describes the problem that is to be addressed by the project. In this instance it is stated clearly in the Condition set out by An Bórd Pleanála, namely the protection of the capacity provided by the M50 Upgrade over its intended design life.

The National Roads Authority is charged with the management of the national road network, in such manner that the primary functions of the road network can be protected. It is widely accepted that national roads are an important driver of economic growth and competitiveness, supporting balanced regional development, and ensuring access to jobs, businesses and education, as well as securing connections between communities and markets.

Road space, for the most part, operates by demand being met on a first-come first-served basis. There are limited current interventions on national roads which allocate road space to those who need it most, apart perhaps from the Dublin Tunnel where capacity is specifically reserved for freight movement.

The subsequent behaviour of users leads to significant external impacts, where additional trips on the network lead to congestion, journey time, reliability and environmental impacts imposed on other users. This leads to significant inefficiencies in the demand for road space, particularly under congested conditions, where lower-value discretionary traffic can impact on the journey time of higher-value traffic (including business and freight) which is of greater importance to the national economy.

The analysis of existing conditions presented in Section 2 demonstrates a strong growth pattern on the M50 since the completion of the upgrade. The analysis suggests that the M50 is already approaching its limit of capacity, and in some cases this is already being exceeded at peak times.

In discussion within the Steering Group (comprising Dublin City Council, Dún Laoghaire Rathdown, Fingal and South Dublin County Councils and the NRA) it was considered that whilst traffic capacity of the M50 is static, this increasing demand is likely to lead to a number of consequential problems, which comprise:

- An erosion of the strategic function of the M50 as the hub of the National Road system most especially the motorway network;
- Consequential restraint on the transportation of goods and services and hence economic activity, both nationally and within the Greater Dublin Area;
- The increased risk of collisions that results from high-speed traffic flow in congested or near-congested conditions, and the subsequent risk of knock-on incidents that may result from traffic disruption; and
- Degradation in air quality and noise impacts as traffic flows increase to the point of congestion.

[4] *Guidelines on a Common Appraisal Framework for Transport Projects and Programmes: DTTAS: June 2009: Section 9.1.7.*

The objective of demand management is therefore to address such inefficiencies by ensuring a more optimised allocation of road capacity such that the maximum level of benefit can be derived from the provision of such roads. The indicative scheme of specific demand management measures that has been developed achieves this.

3.2 Specific Objectives of the Demand Management Measures

The objectives are the main frameworks that guided the development and assessment of alternative demand management solutions. Throughout the study, measures were benchmarked and evaluated against these Objectives, which were structured around the five criteria referenced in the Common Appraisal Framework. These are:

Economic Objectives:

- To maximise the value of the M50 (and the whole transport network) through reducing journey time and vehicle operation costs associated with congested conditions;
- To maximise the value of the M50 through improving the reliability of journey times;
- To support the study objectives in the most cost effective manner;

Integration Objectives

- To be consistent with and support other Local, National and EU Policies

Environmental Objectives

- To minimise network-wide transport emissions;
- To manage noise impacts in populated areas;

Safety Objectives

- To reduce the frequency and severity of collisions;

Accessibility and Social Inclusion Objectives

- To maintain and support access to business, employment, education, health and recreation, along with access to key export markets;

These objectives formed the basis for the comparison of alternatives.

4.0 Potential Demand Management Solutions

4.1 Definition and Analysis of Alternatives

4.1.1 Structure of Sifting

The demand management studies for the M50 examined the opportunities for using a wide range of measures, including Intelligent Transport Technology and Fiscal Measures to manage traffic demand.

As part of the NRA Traffic Management Study[5], a review of international experience in development and implementation of traffic and demand management strategies was undertaken. The case study review categorised the available implementation options into six categories, as follows;

- Fiscal Measures;
- Intelligent Transport Systems (ITS) or Traffic Control Measures;
- Traffic Control Centres;
- Smarter Travel measures;
- Other Measures; and
- Combined Initiatives.

4.1.2 Sifting of Potential Measures

The case studies allowed high level conclusions to be drawn regarding the benefits that different strategies and technologies could bring. When compared against the objectives described in Section 3 it was possible to undertake a sifting exercise to define those measures which should be brought forward for further consideration. The sifting exercise, along with a short summary of key considerations, is presented below in Table 4.1.

Table 4.1 - Sifting of Potential Demand Management Measures

Category	Measure	Initial Assessment	Possible ✓ Reject ✗
Fiscal	Single Point Tolls	Existing single point toll does little to support objectives – leads to diversion between N3 and N4 with limited impact elsewhere on M50	✗
	Distance Based Tolling	Strongly supports objectives and to be examined	✓
	Cordon Charging	Does not support objectives – leads to high diversion and resulting traffic impact associated with local trips	✗
	Toll by Time	Variable tolls supports scheme objectives, although it is recognised that this can be difficult to implement	✓
	Toll by Congestion	Would be difficult to achieve and is therefore not taken forward	✗
	Toll by Vehicle Type	Maintain existing mechanism, but examine reduction in level of HGV tolls	✓

[5] *National Roads Traffic Management Study: National Roads Authority, February 2011*

Category	Measure	Initial Assessment	Possible ✓ Reject ✗
	Analysis of tolling options and resulting impacts suggests that the objectives of the study can be best met through the development of a distance based system which varies by time and charges a lower individual toll at each point. This achieves the objectives of a distance based system, but can be delivered as an expansion of the existing free-flow tolling operation and at limited technical risk.		
ITS / Control	Access Control	Only feasible at a small number of individual sites, mainly along South Eastern motorway.	✓
	Incident Detection	Can lead to strong benefits. Existing Dublin Port Tunnel (DPT) system could be extended through full M50	✓
	Variable Speed Limits	Good safety benefits at higher flows	✓
	Intelligent Markings	Limited potential on M50	✗
	It is proposed that Incident Detection and Variable Speed Limits form part of the management of the M50 in the short to medium term. Access control is only feasible at a small number of locations, and will be examined as such.		
Capacity	Reversible Lanes	No real potential on M50 due to requirement for additional width	✗
	Hard Shoulder Running	Not technically feasible other then on South Eastern motorway. This will be examined	✓
	There are no practical means of increasing capacity between Junction 3 and Junction 14 either through reversible lanes or hard-shoulder running. Hard Shoulder Running can be delivered beyond Junction 14, and will be examined.		
Priority	High Occupancy Lanes	Case studies and high level feasibility study suggests limited potential as a standalone measure	✗
	High Occupancy Toll Lanes	Could only be implemented in areas where there are no background tolls. A potential alternative to distance-based tolling of the M50.	✓
	Public Transport Lanes	Limited public transport demand along M50, and hence would cater for small number of users to detriment of others	✗
	Freight lanes	Provides benefits to HGV's but would lead to net increase in congestion at current levels of HGV activity as HGV lanes would operate significantly below capacity to the detriment of other users denied use of the lane.	✗
	Public Transport Freight Lanes	Caters for higher number of users, but may need VSL to function properly. HGV and freight are low proportion of M50 traffic and hence may still lead to net increase in congestion. May become necessary where congestion is unavoidable (i.e. where there is no background fiscal	✗

Category	Measure	Initial Assessment	Possible ✓ Reject ✗
		strategy) to maintain strategic function.	
	Public Transport Freight Toll Lanes	Maximises lane efficiency, but could only be implemented in areas where there are no background tolls	✓
	The concept of Public Transport Freight (PTF) Lanes has been suggested as the most appropriate means of delivering priority. This might best be achieved through reallocation of the fast lane, but only under conditions where variable speed limits are activated. A facility for tolled use by other vehicles could be allowed in situations where there are no background tolls. This may be a part-time measure only.		
Information	Internet	Low cost measure with good benefits	✓
Information	Telephony	Limited use and high costs warrant unsuitable, unless this can be provided as added-value to an existing facility.	✗
Information	Roadside Information	Adopt to supplement other systems only	✓
Information	In-Car Systems	Will become available soon, although these are not considered specific to the M50	✗
Information	*Other than roadside information, measures will be delivered regionally or nationally, and are not specific to the M50.*		
Smarter Travel	Travel Planning and Awareness	Measures to be considered which can support in managing M50 demand	✓
Smarter Travel	Planning Policies	Development adjacent to national roads is covered under the DoE Spatial Planning Guidelines[6]	✓
Smarter Travel	*Support travel planning at local level, supported by relevant planning policies at national level.*		
Control	National Control Centre	To be progressed should the study identify a need for traffic control measures supported by a control centre	✓
Control	Regional Control Centre	Limited potential	✗
Control	Network Patrols	Existing arrangements could be extended	✓
Control	*National Control Centre will initially locate in the Dublin Port Tunnel, and control of M50 could represent an initial phase of the rollout of the centre.*		

The measures brought forward for further investigation and analysis are summarised in Table 4.2.

[6] *http://www.environ.ie/en/DevelopmentHousing/PlanningDevelopment/NationalSpatialStrategy/*

Table 4.2 - Summary of Measures to be Considered Further

Category	Measures Taken Forward
Fiscal Measures	• Distance-Based Tolling • Tolling by Vehicle Type and Time of Day
Intelligent Transport Systems	• Variable Speed Limits • Incident Detection • Access Control
Capacity Enhancements	• Hard Shoulder Running
Priority Measures	• High Occupancy Toll Lanes • Public Transport/Freight/Toll Lanes
Information	• Internet • Roadside Information
Smarter Travel	• Travel Planning • Planning Policies
Control	• National Traffic Control Centre • Network Patrols

The resulting measures scheduled above are discussed in greater detail in the sections below. Each section describes the feasibility work and other analysis that has been undertaken in respect of each, concluding on its ability to support the required objectives.

4.2 Analysis Tools

4.2.1 Overview

In order to undertake a robust assessment and appraisal of the potential measures a detailed traffic model was developed specifically for the project. The Dublin Area Traffic Model is a local area model encompassing the M50 and the wider network within Dublin and was developed based on the National Transport Authority (NTA) Greater Dublin Area (GDA) model supplemented by traffic pattern and demand data collected in 2010. Initially the tests were undertaken using the 2010 demand model only with outputs factored to future demand levels externally using appropriate growth factors. This approach is likely to have underestimated the benefits associated with the measures since, as described in Section 2.5, future congestion levels would be expected to increase significantly once capacity has been reached. Therefore the initial assessment of the benefits is considered conservative and has been undertaken to ensure the feasibility of the indicative scheme. It is recommended that should the scheme be brought forward to the next stage, traffic models are developed for future years which would take full account of decongestion and other potential scheme impacts.

Future year traffic forecasts were subsequently developed based on the methodology set out in *5.3 Traffic Forecasting* of the NRA PAG. That guidance sets out separate methodologies for establishing trip end growth for internal and external zones within a local area model (LAM).

To enable the development of growth factors for the NTA zones contained within the Dublin Area Traffic Model, a relationship was established between NTA zones and the zones contained within the NRA's National Traffic Model (NTM).

The NTM is made up of 874 zones, each of which contains demographic data (population, employment and car ownership) for a base year of 2010 and forecast years of 2025 & 2040. Demographic data is available for three future year growth scenarios namely NRA Low, Medium and High. The future year traffic forecasts for the NTM are based on demographic and economic projections which have been prepared at a zonal level. The medium growth projections are consistent with aggregate forecasts prepared by the Central Statistics Office scenario M0F1 which assumes zero net-migration. High and Low projections represent upper and lower bounds on anticipated growth over the same period. The NTM uses a Trip Attraction Generation Model (TAGM) to convert these demographic and economic indicators into trip ends for each NTM zone. Therefore future year growth in traffic for the Dublin Area Traffic model is based on the forecast growth in population and employment within the study area.

4.2.2 Future Demand Forecasts

The trip matrix totals 2010, 2023 and 2038 are outlined in the tables below.

Table 4.3 – Total Growth in Study Area 2010 - 2023

Scenario	2010 Matrix Total	2023 Matrix Total	Overall Growth	% Growth 2010 - 2023
Low	234,719	271,823	37,104	15.8
Medium	234,719	280,548	45,829	19.5
High	234,719	314,780	80,061	34.1

Table 4.4 – Total Growth in Study Area 2010 - 2038

Scenario	2010 Matrix Total	2038 Matrix Total	Overall Growth	% Growth 2010 - 2038
Low	234,719	289,135	54,416	23.2
Medium	234,719	304,571	69,853	29.8
High	234,719	361,941	127,223	54.2

4.3 Fiscal Measures

4.3.1 Overview

The positioning of toll points on the road network requires consideration of a number of variables, all of which influence the impact of the tolls on the surrounding road network. These include considerations such as:

- The number of toll points to be provided;
- The charge to be levied at each toll point;
- The differential in charges between classes of user, and payment types;
- The impact on the surrounding network;
- The resulting proportional cost of toll collection; and
- The net financial position.

4.3.2 Distance-Based Charging using Satellite Positioning Systems

Although satellite based road pricing for all vehicles is based on sound economic theory, it has yet to be implemented on anything beyond a user trial. A National Road Pricing Scheme, using global navigation satellite system (GNSS) with every vehicle equipped with a GNSS-enabled on–board unit to enable distance-based road charging, was prepared for the Netherlands in 2010. The system was successfully trialled in Eindhoven but was suspended in 2012. This Dutch experience to date highlights the myriad of challenges in successfully bringing a project of this scale into the delivery phase (not to mention mobilisation and successful operation) and suggests that an Irish national scheme could take several years to plan and implement. We note that there remains no international experience in successful implementation of full road user charging of this nature.

The main issue restricting the use of the GNSS systems is risk – the capital cost for the Dutch system was estimated at up to €2.5bn, with an operating cost of up to €1bn per annum. Further work would be required to fully understand the cost of implementing and managing such a system as there are no existing systems upon which estimates can be made. In addition, the management of such a system which only operates in one part of a network would be difficult.

4.3.3 Distance-Based Charging using Open or Closed System Multi-Point Tolling

Point tolling uses physical gantries that apply charges to traffic passing them, and hence relies on the ability to capture high proportions of traffic at a single location.

Single point tolling has worked well in urban areas but normally only at tunnels or bridge crossings where alternative routes are relatively long and the cost of the infrastructure is high. On urban motorways, the use of Single Point tolls is more difficult due to the shorter distances between junctions and the consequential ability of users to divert away from short stretches of road in order to avoid the toll at that point. In order to combat this effect, authorities either:

- Develop a closed system, where the payment is calculated on the basis of a recording at both the entry and exit point (closed system multi-point tolling); or
- Develop an open system, where the toll is collected on the basis of a number of individual low-value payments at specific locations along the journey (open system multi-point tolling).

Both these systems were examined as a means of providing a fiscal solution for the M50. It was concluded that both an open and closed system represent viable options for the M50.

Initial analysis showed that as few as four or five toll points at key sections of the M50 would capture more than 80% of trips on the M50. A closed system would capture 100% of trips but would essentially require thirteen toll points (between each junction from J3 to J17) or the equivalent by means of detection of entries and exits at each junction.

On this basis, an assessment of potential solutions for an Open-System Distance-Based Multi Point Toll on the M50, using a range of toll points, was undertaken to enable an understanding of the costs, benefits and impacts of such a solution. Such a system could be designed to provide the flexibility to allow the system to be developed into a closed system in the future if required.

4.3.4 Analysis of Open Distance Based Multi-Point Tolling Solutions on the M50

The range of distance based multi-point tolling options on the M50 hinges on the number of toll points that can be implemented, which in turn defines the appropriate level of charge at each.

Some 27 scenarios were considered for a distance based multi-point tolling solution on the M50 and these can be classified into the following three categories:

- Those which maintain the existing M50 eFlow toll, and provide further lower-value tolls in other locations;
- Provision of consistent toll values at different locations, in order to simplify readability of the system; and
- Provision of different tolls at different locations, including a reduction at the existing toll

location, in order to understand the effects of charging more on longer sections and less on shorter sections, albeit leading to a more complex system.

These scenarios above were input into the Dublin Area Traffic Model and the outputs used as the basis for a comparison of the impacts. Each scenario was assessed using this model based on a number of outputs as per below.

- Overall Network Performance Indicators – Travel Time and Travel Distance;
- The level of toll avoidance at each toll point (Environmental Impact);
- Total Revenue Generation;
- Collection Costs; and
- Traffic Flows - Lane Capacity along each Link.

Five scenarios were brought forward from the initial comparative exercise and were subjected to more detailed testing. This suggested that the inclusion of five tolls would provide significant benefits in terms of demand management. As such a five point toll was used to prepare a feasibility study for Distance Based Multi-Point Tolling on the M50, with the tolls located in the following sections:

- R108 Ballymun to the N2;
- N3 to the N4 (site of existing eFlow);
- N4 to the N7;
- Firhouse to Ballinteer; and
- Sandyford to Carrickmines.

Following on from the above analysis a detailed engineering feasibility exercise was undertaken for each of the five tolling sites proposed. This exercise found that locating a toll gantry on the M1 – Ballymun section may be problematic due to the distance between the junctions. The separation between these junctions is only 2.5km which reduces by a further 0.5km for traffic entering via the eastbound on-ramp at Ballymun. In addition to this, the first lane direction gantry for the M1/M50 junction is just east of the Ballymun merge which results in junction lane weaving movements commencing nearly 2km before the M1 junction, and therefore there is effectively no real separation between the two junctions in the eastbound direction for the purpose of locating a toll gantry that does not potentially compromise the lane direction signs approaching the M1. It was therefore decided to locate the toll gantries on the Ballymun – N2 section and on the East facing slips of the Ballymun junction. This arrangement will perform the same role as the previous toll locations. In order to ensure the southerly toll location performs it demand management role and to mitigate against any inappropriate diversion routes both the Sandyford – Carrickmines section and the west facing Sandyford Interchange slips are tolled.

4.3.5 Indicative Distance Based Variable Multi-Point Tolling Solution on the M50

The emerging preferred option for a Multi-Point Tolling solution on the M50 is set out in Figure 4.1.

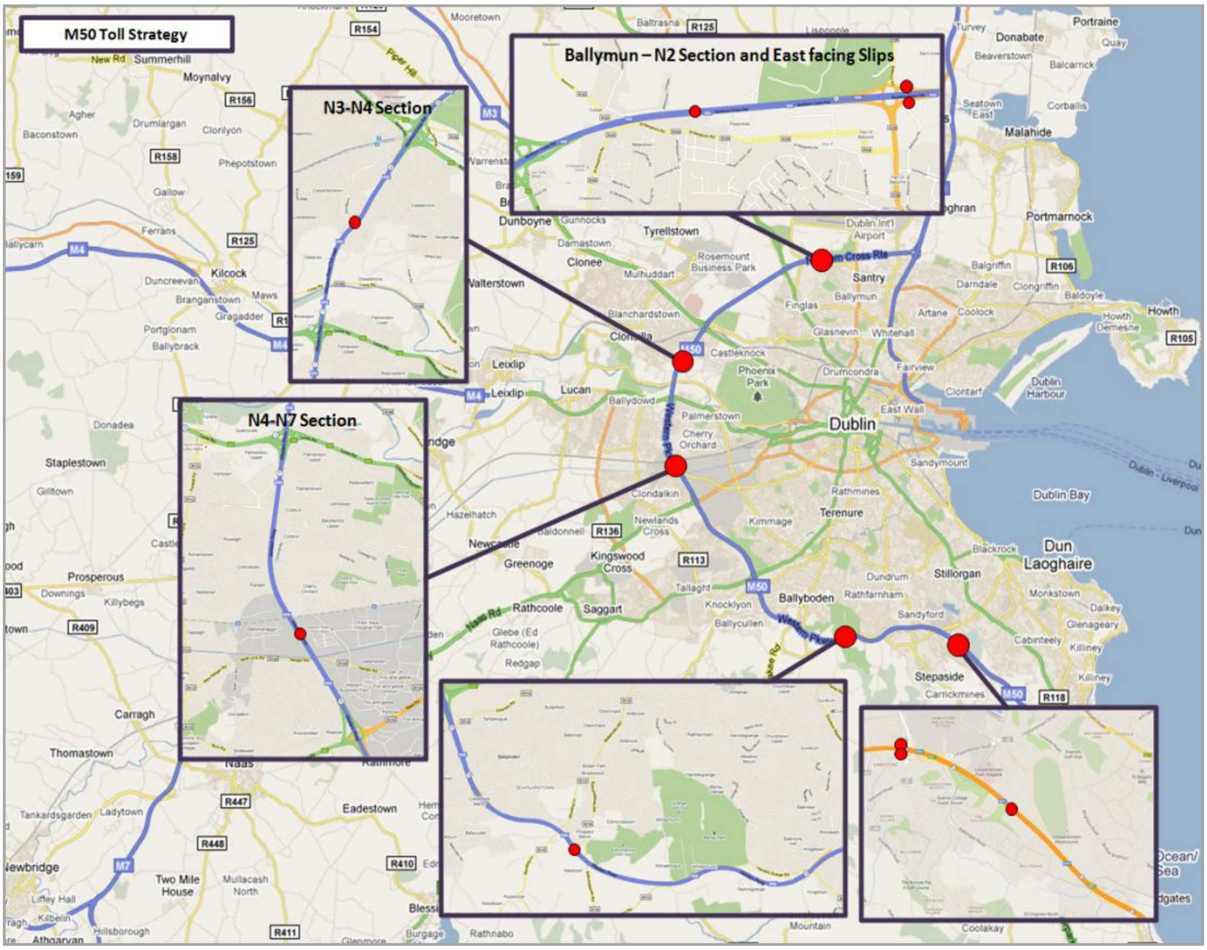

Figure 4.1 - M50 Distance Based Multi-Point Tolling

It is acknowledged that the solution presented here may be subject to review at an appropriate time, should there be a decision to proceed with such a scheme for the M50. The operating cost and accuracy of toll collection equipment and processes are constantly changing. In this regard, it is prudent prior to implementation to undertake a review of the Multi-Point solution, in addition to giving greater consideration to a closed system.

4.3.6 Toll Rates for Car Users and Light Vehicles

The determination of the toll rate at each location requires a delicate balance between the level of toll avoidance that will be generated, the need to cover toll operation costs and achieving an adequate reduction in demand on the M50. The level of registration of users also impacts the toll charge.

Through the continued imposition of an unregistered transaction levy, and the greater geographical coverage of tolling points, it is expected that the level of registration will increase to between 85% and 95% of users. The detailed traffic modelling undertaken identified the impacts of the system using average tolls of between €1.16 and €1.45, with the higher toll achieving a higher degree of demand management.

In determining the indicative system of tolls it was assumed that non-registered users will pay €1.00 more than registered (in line with the existing eFlow cost differential between tag registered users and unregistered users) to take account of the higher collection costs. Assuming the higher level of registration of 95% a toll rate range of €1.11 - €1.40 (for registered users) is appropriate. From a practical perspective it has been assumed that tolls will be rounded to nearest €0.10 and as such the range of peak period toll rates are suggested to be €1.20 - €1.40 for registered and €2.20 - €2.40 for non-registered users.

To align with the objective of managing demand variable toll rates will be applied for peak, inter-peak and off-peak periods. It is considered appropriate that the off-peak toll rate for car users that travel the full length of the M50 should be similar to the rate they pay at the moment (€2.10 for registered). An off-peak rate of €0.40 would give a toll of €2.00 for travelling the full length, and a rate of €0.50 a toll of €2.50.

It is considered appropriate also that inter-peak toll rates are set to reflect the fact that inter-peak demand is nearer peak levels than off-peak levels, i.e. not simply a mid-way point between the upper and lower values.

Based on the above the proposed indicative toll rate ranges for cars are shown in Table 4.5 below.

Table 4.5 - Indicative Ranges for Car Toll Rates at Individual Toll Points

Toll Type	Peak Period Toll Cost		Inter-peak Toll Cost		Off-peak Toll Cost	
	Low	**High**	**Low**	**High**	**Low**	**High**
Registered	€1.20	€1.40	€0.90	€1.10	€0.40	€0.60
Unregistered	€2.20	€2.40	€1.90	€2.10	€1.40	€1.60

NB: Toll rates are shown at 2013 levels. At time of implementation appropriate indexation will be applied to these rates.

4.3.7 Toll Rates for HGV's

The Eurovignette Directives[7] set the rules on the charging of heavy goods vehicles for the use of certain infrastructure. In accordance with these rules the following principles apply:

- HGV tolls **shall** vary by emissions class
- HGV tolls may vary by time of day
- Peak period **shall** not exceed 5 hours per day (i.e. 2 x 2.5 hours peaks)
- HGV's **shall** be charged an infrastructure charge (up to a maximum figure)
- HGV's may be charged an external cost charge

This infrastructure charge is based on the principle of the recovery of the construction costs and the costs of operating, maintaining and developing the infrastructure network concerned. Such a charge would be levied via the implementation of an HGV toll as part of the fiscal strand of the indicative M50 Demand Management scheme.

The costs of the M50 upgrade and installation of tolling equipment, along with the costs of operating and maintaining the M50 and this equipment over a 30 year useful life, were identified and apportioned between different classes of vehicle based on expected volumes of traffic and the different levels of damage caused by different classes of vehicle. From this the share of the total costs that can be associated with HGVs was identified.

The Directive requires that the present value of the tolls paid by HGVs must be no greater than the present value of the construction, operation and maintenance costs associated with HGVs. This effectively sets a maximum average toll per HGV journey which is based on expected traffic volumes.

[7] *EU Directive 1999/62/EC of 17th June 1999, OJ L 187/42 of 20.7.1999 as amended by Directive 2006/38/EC of 17th May 2006, OJ L 157/8 of 9.6.2006 and Directive 2011/76/EU of 27th September 2011 OJ L 269/1 of 14.10.2011*

The present value of the total costs of upgrading, operating and maintaining the M50 has been calculated to be €957m (as at 2010). Of these costs 38%, or €367m, has been identified as attributable to HGVs (vehicles >2 tonnes).

To comply with the Directive any future actual toll system will need to have a range of different HGV tolls for different emission class of vehicle. The existing eFlow system has a range of HGV tolls that vary by types of HGV vehicle but not by emission class. At this stage the indicative scheme of M50 Demand Management measures put forward will include variable tolls for different times of the day and different vehicle types. A future scheme will require differentiation by emission classes.

In order to inform the range of HGV toll rates being proposed as part of the indicative M50 Demand Management scheme a calculation was undertaken to identify the maximum "average" toll that could be applied to HGVs so as to comply with the maximum revenue requirement of the Directive. This average maximum toll is the toll paid by per HGV trip on the M50, i.e. not simply the toll paid at any one toll point. Therefore the M50 traffic model was interrogated to identify the average number of the five proposed toll points that HGV traffic would pass. This was identified as 1.47 toll points. The resulting average maximum toll rate at each individual toll point is shown in Table 4.6.

Table 4.6 - Maximum Average M50 HGV Toll

	HGVs (2 – 10t)	HGVs (>10t)	HGV All
Maximum Average Toll (€) per M50 Trip	3.80	6.27	5.16
Maximum Average Toll (€) at Each Toll	2.59	4.27	3.51

As highlighted earlier, the indicative scheme will include variable toll rates which will be applied for peak, inter-peak and off-peak periods. One requirement of the Directive is that the peak period applied to variable tolls **shall** not exceed 5 hours per day (i.e. 2 x 2.5 hours peaks).

In order to define the limits of the three periods traffic flow and speed data was collated for the five proposed toll locations and the total two way flows on the M50 for all the tolling sites proposed in Figure 4.1 above were combined as shown below in Figure 4.2. The figure shows the occurrence of significant peak periods but also highlights the significant difference between the interpeak i.e. period between two peak periods and the off peak i.e. night time period.

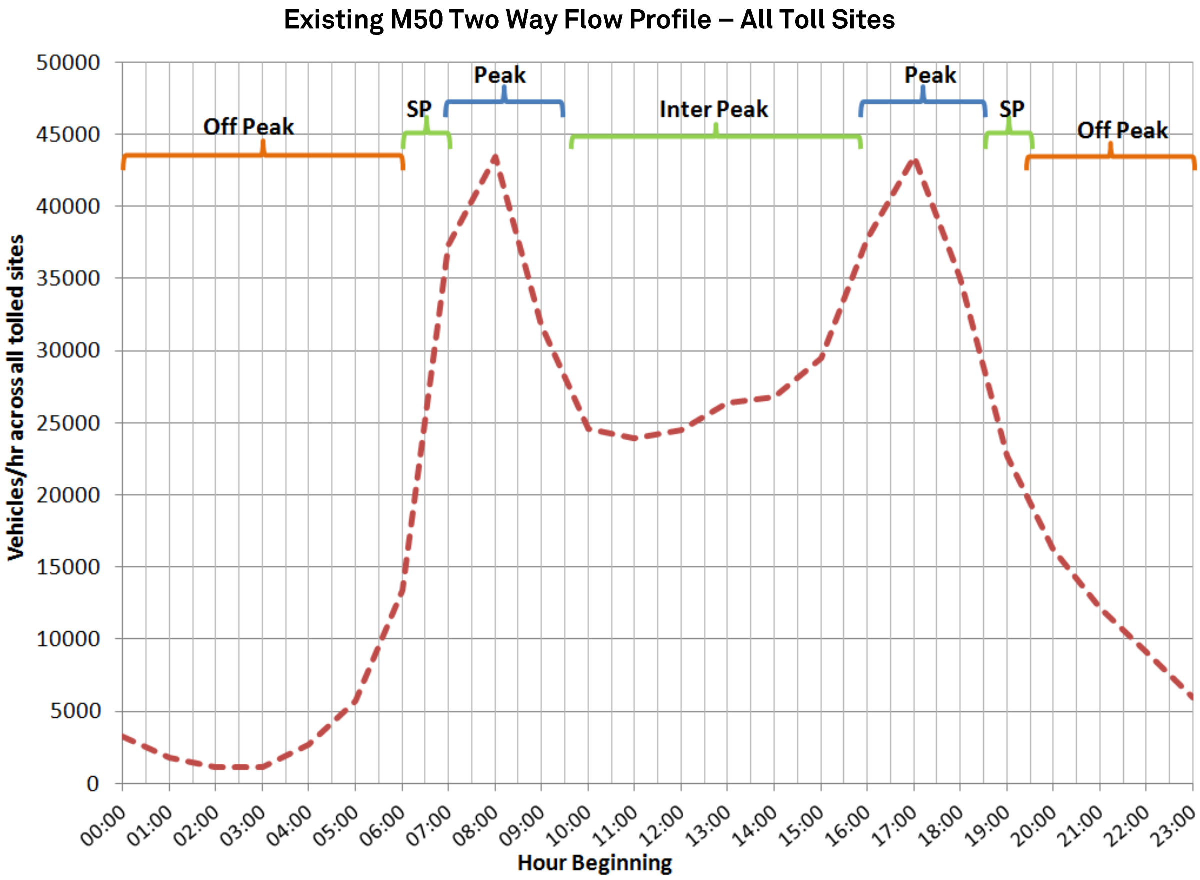

Figure 4.2 – Proposed Peak, Inter-peak, Shoulder-peak and Off-peak periods based on actual M50 flow profile for proposed toll locations

From a practical perspective the times of day for peak tolls for HGV's have to be the same as the peak periods for cars/light vehicles and as such the peak periods are limited to a 2.5 hour period.

Based on this the following periods are proposed, as shown in Figure 4.2.

Peak periods (2 x 2.5 hours):

- 07:00 - 09:30
- 16:00 - 18:30

Inter-peaks / Shoulder-peaks:

- 06:00 – 07:00
- 09:30 – 16:00
- 18:30 – 19:30

Off-peak:

- 19:30 – 06:00

In order to be able to ensure that the average HGV toll at each point is less than the average maximum allowed under the Directive the daily HGV flow profile on the M50 was interrogated to identify the proportion of HGV's in the peak, inter-peak and off-peak periods.

The proportion of the HGV flow in each of these three periods is shown in Table 4.7 below.

Table 4.7 - Proportion of HGV Flow for Each Period

	Peak	Inter-Peak/ Shoulder-peak	Off-peak
Percentage of HGV Flow	29%	61%	10%

In setting toll rates (infrastructure charge) for HGV's care needs to be taken to ensure that they are not set so high as to result in HGV's diverting onto alternative routes but instead result in HGV's varying their time of travel outside of peak periods. With this in mind it is considered that the off-peak toll rate for HGV's that travel the full length of the M50 should be similar to the rate they pay at the moment. Accordingly Table 4.8 below shows the proposed off-peak toll rates for HGV's.

Table 4.8 - Proposed Off-peak HGV toll rate

	HGVs (2 – 10t) 45%	HGVs (>10t) 55%	HGV Ave
Existing eFlow Toll (€)	4.20	5.20	4.75
Proposed Off-peak Toll @ Each Point (€)	0.80 – 1.00	1.00 – 1.20	0.90 – 1.20
Proposed Off-peak Toll Full M50 (€)	4.00 – 5.00	5.00 – 6.00	4.50 – 5.50

In setting inter-peak/shoulder-peak and peak toll rates they should be set at a rate that will not lead to HGV traffic diverting off the M50, but which encourages use outside of the peak period, as well as the rates taking account of, and being less than, the average maximum toll rate allowed under the Directive. Based on the above the proposed indicative HGV toll rate ranges are shown in Table 4.9.

Table 4.9 - Proposed HGV Toll rates

	HGVs (2 – 10t)	HGVs (>10t)	HGV Ave
Proposed Peak Toll @ Each Point (€)	2.30 – 2.60	3.60 - 3.90	3.02 – 3.32
Proposed Inter-peak/Shoulder-peak Toll @ Each Point	1.60 – 1.90	2.90 – 3.20	2.32 – 2.62
Proposed Off-peak Toll @ Each Point (€)	0.80 – 1.00	1.00 – 1.20	0.91 – 1.11
Average HGV Toll @ Each Point (€)	1.72 – 2.01	2.91 – 3.20	2.38 – 2.67
Max Average Toll @ Each Point (€)	2.59	4.27	3.51
Percentage of Maximum Toll	67% – 78%	68% - 75%	68% - 76%

NB: Toll rates are shown at 2013 levels. At time of implementation appropriate indexation will be applied to these rates.

It is noted from the above that the average proposed HGV toll rate ranges are significantly less than the maximum allowed under the Directive.

4.3.8 Summary of Indicative Toll Payment Ranges

A summary of typical toll payments by vehicles has been presented below in Tables 4.10 – 4.12. The tables show the scale of the average payments made, and the equity of the existing and proposed arrangements. The analysis shows that the capture rate will increase from 39% to 81%, providing a more equitable means of contribution to the tolling activities.

*Table 4.10 - Summary of Tolls Paid by M50 Users for Indicative Scheme – **Peak Hours***

	Existing Single Point			Proposed at Each Point	
	Tag	Video	Unregistered	Registered	Unregistered
Toll for Cars	€2.10	€2.60	€3.10	€1.20-1.40	€2.20-2.40
Tolls for HGV 2t - 10t	€4.20	€4.70	€5.20	€2.30-2.60	€3.30-3.60
Tolls for HGV > 10t	€5.20	€5.70	€6.30	€3.60-3.90	€4.60-4.90
Tollable Traffic	39%			81%	
Ave Toll Paid	€2.50			€1.25 - 1.45	

NB: Toll rates are shown at 2013 levels. At time of implementation appropriate indexation will be applied to these rates.

*Table 4.11 - Summary of Tolls Paid by M50 Users for Indicative Scheme – **Inter Peak/Shoulder-peak Hours***

	Existing Single Point			Proposed at Each Point	
	Tag	Video	Unregistered	Registered	Unregistered
Toll for Cars	€2.10	€2.60	€3.10	€0.90-1.10	€1.90-2.10
Tolls for HGV 2t - 10t	€4.20	€4.70	€5.20	€1.60-1.90	€2.60-2.90
Tolls for HGV > 10t	€5.20	€5.70	€6.30	€2.90-3.20	€3.90-4.20
Tollable Traffic	39%			81%	
Ave Toll Paid	€2.50			€0.95 - 1.15	

NB: Toll rates are shown at 2013 levels. At time of implementation appropriate indexation will be applied to these rates.

*Table 4.12 - Summary of Tolls Paid by M50 Users for Indicative Scheme – **Off-Peak Hours***

	Existing Single Point			Proposed at Each Point	
	Tag	Video	Unregistered	Registered	Unregistered
Toll for Cars	€2.10	€2.60	€3.10	€0.40-0.60	€1.40-1.60
Tolls for HGV 2t - 10t	€4.20	€4.70	€5.20	€0.80-1.00	€1.80-1.90
Tolls for HGV > 10t	€5.20	€5.70	€6.30	€1.00-1.20	€2.00-2.10
Tollable Traffic	39%			81%	
Ave Toll Paid	€2.50			€0.45 - 0.65	

NB: Toll rates are shown at 2013 levels. At time of implementation appropriate indexation will be applied to these rates.

4.3.9 Implementing Variable Tolls

As set out above, variable tolls have been considered by vehicle type and by time of day. Whilst imposing a uniform toll for all vehicle types was considered, this was discounted as it does not support the principles set out in the European Transport White Paper[8], which seeks to move towards a user-pays basis for road charging. As heavy vehicles generate additional congestion and greater levels of road wear and tear, a uniform toll would lead to a situation whereby freight would be subsidised by other users.

With regard to time of day tolling, it is noted that with a multi-point system users would expect knowledge of the full range of tolls that they would be required to pay before choosing a route and time. Accordingly, implementation of the indicative scheme should include the provision of information on variable toll rates as part of the information provided by traffic websites and other trip-related information channels, including variable message signing displaying the applicable

[8] *White Paper "Roadmap to Single European Transport Area – Towards a competitive and resource efficient transport system" COM(2011)144, 28th March, 2011*

toll rates upon entry to the M50.

4.3.10 Consideration of Applying Maximum Daily Charges

The basis for the system set out in this report is founded on a 'user pays' principle, which seeks to charge users for road use on the basis of usage. In other words, the charge increases as the use of the network increases, translating into higher charges for more frequent use or longer distance trips.

Nevertheless consideration was given to the possibility of introducing a maximum charge (either trip based or daily based) that seeks to reduce the financial burden on those who use the system most frequently, or make relatively long trips. In order to accord with the principles in the European Transport White Paper[9], at this stage it is not considered appropriate for such a maximum charge to be included as part of the indicative scheme, although it is anticipated that charges would be continually monitored to ensure that no one user group or trip type was being unfairly disadvantaged.

4.3.11 Tolling Technology

The tolling system will use the technology that is currently employed at the M50 eFlow toll point. The following is required as part of the roadside installation:

- Gantries (2 gantries per toll site per direction);
- A vehicle presence detector;
- Cameras with Automatic Number Plate Recognition (ANPR) technology for recording video-registered customers;
- Directional Short Range Communications (DSRC) beacons for reading the On Board Units (OBU or "tag") of tag-registered customers; and
- Wired communications systems for transfer of data to the back office;

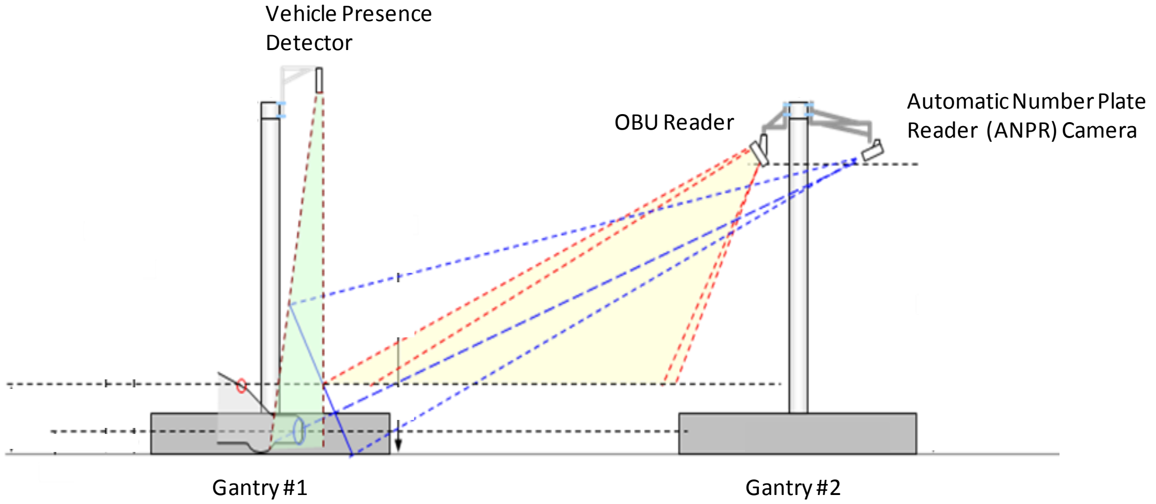

Figure 4.3 - Road User Charging Installation

In addition to the standard installation set out above, it is also proposed to include rear-facing ANPR cameras to support the image recognition process. This will further improve the quality of

[9] *White Paper "Roadmap to Single European Transport Area – Towards a competitive and resource efficient transport system" COM(2011)144, 28th March, 2011*

number plate recognition.

At the back office, a number of investments are necessary to ensure that the existing operation can successfully manage the transition to a multi point system. These include a new system for transaction management which is currently configured for a single point system only. The required investment in the back office is included in the scheme cost for the indicative M50 multi point tolling scheme.

4.4 Intelligent Transport Systems/Traffic Control

4.4.1 Variable Speed Limits

The study has examined the practicality and effectiveness of Variable Speed Limits (VSL) along the M50. Good guidance exists on the implementation of VSL, as does good information on its impacts and benefits. The feasibility studies have highlighted that much of the infrastructure currently exists for the provision of VSL along the M50 between the M1 (Junction 3) and Firhouse (Junction 12).

In order for a VSL to be adopted as an efficient means of reducing overall travel time on any network, a number of conditions should exist, such as a drop in capacity at the end of a congested area, the ability to limit the flow of traffic into the congested area, lane gains at merges and a sufficient length of motorway to control the flow of traffic into the congested area.

Based on the conditions outlined above, the section of the M50 between Junction 3 (M1) and Junction 12 (Firhouse) is suited to the implementation of VSL, and would be expected to have a notable impact on journey time reliability and safety as the M50 experiences periods of near-congestion. In addition, consideration could be given at a future date to extending VSL south from Firhouse to manage congestion and improve reliability and safety along the full length of the M50 to the N11 junction (Junction 17).

4.4.2 Incident Detection

The studies have included the provision of Incident Detection as a key strategy for managing demand along the M50. The MIDAS Incident Detection system is proposed on the basis that much of the necessary infrastructure has already been provided (MIDAS loops were installed as part of the M50 contract in anticipation of a subsequent requirement for incident detection and management).

Outstanding requirements comprise the provision of an appropriate incident management desk within the Traffic Control Centre, and the establishment of lines of communication between the incident room, key media outlets and the emergency services. The detection and management of incidents will reduce the safety risks associated with knock-on incidents following a collision or breakdown, and provide ample warning to other road users of potential disruption such that this can be taken into account in trip planning. Guidance developed by the Highways Agency[10] outlines that at a lane flow greater than 15,000 AADT, the case for Incident Detection is strong. This guidance is set on the basis of standard unit rates for the provision of MIDAS infrastructure on existing roads. MIDAS infrastructure, in the form of gantries, loops, telephonic systems, ANPR and cabling, was installed on the M50 as part of the recent upgrade, as a result the marginal cost for operation of the Incident Detection function using this infrastructure will be reduced . The study concluded that there is a strong case for the delivery of Incident Detection on the M50 using

[10] *TD45/94: Motorway Incident Detection and Signalling: Highways Agency: December 1994*

this method, supported by the Traffic Control Centre.

4.4.3 Ramp Metering

Ramp metering may be defined as the installation of traffic signals on a grade separated junction on-ramp in order to regulate the flow of traffic joining a motorway or dual carriageway. The purpose of ramp metering is to prevent or delay the onset of traffic flow breakdown on the main carriageway, maximising throughput whilst attempting to minimise disruption to the local road network. This measure is usually implemented to improve congested conditions during peak traffic flow periods.

There are a number of aspects that need to be considered as part of any assessment of the feasibility of implementing ramp metering at a particular site. These are the traffic conditions, the geometric layout and existing safety conditions.

In order for ramp metering to be effective, a road must experience significant delay which can directly or indirectly be attributable to traffic merging at an on slip. It is necessary to consider traffic conditions relating to three separate elements of the road network prior to assessing site suitability. These are mainline traffic flow, the on-slip traffic flow and traffic flow on the adjacent local road network.

It has been found through experience that sites which have the following characteristics can benefit greatly from ramp metering if the site is well designed and the correct metering strategy can be applied:

- Short or sub-standard merge areas;
- Where a bottleneck exists downstream on the main carriageway such as a bend or a gradient;
- Two lane on-slips which have been artificially reduced to one lane in an attempt to restrict joining traffic;
- Sufficient distance between the stop line on the merge and the main carriageway for vehicles to accelerate to the desired operational speed; and,
- Ability to store a sufficient number of vehicles such that, when queuing occurs, impact to movements on the adjacent local traffic network is minimised.

The assessment of sites has concluded that the number of junctions suitable for Ramp Metering on the M50 is relatively limited, and is confined to the South Eastern Motorway. This is mainly due to the provision of Free-flow junctions and Lane Gains on the M50 between Junction 3 and Junction 12. East of Junction 12 (Firhouse), the M50 is more geometrically suited to the provision of Ramp Metering but much of the existing disruption is associated with diverging activity and queuing on exit ramps. Ramp Metering will not address this problem, with the exception of a short-term scenario at the Cherrywood Northbound merge.

In summary the work concluded that ramp metering would not provide benefits to the M50.

4.5 Capacity Enhancement

4.5.1 Hard Shoulder Running

A feasibility study of the provision of Hard Shoulder Running on the M50 has demonstrated that the current cross section is not compatible with the use of the hard shoulder as a running lane. The current design standard for the width of the hard-shoulder is 2.5m, with 3.5m running lanes.

There is no potential for reorganising the cross section to provide for Hard Shoulder Running without additional widening of the carriageway, or a reduction in the width of running lanes to 3.3m. The South Eastern Motorway section of the M50 has sufficiently wide hard shoulders to allow hard shoulder running however an assessment found that providing an additional lane in the median would be more cost effective than hard shoulder running.

Furthermore, with the M50 supporting auxiliary lanes, the provision of Hard Shoulder Running would be challenging to continue through junctions. As such, they would increase the capacity of the auxiliary lanes and may not therefore lend any significant benefit to the operation of the M50.

4.6 Priority Measures

4.6.1 High Occupancy Toll Lanes

The provision of High Occupancy Toll Lanes has been considered on the basis that their provision would achieve the following outcomes:

- They would increase the occupancy within vehicles as a result of the reduced journey time that is available; and
- They would maximise value of the M50 through facilitating faster journey times for higher value road users (e.g. high value commercial activity)

The current studies have concluded that a fiscal solution, such as the distance based multi-point tolling scheme, will be a necessary element of the final scheme of demand management measures if it is to be successful in addressing traffic demand. Where a fiscal proposal is implemented, this is not compatible with a lane-specific tolling solution. As a result, this solution is not taken forward.

4.6.2 Public Transport/Freight/Toll Lanes

For similar reasons set out above, it is not considered that a Public Transport/Freight Toll Lane would be compatible with a fiscal solution for the M50, and this is therefore not taken forward.

4.7 Information Measures

4.7.1 Internet

The provision of Variable Speed Limits, Incident Detection, and supporting Road User Charging schemes will require a high level of deployment of roadside detection and monitoring equipment, which will be collated and monitored through the Traffic Control Centre. The provision of information to road users via the internet – either through posting on web pages, or news feeds, is a low cost means of providing relevant, up to date information on the road network. During times of congestion, this information can be used to actively encourage potential road users to make alternative travel arrangements, and in this context can be an effective demand management tool. Such a facility is taken forward on the basis of its low marginal cost and high relative impact in comparison to costs.

4.7.2 Roadside Information

Roadside information is disseminated through Variable Message Signs, which are currently provided throughout the Dublin Area, with approximately 35 signs provided along the M50. Roadside information can provide dynamic information that is fully up to date to road user's mid-trip, and therefore has a significant advantage over web feeds in this context. The provision of roadside information is taken forward given the low marginal cost of feeding such information through existing Variable Message Signs.

4.8 Smarter Travel

4.8.1 Travel Planning and Awareness

The current studies have investigated the potential for Area-Based travel planning in order to manage demand on the M50. It is concluded that travel planning can have relatively significant local impacts in terms of reduced traffic demand, or flattening of the peak period profile. This can lead to reductions of up to 20% in local traffic generation during peak periods.

Whilst the impact of such strategies are widespread, and are not confined to an individual corridor such as the M50, it is nevertheless noted that through a regional focus on area-wide travel planning at key sites, significant gains should be achievable. A number of locations have been proposed in this regard:

- Park West;
- City West;
- Sandyford; and
- Cherrywood.

Travel planning at various levels, be it area based or individual workplaces, still forms one of the most effective soft measures in mobility management. Average reductions in car use as a result of workplace travel plans is 15%, with reductions of up to 30% for school travel plans and 15% for personalised travel plans.

4.8.2 Planning Policies

The Spatial Planning Guidelines[11] published in January 2012 brought a number of principles to the fore in terms of the planning for development along national roads corridors. These guidelines support the principles of demand management and will support achieving the objectives of the current studies.

4.9 Network Control

4.9.1 National Control Centre

The Intelligent Transport Systems measures set out earlier are all based on the provision of a traffic control centre to monitor road conditions, respond to incidents and provide relevant information to road users. The existing Control Centre located in the Dublin Port Tunnel is insufficient in its current layout to meet the requirements of an increased level of management of the national roads network, and an expansion of that facility is currently being examined. It is envisaged that a single control centre would manage all the operational functions of the national roads network.

For the management of tolling facilities, it is not necessary that this should be accommodated at the same location as the operational control centre, as there is no over-riding requirement for interaction between these two facilities.

4.9.2 Network Patrols

The incident management and response function of the Traffic Control Centre will require some

[11] *Spatial Planning and National Roads, Guidelines for Local Authorities: Dept of the Environment, Community and Local Government: Jan 2012*

means of dealing with live incidents on the M50. The concept of network patrol is a good fit with the scope of the PPP operator of the M50 who currently performs operations and maintenance on the M50 and already provides incident support to the emergency services.

5.0 Summary of Indicative M50 Demand Management Scheme

5.1 Identification of Indicative Scheme

The further analysis of the shortlisted measures described above allowed the indicative package of measures to be defined in order to address the demand management objectives set out for the M50. These measures are outlined below in Table 5.1.

Table 5.1 - Summary of the Indicative Scheme of Specific Demand Management Measures

Category	Measures Taken Forward
Fiscal Measures	Distance-Based Tolling Tolling by Vehicle Type Variable Time Tolling
Intelligent Transport Systems/Traffic Control	Variable Speed Limits Incident Detection
Information	Internet Roadside Information
Smarter Travel	Area-Based Travel Planning
Control	National Traffic Control Centre

A schematic layout and architecture of the preferred strategy is presented overleaf as Figure 5.1. The schematic shows the extent of the Variable Speed Limit and Incident Detection between the M1 and Firhouse, supported by Variable Message Signs and web information as a means of disseminating information. The National Traffic Control Centre is a key element of this suggested deployment strategy.

The locations of the toll points are also shown, along with the e-Flow back office which manages the toll collection system. If it was decided at some stage in the future to implement a variable distance-based toll system on the M50 consideration should be given to the option of implementing a closed system or of providing a higher number of toll points in an open system. Ultimately any multi-point tolling scheme will have the potential to evolve to a closed system which would be able to better protect the traffic capacity of the M50 in the longer term.

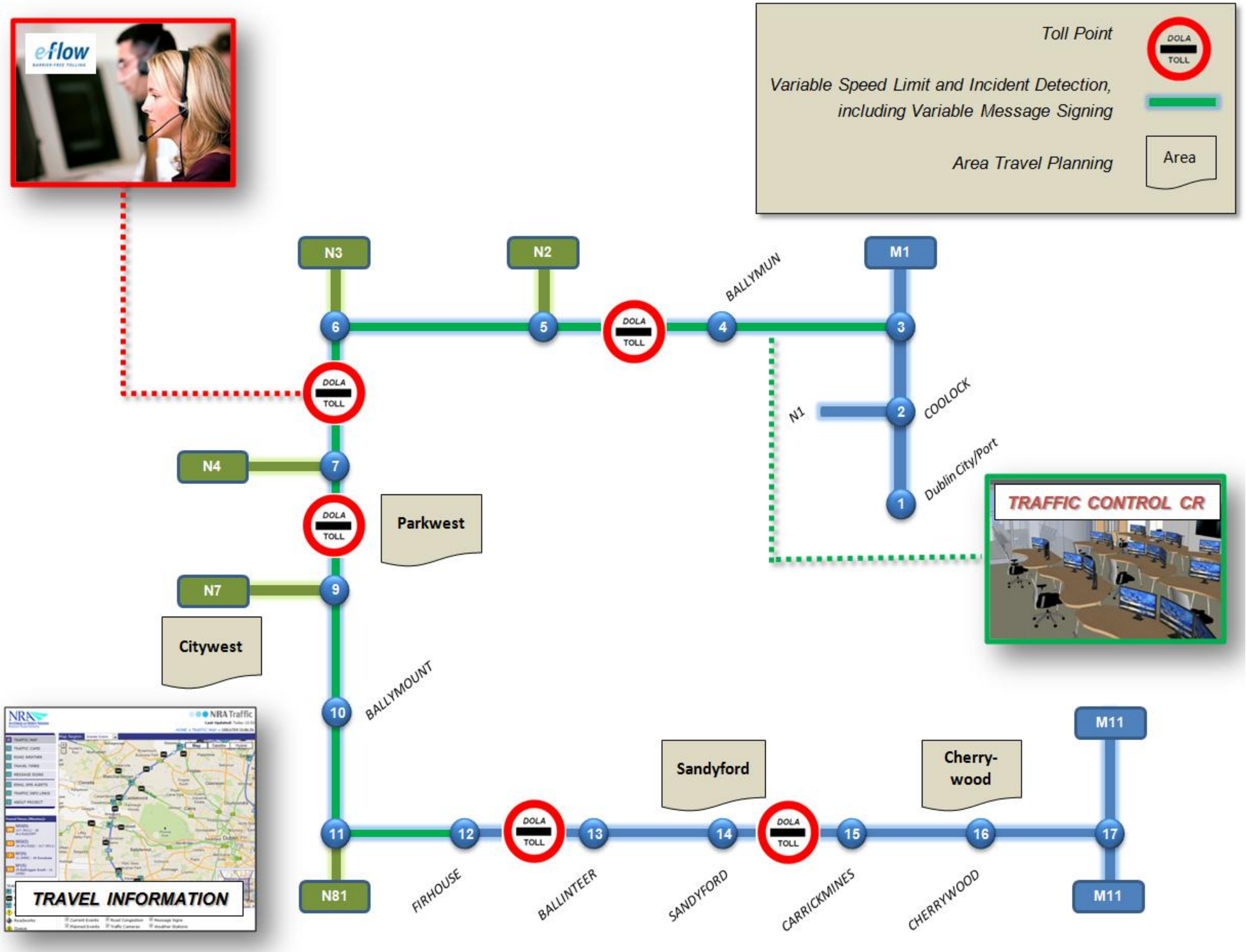

Figure 5.1 - Proposed Indicative Scheme of Specific Demand Management Measures

5.2 Key Stakeholders

During the study, the Steering Group discussed the study with the Department of Transport, Tourism and Sport (DTTAS), the National Transport Authority (NTA) and the Strategic Policy Committee (SPC) of the four Local Authorities. The purpose of the discussions was as follows:

- To provide information on the work undertaken and the measures that were emerging from the studies;
- To ensure that the work was fully compatible with other policies and plans being developed at government level; and
- To identify the legal and institutional framework that would be necessary to implement the measures included in the emerging proposals.

Specifically presentations of the emerging package of measures, followed by questions and answer sessions, were made to the SPC's on the following dates:

- 11th June 2013, Dún Laoghaire Rathdown County Council;
- 12th June 2013, Dublin City Council;
- 1st July 2013, Fingal County Council; and
- 5th September 2013, South Dublin County Council

In general, with the exception of some specific local issues, there was a lot of commonality in the questions asked and the views expressed by the SPC members. The key issues raised / comments made were:

- A degree of acceptance that the problem would occur in the future, but not that it was occurring yet;
- Strong opposition to the proposed fiscal measures (tolling), with little or no support for increased tolls along the M50, particularly in view of the current economic climate;
- Proposals to introduce variable toll rates at different times of the day;
- It was felt that the proposed tolling was being taken as a way of generating revenue rather than managing demand;
- Concern about the impact of traffic diverting onto the local road network;
- Some acceptance that it would be fairer for more users to be tolled, although the current eFlow toll was still viewed as a toll for using the bridge across the Liffey rather than a toll for using the M50;
- Recognition that a lot of valuable work had been undertaken in the study;
- Almost unanimous support for all the non-fiscal measures.

Discussions with DTTAS suggested that some modifications to the existing traffic signage regulations would be necessary for the implementation of the Variable Speed Limits, although this could be incorporated into an ongoing exercise to review the existing regulations.

Of particular note is the fact the SPC consultations raised the potential for a distributed pricing scheme with tolls varying across the day based on the traffic demand. The study team took time to consider the feedback from the various stakeholders and as a consequence reviewed the fiscal proposals. As a result a significant change was made to the proposed measures, with variable tolls for different times of the day being introduced to reflect the varying level of demand at different times of the day.

5.3 Benefits and Impacts of the Measures

5.3.1 Fiscal Measures – Distance Based Multi Point Tolling

Transport Model

The introduction of tolls leads to a number of changes in travel behaviour:

- **Reassignment**, where M50 users change their routing to avoid tolls. For such users, the perceived additional cost associated with using longer routes is therefore less than the cost of the toll;
- **Mode switching**, where M50 users change travel mode due to the increased cost associated with travelling by private car. Such responses include switching to bus or rail for longer trips, or to walking or cycling for shorter trips;
- **Demand changes**, which describe decisions to travel to alternative (lower cost) destinations, to link trips together in order to reduce overall travel costs, or decisions not to make a trip at all.

In all these cases, it is those M50 users that derive only marginal benefit from their particular trip who change their travel behaviour. In other words, those M50 users who derive value from their trip that is only marginally higher than the cost of the trip. In such cases, a slight increase in travel costs will displace such users from the M50, ensuring that a higher level of road space remains for those who derive higher values from making trips on the M50.

PAG Unit 5.2: Construction of Transport Models describes the various types of transport models that can be used to assess the impacts of transport schemes. The guidance describes the following:

- **Reassignment Models**, which use a fixed traffic demand matrix, and assess impacts of reassignment only; and
- **Variable Demand Models**, which include consideration of demand changes.

An excellent reassignment model exists for the Greater Dublin Area developed by the National Transport Authority (NTA) which includes the capability to model mode switching and some demand changes. The NTA model represents the urban area in a high degree of detail, allowing local impacts of reassignment to be better understood. As part of the NRA Traffic Management Study (TMS)[12], the NTA model was further refined along the M50 corridor to allow any reassignment impacts to be assessed.

For assessing Variable Demand effects including assessing the impact of toll schemes, the NRA National Transport Model (NTpM) was developed as part of the NRA Traffic Management Study (TMS).

The NTpM contains traffic, rail and bus demand elements with the Variable Demand Model (VDM) as the central tool of the model suite interfacing with the traffic and public transport elements of the NTpM. The NTpM was completed in 2011, and is employed by the National Roads Authority in strategic planning studies, transport policy impact assessments and appraisal of road tolling schemes. The NTpM has been used in combination with the Dublin Area Model to allow both the

[12] *National Roads Traffic Management Study, NRA, February 2011*

variable demand and traffic impacts to be fully assessed as part of the M50 Demand Management Strategy.

Benefits and Impacts

The NTpM and the Greater Dublin Area Traffic Model described above were used to assess the key changes in travel behaviour that would be expected as a result of the multi-point tolling scheme. The key changes are:

- Traffic flow changes on the M50 and alternative routes as a result of toll avoidance;
- The efficiency of the overall transport network due to the change in transport demand using the network (mode shift, reduced trip frequency etc); and
- Emissions impacts due to the overall change in transport demand that results from the proposals

The key benefits and impacts of the Multi-Point Tolling scheme in the peak periods are described in the following sections and include:

- Approximately 10% of total M50 traffic will reassign to using the local road network during the peak periods – with this demand spread across the network : minor mitigation works may be required;
- Reduction in overall traffic demand on the M50 by approximately 10% during the peak periods, as a result of increased public transport use and changes in travel behaviour;
- Improved net revenue and reduced cost margin of existing system; and
- Net reduction in collisions.

5.3.1.1 M50 Congestion

The fiscal measures within the indicative scheme on the M50 result in a substantial reduction in the toll charges at the existing toll point at the M50 eFlow, in addition to the provision of four additional toll points on the mainline, and tolls on the Ballymun east facing slips and Sandyford west facing slips.

The traffic modelling analysis confirms that the scheme will be successful in reducing traffic demand on the M50, with decreases of up to 40% expected on the most congested sections, although a marginal increase is evident through the existing toll point (between Junctions 6 and 7) due to the reduction in the level of the toll there. The impact of the tolling scheme is shown graphically in Figure 5.2 below.

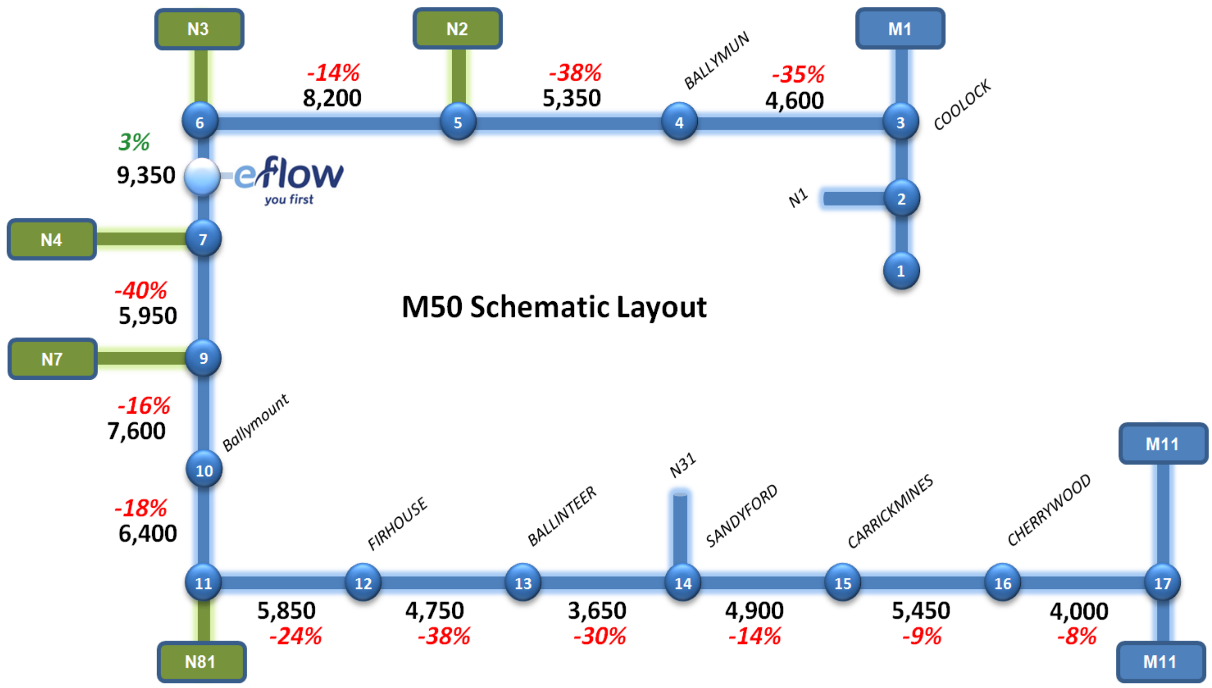

Figure 5.2 – Base Year AM Peak Flows with Tolling Scheme in place

Section 2.5 of this report described how in the absence of any demand management measures by 2023 demand will exceed safe operating capacity on some 50% of the various sections of the M50 in the AM peak hour, see Figure 5.3 below.

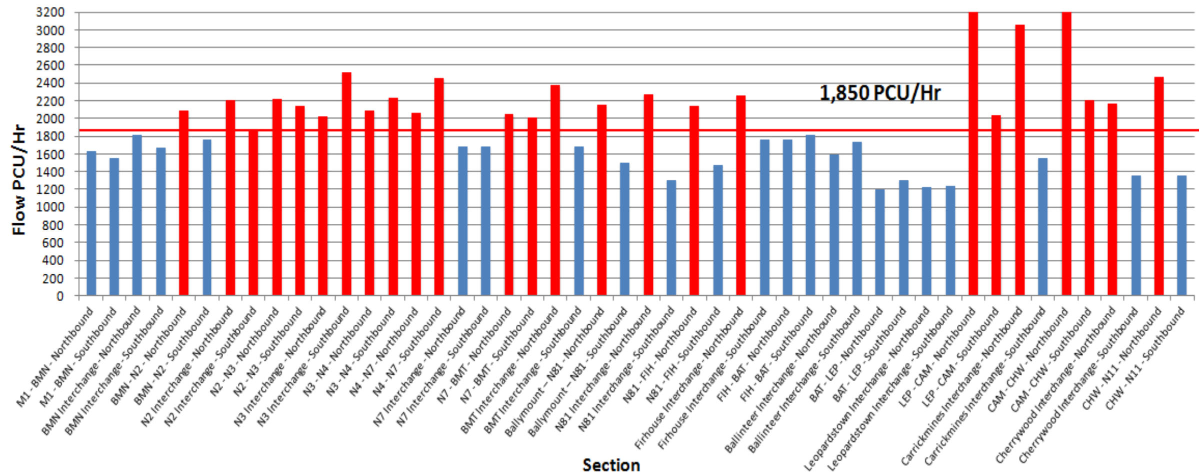

Figure 5.3 - Forecast of Demand and Capacity for 2023 (including GDP Uplift) – No Tolling

Reference to Figure 5.4 below shows that the implementation of the proposed scheme is forecast to have significant benefit in reducing the traffic flows at peak times, to the extent that in 2023 only about 20% of sections of the M50 will exceed the safe operating capacity in the AM peak hour.

To address the remaining sections on which flows still exceed the safe operating capacity control measures, in particular Variable Speed Limits, will assist in managing the traffic by reducing the likelihood of incidents occurring and improving the level of service provided by the M50. The inclusion of control measures in the Demand Management Strategy reduces the reliance on fiscal measures and avoids the need for higher toll rates on these sections to manage demand.

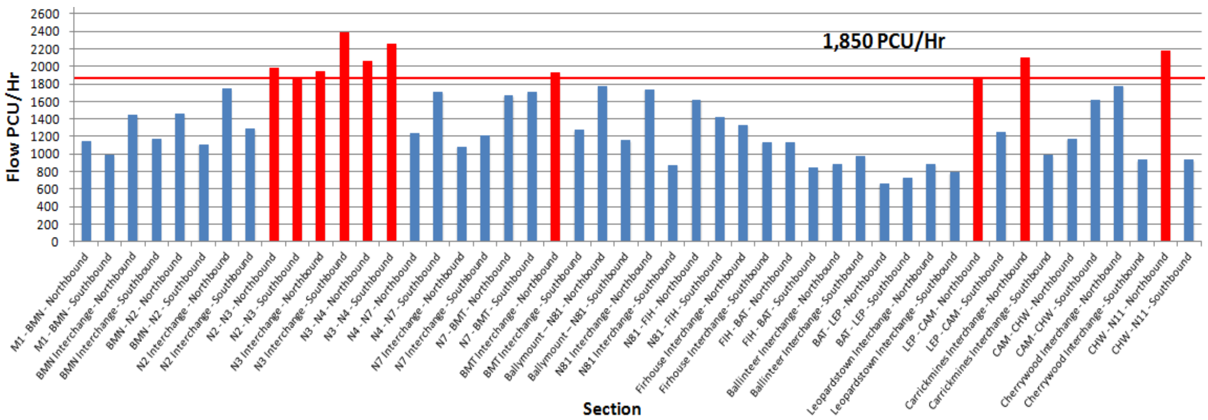

Figure 5.4 – Forecast of Demand and Capacity for 2023 (including GDP Uplift) – Tolling Implemented

Figure 5.5 below reproduces the equivalent historic graph for November 2011. Comparison with Figure 5.4 above shows that, with the exception of the sections between the N2 and the N4, traffic conditions on the M50 in 2023 with the tolling scheme in place will be comparable with conditions that existed in November 2011 shortly after upgrade works were completed.

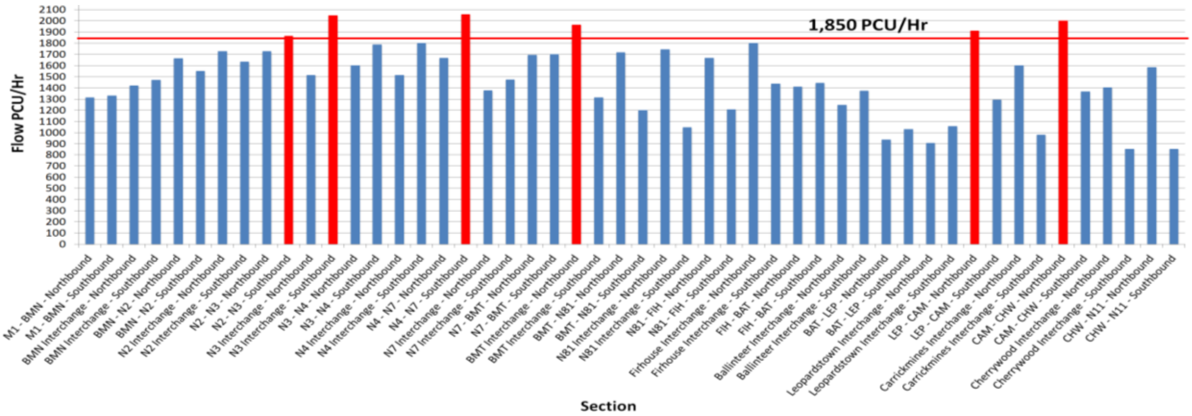

Figure 5.5 - Demand and Capacity Recorded for November 2011

These reductions will result in a the elimination of congestion on all but a small number of sections, with a significant reduction in the number of incidents, and journey times, as well as an increase in the reliability of journey times compared to the do-nothing scenario. Traffic control measures, including variable speed limits, can be used to manage those sections that remain susceptible to congestion.

M50 Link Flows

Figure 5.6 provides a graphical representation of the changes to traffic flows across the wider network as a result of the M50 tolling proposals, with green highlighting an increase in traffic volumes, and red highlighting a decrease.

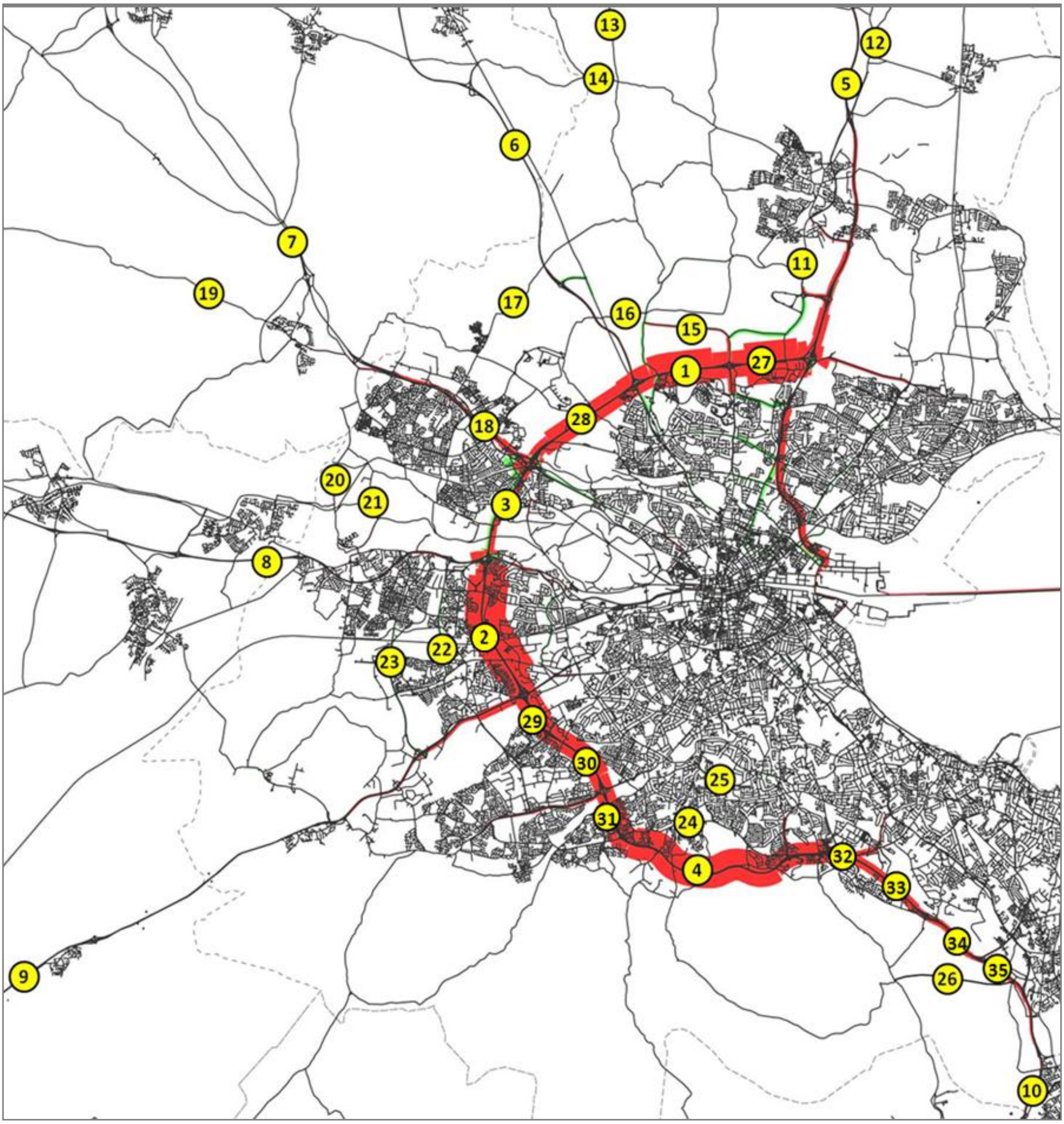

Figure 5.6 - Traffic Impact of M50 Proposals

The various M50 sections are numbered in Figure 5.6 and are referenced in Table 5.2 below, which provides a summary of traffic flow changes forecast on these sections, along with the percentage change in demand.

Table 5.2 - Traffic Impact of M50 Distance Based Multi Point Tolling (AM Peak - Base Year Flows)

Location		Do Minimum	Do Something	Diff	% Change
Impact on M50 Toll Points					
1	Ballymun - N2	8,586	5,335	-3,251	-38%
2	N3 - N4	9,057	9,349	292	3%
3	N4 - N7	9,951	5,953	-3,998	-40%
4	Firhouse - Ballinteer	7,621	4,740	-2,881	-38%
33	Sandyford - Carrickmines	5,701	4,921	-780	-14%
Impact on Other M50 Links					
27	M1 - Ballymun	7,062	4,604	-2,458	-35%
28	N2 – N3	9,596	8,228	-1,368	-14%
29	N7 - Ballymount	9,061	7,587	-1,474	-16%
30	Ballymount - N81	7,796	6,387	-1,409	-18%
31	N81 - Firhouse	7,682	5,865	-1,817	-24%
32	Ballinteer - Sandyford	5,252	3,141	-2,111	-40%
34	Carrickmines - Loughlinstown	5,992	5,013	-979	-16%
35	Loughlinstown - N11	4,333	3,666	-667	-15%

5.3.1.2 M50 Level of Service Improvements

The Level of Service (LOS) for a road is a quality measure describing operational conditions within a traffic stream and is defined by the US Highway Capacity Manual (HCM)[13]. This is measured in terms of speed, travel time, freedom to manoeuvre, traffic interruptions, and comfort and convenience. Six LOS are defined from A to F, with LOS A representing the best operating conditions and LOS F the worst.

The HCM defines each level of service for motorways (freeways) as follows:

- LOS A describes free-flow operations. Vehicles are almost completely unimpeded in their ability to manoeuvre within the traffic stream. The effects of incidents or point breakdowns are easily absorbed at this level.

- LOS B represents reasonably free flow, and free-flow speeds are maintained. The ability to manoeuvre within the traffic stream is only slightly restricted, and the general level of physical and psychological comfort provided to drivers is still high. The effects of minor incidents and point breakdowns are still easily absorbed.

- LOS C provides for flow with speeds at or near the free-flow speeds of the motorway. Freedom to manoeuvre within the traffic stream is noticeably restricted, and lane changes require more care and vigilance on the part of the driver. Minor incidents may still be absorbed, but the local deterioration in service will be substantial. Queues may be expected to form behind any significant blockage.

- LOS D is the level at which speeds begin to decline slightly with increasing flows and density begins to increase somewhat more quickly. Freedom to manoeuvre within the traffic stream is more noticeably limited, and the driver experiences reduced physical and psychological comfort levels. Even minor incidents can be expected to create queuing,

[13] *Highway Capacity Manual, US Transportation Research Board, 5th Edition 2010*

because the traffic stream has little space to absorb disruptions.

- LOS E describes operation at capacity. Operations at this level are volatile, because there are virtually no usable gaps in the traffic stream. Vehicles are closely spaced leaving little room to manoeuvre within the traffic stream at speeds that still exceed 80 km/h. Any disruption of the traffic stream, such as vehicles entering from a ramp or a vehicle changing lanes, can establish a disruption wave that propagates throughout the upstream traffic flow. At capacity, the traffic stream has no ability to dissipate even the most minor disruption, and any incident can be expected to produce a serious breakdown of flow with extensive queuing. Manoeuvrability within the traffic stream is extremely limited, and the level of physical and psychological comfort afforded the driver is poor.

- LOS F describes breakdowns in vehicular flow. Such conditions generally exist within queues forming behind breakdown points.

The reductions in mainline flows as a result of the tolling scheme will improve the Level of Service on the M50 significantly. Typical improvements to the Level of Service are outlined in Figure 5.7 below for one of the most highly trafficked sections of the M50. The figure below presents Level of Service in terms of density of traffic based on speeds and vehicle flow per lane per hour.

The positive impact of the tolling measures on the level of service along the N4-N7 section is evident due to the location of a toll along the section.

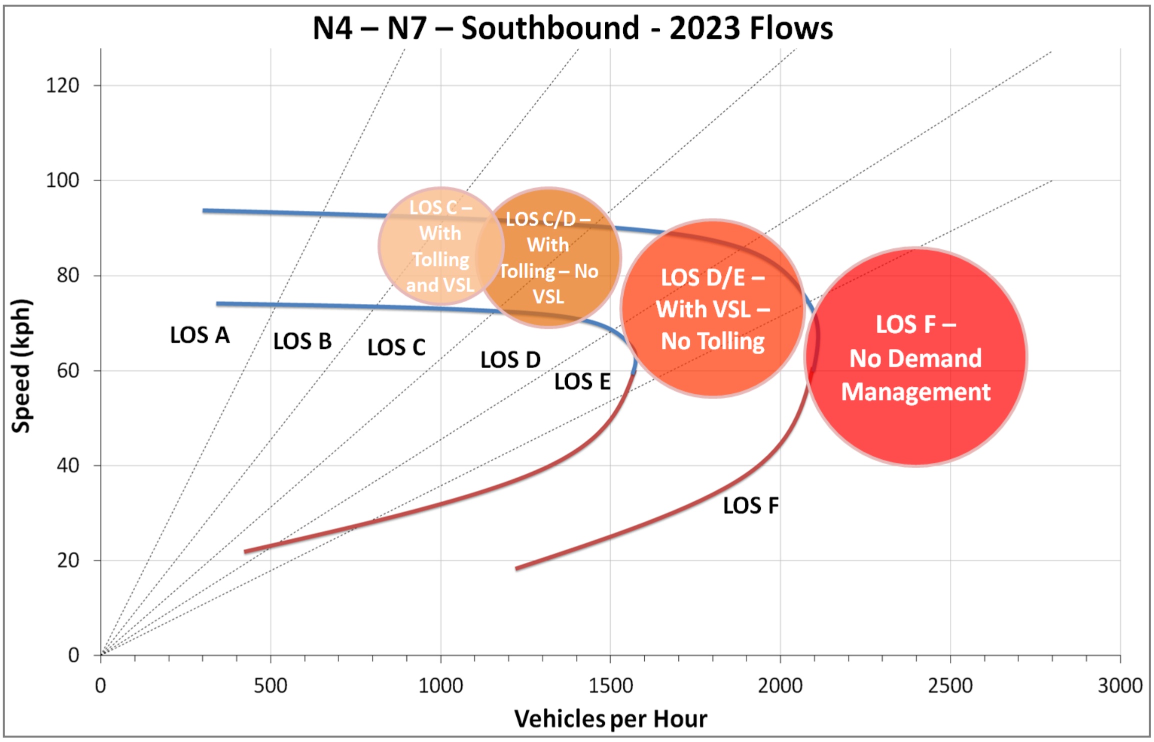

Figure 5.7 – Impact of Preferred Scheme on Level of Service Provision – AM Peak

The implementation of the tolling scheme will improve the LOS from F to C/D. Note that this is improved further to LOS C when the benefits of the Variable Speed Limits (VSL) are also taken into account, see Section 5.3.2 below. However it should be noted that VSL alone will not manage the demand and hence will not protect the operation of the M50 effectively.

5.3.1.3 *Impact on Wider Road Network*

Examining the results of the traffic modelling, shown graphically in Figure 5.6, it is clear that the increase in traffic on other roads as a result of reassignment of traffic from the M50 is relatively diluted. The largest absolute increases occur on the Outer Ring Road, the R132 Dublin Road and Fonthill Road which fulfil a distributor function through the areas they serve.

The key changes in traffic flows are:

- An increase on a number of the regional roads connecting Swords with the N2/Ballymun/Finglas area. This reflects the high traffic demand generated from the Swords Area with destinations in the northern fringes of Dublin City.
- An increase on the north-south roads connecting the N4 and N7 through the Lucan/Clondalkin Area. The increase on the Outer Ring Road is particularly evident, while both the Outer Ring Road and the Fonthill Road have been the subject of significant investment in recent years to facilitate movement through this area; and
- Some minor rerouting onto alternative east-west routes in the vicinity of Ballinteer such as Grange Road and Taylors Lane.
- Minimal increases on local roads adjacent to the M50 corridor as vehicles from areas in Sandyford south of the M50 use alternative routes.
- In addition, some traffic will utilise the N11 in place of the southern section of the M50 when travelling to/from locations to the south and west of the city centre.

Various other roads numbered in Figure 5.6 earlier are referenced in Table 5.3 below, which provides a summary of traffic flow changes forecast on these sections, along with the percentage change in demand.

Table 5.3 - Traffic Impact of M50 Distance Based Multi Point Tolling (Base Year 2010 Traffic Flows)

Location		Do Minimum	Do Something	Difference	% Change
Impact on Other Roads		AADT	AADT	AADT	
5	M1	73,829	71,801	-2,028	-3%
6	N2	31,313	31,646	333	+1%
7	M3	7,438	7,380	-58	-1%
8	N4	58,843	59,317	474	+1%
9	N7	87,038	84,967	-2,071	-2%
10	N11	57,873	55,497	-2,376	-4%
11	Dublin Road R132	10,271	14,014	3,744	+37%
12	R132 Blake's Cross	7,797	7,195	-602	-8%
13	R122 Naul	2,102	4,000	1,898	+90%
14	Rathbeale Road	12,800	15,716	2,916	+23%
15	Ballymun Road	5,246	9,823	4,578	+87%
16	R121 St Margaret's	9,690	16,588	6,898	+71%
17	R121 Hollystown	5,348	7,135	1,787	+33%
18	N3 at Blanchardstown	44,987	36,523	-8,464	-19%
19	R156 Dunboyne	6,902	4,591	-2,311	-34%
20	R149 Clonee Rd	20,295	16,002	-4,293	-21%
21	Luttrelstown Road	16,526	13,731	-2,795	-17%
22	Fonthill Road	28,680	32,382	3,702	+13%
23	Outer Ring Road	29,691	37,721	8,030	+27%

Location		Do Minimum	Do Something	Difference	% Change
24	Grange Road	12,231	16,079	3,848	+32%
25	Nutgrove Avenue	17,096	18,924	1,828	+11%
26	Ballycorus Road	5,412	7,273	1,861	+34%

A number of relatively large percentage increases in flows are noted, although in many cases the background traffic volumes are such that the increased daily traffic could be accommodated within the existing road cross section. However it is recognised that there will be some roads where the additional flows will need to be managed through supporting measures such as traffic management measures, safety schemes, online improvements or junction improvements.

In some locations proposals already exist for improvements to the local road network, for example in the Sandyford / Cherrywood / Glenamuck area, where there are a number of proposals that form part of the wider strategy associated with the large amount of new development in close proximity to the M50. These new / upgraded roads will provide additional capacity to cater for the additional traffic that reassigns from the M50 to the local road network.

5.3.1.4 Impact on M50 Junctions

Tables 5.4 and 5.5 below show future traffic flows (2012 modelled flows factored to 2023) on the merges and diverges along the M50 Corridor. The assessment found that on average, traffic flows on the M50 merges/diverages will decrease by 18%. The table provides commentary where no increases are envisaged and provides information on merges/diverges which will experience increases as a result of the M50 Demand Management or where issues are envisaged in the future.

Table 5.4 - Future Assessment of M50 Junctions – AM Peak

Location	Junction Type	Impact	Northbound		Southbound		Comment
			On	Off	On	Off	
M1	Freeflow						Significant decreases envisaged as a result of M50 Demand Management.
Ballymun	Signalised						Significant decreases envisaged as a result of M50 Demand Management.
N2	Freeflow	% Increase		+24%	+22%		Decreases in N/B merge and S/B diverge flows and increases in N/B diverge and S/B merge envisaged due to diversion off the tolled section. However flows not expected to cause any significant issues at junctions.
		2023 DoSmth Flow		1595	2340		
N3	Freeflow	% Increase		9%	34%		Decreases in N/B merge and S/B diverge flows and increases in N/B diverge and S/B merge envisaged due to diversion off the tolled section. However flows not expected to cause any significant issues at junctions.
		2023 DoSmth Flow		1514	1010		
N4	Freeflow	% Increase	+76%			+103 %	Significant decrease in N/B diverge and S/B merge. Significant increase in N/B merge and S/B diverge. Mainline flow under bridge and south of N4 reduces significantly which should ease merging onto M50.
		2023 DoSmth Flow	1939			2650	
N7	Freeflow	% Increase		+13%	+16%		Significant decrease in N/B merge and S/B diverge. Increase to NB diverge traffic and SB merge in AM and PM peaks. Mainline flows reduce significantly easing merging onto mainline.
		2023 DoSmth Flow		2214	2076		
Ballymount	Signals	% Increase					Significant decreases envisaged as a result of M50 Demand Management.
		2023 DoSmth Flow					
N81	Signalised Roundabout	% Increase	+3%				Significant decreases envisaged as a result of M50 Demand Management.
		2023 DoSmth Flow	1262				
Firhouse	Signals	% Increase	+51%			+21%	Increase to N/B merge and S/B diverge. However mainline flows significantly reduce which will ease merging. Increase to SB Off Slip also however flows well within infrastructure capacity. M50 protected by signals at top of slip roads.
		2023 DoSmth Flow	1423			470	
Ballinteer	Roundabout	% Increase					Significant decreases envisaged as a result of M50 Demand Management.
		2023 DoSmth Flow					
Sandyford	Signalised Roundabout	% Increase		+9%	+34%		Increase to NB diverge. However flows well within infrastructure capacity. M50 protected by signals on downstream signalised roundabout. Increase to SB merge also. However flows well within infrastructure capacity.
		2023 DoSmth Flow		1927	287		
Leopardstown	Signalised Roundabout	% Increase					Significant decreases envisaged as a result of M50 Demand Management.
		2023 DoSmth Flow					
Carrickmines	Roundabout	% Increase			+4%		Significant decreases envisaged as a result of M50 Demand Management.
		2023 DoSmth Flow			803		
Cherrywood	Signals	% Increase		+4%			No significant changes envisaged as a result of M50 Demand Management.
		2023 DoSmth Flow		379			
M11	Freeflow	% Increase		+2%			No significant changes envisaged as a result of M50 Demand Management
		2023 DoSmth Flow		927			

Table 5.5 - Future Assessment of M50 Junctions – PM Peak

Location	Junction Type	Impact	Northbound		Southbound		Comment
			On	Off	On	Off	
M1	Freeflow						Significant decreases envisaged as a result of M50 Demand Management.
Ballymun	Signalised						Significant decreases envisaged as a result of M50 Demand Management.
N2	Freeflow	% Increase		+22%	+24%		Decreases in N/B merge and S/B diverge flows and increases in N/B diverge and S/B merge envisaged due to diversion off the tolled section. However flows not expected to cause any significant issues at junctions.
		2023 DoSmth Flow		2340	1595		
N3	Freeflow	% Increase		34%	9%		Decreases in N/B merge and S/B diverge flows and increases in N/B diverge and S/B merge envisaged due to diversion off the tolled section. However flows not expected to cause any significant issues at junctions.
		2023 DoSmth Flow		1010	1514		
N4	Freeflow	% Increase	+103 %			+76%	Significant decrease in N/B diverge and S/B merge. Significant increase in N/B merge and S/B diverge. Mainline flow under bridge and south of N4 reduces significantly which should ease merging onto M50.
		2023 DoSmth Flow	2650			1939	
N7	Freeflow	% Increase		+16%	+13%		Significant decrease in N/B merge and S/B diverge. Increase to NB diverge traffic and SB merge in AM and PM peaks. Mainline flows reduce significantly easing merging onto mainline.
		2023 DoSmth Flow		2076	2214		
Ballymount	Signals	% Increase					Significant decreases envisaged as a result of M50 Demand Management.
		2023 DoSmth Flow					
N81	Signalised Roundabout	% Increase				+3%	Significant decreases envisaged as a result of M50 Demand Management.
		2023 DoSmth Flow				1262	
Firhouse	Signals	% Increase	+21%			+51%	Increase to N/B merge and S/B diverge. However mainline flows significantly reduce which will ease merging. Increase to SB Off Slip also however flows well within infrastructure capacity. M50 protected by signals at top of slip roads.
		2023 DoSmth Flow	470			1423	
Ballinteer	Roundabout	% Increase					Significant decreases envisaged as a result of M50 Demand Management.
		2023 DoSmth Flow					
Sandyford	Signalised Roundabout	% Increase		+34%	+9%		Increase to NB diverge. However flows well within infrastructure capacity. M50 protected by signals on downstream signalised roundabout. Increase to SB merge also. However flows well within infrastructure capacity.
		2023 DoSmth Flow		287	1927		
Leopardstown	Signalised Roundabout	% Increase					Significant decreases envisaged as a result of M50 Demand Management.
		2023 DoSmth Flow					
Carrickmines	Roundabout	% Increase		+4%			Significant decreases envisaged as a result of M50 Demand Management.
		2023 DoSmth Flow		803			
Cherrywood	Signals	% Increase			+4%		No significant changes envisaged as a result of M50 Demand Management.
		2023 DoSmth Flow			379		
M11	Freeflow	% Increase			+2%		No significant changes envisaged as a result of M50 Demand Management
		2023 DoSmth Flow			927		

Locations where issues were identified are shown in Table 5.6 below, along with potential short-term traffic management measures to mitigate the issues.

Table 5.6 – M50 Junctions – Issues and Potential Solutions

Location	Issue	Potential Solution
N4	Significant decrease in N/B diverge and S/B merge. Significant increase in N/B merge and S/B diverge. Mainline flow under bridge and south of N4 reduces significantly which should ease merging onto M50.	N/B On Slip from N4 E/B is single lane and likely to need existing hard shoulder converted to additional lane with Type F Two-lane Lane Gain merge. S/B diverge likely to need to change to Type D (Option 1) Lane Drop diverge to cater for increased diverging traffic.
N7	Significant decrease in N/B merge and S/B diverge. Increase to NB diverge traffic and SB merge in AM and PM peaks. Mainline flows reduce significantly easing merging onto mainline.	N/B diverge likely to need to change to Type D (Option 1) Lane Drop diverge to cater for increased diverging traffic. S/B merge geometry and type has sufficient capacity to cater for increase in traffic.
Firhouse	Increase to N/B merge and S/B diverge. However mainline flows significantly reduce which will ease merging. Increase to SB Off Slip also however flows well within infrastructure capacity. M50 protected by signals at top of slip roads.	SCOOT signal timings/priority likely to need adjusting.

5.3.1.5 Summary of Traffic Impacts

In summary, the assessment demonstrates that the impact of the M50 toll scheme will be positive in terms of reducing demand on the M50, although the consequential increases on other roads will require the consideration of some targeted traffic management measures in the final scheme to mitigate these impacts. Such measures would seek to reduce toll avoidance through sensitive areas, or improve safety and/or capacity on those roads which receive additional traffic.

The business benefits to commercial traffic would be significant, with a reduction in journey time variability and greater ability for just-in-time haulage, in addition to reductions in journey times during peak periods.

5.3.1.6 Environmental Benefits

There are significant environmental benefits resulting from the indicative toll scheme, for example a reduction in traffic emissions in the Lucan and Strawberry Beds areas as a result of the reduction in vehicle diversion, a significant number of vehicles currently divert through these areas as a result of the relatively high single point toll of €2.10 - €3.10 for cars at the M50 eFlow. As this toll reduces, further users are attracted to the M50, with positive impacts outweighing negative impacts of new tolls elsewhere.

5.3.2 Control Measures – Variable Speed Limits and Incident Detection

Benefits accruing from the implementation of a Variable Speed Limit system on the M50 will arise from both a reduction in the number of incidents, and an increase in the consumer's perception of reliability on the route. An analysis of these benefits was undertaken for all links on the M50 between the M1 and the N81, incorporating growth in traffic demand on the M50 over a 10-year period.

5.3.2.1 Level of Service (LOS) Benefits

Section 5.3.1.2 earlier described the concept of Level of Service (LOS). Research undertaken by the NRA[14] found that "*Traffic Control seeks to protect the traffic conditions that exist under Level of Service E from deteriorating into Level of Service F. From the discussion thus far, it is clear that the transition from LOS E to LOS F is not necessarily related to traffic flow – instead it is a function of the level of turbulence within the traffic stream. Indeed, it is likely that LOS F will support a lower overall traffic volume than LOS E due to the bottleneck resulting from the breakdown.*"

Referencing back to Figure 5.7 shows that the implementation of Variable Speed Limits in isolation will typically improve the traffic conditions from LOS F to LOS D/E. As such this measure achieves the aim of preventing traffic conditions reaching LOS F. It is evident that, when utilised in conjunction with distance based tolling, VSL serves to reduce the impact of any residual capacity issues by reducing turbulence and maintaining consistent speeds, resulting in a reduced likelihood of incidents.

5.3.2.2 Reliability Benefits

Reliability benefits refer to improvements in journey time reliability. Day-to-day variations in traffic congestion arise from day-to-day variations in demand. As congestion builds, journey times become increasingly unpredictable. These fluctuations in journey time represent additional disutility to drivers, over and above the actual delay experienced. Reliability is measured in terms of Standard Deviation (SD) from the mean journey time. Typically the higher the ratio of flow to capacity (V/C) on a given lane, the greater the Standard Deviation of travel time. Variable Speed Limits stabilise flow and create more uniform lane utilisation between the nearside, middle and offside lane. As a consequence of more evenly balanced lane distribution, traffic flow will improve along the most heavily congested sections of the M50.

In order to quantify the benefits that this reduction in ratio of flow to capacity will afford, it was first necessary to determine the existing Standard Deviation of journey time on the M50. Table 5.7 summarises the results of this analysis, specifically for the offside lane, based on traffic flows in 2013.

Table 5.7 - Impact on Standard Deviation of Journey Time - 2013 Peak Hour Offside Lane

Link	Do Minimum Standard Deviation (Sec)	Do Something Standard Deviation (Sec)	Reduction in Standard Deviation (Sec)
Northbound			
M1 - Ballymun	5	5	0
Ballymun - N2	31	5	26
N2 - N3	52	5	47
N3 - N4	9	5	4
N4 - N7	38	5	33
N7 - Ballymount	53	5	48
Southbound			
M1 - Ballymun	0	0	0
Ballymun - N2	6	5	1

14 *A Study of Lane Capacity in the Greater Dublin Area, Transportation Research and Information Note, NRA, February 2012*

Link	Do Minimum Standard Deviation (Sec)	Do Something Standard Deviation (Sec)	Reduction in Standard Deviation (Sec)
N2 - N3	19	5	14
N3 - N4	54	6	48
N4 - N7	54	10	44
N7 – N81	54	54	0

The analysis shows that the Variable Speed Limits will significantly improve journey time reliability along the M50, allowing for more precise trip planning by road users. This journey time reliability improvement will be valued most by those road users with a high value of travel time – more specifically business travel, freight and public transport vehicles.

5.3.2.3 Incident Impact Reduction Benefits

VSL has been shown to reduce total annual incidents. The benefits derived from this reduction have two components. The first is the monetary saving associated with reducing the number of fatal or serious injuries. The second is the time savings experienced by other road users who would otherwise be delayed by incidents on the carriageway.

Historical incident data on the M50 was interrogated for the years 2010 and 2012 to provide an indication of incident locations on the M50. Based on this data the number of incidents on the M50 during these years can be estimated at approximately 67 per year or 1.3 incidents per week. Excluding mechanical breakdowns, which will not be prevented by VSL (although VSL facilitates greatly enhanced management of mechanical breakdowns), this reduces to approximately 40 collisions per annum. Figure 5.8 illustrates the locations of these incidents, with the majority occurring to the north of the N81.

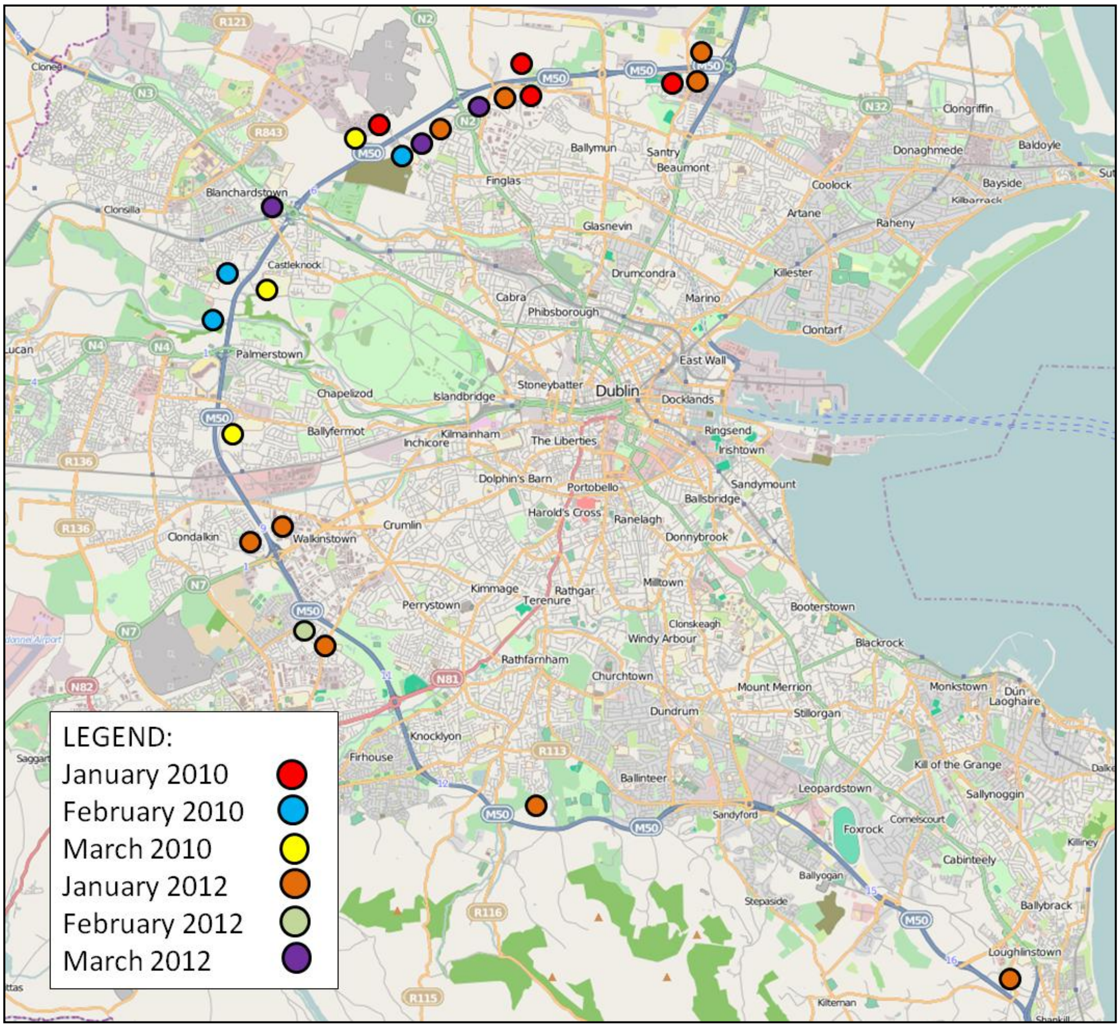

Figure 5.8 – Sample of 2010 - 2012 Incident Data – M50

The impact of Variable Speed Limits and Incident Detection has been shown to reduce the frequency of incidents, which includes for both breakdowns and collisions, by between 15% and 40%, depending on the existing rate of incidents and the level of intervention. It is therefore expected that the proposed measures will lead to a reduction of between 10 and 25 incidents on the M50 per year on the basis of existing incident data. As the volume of incidents increase as a result of increases in traffic flow and more turbulent flow conditions, the corresponding impact of the proposed measures will also increase.

5.3.2.4 Reduction in Incident Delay Benefits

Any incident, whether a collision or mechanical breakdown of a vehicle, that occurs on a carriageway will give rise to delays for motorists. Whilst the prevalence of incidents arising from a mechanical breakdown will remain unchanged with the proposed measures in place the impact these breakdowns have on congestion will be reduced due to reduced response times and efficient management of flow using VSL.

Mechanical breakdowns cause brief blockages of at least one traffic lane while serious incidents involving personal injuries or fatalities can result in lengthy closures of one or more lanes. The impacts of such delays have been assessed using a VISSIM micro-simulation model of a section of the M50. The 4.6km four-lane southbound section of the M50 between the N4 and N7 junctions was modelled.

A number of lane closure scenarios were assessed, with 1, 2 and 4 lanes closure for periods of 15, 30, 45 and 60 minutes. The following assumptions were made:

- Fatal or Serious Collisions make up 6% of all collisions each year and result in delays of 60 minutes or more (on average) and will result in a 4 lane closure.
- All other collisions result in delays of approximately 30 minutes and will result in a 2 lane closure.
- Annual number of incidents includes collisions and breakdowns (40% of total). It has been assumed that breakdowns will last on average 15 minutes and result in 1 lane closure.

Assuming a 15% to 40% incident reduction rate due to Variable Speed Limits and Incident Detection, the analysis suggests that the proposed measures will lead to a saving of between 10,000 hours and 27,000 hours of traffic delay per annum.

5.3.3 Information Measures – Variable Message Signs and Travel Information

The existing Variable Message Signs on the M50 would be used as part of the Demand management measures, but would be complimented by broader use of web-based information tools. The concept is that users will be able to develop a knowledge of historic and current network conditions either:

- Pre-trip, through the use of the travel information website;
- Pre-trip through the dissemination of travel bulletins using SMS or Twitter alerts; or
- In-trip, using the Variable Message Signs.

The cost of issuing up to date travel information via web-based channels is extremely low, but will provide the most widespread form of travel information. This can be used to provide adequate notice of events, maintenance or unplanned network disruption such that travel choices can be changed in response. This is a dynamic form of demand management and is a critical part of managing periods of planned or unplanned congestion on the road network.

Variable Message signs are a more capital intensive form of providing live information. Nevertheless, they are a safe means of providing in-trip information to road users, who will have restrictions on their access to web-based information whilst driving. It is noted that this infrastructure is already in place throughout much of the M50 and the main approach roads. The result of the measures proposed here will be that road users will have full information on the condition of the M50, and can plan their trip accordingly.

5.3.4 Smarter Travel Measures – Area Based Travel Planning

Evidence of the success of previous examples of Area Based Travel Planning projects around the UK is well documented. As noted earlier, the largest proponent for this type of approach has been the Highways Agency in England who, through their 'Influencing Travel Behaviour' programme has aimed to tackle congestion and improve air quality on some of Britain's busiest roads by changing attitudes to travel, increasing available choice of modes and furthering co-operation.

In a recent joint presentation entitled '*Travel Plans – the Potential is Realised*[15]' the case for this approach was made by the Highways Agency and TRL by presenting results from a number of key

[15] *Travel Plans – the Potential is Realised, Evidence from the Highways Agency's ITB Programme, Highways Agency and TRL*

sites from around the UK. In particular, results were analysed from Cambridge Science Park on the A14, Solent Business Park in Hampshire off the M27, and Northampton General Hospital off the A45.

The following bullets summarise the main findings:

- Single Occupancy Vehicle trips reduced by 1% in Cambridge, 12% at Solent with Northampton General showing a 10% reduction;
- Increases in Active Travel (walking and cycling) varied from 1.3% at Cambridge, 5% at Solent and 3% in Northampton;
- Car sharing increased by 1.2% in Cambridge, 14.5% at Solent and 3% in Northampton;
- The benefit to cost ratio of the projects at the three sites were 13:1, 3.7:1, and 5.5:1 respectively; and
- Journey times for trips using the strategic road network near each of the sites reduced by between 1% in Northampton and 7.3% at Solent with Cambridge showing a reduction of 5.6%

These results highlight that, even in the case of the example with the most modest levels of success, significant impacts are observed particularly in the increase of car sharing against single occupant car trips, and in journey time reductions. It may also be observed that the benefit to cost ratio for the project with the lowest proportional increase in car-sharing has the highest benefit to cost ratio of the three which could indicate that this was the site with the most significant initial issue, or that this was the scheme with the lowest level of funding available. It is noted that the benefit to cost ratio is highly dependent on the initial level of congestion and is therefore highly sensitive to initial conditions.

The key qualitative successes of these schemes include;

- Launching car sharing websites and incentivising these using travel vouchers and financial rewards;
- Increased cycling and public transport use promoted via travel plan bulletins, posters, websites and other local media outlets;
- Designation of car-sharing bays at workplaces;
- The setting up of new travel related forums for businesses and interested parties at locations around the country to discuss and tackle common travel issues using a co-ordinated approach with shared risks and benefits;
- Increase cycle parking facilities at sites nationally; and
- Improved bus services at many sites brought about by direct contact with public transport operators and improved communication between parties.

For the four locations have been identified as suitable for area-wide Travel Planning (Park West, City West, Sandyford/Stillorgan and Cherrywood) if the different aspects of the schemes identified above are implemented effectively it is anticipated that there will be average reductions in car use at these locations of 15% as a result of workplace travel plans, with reductions of up to 30% for school travel plans and 15% for personalised travel plans.

5.4 Implementation and Phasing

The implementation of the measures included throughout this document requires a number of preliminary activities to support the eventual delivery of the demand management activities. Key requirements are outlined below:

5.4.1 Fiscal Measures – Distance Based Multi Point Tolling

The implementation of tolling will require the preparation and approval of a Draft Toll Scheme. The toll scheme would draw on the information prepared as part of this study, and would require a period of approximately three years for consultation (including an approval process from the necessary bodies, namely, the Minister for Transport, Tourism and Sport, the NTA and the European Commission) and implementation. The scheme would be also subject to the statutory process set out in the Roads Act which requires approval by the NRA Board. The scheme would also consider the mitigation of impacts that would be necessary on local roads as a result of the tolling proposals.

The necessary infrastructure and back office could be delivered as an expansion of the M50 eFlow system.

5.4.2 Control Measures – Variable Speed Limits (VSL)

The use of VSL on the M50 will require some clarification or revisions to the Traffic Signs Manual (TSM). This may be a clarification that TSM sizes are 'minima' in order to facilitate the use of a standardised size for VSL signs showing different limits, and for repeater signs. It may be appropriate to develop a guidance document which can support the TSM in this regard, and can be informed by an initial Pilot Study. The use of VSL in areas where the national speed limit applies will not likely require the use of repeater signs.

VSL can be deactivated where there is no requirement for repeater signs. Where repeater signs are required, this can be facilitated by the VSL scheme which will require continuous activation of the VSL displays. These issues may be best addressed through the supplementary guidance note to the TSM. Furthermore, signs dictating the Start and End points of VSL are necessary for incorporation into the TSM.

The Road Traffic Act 2004 provides for the application of variable speed limits at locations where special circumstances prevail. The purpose of the provision is to allow for a reduction in the speed limit that normally applies where those special circumstances apply. In Dublin Port Tunnel the speed limits set by the Dublin City Council Special Speed Limit Bye- Laws, 2011 specify two speed limits. The following is a quote from the bye laws:

> *'Eighty kilometres per hour shall be the special speed limit for mechanically propelled vehicles on each of the roads specified in the Fourth Schedule to these bye-laws except when the circumstances set out in Article 7 of these bye-laws apply.*
>
> *Fifty kilometres per hour shall be the special speed limit for mechanically propelled vehicles on each of the roads specified in the Fourth Schedule to these bye-laws in the event of an incident or maintenance works causing an obstruction or when there is a risk of congestion on the roads.'*

The Act makes it clear that the circumstances where such an approach is to be introduced must be set out in the bye-laws. The circumstances could involve the following wording:

> *'Hundred kilometres per hour shall be the special speed limit for mechanically propelled vehicles on each of the roads specified in the Fourth Schedule to these bye-laws except when the circumstances set out in Article 7 of these bye-laws apply.*
>
> *Eighty kilometres per hour shall be the special speed limit for mechanically propelled vehicles on each of the roads specified in the Fourth Schedule to these bye-laws when there is a risk of congestion on the roads.'*
>
> *Sixty kilometres per hour shall be the special speed limit for mechanically propelled vehicles on each of the roads specified in the Fourth Schedule to these bye-laws in the event of an incident or maintenance works causing an obstruction or when there is a risk of congestion on the roads.'*

It will be necessary to set out within the bylaws the circumstances that trigger the introduction of the eighty and sixty kilometres speed limits.

Enforcement of VSL on the UK Motorway network is achieved using a system called HADECS – Highways Agency Digital Enforcement System. This system consists of a combination of radar speed detection, multiple digital cameras and data encryption techniques to provide a Home Office approved record of offending vehicles within Managed Motorways[16]. The data is stored in a secure data store accessible to the enforcement authorities, known as RERS (Remote Evidence Retrieval System), which can be interrogated by the police back office to view the photographic evidence, perform a secondary speed check and determine whether to proceed with the case. It is necessary as part of the current development to establish that this provides the necessary evidence pack for enforcement under the Irish judicial system.

It is estimated that a period of 12-15 months would be sufficient to progress the necessary preliminary works and statutory procedures outlined above. Following this, and given the limited infrastructure requirement, the construction and testing stage is expected to take a further 12-15 months.

With regard to the M50 between Junction 12 (Firhouse) and Junction 17 (M11), it is clear that the implementation of Variable Speed Limits will require a larger capital cost, given that the gantry and communications infrastructure is not in place. Furthermore, it is noted that the construction of the section of the M50 east of Junction 14 (Sandyford) has provided for the future construction of a third lane using a designated reservation in the central median. As such, it is sensible that the provision of that third lane is implemented as a first response to capacity constraints on this section of the M50, and that the provision of the necessary infrastructure of Variable Speed Limits could be delivered as part of those works. Implementation of VSL on the M50 east of Junction 12 is not included in the current measures but could be included as a subsequent phase.

5.4.3 Information Measures and Area Travel Planning

Both these measures use existing infrastructure and institutional frameworks to deliver the necessary outputs. The dissemination of information through web-based systems is already available through *www.nratraffic.ie*, and is currently in the process of being upgraded to

[16] *Managed motorways are motorways that use active traffic management techniques such as VSL or Hard Shoulder Running to increase traffic capacity*

incorporate the significant information already being collected on the M50. The implementation of feeds through social media can be achieved quite rapidly once the necessary communication lines are in place, and at very low cost.

With regards to Area Based Travel Planning, it is possible to implement this initiative immediately through the Local Authorities with a view to benefits being derived within 12-15 months of commencement.

5.4.4 National Traffic Control Centre

It is the intention that the functions of the NTCC will be evolved in tandem with the NRA's provision of operations and maintenance on the dual carriageway part of the national roads network. The NRA is currently in the process of developing a 10-year plan for the evolution of the National Traffic Control Centre which will incorporate anticipated functions on the M50 in addition to likely requirements across the Strategic Road Network. The NTCC will therefore react continuously to new requirements throughout this period as it follows this 10-year plan. The development of the NTCC is in accordance with NRA objective of improving its capacity to manage the network and the NTCC will be specified such that it can manage the ultimate M50 scheme.

5.4.5 Summary

On the basis of the above, the necessary work-packages and the timescale for their implementation are outlined in Table 5.8. The implementation of the measures will be subject to various governmental approval and statutory procedures.

Table 5.8 - Planning and Implementation Period from Decision to Proceed with any of the Measures

	Year 1	Year 2	Year 3	Year 4	Year 5
Variable Speed Limits	Planning	Implementation			
Incident Management System			Implementatio n		
Distance Based Tolling	Planning	Implementation			
Smarter Travel Planning	Planning			Implementation	

5.5 Risk Analysis

A summary of risks to the delivery of the strategy is outlined in Table 5.9. The monitoring of risks throughout the implementation stage is necessary to understand the impact on the overall project. This should, and will, form part of the project delivery stage.

Table 5.9 - Risk Register: Phase 1 (Feasibility)

Risk	Details	Likelihood	Action
Legislative	That the implementation of Variable Speed Limits may not become achievable through the current regulations	Low	Continue separate task to explore and implement legislative changes that are necessary
Enforcement	That the required evidence pack cannot be established by HADECS for implementation of Variable	Moderate	Work with suppliers to develop an alternative commercial product.

	Speed Limits		
Political	That a decision to implement tolling may change during the implementation stage	Moderate	Cost of scheme preparation and implementation is low. Any reversal will not lead to significant sunk costs, but will reduce the effectiveness of the overall strategy.
Affordability	That disposable income levels will decline, reducing the affordability of tolls	Low	Reducing income may also reduce the cost of operation, which is driven by labour costs. Some understanding of affordability should be developed during the project preparation stage.
NTCC Functionality	That the NTCC will not be sufficiently equipped to accommodate the additional traffic control functions	Low	Examine alternative locations where the VSL and Information functions can be managed.
Economic	That strong economic growth will resume, leading to very high levels of traffic growth on the M50	Moderate	Seek to accelerate fiscal measures such that growth can be managed. Strong publicity in advance of implementation will encourage predictive behaviour – road users will adapt to the change before it is implemented.

6.0 Conclusions

This study has been undertaken by the Steering Group to comply with the conditions imposed by An Bord Pleanála as set out below.

> ***Condition 7:*** *A scheme of specific demand management measures for the M50 motorway corridor shall be published by the relevant road authorities not later than three years after the M50 Motorway Upgrade Scheme has been completed.*
>
> ***Reason:*** *To protect the traffic capacity provided by the M50 Motorway Upgrade Scheme over its design life.*

The study has identified that in the peak periods congestion is already beginning to occur on the busiest sections of the M50 as a result of significant increase in demand since the upgrade was completed. The study has also shown that demand for use of the M50 will continue to rise in the coming years, with congestion, delays and incidents all increasing significantly if this demand is not actively managed.

In response the Steering Group investigated a wide range of possible alternatives and developed an indicative scheme of specific demand management measures for the M50, covering the M50 between Junction 3 (M1) and Junction 17 (M11). The various elements of the indicative scheme are set out in Table 6.1 below;

Table 6.1 - Summary of the Indicative Scheme of Specific Demand Management Measures

Category	Measures Taken Forward
Fiscal Measures	Distance-Based Tolling Variable tolling Tolling by Vehicle Type
Intelligent Transport Systems/Traffic Control	Variable Speed Limits Incident Detection
Information	Internet Roadside Information
Smarter Travel	Area-Based Travel Planning
Control	National Traffic Control Centre

The assessment of the fiscal measures has been based on an indicative five toll point open system, which provides a coverage rate of greater than 80% of trips. This has been derived to demonstrate the benefits and impacts of such a solution as a proxy for a pure distance based closed charging system, which would capture 100% of users via toll points at all entry and exit points.

With current technology the collection costs associated with a closed system would be higher compared to a five point system, which could lead to tolls having to be higher to cover the cost. Therefore, the five toll point open system has been put forward at this time.

However, it is worth noting that the cost of closed system tolling is anticipated to reduce as technology develops and improves in the future and as large-volume transaction systems become more cost-effective. As such any future development of a variable distance-based toll system on the M50 should consider the option of implementing a closed system or of providing a higher number of toll points in an open system. Ultimately any multi-point tolling scheme will have the potential to evolve to a closed system which would be able to better protect the traffic capacity of the M50 in the longer term.

The study showed clearly that fiscal measures had by far the most significant impact on managing future demand on the M50. In this regard it is important to note that in the absence of the introduction of the fiscal measures identified (i.e. variable distance-based tolling) it is unlikely to be possible to protect the traffic capacity provided by the M50 Motorway Upgrade Scheme over its design life.

This study demonstrates the feasibility of the indicative demand management measures which can provide a basis for the development of a detailed scheme for implementation.