Sustainable Freight Distribution in a Historic Urban Centre:

Final Report

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- DCBA
- Dublin City Council
- Dublin Transportation Office
- IBEC
- LVA
- Musgraves
- NOVEM
- RAI
- RGDATA

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BESTUFS	Best Urban Freight Solutions
CNG	Compressed Natural Gas
CSO	Central Statistics Office
DCC	Dublin City Council
DCCBA	Dublin City Centre Business Association
DoT	Department of Transport
DTO	Dublin Transportation Office
EPA	Energy Procurement Agency
EV	Electric Vehicles
FQP	Freight Quality Partnership
GDA	Greater Dublin Area
HGV	Heavy Goods Vehicle
IBEC	Irish Business and Employers Confed
ICT	Information Communications Technology
IPA	Impact Pathway Analysis
JIT	Just In Time
LGV	Light Goods Vehicle
LVA	Licensed Vintners Association
LSDP	London Sustainable Development Plan
LNG	Liquefied Natural Gas
MSVC	Musgrave SuperValu Centra
NG	Natural Gas
PSP	Forum for Physical Distribution
RAI	Restaurant Association of Ireland
RGDATA	Retail, Grocery, Dairy and Allied Trade Association
TKM	Tonne Kilometres
UDC	Urban Distribution Centre
UNITE	Unification of accounts and marginal costs for Transport Efficiency
VKM	Vehicle Kilometres

EXECUTIVE SUMMARY

INTRODUCTION

Cities with historic urban centres are faced with the challenge of managing city freight in a sustainable manner. This is particularly true for Dublin where the level of congestion is high. The factors that drive congestion are multi-faceted and relate to developments in society and in the economy. The increasing traffic intensity can be linked directly to the rapid growth of the Irish economy. The emergence of the post-industrial "7 day, 24 hour society", the changes in supply chain management practices and the demands on distribution systems made by e-commerce and e-living are developments that create new challenges for traffic managers who wish to ensure continuing mobility and the enjoyment of a sustainable quality of life by the inhabitants

During the last decade, the Celtic Tiger economy has led to a doubling of vehicle registrations and consequent major increases in the lengths of commuting peaks and journey to work times. The deteriorating traffic environment has adversely affected business in terms of compromised customer service, higher haulage costs and more difficult customer access. This research was prompted by the recognition that mobility and efficient goods distribution in particular, are crucial for the continuing vitality and regeneration of the city. The research was carried out in the context of other more macro studies conducted by the DCC, DTO, and IBEC on regional freight management and on matters relating to Dublin Port. The following project hypothesis is proposed:

"a logistics regime & configuration can be found that justifies the use of urban delivery centres and eco-friendly vehicles, because they can offer a more sustainable solution for managing freight deliveries in the historic city centre"

PROJECT APPROACH

The experience of other European cities indicates that measures such as external urban distribution centres (UDCs,) down-town platforms for last mile deliveries, a high utilisation of vehicle capacity, a better use of the available infrastructure by peak spreading, and the deployment of clean and low noise vehicles and ancillaries, can offer sustainable solutions.

A research methodology for the project was developed to:

- Create a picture of freight delivery patterns on the congested city streets
- Identify possible niche applications for more sustainable solutions
- Evaluate the feasibility and possible impacts of the scenarios proposed

It was found that research models to support urban freight policies are relatively underdeveloped compared with the international research efforts that are focused on passenger transport. Urban freight modelling itself is at an earlier stage of development than passenger modelling. This report describes current urban freight models and highlights the fact that a model for the Greater Dublin Area is required in order to produce reliable results that predict the level of freight transport for the

transport system. Without the availability of such a model, development and continual evaluation of a long-term urban freight strategy for city will be difficult.

Having reviewed current international best practice, the next stage of the project involved the collation of relevant delivery information. This was done by surveying deliveries to over 150 city centre businesses. Furthermore, a pilot survey of deliveries to Trinity College Dublin was also carried in order to perfect the survey methodology. The surveys carried out as part of the project have generated new data that describe deliveries in terms of key variables, (1) the time of day (2) types of goods carried (3) types of vehicles and packaging used (4) dwell times for deliveries (5) how and where unloading occurs (6) the origins of the suppliers.

It was found that the busiest period occurs between 9 and 12 am. Deliveries peak between 10 and 11 am with 16% arriving at this time. By contrast only 2% of deliveries are made in the quiet off-peak times between 17.00 and 23.00 hrs.

LGVs accounted for 55% of all deliveries, HGVs accounted for 40% while cars and motorcycles only accounted for 6%. The average dwell time on the streets was 14 minutes although this varied greatly across different types of businesses. The average distance travelled from suppliers to customers was 14 miles.

Of the 21 geographical zones in the greater Dublin area (using the DTO coarse zoning system), the most important delivery generating zones are in the south west, the city centre, the south county and through the port for supplies coming from outside the country (Zones 1, 6, 12, and 14). Certain categories of goods are linked to particular zones. Most pharmaceuticals originate in Tallaght and most clothing tends to arrive through the port. Food, beverages and pharmaceuticals are consolidated for delivery at identifiable depots along the M50 and on the periphery where the bigger depots are managed by the leading logistics service providers like TDG, MSVC and United Drug.

A high proportion of deliveries are kerb side (49%). Many of these are by HGVs which have a higher than average dwell time of more than 22 minutes. Dedicated loading bays are used for 39% of deliveries and shared facilities are available for the remaining 12%.

On the basis of an analysis of the available data, niche applications and possible scenarios were identified for more sustainable logistics solutions. The criteria used to develop these scenarios were (1) the likely reduction in delivery trips (2) trips taken out of peak (3) the environmental benefits (4) operational feasibility and (5) the willingness of the parties concerned to buy-in to the solutions proposed.

1. External consolidation at Urban Delivery Centres (UDCs)
2. Internal consolidation – "Managing the Last Mile"
3. The Adoption of Eco-Friendly Technologies for Deliveries to the City Centre
4. City Access Control

SCENARIOS EVALUATED

1. External Consolidation at Urban Delivery Centres (UDCs)

By consolidating loads and by optimising vehicle capacity, a UDC can minimise the need to access the city. A UDC can also facilitate night working and the transfer of goods from HGVs to smaller vehicles more suitable for deployment on the narrow streets. This report outlines the operation of the Musgrave Distribution Centre at Kilcock and details the reduction in trips facilitated by the centre. In terms of quantifying the environmental benefits of the distribution centre, it was found that the savings in terms of exhaust emissions, greenhouse gases and night time noise would amount to €105,245 over the course of a year.

It is recommended that the development of an Urban Distribution Centre in South West Dublin be viewed as a long-term approach to managing food related deliveries to the city centre. Preliminary set up costs of land and buildings were estimated to be in the region of €41 million. However in order to quantify the benefits of the centre over the next number of years, it is recommended that a comprehensive cost/benefit analysis be carried taking into account both the financial payback, and both user and non-user benefits.

2. Internal Consolidation – Managing the Last Mile

Downtown platforms are an innovative way of managing last mile deliveries. Goods can be delivered less frequently from outlying suppliers to the city centre (sometimes during the off-peak), sorted, and distributed locally by walking or cycling couriers. Consignments can also be collected or dropped to the platform by customers.

DHL successfully operates a platform in the city centre business district for mail deliveries. This platform removes 12 LGVs from the city centre during the working day. A justification is made for establishing a platform on the periphery of TCD to intercept the goods arriving at the campus and to control the current free for all access. There is also potential for replicating the platform model in other parts of the city where the density of businesses is high – government office complexes, hospitals and institutions and the newly developing commercial districts.

3. The Adoption of Eco-Friendly Technologies for Deliveries to the City Centre

The availability of low noise and low emission vehicles and related ancillaries was examined in the report in order to make night working more acceptable and to mitigate nuisance in pollution hot spots in the city centre. Natural gas (NG) finds favour in the UK, in Italy and India as a low emission and low noise alternative fuel. NG whether in compressed (CNG) or liquefied (LNG) form would not be a realistic option for Dublin. The continuing poor availability and the high costs of deploying electric vehicles (EVs) and hybrid diesel electric vehicles (HEVs) is disappointing. While EVs may offer an elegant solution for certain niche applications (parcels deliveries, service and utility vehicles) this option cannot be recommended.

Modified conventional diesel HGVs and LGVs and related ancillaries (role cages, tail gates, trailer bodies, reversing cameras, refrigeration units) offer the most realistic solution for sustainable night deliveries in Dublin.

As a practical demonstration, the possibility of showcasing a modified 17 tonne gvw HGV and related ancillaries for the delivery of dry and chilled goods to grocery stores in the Musgrave franchise chain is proposed.

4. City Access Control

The possibility of introducing city access control measures as introduced in other cities was explored. A City Freight Consultation Forum is deemed a necessary step for securing across the board consensus for innovation and change.

The potential impact of a possible time-based city access system for the city centre was evaluated. Allowing only trucks that use dedicated parking places to deliver during the day (using DCC pilot clearway hours 7:00-10:00 and 12:30-19:00) would have the effect of compressing the distribution activities into a shorter period at the start of the day. In the overall survey, it was found that 93% of trucks arrive before 14:00. Results also indicated that this scenario would produce an increase in the cost of noise of 10%.

Analysis also showed that when all delivery vehicles were restricted to delivery hours of 10:00-12:30 and 19:00-07:00, the number of deliveries occurring at the peak time (10:00-11:00) increased by 6%. Most of the deliveries previously occurring in restricted hours are accommodated in the hours between 19:00 and 23:00 where the average increase in the number of delivery trips of almost 6% each hour is observed. An environmental analysis using the cost of noise showed that this scenario brought about an increase in the cost of noise of 41%.

Finally, analysis showed that when vehicles were restricted to allowable delivery hours except those vehicles that used dedicated or shared loading bays, the time period from 10:00 to 13:00 proved the busiest time for deliveries (20% of the total delivered during this time). This represents an increase of 4% in the number of delivery trips from the situation observed in the original survey. An increased level of business activity in the morning in comparison to the evening was also noted. Environmental analysis also showed that this scenario produced the least additional noise cost.

CONCLUDING NOTE

It is hoped that findings from this study will serve to better inform relevant stakeholders regarding current trends of freight distribution in Dublin City Centre and to highlight possible courses of action both in the short-term and the long-term. The solutions and scenarios proposed in this report are intended to complement the traffic management measures that are being currently developed by Dublin City Council in collaboration with the Dublin Transportation Office. A further output from this project is expected in a year’s time in the form of a doctoral thesis examining the area of freight demand. Research carried out on this project has helped to form background information for the thesis.

1 INTRODUCTION AND AIMS OF THE PROJECT

1.1 INTRODUCTION

This report details the final results and analysis carried out on the project entitled "Sustainable Freight Distribution in a Historic Urban Centre", funded under the Pilot Transport Research Programme of the Higher Education Authority. The report constitutes a review of work carried out over the two-year project time frame.

In broad terms, details of the background to the theme of the project are provided, along with a review of the current situation relating to freight distribution and related topics. Specifically, the project addresses the issues integral to sustainable freight distribution- freight policy, freight modelling, city centre accessibility, goods consolidation and silent and clean technologies for deliveries to the city centre. In addition a description of the methodology used for a survey of deliveries to city centre businesses is described. The results of the survey are outlined and their implications are discussed. Finally, recommendations for more sustainable freight distribution for both the short and long term are provided.

1.2 BACKGROUND TO THE PROJECT

Motivation for this project lies in a desire to provide a long-term sustainable solution for freight deliveries in Dublin City Centre. A recent survey by IBEC indicated that 90% of businesses in Dublin are adversely affected by congestion (IBEC, 2002). Negative impacts on businesses include late deliveries, resulting in compromised customer service, high haulage costs and poor staff punctuality. All of these factors affect the competitiveness of an organisation. Moreover, one third of city-based firms would consider re-locating to a less congested region. These findings are a firm reflection of the increasing problems faced by firms based in the city centre as a result of congestion.

Specifically the scale of the congestion challenges facing the authorities can be seen from the following:

According to the DTO estimations (DTO, 2003), 66.5 million tons of road freight was carried in the Dublin area in 2000, which is equivalent to 28.4% of total freight activity in the country as a whole. One half of the tonnage carried in the Dublin area is internal, originating and terminating within the area. About 24% of this freight is port related.

1. Data gathered by the DTO (DTO, 2003), would indicate that average journey times on the key radial routes have increased by 62% in the period 1991 to 1997. Commuting peak times in the mornings have increased in the same period from 1 hour to 2 hours. The travel times on the main radial freight routes into the city are badly affected – average speed on the important East West link along the River Liffey Quays to the port is now reduced to 11 km/hr at peak times.
2. Traffic congestion is driven by the unprecedented boom in private car registrations. Registrations have grown from a little over 100,000 in 1990 to 240,000 in 2000 (CSO, 2002).

3. HGV movements in Dublin are concentrated on a relatively small number of key port access routes where freight movements must compete with other users on congested streets (Dept. of Marine & Natural Resources, 2002).

Congestion within Dublin City Centre seriously affects the quality of life for city residents and operating conditions for business owners. The hypothesis of the project is the following:

"*That a logistics regime and configuration can be found that justifies the application of advanced eco-friendly vehicles in conjunction with a dedicated UDC that is feasible and that offers an environmentally beneficial, socially acceptable and economically sustainable solution for freight collection and deliveries in a historic part of Dublin*"

In other words, the primary aim of the project is to ascertain whether city centre deliveries can be managed in a way that is acceptable to businesses while taking the environmental and social costs of the city into account.

Specific challenges currently facing city planners include addressing the following:

- How can the growing social and environmental nuisance of the starting and end-points of the supply chain in the city be ameliorated?
- How can the excessive occupation of public spaces by large moving or parked vehicles be minimised?
- Can the environmental and social costs of city centre deliveries be managed in a sustainable way that is also acceptable to businesses?
- Finding an approach for city centre deliveries that is cost effective for the city
- How should Dublin prepare for an alternative fuels economy?

1.3 SUPPLY CHAIN DEVELOPMENTS AND URBAN FREIGHT

Freight transport is an essential and unavoidable fact of city life involving a large number of affected user groups. Private actors involved in freight transport include shippers, transport operators, logistics service providers, receivers (shop owners), vehicle manufacturers, consultants and various trade associations. Public actors, on the other hand include citizens, local governmental organisations, national government and numerous other associations and organisations.

Globalisation of economic activities, changes in consumer behaviour and advancements in relevant technologies have brought about a number of developments in freight transport. The actions of actors at each level of the supply chain influence the overall nature of freight transport. For example, the increased utilisation of global supply chains by businesses for their sourcing and distribution activities has led to the integration of urban goods transport with long-haul transport. Furthermore, the use of Information and Communications Technology (ICT) by businesses for optimising the flow of goods through the supply chain by reducing the number of warehouses and centralising inventory is becoming increasingly prevalent (OECD, 2003).

Developments in the retail sector have also impacted upon freight transport. In an effort to minimise costs by saving storage space and reducing stock, retailers often

enforce strict demands on the supply chain such as just-in-time (JIT) deliveries and shorter delivery lead times. There has been a move towards smaller, more frequent deliveries in order to maximise selling space. This in turn has repercussions for the transportation efficiencies possible further up the supply chain for the suppliers of goods to the retailers. Deliveries have become more frequent with multiple trips often being made by vehicles with the quantities being delivered being correspondingly smaller. Strict time windows requested by retailers have also led to smaller loads of goods being transported more frequently.

At the customer level of the supply chain, the importance of e-commerce has meant that a fast and reliable delivery service is required. Consolidated deliveries to shops with delivery trucks are replaced by direct deliveries to consumers carried out by courier services using small vans. This delivery service is often required to be time sensitive due to the nature of individual customer demands.

1.4 THE GROWTH OF ROAD FREIGHT TRANSPORT

The increase in freight transport and the demand for just-in-time tailor-made urban goods deliveries poses considerable difficulties for transportation planning and sustainability in cities.

The extent of road freight transport in Europe is reflected in the statistics available relating to the area. In 2001, the volume of road transport in the EU is estimated to have been 1329 billion tonne-kilometres. Of this total, national transport accounted for 75 %, international transport 22% and cross-trade for 3%. Ireland recorded the largest rise in road transport for the period 1990-2001 with a jump of 135% from 3978 million tonne kilometres(tkm) to 9122tkm (EuroStat, 2001). More specifically in Dublin, the volume of goods imported and exported through Dublin port has grown significantly since 1997. The traffic that this business generates at 350,000 truck movements per annum is expected to cause major congestion in the city centre until the port relief tunnel opens in 2005 (Dept. of Marine & Natural Resources, 2002).

Overall freight transport has increased dramatically in the past decades within urban areas as well as between cities. Forecasts point to a continuation of this trend for the foreseeable future. The majority of growth in freight transport has been road based. This is largely due to the low variable costs, reliability and flexibility of the mode. The prospects for a significant increase in rail freight traffic in Ireland are not good however (Dept. of Environment & Local Government, 2002).

Combined with this increase in freight traffic has been a large increase in passenger car traffic. Car numbers in Ireland are expected to double between 1996 and 2016 from 1.1m to 2.1m. Over this period as a whole, car numbers will grow by some 3.5 percent on average (Dept. of Environment & Local Government, 2002). This trend has also been the focus of heightened concern to national and city governments. Noise, pollution and accidents are all negative repercussions of rising traffic numbers. Ultimately, as passenger car traffic increases, the distribution of goods and services is made less efficient.

It is within this difficult environment that freight transport takes place. Problems suffered or indeed caused by freight traffic are numerous and often interrelated.

Accessibility problems are both encountered and caused by urban goods transport. These problems are mainly attributable to insufficient infrastructure, access restrictions and congestion. On-street parking can be a major problem in city centres. It has been estimated in various surveys undertaken in European Cities that where controls are not sufficiently strict, the percentage of illegal parking can reach a level of 65-70 per cent (OECD, 2003). Road freight transport also contributes to environmental problems such as emissions, noise, vibration and physical hindrance. Transport produces 30% of European CO2 emissions with road transport accounting for 84% of emissions (Commission of the European Communities, 2001b). The environmental impact of transport is reflected in the fact that proportion of emissions from road transport in the national total accounted for 17% of all emissions in 2002, up from 9.5% in 1990 (EPA, 2004). Therefore, projects that promote more sustainable approaches to freight distribution have a great deal to offer in terms of environmental benefits. Safety problems are also a concern arising from goods transport due to the size and manoeuvrability of vehicles.

However, in spite of the inherent problems associated with urban freight transport, it is important to highlight the crucial role that urban goods transport plays in the economic and social viability of a city. Indeed it is worth highlighting the fact the OECD Working Group on Urban Freight Logistics (2003) have stated that "awareness of urban goods transport seems to be rather one-sided, focusing more on its problems than on its importance".

Therefore, all stakeholders involved require a clear understanding of urban freight transport to ensure the development of a management strategy for the future that takes into account commercial and sustainability objectives for a city.

1.5 PROJECT AIMS AND OBJECTIVES

The primary aim and long term goal of this project is to ascertain whether city centre deliveries can be managed in a way that is acceptable to city centre businesses while bearing in mind environmental concerns.

One of the most important tasks involved in the project was the survey of deliveries to city centre businesses. Chapter 3 of the report describes the methodology used in the survey along with analysis carried out on the information gathered. The survey was a valuable source of qualitative and quantitative delivery information and indicated a number of key trends that are described in the report. Evaluation of the survey results also helped in the formulation of a number of goods delivery strategies. The project focuses on the efficient organisation of urban logistics through a number of possibilities: organised consolidation of goods, where goods can be transferred from big trucks into smaller vehicles (Chapter 5), the use of eco-friendly vehicles (Chapter 7), and a number of other delivery scenarios such as managing the last mile of deliveries (Chapter 6) and city access control (Chapter 8).

In addition to the analysis of goods delivery strategies, the report also provides information on the area of freight modelling (contained in Appendix B). This section presents a number of international freight modelling case studies and describes in detail the type of data required to build these models.

Finally, a number of conclusions and recommendations are presented in Chapters 10 and 11. These conclusions and recommendations are the culmination of work carried out during the course of the two-year study. It is hoped that findings from this study will serve to better inform interested parties on the nature of freight distribution in Dublin City Centre and to highlight possible courses of action both in the short-term and the long-term. The solutions put forward in our report are intended to complement the traffic management measures that are being currently developed by Dublin City Council in collaboration with the Dublin Transportation Office.

2 URBAN FREIGHT POLICY: AN INTERNATIONAL PERSPECTIVE

2.1 INTRODUCTION

It is instructive to give a general overview of current international R&D and Demonstration activities as they relate to urban freight transport policies.

In the chapters that follow, scenarios and possible solutions that have emerged from our analysis of delivery patterns to city centre businesses and that are modelled on selected case histories found in the literature, are evaluated.

It is recognised that efficient freight transport supports the commercial life of the city and contributes substantially to the overall competitiveness of the urban economy (Plowden & Buchan 1995). While city freight is a necessary driver of the economic life of a city, it has negative effects in terms of adding to congestion and environmental degradation, and of reducing safety and accessibility to homes and businesses.

Many European cities with historic urban centres have felt obliged to develop innovative solutions for managing city freight in a more sustainable manner. These cities participate in the CEC/DG-TREN sponsored thematic network on city freight known as "BESTUFS" (Best Urban Freight Solutions). Irish membership of this network (currently held by TCD) enables interested parties to share in the research and demonstration experiences reported by the municipal authorities in cities that include Paris, London, Brussels, Milan, Copenhagen, Budapest, Berlin and La Rochelle (BESTUFS, 2003). Relevant case histories are described in later chapters.

Allen et al identifies the changes in the supply chain management practices that have a growing impact on city traffic and on the related urban environment (Allen et al, 2003). These are:

1. An increase in the intensity of daily and weekly deliveries
2. A bigger proportion of larger and heavier vehicles appearing on the streets, driven by the cost advantages for the carriers
3. An increasing reluctance by retailers to retain stock and to expect just-in-time deliveries from their suppliers.

The demand by retailers for smaller, more frequent deliveries to premises generates additional traffic. In addition the out-sourcing of logistics services by companies to sub-contractors adds to the numbers of commercial vehicles accessing the city and may militate against the most efficient consolidation of loads and may add to traffic.

These trends are taking place against a background of a growing public demand for more sustainable urban living and a more acceptable quality of life. Better approaches for managing all forms of urban transport including city freight, is expected by the public.

A successful urban freight strategy should help to achieve operational and logistical efficiencies along the supply chains (Ogden, 1992). In our study for example, we have followed the solutions proposed by Ogden by examining how these efficiencies might be achieved by encouraging better consolidation at out of town and down town urban distribution centres (UDCs) and platforms. UDCs can be shown to help ease congestion by minimising the need to access the city centre and take commercial traffic out of peak by facilitating nighttime deliveries.

The following sections in this chapter deal with international urban freight policy. A brief synopsis of the recent OECD report on delivering urban goods is provided

2.2 THE OECD URBAN GOODS DISTRIBUTION REPORT

According to a major OECD report entitled "Delivering the Goods – 21st Challenges to Urban Goods Transport", urban freight policy has merited relatively little attention in comparison with the movement of people by car and by public transport (OECD, 2003). The OECD report provides a useful overview of evolving international city freight transport policy and affirms the experience reported by the BESTUFS research and demonstration projects, which are described in the latter chapters of our report.

The OECD report specifically focuses on challenges to urban goods transport. It is the first OECD report that is fully devoted to the theme of the delivery of goods in urban areas. The report analyses measures taken in many cities in the OECD area and provides recommendations for dealing with urban freight logistics and the associated problems.

According to the OECD report, the issues affecting urban goods are driven by the wide pattern of developments in society – the emergence of the post-industrial society, increasing urbanisation, the 24 hour day - seven day week, the desire for sustainability, the competition for limited urban road space, the impacts of globalisation and the revolution in supply chain management practices.

The report finds that countries are in different phases concerning the development of policies for managing urban goods transport. Cities are confronted with the common and difficult challenges of maintaining their quality of life while having a reasonably efficient goods transport policy that serves their needs.

The survey of the OECD member states found a number of common themes:

1. A lack of consistency in policies between the national, regional and local authorities
2. A focus on a passenger transport perspective rather than on a freight perspective
3. A focus on short-term solutions with little appreciation of the longer term side- effects or on what is happening in the supply chain as a whole
4. There is a widespread need for firm data to underpin planning and a need to employ ex-ante and ex-post evaluation methodologies to monitor the cost effectiveness of various policy options.
5. Regulations by the municipalities often lack enforcement and harmonisation.

6. Public-private consultation platforms are helpful for resolving differences between the various stakeholders who have different and often conflicting interests.
7. Consolidation of goods deliveries is an emerging trend but this needs to be facilitated through the appropriate policies and public supports
8. Innovative solutions involving elective time-sharing, the introduction of environmental zones and eco-friendly transport and pricing regimes to divert freight from residential areas, have been shown to work
9. A lack of awareness and knowledge of urban goods transport not only among the general public but also among governments and city planners. This has often led to transport related policies and facilities being planned merely from a passenger transport perspective.

In its recommendations the OECD (OECD, 2003) calls for:

1. A greater public awareness of the issues involved and leadership by the authorities
2. Consistent data collection and benchmarking is needed to underpin and to develop the appropriate policies
3. A facility to consolidate final loads is seen as an important tool for achieving sustainable mobility. Where consolidation involves transhipment into smaller vehicles at urban distribution centres, a high degree of vehicle utilisation is necessary to compensate for the additional costs involved and to minimise the number offsetting trips generated by these smaller vehicles.
4. International harmonisation of the regulations governing truck size and weight, dimensions, low emissions and noise are needed
5. Infrastructure capacity should be used more imaginatively on a 24-hour basis – night delivery is particularly favoured for easing congestion at peak times
6. Adequate logistics facilities need to be provided by the authorities, which will accommodate loading and un-loading operations more efficiently. For example off-road facilities should be included in all new building permits.
7. The use of cleaner, low noise and more eco-friendly transport should be encouraged – this also applies to the ancillary "silent" handling equipment for night deliveries

There is scope for developing more innovative "city logistics" ICT related systems to optimise planning, routing and vehicle deployment.

2.3 URBAN GOODS POLICY IN JAPAN

In 1997 the government of Japan authorised a programme entitled the "Comprehensive Program of Logistics Policies" which includes urban freight transport (Visser, 1999). The objectives of the programme are to:

- Enable Japan to offer one of the most attractive logistics services in the Asian-Pacific Region
- Provide logistics services at a reasonable cost
- Cope with the energy, environmental issues and safety problems arising from freight logistics.

The policy measures that were implemented as part of the programme include:

- Improving the infrastructure
- Providing subsidies for investments in logistics-related facilities
- Encouraging shared consolidation, collection and delivery points in metropolitan areas
- The development of logistics hubs in the vicinity of major highway interchanges, and in industrial and port side zones.
- The development and standardisation of the ITS logistics applications
- Providing road traffic information through bringing a standard Vehicle Information System (VIS) into nationwide use

In 2001, a revised version of the programme was introduced. Urban freight transport is considered an important area in which to achieve efficient and environmentally friendly logistics systems in Japan. Two quantitative targets were set on the load factors and peak-hour average travel speed in three major metropolitan areas: from the current 45 percent to a target of 50 percent, and from the current 21km per hour to a target of 25 km per hour respectively. In order to meet these targets, the program emphasises the importance of co-ordination and cooperation between public and private sectors, and between national and local governmental agencies. The programme requested that local agencies establish an independent organisation to plan local logistics policies and forums to exchange information on local logistics policies inviting private representatives from the associations of carriers, retailers and other concerned stakeholders. The Japanese policies are reflected in the OECD review mentioned above.

2.4 URBAN GOODS POLICY IN THE EUROPEAN UNION

Since the early 1980s the European Commission (CEC) has supported a comprehensive programme of research, development and demonstration (RD&D) in transportation. Ireland currently participates in EU wide thematic and information networks, namely BESTUFS and UNITE (Link et. al, 2001).

In France, research into urban transport is conducted under the auspices of GART, a consortium of municipal authorities. The French municipalities have developed innovative solutions for mitigating congestion in their historic urban centres. These include the use of down town consolidation platforms or shared “relay centres” (Paris), the use of fleets of small electric vehicles (La Rochelle) and more sustainably managed night deliveries (Dijon, Orleans, Marseilles and Paris).

In Britain there is a focus on developing eco-friendly and clean transport (Transport Energy, 2003). Government incentives are available to stimulate a new market for alternative fuels in commercial fleets with the result that LPG and CNG have captured a significant market share. Furthermore, the British Government’s Sustainable Distribution Strategy Report (DoT, 1998) provides an overall policy framework, emphasising the twin goals of increased efficiency and reduced environmental impacts. The document fulfils the government’s commitment in the White Paper “ A New Deal for Transport”, to set out a comprehensive integrated strategy for the sustainable distribution of goods and services in the UK. It deals with supply chain management as well of modes of transport. In the report, it is stated that the UK government’s objectives are to:

- Improve the efficiency of distribution
- Minimise congestion
- Make better use of transport infrastructure
- Minimise pollution and reduce greenhouse gas emissions
- Manage development pressures on the landscape-both natural and man-made
- Reduce noise and disturbance from freight movements
- Reduce the number of accidents and cases of ill-health associated with freight movement

Achieving an efficient and sustainable distribution system for goods and services is one of the greatest challenges facing the city of London. The Mayor of London's Transport Strategy builds on the objectives set out in the national Sustainable Distribution Strategy. One of the main mechanisms that the Mayor has put in place in order to achieve efficient and sustainable freight distribution for the city has been the creation of the London Sustainable Distribution Partnership (LSDP). The LSDP was established in early 2002 and has identified a number of key issues affecting sustainable distribution in London in the past two years. The current work areas of the LSDP are: (i) road based distribution and delivery issues; (ii) rail freight development, (iii) the use of London's waterways. Furthermore, the Transport Strategy emphasises the importance of the establishment of Freight Quality Partnerships (FQPs). LSDP is providing guidance to newly formed FQPs. Members of the LSDP come from a wide variety of interest groups. Members include The Greater London Authority, London Development Agency, The Department of Transport, Freight Transport Association, Association of London Government, Road Haulage Association, British Retail Consortium, Association of Convenience Stores, London Chamber of Commerce and Industry and the University of Westminster. The value of such a diverse group is to bring expertise, knowledge and example of good practice to deliveries and distribution in London.

In the Netherlands, the Ministry for Transport and Public Works supports a consortium of towns and cities to develop innovative solutions for managing urban freight, known as the Forum for Physical Distribution in Urban Areas (PSD, 2004). These forums focus on night deliveries and on low noise vehicles and ancillaries. The policy agenda of these forums is developed in co-operation with both the public and private sector. The government seeks co-operation with the private sector and develops policies in full consultation with the private sector, in order to create win-win situations. This means that instead of regulation, local, regional and national governments now sign covenants with organisations representing business or directly with businesses. In these covenants the private sector agrees to behave in a particular way, while the public sector either provides facilities, finances or reassesses and alters regulations.

Reference is also made in later chapters to successful initiatives undertaken by the authorities in selected Italian and German cites and to promote the use of eco-friendly low emission vehicles.

Different permitting policies have been tried and evaluated in selected Scandinavian and UK cities to promote more sustainable solutions by means of incentives and

controls. The relevance of this experience for Dublin is examined in later in our report.

As part of its future research programme under FP6, the CEC (DG-TREN) would like see a greater emphasis on urban freight modelling. Freight modelling is relatively underdeveloped and the current standing and applicability of urban freight modelling is examined in later in our report.

The interim report of this project (July 2003) contains further examples of the state of the art in urban freight transport.

2.5 CONCLUSION

It is acknowledged that freight transport is essential to the sustainable development of cities. However, the importance of its role in urban transport policy is often overlooked. This chapter has highlighted the emphasis that countries such as Japan, the UK and the Netherlands place on urban freight transport. The challenge currently facing relevant authorities in Dublin is to encompass a clear policy for freight distribution in the overall transport policy for the city. The need for a comprehensive freight policy is made all the more necessary by the development of the Port Tunnel, one of the most significant pieces of infrastructure for HGVs in the past number of years. One of the most notable features of urban freight policy in Japan, the UK and the Netherlands is the importance attached to co-operation between the public and private sector when formulating policies. This is a recommended approach to policy formulation because it will help to achieve across the board consensus from various interest groups.

3 SURVEY METHODOLOGY AND ANALYSIS

3.1 INTRODUCTION

The survey of deliveries to city centre businesses forms the cornerstone of this Sustainable Freight Distribution project. Results from the survey are integral to identifying freight distribution trends in Dublin City Centre. Accordingly, a great deal of time and effort was invested in setting up the survey and ensuring that an acceptable response rate was achieved in order to elicit meaningful results.

The implementation and subsequent analysis of a pilot survey of goods deliveries to Trinity College Dublin is described in this chapter. The chapter also describes the initial approach to the survey, obstacles encountered, actions taken to overcome the obstacles and comprehensive analysis of the data gathered.

3.2 SURVEY PREPARATION

Preparatory work prior to carrying out the survey involved a number of consultation meetings with various organisations and designing a suitable survey questionnaire for city centre businesses.

3.2.1 Consultation Meetings

Consultation meetings were held with a range of different participants with a vested interest in freight transport in the opening months of the project. Parties who provided input regarding the survey included trade associations and other concerned organisations including the following:

- Dublin City Centre Business Association (DCCBA)
- Retail Grocery, Dairy & Allied Trades Association (RGDATA)
- Licensed Vintners Association (LVA)
- Irish Business & Employers Confederation (IBEC)
- Restaurant Association of Ireland (RAI)
- Fastrack
- SDS
- Dublin City Council (DCC)
- Department of Transport (DoT)

All of the parties consulted, particularly the trade associations expressed a positive response to the project. The LVA and DCCBA expressed the viewpoint that a study into sustainable freight distribution in Dublin City is much needed. These associations also expressed their willingness on behalf of their members to participate in the project as much as possible. The various trade associations indicated their willingness to provide a mailing list of members to allow for inclusion in the survey of city centre businesses. Furthermore, the associations also provided letters of support for the project. These letters can be viewed in Appendix C.

Consultation meetings with the above parties provided feedback on freight distribution issues in Dublin City Centre. Trade associations provided an overview of

difficulties experienced by their members in relation to receiving deliveries. The availability of loading bays is a major issue for businesses. The DCCBA representative expressed the view that more stringent policing of loading bays is needed in order to clamp down on illegal parking in the bays. Nighttime deliveries to business premises are another major issue. The point made regarding the decision to accept nighttime deliveries was that cost is the deciding factor. Staffing and security costs are a considerable impediment to out of hours deliveries.

Companies making deliveries (SDS and Fastrack), on the other hand provided a different perspective to freight distribution. A representative of SDS highlighted the areas in Dublin where company vehicles are most likely to be delayed in traffic. These routes include Newlands Cross, most parts of the city centre (Dublin 1 and 2) and Rathmines. When the issue of eco-friendly vehicles was raised, the SDS viewpoint is that as long as it can be proved that a vehicle is cost effective and reliable, then that vehicle merits consideration for future vehicle acquisitions.

3.2.2 Objectives of the Survey

The primary aim of the survey is to obtain detailed quantitative delivery information from 150 businesses. Prior to the construction of the survey form, the project team compiled a list of essential data requirements, which would require attention in the delivery survey. These data requirements include the following:

- Type of goods carried
- Quantity of goods
- Packaging used
- Type of delivery vehicle used
- Location of supplier
- Dwell time of delivery
- Location of loading/unloading of goods
- Location of business
- Type of business

All of this data is necessary in order to create a detailed picture of delivery trends in the city centre.

3.2.3 Design of the Survey Form

Due to the precise nature of the data requirements, especially in relation to the quantities involved, it was decided to request self-completion delivery logs for the businesses surveyed. It was considered that a written report of a business's deliveries would provide a more accurate reflection of delivery patterns than a face-to-face interview. However, having analysed the data requirements from the survey, it became clear to the project team that completing the survey form was likely to be a rather onerous task for participants.

Therefore, it was important to construct the form in a manner that would minimise the burden as much as possible. The structure of a number of other similar questionnaires was examined including (Allen et. al, 2000) This survey form was of particular

interest because it was used in a research project carried out by the Transport Studies Group, Westminster and funded by the EPSRC as part of the Sustainable Cities Programme.

As can be see from Appendix D, the form is designed in a diary format with columns allocated for nine categories of delivery information:

- Time of delivery arrival
- Time of delivery departure
- Type of goods
- How packaged
- Quantity of packages
- Type of delivery vehicle
- Who supplied the goods
- Location of supplier
- Where loading/unloading takes place
- Vehicle Type

The format of the survey form ensured that respondents were only required to provide short answers for each of the nine categories. For example, in the categories for time of delivery arrival and departure, respondents simply write in the appropriate times. This information allows calculations to be made regarding dwell time of a delivery. In relation to the category for "Type of Vehicle Used", four options were highlighted for respondents- truck, van, car and motorbike.

Ideally, it would be desirable to request businesses to complete the delivery diaries for an entire week. Unfortunately this would demand even greater effort on the part of respondents. The DCCBA, which has considerable experience with surveying members emphasised the high levels of survey fatigue currently present amongst city centre businesses. Conscious of this fact, it was decided to use the survey forms to ascertain a "typical" delivery day for each business surveyed. In order to gauge delivery patterns for a typical day, respondents were requested to answer three additional questions appended to the survey form. These questions related to whether the number of deliveries received was typical for an average day. If the day's deliveries were not typical, respondents were asked to quantify within a certain range, by how much the deliveries were not typical. In other words, the number of deliveries more or less than on a typical day was ascertained.

The category dealing with the locations where loading and unloading take place provides useful data on two levels, each of which relate to traffic management. Firstly, results will provide statistics regarding the percentage of deliveries in the survey using loading bays or on-street parking. Secondly, since the time of delivery arrival and departure is captured in the survey, it will be possible to identify the proportion of deliveries, which are made outside the time windows outlined by the DCC.

3.3 TCD PILOT SURVEY

As part of the overall survey of 150 city centre businesses, it was decided to carry out a delivery survey in Trinity College Dublin (TCD). The purpose of this survey was two-fold. Firstly, it was useful as a pilot study to perfect the method of data collection to be used for the main survey. Secondly, the TCD survey constitutes a substantial individual case study as part of the larger survey. This is largely due to the fact that the TCD campus is a mainly non-commercial environment, occupying some 47 acres of land in Dublin City Centre, and as such is uniquely placed as a delivery destination. The survey of deliveries to TCD provided an opportunity to examine delivery patterns to a self-contained campus.

The College has two gate entrances- Lincoln Gate, which remains open all day from 7:00 – 00:00 and Pearse Gate, which opens for morning and evening peak periods. Following a successful trial run, it was decided to carry out the survey during the college 'Green Week' of 10th to 15th February 2003 (Green week was a College wide promotion of environmental awareness). This week was selected in order to maximise awareness among students and staff. Companies that deliver frequently to the college were notified about the survey and were asked to cooperate.

The survey itself was carried out by the project team and a number of other college students. Two survey attendants were located at Lincoln Gate, the main delivery entrance. Following discussions with College authorities, it was decided to use security camera footage instead of survey attendants at the Pearse St. Gate. This decision was taken for two reasons: firstly, the gate is only open for a total of four hours a day and secondly trial runs of the survey indicated that a minimal number of commercial vehicles use this entrance.

3.3.1 Storage of Survey Data

Following the completion of the gate survey, the survey forms were collated, and an ACCESS Database storing all of the information was created. This database comprises a table of 32 fields. It was created as a means of preserving the integrity of the data and to allow improved speed of survey data retrieval. Database storage also allows for data manipulation through Structured Query Language (SQL). Once the data had been entered into the database, a number of simple SQL queries were run on the database in order to ascertain basic survey information such as the response rate.

Although SQL is useful for data manipulation, it was necessary to analyse the survey data using more comprehensive statistical software. SPSS (Statistical Package for the Social Sciences) is a widely used tool that allows for data collection, data access and management, analysis, reporting and deployment. It allows the user to score and analyse quantitative data very quickly. Use of SPSS to analyse the survey data involved exporting the data from the original ACCESS database into SPSS. 38 variables (used to define the categories of data collected) were then defined and can be viewed in table 3.1 below.

ID	Delivery ID number	Purpose	Delivery, Service, Waste Other
Day	Day of week	Delivery	Boolean Value
Shift	Number Shift (1-15)	Good	Description of good
CompName	Full company name	CatGood	One of 7 categories
Cmmrcial	Boolean value	Service	Boolean Value
ArrTime	In hours and minutes	Building	Where in TCD
Derttime	In hours and minutes	LocCat1	Location in tcd
DwellTim	In minutes	Loccat2	Location in tcd
Vehicle	Truck van car or motorcycle	Loccat3	Location in tcd
RegYear	Only yr of reg plate	Package1	Type of packaging for 1st good
RegCount	County of reg plate	Package2	Type of packaging for 2nd good
Regnumb	Reg plate number	Qty1	Quantity of good 1
Strttrip	Where trip started	Qty2	Quantity of good 2
Codestrt	Dublin Postal Code of where trip started	Breakdow	Breakdown of quantity
Dtozone1	DTO Coarse Zone of where trip started	Numberwk	Number of visits/wk
Cntystrt	County at the start of trip	Numberyr	Number of visits/yr
Countyb4	County immediately prior to TCD visit	Response	Boolean value
Before	Area visited prior to TCD	Daily	Boolean Value
Codeb4	Postal code prior to TCD	Dtozone2	DTO Coarse Zone prior to TCD

Table 3.1 Variables used in SPSS

3.4 ANALYSIS OF THE PILOT SURVEY

Specific areas of interest for statistical analysis included:

- Response rate
- Number of deliveries
- Dwell times
- Overview of goods delivered to the campus
- Breakdown of packaging used
- Origins of deliveries (and destinations) (by Dublin code and by DTO zone)
- Breakdown of vehicle types
- Correlations between certain key variables
- Companies making multiple deliveries in the same day

3.4.1 Response Rate

Analysis of the survey data produced a number of interesting results. The response rate achieved was 82%. This is considered to be highly satisfactory. Over the course of the week of the survey, TCD received 699 commercial visits. Of this total, 365 visits were for the purpose of delivering goods while the remainder are mainly attributable to the provision of services to the college and waste management.

3.4.2 Number of Deliveries

Thursday and Monday emerged as the busiest days for deliveries to the college with 106 and 91 deliveries respectively. The time period from 11.00 – 15.00 seems on average the busiest period with an average of 38 deliveries being made each day during that time. Particularly high levels of deliveries are made during this period on two days, Monday and Thursday, where on average the number of deliveries made increases by 133% compared with the same period on the other days. This is an interesting finding and highlights the variability that can exist. It will be important to see if this level of variability is identified in the large study. The morning period is the second busiest period with on average 28 deliveries made each day during that period. Delivery frequency declines considerably to an average of 8 in the late afternoon (15:00-19:00). Figure 3.1 below shows the frequency of deliveries by time of day.

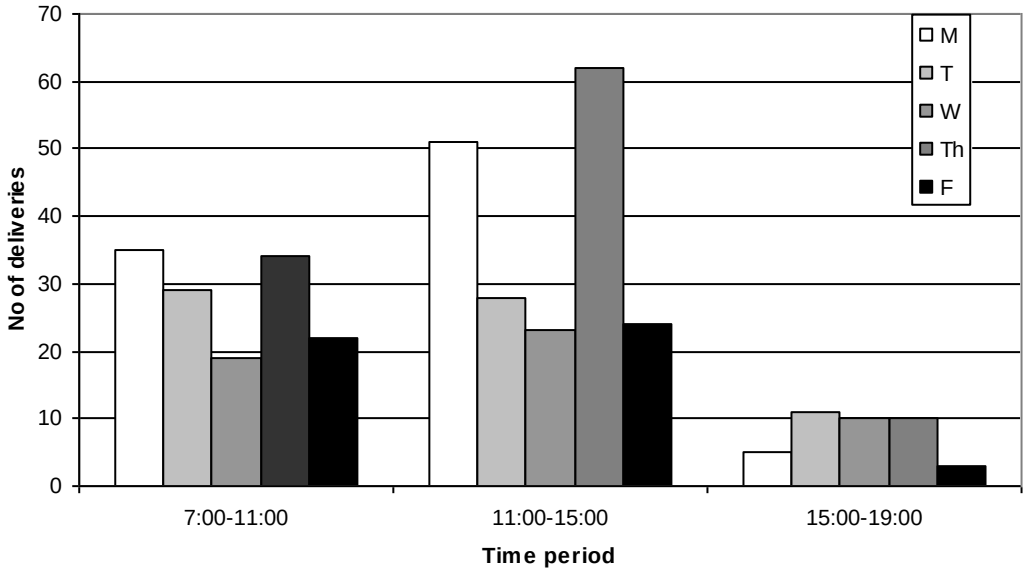

Figure 3.1 Frequency of Deliveries by Time of Day for TCD Survey

3.4.3 Average Dwell Times for Deliveries

Figure 3.2 below displays the average dwell time per time period for deliveries and it can be observed that mean dwell time was greater during the 7am to 11am period than for the other periods. Overall mean dwell time for deliveries was 23 minutes. Dwell time for commercial service visits on the other hand was 99 minutes.

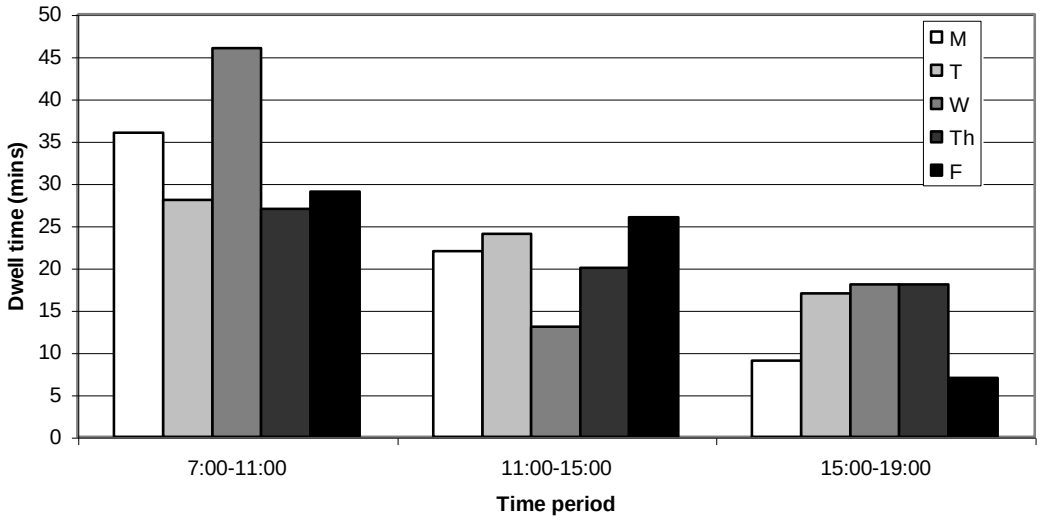

Figure 3.2 Mean Dwell Times by Time of Day for TCD Survey

3.4.4 Overview of Goods Delivered to TCD

The types of goods delivered to TCD generally fall into one of seven categories: catering supplies/beverages, laboratory supplies, stationary, construction materials, electrical goods, courier parcels and miscellaneous. The breakdown into the seven categories is clear in table 3.2 below.

		Frequency	Percent
Valid	Catering Supplies/beverages	64	17.5
	Lab Supplies	72	19.7
	Stationary/Books	61	16.7
	Construction Materials	33	9.0
	Electrical Goods	36	9.9
	Courier Parcels	69	18.9
	Other	28	7.7
	Total	363	99.5
Missing	System	2	.5
Total		365	100.0

Table 3.2 Breakdown of Types of Goods

3.4.5 Packaging Used in Deliveries

Nine forms of packaging was observed for these goods- box, parcel, tray, bag, pallet, drum, letter, carton and loose. The breakdown between types of packaging is best viewed in Figure 3.3. A box was the most common type of packaging used (54%). Parcels and loose packaging both accounted for 16 % each of deliveries, while carton represented the smallest proportion with just 1%.

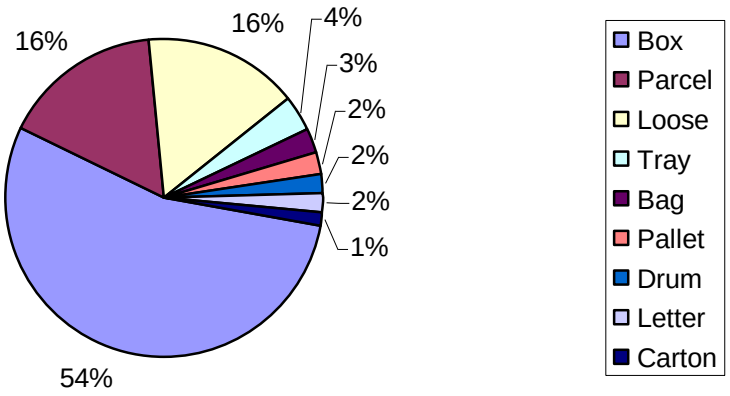

Figure 3.3 Pie Chart Illustrating Frequencies of Types of Packaging Used in TCD Survey

3.4.6 Relationships Between Key Variables

Further statistical analysis of packaging involved a correlation exercise. The purpose of this exercise was to measure the relationship between the seven categories of goods and packaging used. The hypothesis tested was that there is a correlation between types of packaging and types of goods. This has relevance in terms of how the goods are transported and delivered. Measures of correlation indicate both the strength and the direction of the relationship between a pair of variables (Bryman and Cramer, 2001). In order to estimate the strength of a relationship, a correlation coefficient is calculated. The most common measure of correlation is "Pearson's Product Moment Correlation Coefficient", also known as Pearson's *r*. Using this measure, a correlation coefficient of -0.126 (indicated in Table 3.3 below) was calculated.

Correlations

		Goods according to category	Packaging
Goods according to category	Pearson Correlation	1.000	-.126*
	Sig. (2-tailed)	.	.018
	N	363	355
Packaging 1	Pearson Correlation	-.126*	1.000
	Sig. (2-tailed)	.018	.
	N	355	357

***. Correlation is significant at the 0.05 level (2-tailed).**

Table 3.3 Correlation Between Type of Good and Packaging

Cohen and Holliday (1982) suggest that a coefficient of 0.19 or below represent a very low correlation. Therefore the null hypothesis (indicating no relationship between the variables) is accepted. This finding highlights the fact that assumptions

regarding this relationship are poor indicating that there is variability in how categories of goods are packaged.

3.4.7 Delivery Origins

Another aspect of the gate survey data, which was of interest, was the origin of each delivery. Drivers of delivery vehicles were asked where their delivery trips had started that day and the location of their last delivery drop before visiting TCD. New variables were created in SPSS categorising both types of origin locations according to the Dublin Transportation Office (DTO) coarse zone system. This system has 21 zones, which are aggregated from the 66 zones used in the Dublin Transportation Model. Details of the areas contained in each coarse zone may be viewed in Appendix E.

Tables 3.4 and 3.5 below are reports generated by SPSS. Table 3.4 details the zones where delivery trips began at the start of the day. Table 3.4, shows that Zone 1 (city centre/within the canal ring) is the source of the greatest proportion of the origins of deliveries (22%). In other words just over one fifth of suppliers are located in the city centre. Zones 6 (includes areas such as Inchicore, Crumlin, Kimmage, Walkinstown and Cherry Orchard.) and 12 (accounts for areas such as Ballyboden, Firhouse, Clondalkin, Ballymount and Tallaght) account for almost 16% and 13% of delivery origins respectively. A number of industrial estates are present in Zones 6 and 12. This may help to explain the popularity of the zones as delivery origins.

Table 3.5 below illustrates the zones visited immediately prior to the TCD delivery drop:

In approximately 47% of cases, Zone 1 (city centre/within the canal ring) was the last zone visited before delivering to TCD. Zones 6 and 14 each accounted for 11% of deliveries immediately prior to TCD. Zone 14 covers areas such as Dun Laoghaire, Dalkey, Blackrock, Stillorgan, Ballinteer, Clonskeagh and Dundrum

Zone Area	Zone number	Frequency	Percent
City centre (Central Business District)	1	171	46.8%
Dublin Port area	2	8	2.2%
North east city	3	2	0.5%
North west city	4	22	6.0%
South east city	5	5	1.4%
South west city	6	40	11.0%
Fingal west	7	12	3.3%
Fingal east	8	18	4.9%
Fingal north west	9	0	0.0%
Fingal north east	10	1	0.3%
South Dublin (Lucan, Clondalkin)	11	0	0.0%
South Dublin (Tallaght)	12	21	5.8%
South Dublin (Saggart, Rathcoole)	13	2	0.5%
Dun Laoghaire/Rathdown north	14	40	11.0%
Dun Laoghaire/Rathdown south	15	1	0.3%
Meath	16	3	0.8%
Kildare	17	2	0.5%
West Wicklow	18	0	0.0%
East Wicklow	19	5	1.4%
Louth	20	5	1.4%
Externals	21	7	1.9%
Total		**365**	**100.0%**

Table 3.4 DTO Coarse Zone System: Origin of Deliveries (Where Delivery Rounds Started)

Zone Area	Zone number	Frequency	Percent
City centre (Central Business District)	1	171	46.8%
Dublin Port area	2	8	2.2%
North east city	3	2	0.5%
North west city	4	22	6.0%
South east city	5	5	1.4%
South west city	6	40	11.0%
Fingal west	7	12	3.3%
Fingal east	8	18	4.9%
Fingal north west	9	0	0.0%
Fingal north east	10	1	0.3%
South Dublin (Lucan, Clondalkin)	11	0	0.0%
South Dublin (Tallaght)	12	21	5.8%
South Dublin (Saggart, Rathcoole)	13	2	0.5%
Dun Laoghaire/Rathdown north	14	40	11.0%
Dun Laoghaire/Rathdown south	15	1	0.3%
Meath	16	3	0.8%
Kildare	17	2	0.5%
West Wicklow	18	0	0.0%
East Wicklow	19	5	1.4%
Louth	20	5	1.4%
Externals	21	7	1.9%
Total		**365**	**100.0%**

Table 3.5 DTO Coarse Zone System: Origin of Deliveries Immediately Prior to TCD

Having analysed the proportion of deliveries originating in the various DTO zones, a statistical correlation exercise was then carried out. The purpose of this exercise was to test the hypothesis that if the supplier's base is in zone 1, then the stop before TCD is more likely to be in zone 1.

Using the Pearson's measure, a correlation coefficient of 0.458 (indicated in Table 3.6 below) was calculated. This figure constitutes a significant correlation in SPSS and therefore the null hypothesis is rejected. Cohen and Holliday (1982) suggest that a correlation coefficient in the range of 0.40 and 0.69 is considered modest. This modest correlation could suggest that for suppliers located in the city centre, their delivery routes are focused primarily in the city centre.

Correlations

		DTO Zone at Start of Trip	DTO Zone Prior to TCD
DTO Coarse Zone Start	Pearson Correlation	1.000	.458**
	Sig. (1-tailed)	.	.000
	N	364	364
DTO Coarse Zone Before TCD	Pearson Correlation	.458**	1.000
	Sig. (1-tailed)	.000	.
	N	364	365

****. Correlation is significant at the 0.01 level (1-tailed).**

Table 3.6 Correlation Between DTO Zone at Start and DTO Zone Visited Prior to TCD

3.4.8 Types of Vehicles Used for Deliveries to TCD

A breakdown of vehicle types revealed that 69% of deliveries were made using vans. Trucks accounted for 17% of the total while car and motorcycle deliveries constituted 11% and 3% respectively. In relation to service trips to the campus, vans again were used in the majority of cases - 62%. The predominance of vans as delivery vehicles in the survey was duly noted and therefore is an issue to be aware of during the wider survey.

3.4.9 Multiple Deliveries to the Campus

One further trend observed in the data from the survey, and of particular interest related to certain companies making multiple deliveries on the same day. This trend could reflect a demand for 'just in time' products although it is more likely to suggest that there is a lack of a co-ordinated delivery system on the part of the supplier.

From the survey data, it was ascertained that over the course of the week of the survey, 13 companies made multiple deliveries on the same day. In total 18 incidences of multiple deliveries by the same company on the same day were uncovered. Ten of these thirteen companies were courier companies.

As can be seen from above, the pilot study and its subsequent analysis was a useful exercise in highlighting important issues to be aware of during the survey of city centre businesses.

3.5 POSTAL SURVEYS

Having designed the survey form and carried out the pilot study in TCD, the next step was to decide on a method of canvassing businesses to complete the survey. The DCCBA represents a number of business sectors including property, financial, catering and tourism, retail and other general services. Its members comprise the major commercial interests in Dublin postal zones 1 and 2 and retailers in the Dublin City Area. Therefore, it was decided as a starting point in the survey to avail of the association's varied mailing list of members. This list of 150 includes businesses with multiple outlets. The total of DCCBA businesses that received the survey totals 175.

In order to elicit goodwill from the businesses surveyed, a letter of support from DCCBA Chief Executive, Tom Coffey was enclosed along with the survey. The letter of support also stated that businesses that participated in the survey would receive a summary of survey results. It was hoped feedback on the current situation regarding deliveries in the city would encourage participation in the survey.

In total, 21 survey forms were returned from the DCCBA survey. This figure represents a survey response rate of 12%. This response rate is typical for surveys of this kind. With membership of over 700, many of which are located in the city centre, the Licensed Vintners Association (LVA) provided an opportunity to survey the delivery patterns of pubs within the city centre. Of the total membership, approximately 25% are located in the Dublin 1 and 2 areas, with 4% and 7% located in Dublin 7 and 8. For the purposes of the postal survey, 73 survey forms (approximately 10% of total membership) were posted out to LVA members. 50 surveys were sent to pub addresses in Dublin 1 and 2 and the remaining 23 were sent to businesses in Dublin 7, 8 and 4 which lie within the canal boundaries. In order to boost response rates, once the surveys had been posted out, the survey team made telephone calls to half of the pubs surveyed to further encourage participation in the survey. Similar to the DCCBA survey, a letter of support from Frank Fell, Chief Executive of the LVA was enclosed and feedback on the overall survey was promised to participants. Following the LVA canvas, 16 responses were received from pubs– 12 from Dublin 1 and 2, two from Dublin 7 and one each from Dublin 4 and 8. This amounted to a response rate of almost 22%, which is again typical for this type of survey.

Next, RGDATA and RAI association members were targeted for the postal survey to allow inclusion of newsagent shops and restaurants in the survey. Disappointingly, response rates for each of these surveys did not exceed 5%, despite letters of support from both associations. Overall in the postal survey, 500 businesses received delivery survey forms. The aggregated response rate from these businesses was approximately 10%.

3.6 STREET SURVEY APPROACH

In light of the response rate to the postal surveys, it was decided to take a more proactive approach to distributing the surveys amongst city centre businesses in order to reach the survey target of 150. This approach involved individual team members focusing on predetermined streets in Dublin 1 and 2, listed below and highlighted in Figure 3.4.

- Dawson Street
- Nassau Street
- Suffolk Street
- Dame Street
- Kildare Street
- Westmoreland Street
- Aston Quay
- Wellington Quay
- Ormond Quay

- Bachelors Walk
- Middle/Lower Abbey Street
- Henry Street

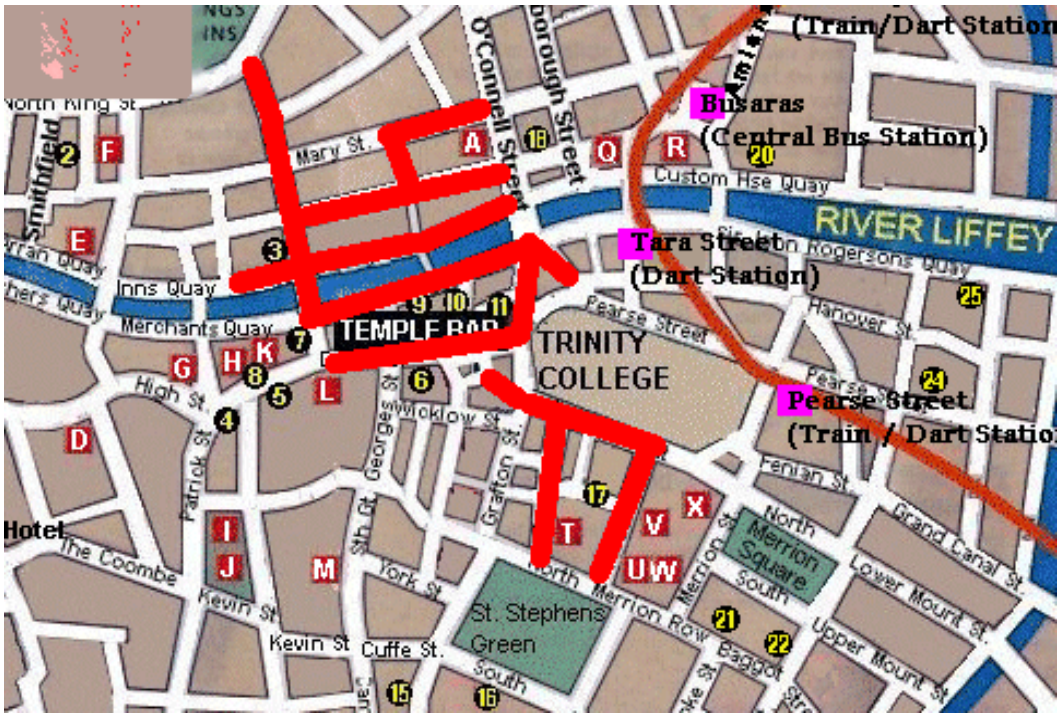

Figure 3.4 Map Highlighting Streets Surveyed

Survey forms were personally distributed in business premises along these streets. Team members called into businesses, asked to speak with the individual responsible for deliveries (or a manager) and explained the purpose of the survey, the overall freight project and its potential importance for city centre businesses. The immediacy of the situation and the assurance that the survey would not take too long encouraged a positive response from many businesses. In a number of cases, it was necessary to call into businesses several times to obtain the completed survey form.

This approach was also helpful for the project from the perspective that useful feedback and comments made by personnel in the shops surveyed were noted along with the data that was collected. Comments made related to companies' reactions to the restrictions currently in place for delivery times. Also, a number of comments focused on the amount of loading-bays available in the city. Numerous shops on Nassau Street pointed to the fact that deliveries are often forced to park on street due to the fact that loading bays are often occupied. Furthermore, it was discovered that deliveries to pharmacies are hampered to an even greater extent than other businesses when there is no loading bay available and delivery vehicles are forced to park a distance away from the premises. This is because of the high security risk involved in transporting pharmaceutical goods.

In terms of public entities, five government departments were surveyed. The government departments were: Department of the Environment, Department of Agriculture and Food, Department of Education and Science, Department of Health and Children and the Houses of the Oireachtas. Due to the high levels of co-operation

in the public sector departments, comprehensive delivery diaries for a week were obtained.

It is considered that the contacts made in the various trade associations have been helpful in forging goodwill among businesses towards the survey. Letters of support from the trade associations provided enhanced credibility to the survey, especially for the street survey approach. This approach, although time consuming, (sometimes three or four visits to businesses are required) has proved itself to be the most effective means of encouraging participation in the survey.

3.7 QUALITY OF FEEDBACK FROM THE SURVEYS

In general, returned survey forms from private companies provide good quality delivery information. Out of all the surveys returned, only three were completely void- these forms had not been completed at all. In a very small number of cases, the name of the supplier was provided but not the supplier's address. This was easily resolved using telephone directory and double-checking with the business once the address was found. In other cases, the individual completing the survey form was absent for either delivery arrival or departure and consequently was unable to fill in both times. Once again, this was generally resolved by contacting the business in question to further clarify delivery times. Contact details of project members are stated on the delivery form itself. In four cases, telephone calls were received from survey participants with queries regarding aspects of the survey. These queries were quickly resolved. Otherwise, survey forms were completed in a satisfactory manner and contain the required delivery information.

3.8 RESULTS OF THE OVERALL BUSINESS SURVEY

3.8.1 Frequency of Deliveries

In total the survey captured 906 individual deliveries. Businesses were categorised into 12 distinct categories. The breakdown of the number of deliveries to each category can be viewed below in Table 3.7.

	Frequency	Percent
Department Store	80	8.8
Restaurant/Food Retail	127	14.0
Pub	123	13.6
Hotel	95	10.5
Convenience Store	37	4.1
Newsagency	58	6.4
Retail (clothing)	36	4.0
Retail (Other goods)	185	20.4
Financial Instit/Office	68	7.5
pharmacy	41	4.5
Supermarket	26	2.9
Shopping Centre	30	3.3
Total	906	100.0

Table 3.7 Breakdown of the Number of Deliveries to each Business Classification

Frequency of deliveries is analysed firstly according to time of day. Figure 3.5 shows the number of deliveries arriving each hour. The busiest period for deliveries occurs between 9am and 12pm. The number of deliveries peaks between 10-11am with 16% of the total arriving during this time. Only 2% of deliveries occurred between 17:00 and 23:00.

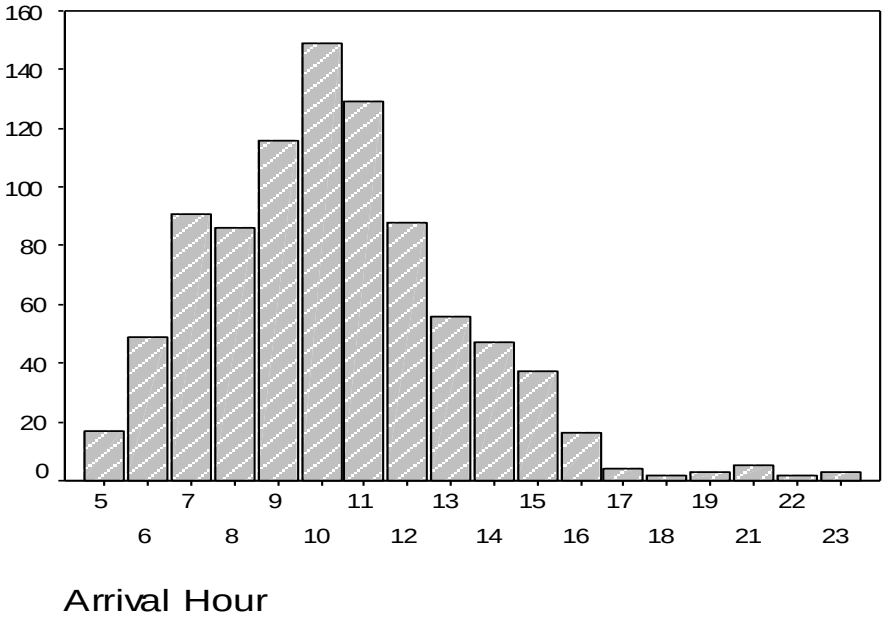

Figure 3.5 Frequency of deliveries arriving each hour

3.8.2 Types of Vehicles Used and Average Number of Miles Travelled

With regard to the nature of delivery vehicle usage, it was found that vans were the most prevalent type of vehicle used, accounting for approximately 55% of all deliveries. Trucks accounted for 40% of the total, while cars and motorcycles only accounted for 6%. The number of trucks captured in the survey (354 in total) is a cause for concern from an accessibility perspective and also from an environmental perspective. It highlights the need for more novel delivery solutions for Dublin to minimise the effects of large vehicles on the streets of the city. The average number of miles travelled from supplier to business destination was calculated as 13.65. However, this varied from business to business, for example the average distance in miles for deliveries to pharmaceutical businesses, restaurants and bars was 10.39, 18.45 and 9.39 respectively.

3.8.3 Average Dwell Time for Deliveries

The average dwell time for deliveries was 14 minutes (in the pilot survey the average dwell time was 23 minutes). This varies across different business types, for example deliveries to clothing retail stores were found to have an average dwell time of approximately 26 minutes, department store deliveries had an average dwell time of approximately 16 minutes and offices/financial institutions had an average dwell time of just 7 minutes.

3.8.4 Delivery Origins

In addition to the analysis of deliveries by time of day, deliveries were also analysed according to the geographical area from which they originated. Delivery origin locations were categorised again according to the Dublin Transportation Office (DTO) coarse zone transport modelling system, which contains 21 zones. Table 3.8 shows that the top six delivery generating areas are the south west of the city (zone 6), the city centre (zone 1), outside of Ireland, the north west of the city (zone 4) and outside of the Greater Dublin Area (GDA) (GDA includes the counties of Dublin, Kildare, Louth, Meath and Wicklow). For purposes of comparison it is useful to note that in the pilot feasibility survey the top six delivery generating zones were Zone 1, Zone 4, Zone 6, Zone 8, Zone 12 and Zone 14. Therefore Zones 1, 6 and 12 are common to both the pilot survey and the overall business survey indicating a strong level of business activity in these areas

Zone Area	Zone number	Frequency	Percent
City centre (Central Business District)	1	159	17.5
Dublin Port area	2	8	0.9
North east city	3	15	1.7
North west city	4	62	6.8
South east city	5	10	1.1
South west city	6	185	20.4
Fingal west	7	20	2.2
Fingal east	8	34	3.8
Fingal north west	9	7	0.8
Fingal north east	10	0	0
South Dublin (Lucan, Clondalkin)	11	17	1.9
South Dublin (Tallaght)	12	95	10.5
South Dublin (Saggart, Rathcoole)	13	8	0.9
Dun Laoghaire/Rathdown north	14	44	4.9
Dun Laoghaire/Rathdown south	15	4	0.4
Meath	16	10	1.1
Kildare	17	16	1.8
West Wicklow	18	1	0.1
East Wicklow	19	13	1.4
Louth	20	8	0.9
Externals	21	62	6.7
Outside Ireland		114	12.6
Undefined		14	1.5
Total		**906**	**100**

Table 3.8 DTO Coarse Zone System: Origin of Deliveries

Having analysed the frequency of deliveries from zones, the next step in the survey analysis was to examine whether certain categories of goods could be linked to certain zones. Table 3.9 below shows the proportion of goods originating in the six high delivery-generating zones. Although food/beverages feature strongly in all of the zones, there are a number of instances of other goods categories that are prominent in particular zones. These include:

- Alcohol in zones 1, 6 and 21
- Pharmaceuticals/Cosmetics in zone 12
- Stationary/Books/Newspapers in all six zones
- Household/Hardware Goods in zone 21 and outside Ireland
- Clothing/Shoes in zone 21 and outside Ireland

	Zone 1	**Zone 4**	**Zone 6**
Food/Beverages/General Catering Supplies	31%	47%	46%
Electrical Goods	.05%	6%	4%
Clothing/Shoes	6%	5%	4%
Household/Hardware Goods	6%	6%	7%
Stationary/Books/Newspapers	7%	13%	8%
Pharmaceutical Goods/Cosmetics	2.5%	11%	5%
Alcoholic Beverages	28%	5%	19%
Post/Parcels	8%	2%	2%
Miscellaneous Retail	11%	5%	5%

	Zone 12	**Zone 21**	**Outside Ireland**
Food/Beverages/General Catering Supplies	47%	26%	12%
Electrical Goods	0%	0.5%	7%
Clothing/Shoes	2%	18%	31%
Household/Hardware Goods	5%	21%	19%
Stationary/Books/Newspapers	10%	10%	18%
Pharmaceutical Goods/Cosmetics	20%	2%	3%
Alcoholic Beverages	13%	16%	2%
Post/Parcels	0%	0.5%	1%
Miscellaneous Retail	3%	6%	7%

Table 3.9 Breakdown of Types of Goods Originating from High Delivery Generating Zones

3.8.5 Packaging Used In Deliveries

In terms of the packaging used for deliveries, boxes were found to be the most common type of packaging used (53%). In approximately 10% of cases, no packaging was used and the goods were delivered loose. Pallets were used in a further 10% of cases, while parcels, kegs and cartons accounted for 7% 6% and 6% respectively. Various other forms of packaging were used in the remainder of deliveries. A pie chart illustrating the breakdown of the type of packaging used can be seen below in Figure 3.6.

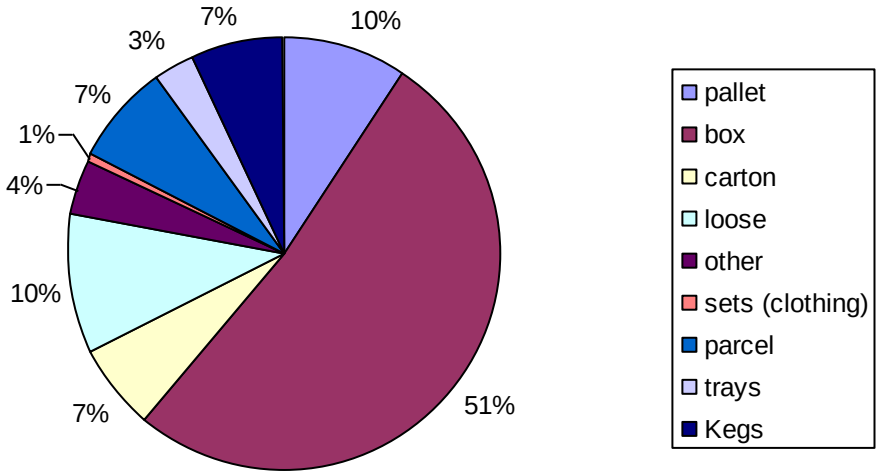

Figure 3.6 Pie Chart Illustrating Frequencies of Types of Packaging Used

Earlier analysis of the packaging used in the pilot survey indicated a correlation coefficient of –0.126 between the type of packaging and the type of goods. This coefficient indicated a very weak relationship between the two variables. When the same correlation exercise was carried out for the overall survey (again using Pearson's Correlation Coefficient as a measurement), a correlation coefficient of 0.224 was obtained. Although still a relatively low figure, it points to a very mild relationship between the variables. The coefficient of determination (COD) is an indication of how far variation in one variable is accounted for by the other variable. In the case of the overall survey, a coefficient of determination of 5% was obtained. In the pilot survey the COD was only 1.5%. The relevancy of the packaging used lies in the consolidation opportunities possible and the choice of vehicles used to transport the goods from the centre to the city centre. Materials handling techniques such as shrink-wrapping and palletization have the potential to improve delivery operations because goods can be consolidated into larger shipping units (Ogden, 1992).

3.8.6 Relationships Between Key Variables

In order to establish if deliveries to certain types of businesses occur at particular times, another correlation exercise was carried out examining the relationship between delivery arrival times and categories of business. It was found that only a very low correlation of 0.104 exists between the two variables. This suggests that at best, only a mild relationship exists between the arrival time of delivery vehicles and the type of businesses that they deliver to at that particular time. In other words, in general the category of business concerned does not appear to dictate the arrival times of deliveries to any significant extent. However upon further analysis of the relationships between arrival time and business category for various streets, some interesting findings were noted. Firstly, a reasonable correlation of 0.335 was found between arrival time and business categories for deliveries to Ormond Quay, Wellington Quay, Bachelor's Walk and Aston Quay (all located along the quays of Dublin's main River, the Liffey in the city centre). Secondly, on the south of the city (Dame Street, Nassau Street, Dawson Street and Kildare Street) a correlation of 0.280 was found. These findings suggest that correlations are more likely to be found at a localised street level than throughout the city centre. This highlights the variable

nature of delivery patterns to Dublin City Centre. It also emphasises the influence that the location of a business on a particular street can have on delivery times. This is something that is reinforced by anecdotal evidence from discussions with suppliers. One particular food and groceries supplier highlighted the fact that certain delivery runs were determined to a large extent by the timing of city centre deliveries, which occurred at a particular time of the day.

Another area of interest for statistical evaluation is the relationship between the delivery arrival time and category of good delivered. A correlation figure of 0.249 was found to exist between the two variables. This mild correlation may help to explain to a certain extent peak delivery hours for certain type of goods. The greatest proportion of food deliveries (over 19%) arrived between 7:00 and 8:00. Furthermore, the greatest proportion of post and parcel arrived between 10:00 and 11:00 and between 11:00 and 12:00 (17% in each case). Peak delivery hour for household goods/hardware occurred between 11:00 and 12:00 when 17% of the total of goods for the category arrived.

3.8.7 Loading Arrangements for Deliveries

Loading arrangements for deliveries formed a further area of interest during the statistical evaluation. 49% of deliveries used on-street parking for unloading goods. Dedicated loading bays (loading facilities operated by the company receiving the delivery) were used for 39% of deliveries, while shared loading bays (loading facilities designated by the city authorities) were used for the remaining 12% of cases. It was observed that 39% of trucks parked on street for deliveries. This has implications for city centre accessibility.

3.9 CONCLUSIONS

Both the pilot survey and the overall business survey proved valuable in terms of providing qualitative and quantitative information on current trends of urban freight distribution in Dublin City Centre. The pilot survey of deliveries to Trinity College Dublin was useful as a trial run of the later survey. It also served to highlight the extent and nature of deliveries to a large and essentially non-commercial environment.

The main obstacle of the overall city centre survey proved to be the low response inherent in surveys of this kind. Postal surveys were helpful to an extent, however it was found that personally delivering survey forms to businesses and collecting them was the most effective survey approach. Although time consuming, this approach helped to ensure direct feedback on various freight issues from the businesses concerned. Common anecdotes heard from the businesses included issues such as the illegal occupancy of loading bays.

Analysis regarding high delivery generating zones identified the south west of the city, the north west of the city, South Dublin and the city centre as areas that generate high numbers of deliveries. Furthermore, a significant amount of deliveries were found to originate outside of the country (almost 13%). The category of food and beverages featured prominently in all of the high delivery generating zones, emphasising the importance of the role of these goods in the general commercial life of the city.

Another issue of general interest highlighted in the analysis of survey data was the use of specialised loading bays for deliveries. From the data, it was observed that 39% of deliveries made by trucks parked on-street. Given that the average dwell time for trucks was found to be greater than 22 minutes, (compared to approximately 10 minutes for vans and 9 minutes for cars) this clearly has implications for city centre accessibility both for pedestrians and for traffic in general.

Overall, the survey helped to provide information at a micro-level regarding deliveries to the city centre. The analysis carried out influenced the development of a number of scenarios, which are described in the following chapters.

4 SCENARIOS ARISING FROM ANALYSIS OF THE LITERATURE, SURVEY DATA & DISCUSSIONS WITH FREIGHT CARRIERS

4.1 INTRODUCTION

In order to identify possible scenarios that might be amenable for sustainable solutions in Dublin city centre the following approach was adopted:

1. A review of case histories in other European cities has suggested scenarios that might be relevant for Dublin was completed
2. By analysing the survey data, potential niche applications emerged in different sectors for which more innovative approaches for organising deliveries could be developed.
3. The operations of a number of selected major logistics service providers was examined and collaboration sought. The information and advice provided by these companies confirmed the attractiveness of the proposals emerging from tasks 1 and 2.

The above tasks together with a consideration of the selection criteria listed below is the basis for the four scenarios for sustainable transport put forward in later chapters:

5. External consolidation at Urban Delivery Centres (UDCs)
6. Internal consolidation – "Managing the Last Mile"
7. The Adoption of Eco-Friendly Technologies for Deliveries to the City Centre
8. City Access Control

4.2 CRITERIA FOR SELECTING SUSTAINABLE SOLUTIONS

The criteria for selecting potentially sustainable and suitable solutions for managing city freight in Dublin city centre included the following:

1. How can the congestion caused by freight deliveries on city streets and the excessive occupation of public spaces by large moving or parked vehicles be minimised
2. Do the scenarios put forward adequately take into account current trends in the overall supply chains in terms of the "24hr, 7day week" and just-in-time deliveries?
3. How do the solutions proposed help to minimise the environmental and social costs to the urban communities?
4. Are the solutions proposed operationally and economically feasible?
5. Will businesses and the logistics service providers find the proposed solutions acceptable and "buy in" to what is proposed?
6. Are the solutions proposed acceptable to Dublin City Council and do they complement the councils overall traffic management strategy?
7. Do the proposed scenarios relate to the policies of the Department of Transport and the EU (DG-TREN) on promoting sustainable transport?
8. Are the technologies proposed readily available at a reasonable cost?
9. What is the potential for a wider replication?

4.3 INTERNATIONAL EXPERIENCE

As mentioned in Chapter 2, the solutions and demonstrations reported by the city freight thematic network were examined. This review has identified a number of promising solutions in the areas of:

1. External consolidation at Urban Distribution Centres

UDCs have been shown to help consolidate loads efficiently on the periphery of cities thereby minimising the need to access the city centre. UDCs also facilitate the transfer of loads from large to smaller more eco-friendly vehicles for use in historic city centres where HGVs are restricted.

2. Internal Consolidation: Managing the Last Mile

For particular niche applications (mail, parcels and newspaper deliveries) the use of down town platforms and "pack stations" for managing local deliveries by walking and cycling couriers, has been successfully demonstrated.

3. The Adoption of Eco-Friendly Technologies for City Centre Deliveries

Despite substantial international investments in R&D to bring to the market clean and eco-friendly vehicles, the results are disappointing. Electric and hybrid electric vehicles (EVs and HEVs) are currently not available at a reasonable cost and continue to suffer severe operational constraints. Conversions to LPG and CNG are operationally feasible but require government incentives at the present time to make these fuels competitive with diesel fuel. It was found that less ambitious programmes to adapt conventional diesel vehicles and related ancillaries to low noise operation for night deliveries can offer a more practical and near term solution.

4. City Access Control

It was found that a number of European cities have developed sophisticated control systems for encouraging more sustainable city freight practices. Some relevant case studies are examined in a later Chapter.

4.4 IDENTIFICATION OF POSSIBLE SCENARIOS BASED ON AN ANALYSIS OF THE SURVEY DATA

4.4.1 External Consolidation at Urban Distribution Centres

An analysis of the survey data identified the origins of different categories of deliveries according to the designated planning zones in the greater Dublin area. It was found that significant consignments of groceries (both dry goods and chilled which account for 38% of all deliveries captured in our survey) originate from a number of large depots located near the M50 motorway to the west of Dublin. Other categories of goods that involve significant volumes of deliveries from hubs to the city centre are mail and parcels, medicines and drugs and stationery and office supplies.

Operational data was obtained from the important distributors in these categories of businesses. The Musgrave Super Value Centra Group (MSVC) and the Transport Development Group (TDG) kindly provided us with data on their grocery distribution activities. Visits were made to the dry goods and frozen foods depots managed by MSVC at Fonthill and Ballymount and to the United Drugs depot at City West. MSVC also offered us logistics data relating to their business plans for a major new regional consolidation hub for dry goods being built in Kilcock and this project is the basis for the UDC scenario described in a later chapter. The TDG group also kindly forwarded useful logistical data and innovative proposals regarding their operations at their eight Dublin warehousing sites.

4.4.2 Internal Consolidation: Managing the Last Mile

Courier deliveries emerged as a significant generator of delivery trips, accounting for example for 19% of all weekly deliveries to the TCD campus and for 71% of all weekly visits to the Department of Education complex at Marlborough Street. How the courier services choose to manage their "last mile" operations therefore has important impacts on traffic flows. We found that DHL has successfully developed the "platform" concept in Dublin for managing mail deliveries to their city centre business customers whereby final deliveries are made by teams of walking couriers. DHL has kindly permitted us to put forward their innovative platform operations in the south inner city as a sustainable solution. An evaluation of the data obtained from the TCD gate survey suggests a justification for setting up a consolidation platform there. A case is therefore developed for establishing an interception platform on the periphery of the college that would mitigate the nuisance caused by commercial vehicles, currently enjoying free access to the campus. This is proposed and examined as an example of what could be done for campus type environments. Two scenarios therefore are described for managing the last mile. The first examines the benefits of the existing DHL platform and the second makes the case for a new consolidation platform to be sited adjacent to the TCD campus in order to control all categories of deliveries accessing the college.

4.4.3 The Adoption of Eco-Friendly Technologies for Deliveries to the City Centre

As part of our remit we examined the relevance and availability of a wide range of "eco-friendly" technologies. Sustainable transport solutions involves not only a reduction in traffic congestion made possible by more efficient logistics, but also the application of vehicles and technologies that can offer clean and low noise transport. Public concerns relating to traffic pollution "hot spots" and to noise nuisance at night has stimulated the suppliers of vehicles (and the related ancillaries) to develop more eco-friendly technical solutions. These developments are also driven by EU directives on noise and on emissions. A range of possible technological options is examined in detail in a later Chapter. Many cities, supported by national governments and by the EU, have invested heavily in alternative fuels (electric vehicles, CNG and LPG). With the exception of LPG however, all the alternative fuels were found to require significant government subsidies. Fleets need to be of sufficient size to justify the significant investments required in setting up a parallel CNG infrastructure and fuel price incentives need to compensate for the payload restrictions involved. As reported in a later chapter, these conditions do not apply in Dublin at the present time.

It will be seen the possible incorporation into existing fleets of new generation low noise and clean diesel LGVs and HGVs was found to be the most attractive eco-friendly option for the fleet operators who have collaborated with the project. For night-time deliveries, the application of low noise architecture and acoustic materials at city centre loading sites could help to ameliorate the nuisance caused to residents. Sites that we visited included the ILAC, Jervis St., and Stephens Green shopping centres. The experience reported by the Dutch authorities under the PEAK programme, is relevant and is described in a later chapter.

4.4.4 City Access Control

As part of project investigations, an examination of the current and planned control systems operated by Dublin City Council was carried out. The survey data was analysed to evaluate the potential impact on deliveries of a proposed time based city access system. These systems are reported in detail in a later Chapter and are modelled on examples demonstrated in other cities.

4.5 MEASURING THE ENVIRONMENTAL & EXTERNAL COSTS & BENEFITS ARISING FROM PROPOSED SCENARIOS

4.5.1 Introduction

This section examines how the environmental benefits of the scenarios proposed might be measured in economic terms. Following a literature review of the methodologies currently available to measure the external environmental and social costs of traffic, it was felt appropriate to apply the CEC sponsored "UNITE" methodology to these particular scenarios (Link et al., 2001, O'Mahony, et al 1997, Gibbons, E., et al, 2002, Kirwan, et al, 1995).

The UNITE project is designed to support policy makers and provides:

- Comparative information from 17 participating countries on the costs and revenues from all transport modes including the underlying economic, environmental and social factors,
- A common methodology for presenting national "Transport Pilot Accounts"
- A methodology for estimating external "marginal costs". A number of case studies have been completed in different traffic and geographical locations in order to measure the external environmental and social costs involved. Some of this experience may be broadly generalised.

The UNITE national pilot accounts reports on the costs of infrastructure, supplier operator costs, accident costs and the taxes and subsidies in force in the different member states. Congestion costs are also reported and are defined as the additional time and fuel costs caused by delay. Environmental costs are reported based on core data relating to the costs of air pollution including the impact on health, global warming and noise nuisance. It is important to note that the terms of reference for the UNITE project specifically did not include a data collection remit and therefore only the existing data in each country could be used.

The particular methodology reported by UNITE for quantifying the costs of airborne pollutants, involves a bottom up approach known as the impact pathway approach (IPA). This consists of the following modelling steps- the estimation of emissions, dispersion and chemical conversion modelling, calculation of the physical and monetary and health impacts. In order to use the IPA model detailed geographically coded information on emissions was provided by the participating UNITE countries and specific case histories were recorded.

The IPA model calculates the cost of global warning by multiplying the amount of CO2 equivalent emitted by an estimated cost factor. Because CO2 contributes to global warming there is no need for a specific dependency on how or where the emissions take place. An average shadow value of €20 per tonne of CO2 emitted is applied. The damage caused by diesel exhaust emissions is assumed to be specifically related to micro particles (PM 2.5 = particulate matter measuring < 2.5μm) calculated in €cent per vehicle km travelled (vkm).

Noise costs are related to the health impacts using exposure-response functions and also to a loss in property values.

According to the UNITE Pilot Accounts for Ireland, the environmental costs are substantial. Using the IPA model it was estimated that the air pollution costs of road transport amounted to €312 million in 1998 and an additional €165 million was attributed to global warming. In addition the adverse affects of noise on health and on the reduced value of the properties affected was estimated at € 352 million (Link et al., 2001)

4.5.2 Other Environmental Assessment Approaches

Two other recently published papers aimed at urban planners are worth noting. A French group has completed an exhaustive environmental assessment of urban goods movements in the cities of Bordeaux (pop 750,000), Dijon (pop 240,000) and Marseilles (pop 1,050,000) (Segalou.et al., 2003). An environmental urban goods model is being developed which relates air emissions and noise to daily traffic flows and to time periods along different parts of the urban networks. The model demands large and complex data sets and does not assign an economic value to the environmental damage that was measured along the different urban networks.

A study to measure the sensitivity of urban freight patterns to various greenhouse abatement policy measures is currently under way in Sydney, Australia (Marquez et al., 2003). The model evaluates the likely impacts of six different possible scenarios and policy instruments. The policy instruments include:

1. Lowering peak congestion
2. Better traffic management
3. Encouraging higher load factors
4. The provision of real time information to drivers
5. Infrastructure improvements
6. Land use change and the relocation of freight generating activities to the periphery.

It is reported that all policy instruments have the potential to reduce emissions and congestion, the most effective being better traffic management systems and higher load factors. The positive effects of infrastructure improvements and land use changes are much less clear because of the displacement effects on freight traffic generation.

The trends in supply chain management (towards just in time deliveries and the 24hr/7day week) can reduce the impacts of the policy options available to the planners. The correlations between these underlying SCM trends and the likely impacts on the environment are not quantified. Neither does the Sydney model assign economic values to the potential environmental benefits accruing from the different scenarios.

4.6 DETAILS OF THE APPROACH USED IN THE UNITE METHODOLOGY

4.6.1 Emissions

The UNITE uses case study material in the context of the generalisation of the IPA methodology. The IPA approach for estimating the extent and costs of airborne pollutants, global warming and noise is considered to be broadly transferable to other similar locations.

In attempting to quantify the likely monetary benefits of the scenarios that we have described in other chapters as mentioned above, three UNITE case histories are considered relevant. These relate to the city of Berlin, Stuttgart and to the Strasburg-Neubrandenburg highway within the built-up areas.

The meteorology and population densities at these German locations are the closest approximations within the UNITE programme to the conditions obtaining in Dublin.

Table 4.1 gives an estimation of the costs of damage arising from exhaust emissions. The damage costs are related to a unit of emission of PM2.5 calculated in €cent per vehicle km (vkm) for a typical HGV Diesel EURO2 vehicle (Link et al., 2001)

Location	**HGV diesel exhaust emissions (PM2.5) €cent/vkm**	**HGV diesel Global warming €cent/vkm**
Berlin	10.19	3.29
Strasburg-Neubrandenburg	7.46	3.28

(vkm = vehicle kilometres)
(HGV is a vehicle > 3.5tgvw)

Table 4.1Costs due to air pollution and global warming from vehicle exhausts in €cent/vkm

4.6.2 Noise

The case studies of German cities used have also estimated the external or marginal costs due to noise annoyance based on assumptions relating to the distribution and

distance the exposed persons from the source, the existing background noise levels and the time of day, the impacts on health and on medical costs.
The marginal costs are much higher at night than at daytime due to the higher disturbance effects felt by residents during the nighttime and the lower background noise levels. The estimated costs due to traffic noise for the German cities are shown in the Table 4.2 below:

Location	**HGV – daytime €cent/vkm**	**HGV – night time €cent/vkm**
Berlin	7.65	23.33
Strasburg-Neubrandenburg	3.04	5.06
Stuttgart	25.75	78.25

(vkm = vehicle kilometres)

Table 4.2Costs due to Noise from Road Vehicles in €cent/vkm

4.7 CONCLUSIONS

The scenarios identified for analysis provide scope for the examination of urban freight distribution in Dublin from a number of perspectives. In the following chapters of this report, each scenario is described in detail and the effects of the implementation of the measures associated with each strategy are explained. Furthermore, the UNITE methodology provides an acceptable means of quantifying the economic costs and benefits of the scenarios.

5 EXTERNAL CONSOLIDATION AT AN URBAN DISTRIBUTION CENTRE

5.1 INTRODUCTION

For at least the past 25 years the concept of Urban Distribution Centres (UDCs) has formed part of the discussion on freight problems and solutions. According to COST 321 (1998) a UDC is a place of transhipment from long distance traffic to short distance (urban) traffic where consignments can be sorted and bundled. Its main purpose is to achieve a high degree of collection in goods flows in order to supply efficient transport from the UDC to the city centre and vice versa. The continued interest in the concept is derived from a number of factors (Whiteing & Edwards, 1996):

1. Awareness on behalf of local planners and policy makers that innovative and perhaps radical solutions to freight distribution are needed to cope with chronic city congestion
2. Established transport and distribution operators striving to obtain competitive advantage through new and improved freight consolidation and urban delivery operations
3. Heightened awareness of the environmental problems linked to road freight transport resulting in pedestrianisation schemes, time bans on deliveries and weight restrictions on lorries in towns and cities.
4. The increased popularity of co-operation and partnerships along the supply chain, for example between retailers and major contract distribution companies.
5. Growing congestion in urban areas, encouraging 'own- account' transport operators in particular to rethink their approach to city centre deliveries

One of the main benefits of urban distribution centres is that they facilitate the implementation of other freight management measures. UDC strategies can be linked to time of day or vehicles size restrictions in city centres. Another important advantage of UDCs from the point of view of this project is that because the fleet of vehicles at the centre is dedicated to urban delivery work, individual vehicles can be specified more appropriately to the town or city in question (Whiteing et al, 2003). For example, attention can be given to suitable vehicle size, and more environmentally friendly vehicles, perhaps with quieter engines and improved emissions.

There are, however, a number of perceived difficulties associated with the establishment of UDCs in a city. Firstly, employment of a UDC ultimately adds an additional step in the supply chain where different agents and organisations control transport activities. This can complicate the relationship between customer and supplier. Also, further handling of goods during loading/unloading in the centre may increase the risk of damage (Beuthe and Kreutzberger, 2001). Compared to direct transport, transport involving a transfer at one point from one mode or means to another is a source of additional transhipment costs. These costs are incurred through handling damage, information discontinuity, and an additional possibility in schedule

unreliability. Other costs incurred can relate to detours that lengthen trip distance, thereby increasing the overall costs.
In terms of ownership of a UDC, Ogden (1992) points to three possible scenarios:

- Ownership by a single private corporation, perhaps owned in turn by one or more freight companies
- A cooperative venture in which each freight company using the facility contributes to its operation expenses and/or receives income from it
- A public corporation, usually owned and operated by the municipality of the area concerned

This chapter will evaluate a number of international examples of UDCs. The chapter will also describe a specific case study of an Irish distribution centre in Kilcock operated by the Musgrave Group. The background to the Musgrave Group, their motivation for establishing the distribution centre in Kilcock and the potential efficiencies of the new operation, both from the point of view of Musgraves and their customers is examined. Another Irish example of a distribution centre in the same industry will be briefly highlighted. In addition, the costs involved in the initiative will be given along with its possible environmental impact, in terms of overall traffic and emissions. The chapter will conclude with a series of recommendations including the possibility of the replication of the initiative.

5.2 INTERNATIONAL EXAMPLES OF URBAN DISTRIBUTION CENTRE INITIATIVES

5.2.1 Kassel

In August 1994, in the city of Kassel in Germany, a scheme known as " City Logistik Kassel" was founded. Kassel has about 200,000 inhabitants and is located in Northern Hessen with good access to the A7 (North-South Motorway) and A44 (connection to the Ruhr area). The implementation of an urban distribution centre was part of the city logistics approach in Kassel initiated by the municipality, the regional Chamber of Commerce and Industry and the association of road haulage companies. The primary aim of the scheme is to organise route consolidation distribution. A single, independent city logistics operator delivers to the inner city on behalf of seven freight-forwarding companies. Between the hours of 6:00 and 8:00 five vehicles are employed to collect the consignments delivered at the forwarders' depots during the night. At the distribution centre, the consignments are sorted according to their exact destination. At about 10:00 urban deliveries commence using two or three 7.5 tons vehicles.

Payment to the logistics operator for services provided is based on a specific city logistics tariff and each freight forwarder is invoiced separately. According to statements made by the companies and surveys carried out, the UDC approach involves no significant change in terms of costs for the freight forwarders (BESTUFS, 2002). Other benefits of the scheme include the fact that consignees in the inner city (who receive deliveries through the scheme) do not report any differences in service quality compared to the former delivery system. By joining forces the forwarding companies, have reduced their number of trips in the city by 80% from 3,900 to 800

per year. Vehicle mileage has been reduced from 6,500 to 2,600km per year (60%). Mileage per day per vehicle has decreased from 25 km to 10 km because of a concentration of deliveries in the same area (EPE, 1999). The motivation of all of the partners involved has been critical for the success of the scheme. The public-private partnership approach used in Kassel ensured that the scheme was operated in a commercial viable manner while simultaneously producing wider benefits in terms of congestion, emissions and noise.

5.2.2 Leiden

Leiden is a historical city in the Netherlands with 117,000 inhabitants and a road structure dating back to the middle ages. In February 1994, the municipality of the city started to plan for a UDC as part of a number of measures to improve congestion in the city centre. The city distribution centre commenced operations in 1997 and was expected to provide:

- A daily reduction of the number of commercial vehicles from 24,000 to 5000 (80%)
- A sharp reduction in pollution in the city centre
- Improved accessibility in the city centre
- Improved road safety
- A template for other cities in the Netherlands and Europe

The primary working area of the UDC was initially the city centre of Leiden. However, this was later expanded to the whole of Leiden and the city's surroundings. In addition, the original location for the centre (close to an important motorway) had to be abandoned due to opposition of citizens' organisations. The new location was in Leiderdorp outside of Leiden.

Although the project in Leiden was a public-private partnership, only one transport company signed up to participate in the UDC. Reasons for non-participation given by transport companies included (BESTUFS, 2002)

- Unwillingness to collaborate with competitors for fear of losing their own customers
- Traffic regulations in Leiden's city centre at the time still accommodated deliveries and therefore no urgency for new distribution systems existed

The regulation for city distribution centres in the Netherlands stipulate that a recognised city distribution centre must, at the end of the first year deliver or collect 100 shipments on average per working day in the city centre. In the case of Leiden, this figure was not achieved and at best 26 deliveries in the city centre were made. This meant that the scheme was not a commercial success since the breakeven point was 600 shipments per day (BESTUFS, 2002). The project also had a negligible effect on traffic volumes. A comparison of truck traffic in September 1996 and October 1999 revealed little difference in incoming truck levels in the two years. As a result of poor performance, the UDC finally stopped operations in 2000.

5.2.3 Bristol

Over the past 25 years, the area of UDCs has been the subject of a number of case studies. The feasibility of UDCs in areas such as Chichester, Bradford, Swindon,

Worcester, Winchester and Cambridge has been examined. It was generally felt that continental experience with similar initiatives was not transferable to the UK. However, in the past four years two prominent consolidation centres have been established, one in Bristol and the other in Heathrow Airport.

A pilot scheme of a consolidation centre commenced in Bristol in May 2004 in Bristol. The scheme will serve retailers in Bristol's core retail area Broadmead. It will involve approximately 20 retailers and will operate for six months, after which the possibility of an ongoing scheme will be assessed. Retailers were selected from an initial survey of 118 retail participants. It is believed that the consolidation centre is the first in the UK to focus on an urban retail environment (ClearZones, 2004). Bristol City Council has engaged logistics company Exel to operate and manage the initiative. The scheme aims to reduce the number of delivery vehicles travelling into Broadmead, which will bring benefits to the city centre in terms of helping reduce congestion and pollution. It also aims to provide an improved delivery service to the retailers involved, which it is hoped will contribute to a reduction in supply chain costs. Furthermore, retailers will be offered other value added services as part of the initiative. These services will include waste collection, item level inventory management and seasonal and peak time storage facilities. The consolidation centre is located on the periphery of the city, close to a strategic road network to maximise consolidation benefits.

5.2.4 London - Heathrow

When the consolidation centre initiative (Energy Efficiency Best Practice Programme) commenced in 1999 (BESTUFS 2002), Heathrow Airport Ltd was under increasing pressure to provide a solution to overcome the airport's physical constraints, grow its retail business and fulfil its environmental objectives to reduce vehicle emissions and the amount of waste brought to the airport. Congestion, both on airport roads and at loading bays was a significant problem with 439 supplier movements being made to 240 retail outlets each day. With the development of Terminal Five, congestion looked set to increase further.

Faced with these issues, Brian Gibb, Head of Retail Development and Logistics at BAA Heathrow (Airport Operator), together with Exel initiated a project to develop a new warehousing and distribution service for retailers at Heathrow Operations carried out at the consolidation centre at Heathrow as part of the project include:

- Receipt of all supplier deliveries at the consolidation centre
- Consolidation by outlet and terminal and timed delivery slot
- Onward timed delivery to individual outlet
- Collection of returns/branch transfers
- Removal of packaging waste for recycling

Following four months of successful trials with a section of retailers in the spring of 2000, BAA decided to implement a large- scale delivery of the scheme with Exel as the primary logistics partner.

A 25,000sq.ft warehouse was acquired close to the airport. The Heathrow Consolidation Centre currently serves 36 retailers, which accounts for 35% of

Heathrow's retailing population. The project aims to have all retailers on board by 2004. This project was the first of its kind in the UK - Pittsburgh Airport in the U.S. is the only other airport that operates anything similar.

Environmental benefits of the consolidation centre include:

- Reduction in vehicle movements for retailers and suppliers to the four Heathrow terminals by 61%. This is measured as the number of terminal inbound deliveries carried out by Exel as a proportion of the supplier deliveries into the Heathrow Consolidation Centre (HCC). The target for Vehicle Capacity Utilisation is 90% On-time delivery performance is currently running at 95%. The target for the reduction of vehicles delivering to the airport is 75%.
- The retailers will receive more effective deliveries on shared, rather than dedicated vehicles designed for the volumes being delivered. Vehicles are scheduled to spend the minimum time necessary for deliveries in the terminals. It is planned that low emission vehicles will be used in the future.
- The Consolidation Centre can manage packaging waste removal on behalf of retailers and volumes collected will be targeted for re-use or recycling wherever possible.
- Staff involvement in the environmental improvement plan is seen as key. Steps are being taken to ensure that staff, especially drivers in the central terminal areas. are well trained and aware of the environmental role they can play. The project also encourages personal responsibility for the environment, such as the reduction of car use by staff as their means of getting to and from work.

Economic benefits of the scheme can be quantified by examining a week's deliveries prior to and following its introduction. For example, in the last week of January 2002, there were 115 inbound deliveries to the consolidation centre, each with an average turnaround time of 12 minutes. Therefore, the total time that suppliers' vehicles spent at the centre that week was 23 hours (115 deliveries X 12 minutes). Previously suppliers' vehicles would have made up to four deliveries to the airport. Each of these would have taken 45 minutes to complete. Assuming an average of three deliveries to the airport, the total time taken by suppliers' vehicles to deliver to the airport prior to the consolidation centre would have been 158.75 minutes (115 X 3 X 45). Assuming a fixed cost of 30 Euro per vehicle per hour, this translates to a cost saving of 7000 Euro (BESTUFS 2002).

Use of the Heathrow Consolidation Centre is now a condition of contract for any new retailers in the airport.

5.2.5 La Rochelle

Another prominent European example of a UDC can be seen in La Rochelle in France. La Rochelle, a city of 135,000 inhabitants on the Atlantic coast was one of the first European cities to implement a sustainable traffic policy. The municipality has promoted the widespread use of electric passenger cars and delivery vehicles in conjunction with an urban delivery centre within the historic city centre (Vermie et al, 2002).

For goods deliveries a central consolidation and dispatching centre located on the periphery of the walled city centre comprising 750 square metres was established by the city authorities. Goods are transferred from HGVs and large vans into smaller electric vehicles where their design makes them well suited to the narrow medieval streets (4 Citroen Berlingo vans and larger IVECO vehicles for pallet loads).

Re-charging terminals are strategically located throughout the city and privileged access and parking is provided and policed by the city authorities.

The organisation and management structure reflects a serious commitment by the city council. The response from businesses has been such as to justify a continuation of the experiment for niche applications that includes parcels deliveries and deliveries to shops, caterers and florists.

While it is recognised that the UDC has introduced a costly additional step into the supply chain, the scheme offers more flexible deliveries unaffected by the parking restrictions that apply to conventional vehicles and gives additional out of town storage to customers thereby freeing up premium retail space. The operation of the scheme has been successfully out sourced to a professional logistics service provider.

The ELCIDIS project (Vermie et al, 2002) was designed not only to promote eco-friendly transport but also to relieve traffic congestion in the city centre by re-organising deliveries. A new by-law restricting access by vehicle exceeding 3.5 GVW tonnes to between 6 and 7.30 am has been enacted.

A mid-term evaluation by external consultants appointed by DG-TREN has found that:

1. 58% of the businesses located in the restricted city centre area receive deliveries via ELCIDIS scheme
2. The main activities are clothing (21%), services (19%), and cafes-hotels and restaurants (17%)
3. The target of 600 parcel deliveries per day is within reach and operating costs are covered.
4. Customers report a high quality and reliable service
5. Residents report a relief in traffic congestion and noise pollution
6. There is satisfactory enforcement of the new by-law favouring EVs
7. Effective collaboration between the city council, local businesses and the citizens has been demonstrated
8. The main auxiliary services to customers are additional storage for staggered deliveries to shops and for Business to Business (B2B) and Business to Consumer (B2C) deliveries particularly for caterers, florists and small hardware vendors
9. Concerns by customers at the relatively high cost of the premium charged by the logistics service provider (€ 1 per consignment)
10. The technical specifications of the EVs meet the logistics requirements of the project and the Citroen vans have proved reliable in service but the first costs are almost twice as high as for the conventional models.
11. Certain traffics such as draperies on hangers and refrigerated foods are unsuitable for small EVs.

The most significant problem facing the scheme is the loss of control suffered by the shippers of the goods (Whiteing et al., 2003) and the relatively high costs of the trans-shipment operation.

5.2.6 Fukuoka

A centralised delivery and collections service began in the Tenjin district of Fukuoka City in Japan as far back as 1978. At this time twenty-nine freight carriers participated in a centralised delivery system under the supervision of the Regional Transport Office of the Ministry of Transport. More recently however (1994), thirty-six freight companies established the Tenjin District Joint Distribution Company in order to facilitate centralised distribution. The central business area in Tenjin district is 370,000m^2 in size and accommodates 2,200 offices. The joint distribution programme operates within the central business area. Freight carriers bring their goods to a distribution centre operated by the Joint Distribution Centre located in the suburbs of Fukuoka City, close to an interchange of urban expressways. The Joint Distribution Company deliver goods from member carriers to each receiver in Tenjin district after sorting goods for each destination. The Joint Distribution Company also collects goods from customers in Tenjin district and unloads them at the distribution centre where the freight carriers deal with them individually. Approximately, 90,000 parcels are delivered each month through the scheme. No subsidies are provided by the public agencies involved. Due to the benefits obtained from the operation of the UDC, the Regional Transport Office is planning to extend the system to other areas such as Kumamoto City. Benefits of the Tenjin-District Joint Distribution Programme include the following:

- Decrease in the number of trucks in the served area (65%)
- Decrease in the total distance travelled (km/day) of 28%
- Decrease in total parking time (hours/day) of 17%

5.3 MUSGRAVE CASE STUDY

Having analysed international examples of UDCs, this section will evaluate an Irish case study of centralised distribution. The examination of a specific case study of a planned distribution centre for food related products is carried out for a number of reasons. Firstly, results from the survey of city centre businesses identified the food/catering supplies/beverages category as one which features prominently among general city centre deliveries. This category accounted for almost 38% of deliveries captured in the survey as illustrated below in Figure 5.1. This is attributable to the fact that food/catering supplies/beverages are delivered to a broad range of businesses – pubs, newsagents, supermarkets, convenience stores, financial institutions and other retail stores.

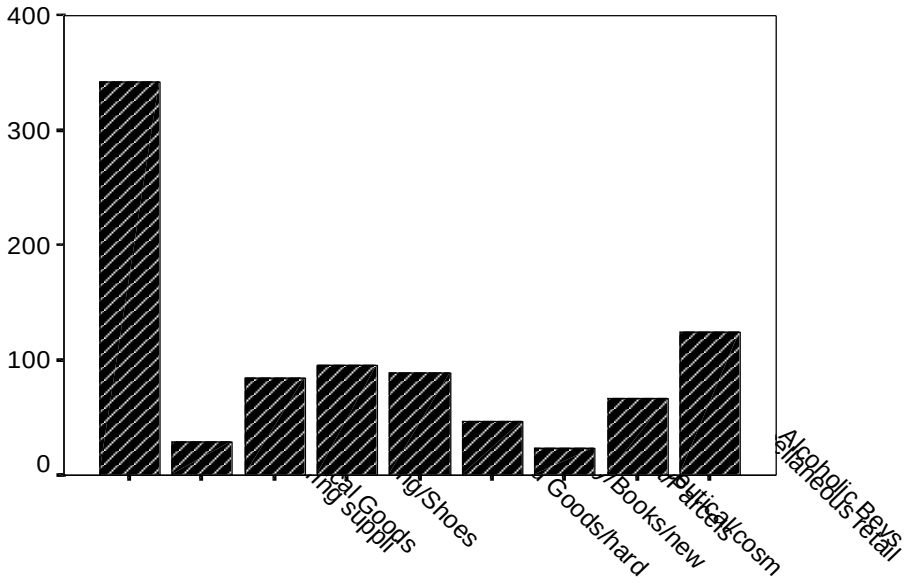

Figure 5.1 Frequency of Types of Delivery Goods

Deliveries to newsagents, convenience stores and supermarkets total 28% of all general food/beverage deliveries. Furthermore, it was found that 38% of food related deliveries to the city centre were made using trucks of some description. Therefore it was felt that there was a need to explore a more efficient means of managing food deliveries to the city centre. Use of a distribution centre located on the perimeters of Dublin was one option, which merited consideration.

In November 2003, the Tánaiste and Minister for Enterprise, Trade and Employment Mary Harney announced the investment by Musgrave SuperValu-Centra (MSVC) in a new warehousing and distribution centre in Kilcock, Co Kildare. It was decided that given the importance of food related deliveries to the city centre, a case study of the new MSVC distribution centre would provide a valuable opportunity to examine in detail the operational issues relating to setting up and running a distribution centre. The commercial nature of the distribution centre is important because it is hoped that its operation may offer a template, both to other similar private initiatives and indeed possibly to local councils who may consider operating distribution centres as a means of managing city centre deliveries. This in effect was the second reason for selecting a real life example of a distribution centre as a project case study.

A third reason for selecting the Musgrave Distribution Centre as a case study was the fact that with 24% of the grocery market share in the Republic of Ireland (for SuperValu and Centra), the company is in a strong position to bring about wide-reaching changes to their distribution system that are acceptable from a commercial perspective while simultaneously mitigating some of the negative impacts that their deliveries may have on traffic and on the environment in general.

As a result it was decided to carry out a case study analysis of the distribution centre in Kilcock. The Musgrave Group was willing to co-operate with this analysis. This centre will be responsible for distribution of ambient goods and will complement existing ambient distribution facilities in Cork and Galway.

5.3.1 Background to the Musgrave Group

Founded in 1876, the Musgrave Group is one of the largest privately owned companies in Ireland. In 2002, Group sales totalled in excess of €2.7 billion. It is estimated that sales have grown by 16% annually over the past five years and pre-tax profits have also grown strongly over the same period. Gross assets of the Group at the end of 2002 were €1.2 billion (Musgrave Group, 2002). The Group is family controlled and over 30,000 people are employed either directly by the Group or indirectly through retail franchisees.

The Musgrave Group owns the franchise to SuperValu and Centra stores (over 590 stores nationally). This division of the Group is known as Musgrave SuperValu Centra (MSVC) and is responsible for providing a centralised purchasing and distribution service to franchisees.

Musgraves also operate a Wholesale Services Division. This division is divided into two separate sections – Musgrave Foodservices and Musgrave Retail Services. Furthermore the company has three distinct businesses, which operate under the two sections. These businesses include a delivered retail business, a delivered foodservice business and a cash & carry business. Nine purpose built facilities for the cash and carry business are located in Cork, Limerick, Galway, Waterford, Belfast, Derry and three in Dublin. These facilities are wholesalers for hundreds of small independent retailers and catering companies throughout the company. Musgrave Foodservices on the other hand provide a one-stop multi-temperature food delivery service to the catering sector in Ireland while Musgrave Retailer Services supplies 32,000 regular retail and catering trade customers (Musgrave Group, 2002).

The Group also operates in the UK and Spain through Budgens and Dialsur respectively. Budgens is present in 26 English counties mainly in the south East of the country and operates more than 230 supermarkets and convenience stores. In Spain, the Musgrave Group has a wholesale and retail distribution business, Distribuidora de Alimentacion del Sureste (Dialsur). The business is based in the Alicante region in South East Spain. Dialsur has a retail chain of 63 outlets (of which 28 are operated by the company). In addition, Dialsur also owns and operates a chain of 18 cash and carry outlets.

The overall structure of the Musgrave group can be seen below in Figure 5.2.

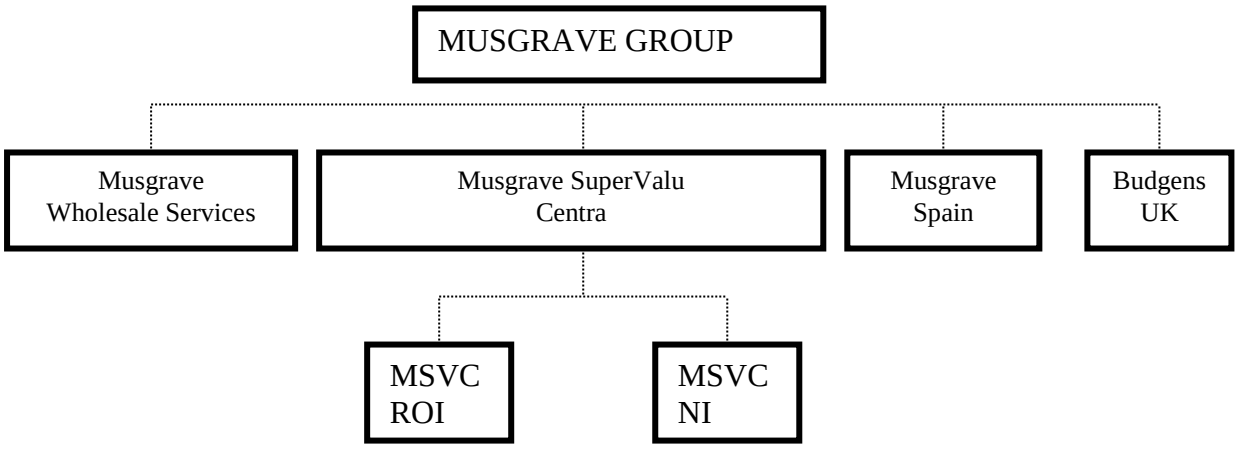

Figure 5.2 Structure of Musgrave Group

5.3.2 Centralised Distribution for Groceries

In 1998, Musgrave became the first Irish Retailer to use centralised chilled, fresh and frozen food distribution to the Irish grocery retail industry through their four national ambient and chill distribution centres (Cork, Galway, Dublin and Belfast). Prior to centralised distribution retailers received their goods through a more traditional distribution system. This often involved retailers receiving numerous deliveries from many different suppliers throughout the week. The onus was on suppliers to deliver to individual stores. This resulted in high transport costs because of the vast number of SuperValu and Centra Stores. Often smaller suppliers had a limited delivery range and were restricted to delivering to stores in their locality. Each individual delivery that arrived at the store required attention from a staff member and resulted in fewer staff members on the shop floor. Furthermore delays in deliveries could often result in stock outs, which compromised customer service.

Centralised distribution at the four national centres now allows for consolidation of products from various suppliers into deliveries for the individual stores. This means the minimisation of deliveries to these stores. Currently, suppliers deliver to one of Musgrave's four central warehouses and deliveries of certain ambient goods to Dublin stores arrive via the Cork warehouse. Individual suppliers still deliver certain products to MSVC stores in Dublin. Graphical illustrations of the two types of distribution systems can be seen in Figures 5.3 and 5.4 below.

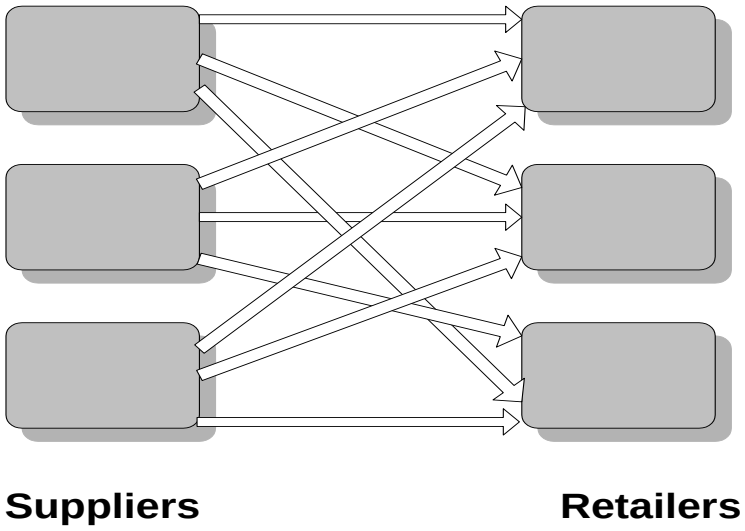

Figure 5.3Traditional Distribution System

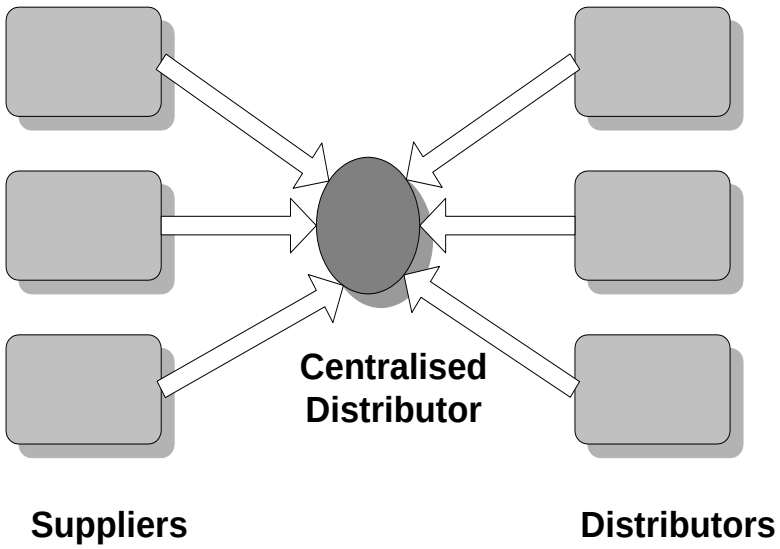

Figure 5.4 Centralised Distribution System

With centralised distribution, MSVC prepare each store's order and deliver to the store within 24/48 hours of the order being placed.

5.3.3 Musgrave Distribution Centre at Kilcock

It is expected that the new Musgrave distribution centre at Kilcock will commence operations in January 2005 and should be fully operational by June 2005. This new warehousing and distribution facility is being developed on a 21-acre site at a cost of approximately €35 million. This figure forms part of the 70 million capital investment in overall logistics infrastructure and information technology. The centre will comprise 150,000 square feet of warehousing, loading bays, offices, canteen and other facilities. When fully operational, it is hoped that up to 150 jobs will be provided in the facility. There is potential on the site for further developing the distribution centre in accordance with any future Group expansion plans.

The motivation for establishing a new distribution centre in Kilcock was prompted by a number of key issues. Firstly as mentioned previously, sustained growth (16% sales growth annually over the past five years) and expansion in the market (combined market share for SuperValu and Centra totals 24%) have placed existing logistics infrastructure under increasing pressure. Distribution capabilities are currently operating at their maximum. Stock outs of particular goods are possible given these conditions. Over a prolonged period of time this may result in compromised customer service, something that MSVC are keen to avoid. The distribution centre in Kilcock therefore forms an important part of the company's overall growth strategy for the future.

The second reason for the development of the centre lies in the fact that it will serve to enhance MSVC control over the supply chain. Again this relates to the service provided to retailers in terms of the on-shelf availability of products.

Thirdly, (and most importantly from the point of view of this project), MSVC stores are historically underrepresented in the Dublin Area in comparison to the rest of the country. However with the expansion in the number of shops in Dublin over the past number of years, this is a trend, which is rapidly changing. This is something that impacted on the choice of location of the distribution centre. Kilcock is a location that is accessible to MSVC stores both in Dublin itself and the Dublin Hinterlands. Figure 5.5 below displays the new M4 motorway (Kinnegad, Enfield Kilcock, are circled below). As can be seen in Figure 5.5 the M4 will easily facilitate distribution in many parts of Leinster including Meath, Westmeath and onwards. Access to an existing national road the N4 (highlighted in figure 5.5 in blue) from Kilcock also facilitates nationwide deliveries. Regional roads also traverse Kilcock (R125, R407 R148 and R158) contributing to the good road network of the area. Although the primary purpose of the Kilcock development is to act as a regional distribution centre, the nature of its location and the scale of operations allow a specific analysis to be carried out on the impacts of centralised distribution by MSVC on overall deliveries within the Canal Ring in Dublin.

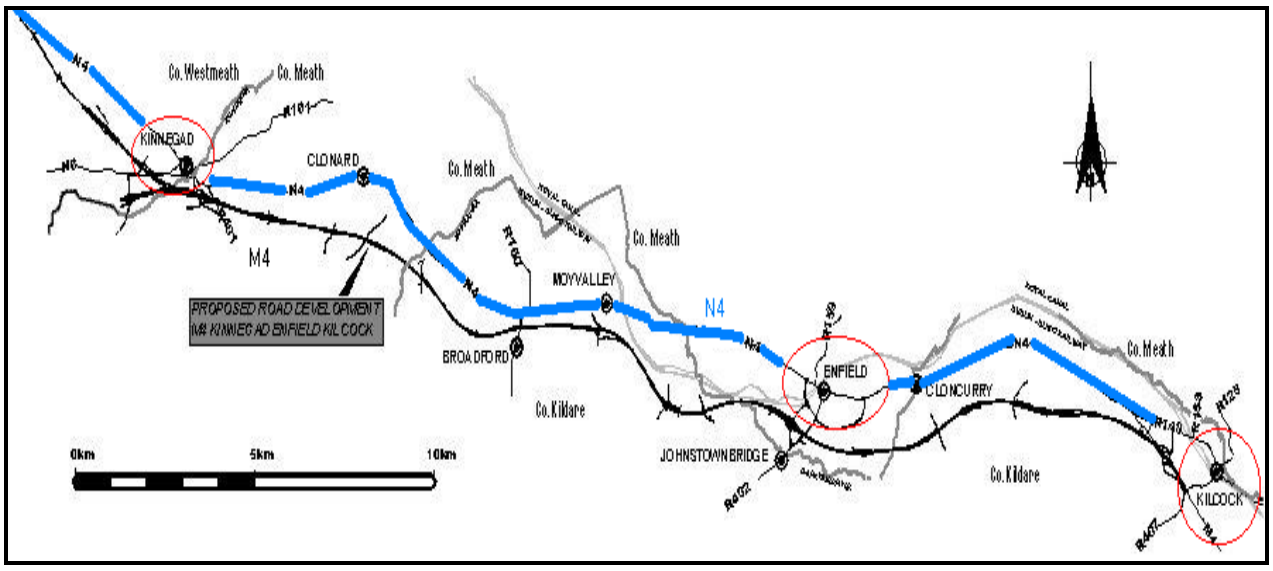

Figure 5.5 M4 Motorway Route

5.3.4 Traffic Benefits of the Kilcock Distribution Centre

In order to quantify the benefits of the Kilcock operation, a comparison was made (using 16 city centre stores) between current delivery operations and future deliveries once Kilcock is in place. Figure 5.6 below illustrates the location of both planned and existing MSVC stores in Dublin.

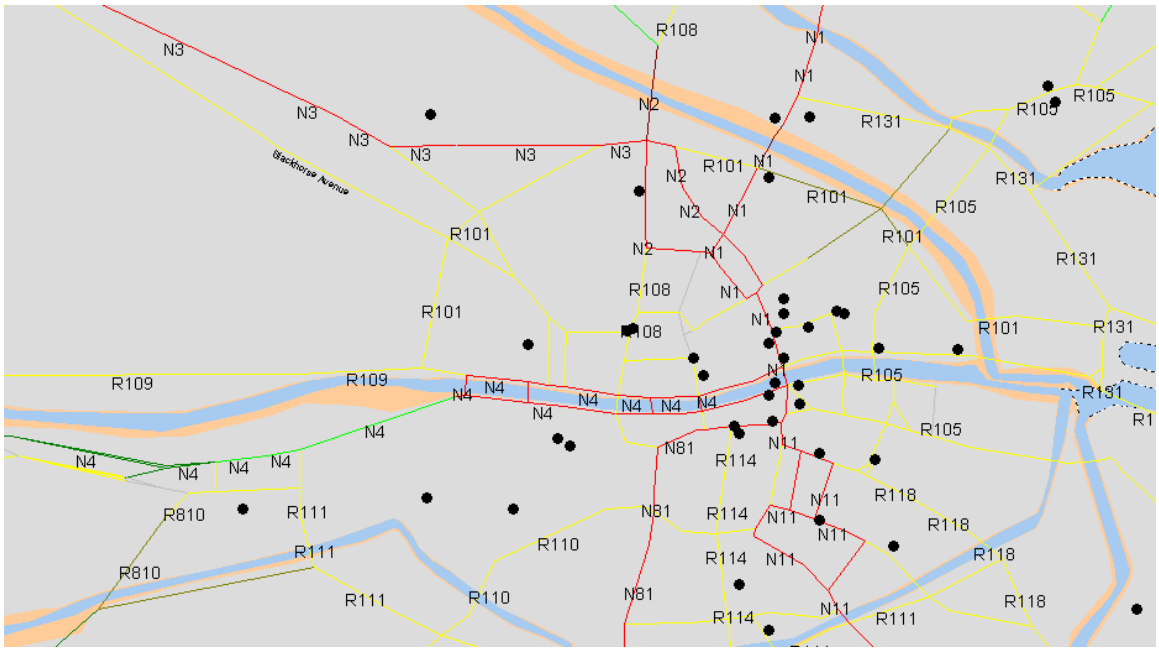

Figure 5.6 Dublin Locations of MSVC Stores

Key areas of interest (which can be viewed in Appendix F) included:

- Delivery frequency per week
- Average volume delivered (in cases)
- Distance involved in deliveries (in miles)

It was discovered that MSVC deliveries to these 16 stores are expected to increase from 17 to 60. This represents an increase of approximately 253% in delivery frequencies. However this is considerably offset by the fact that Musgraves are removing the need for 17 suppliers to deliver direct to all of these stores. Most of these suppliers would deliver twice a week to these stores. Therefore 544 (16 stores X 17 suppliers X 2 times a week) individual deliveries are eliminated from the supply chain through using the Kilcock Distribution Centre. Overall this represents a net benefit of a reduction of 501 deliveries to the city centre. Vehicles used for MSVC deliveries are generally Daf 95 XF tractor-trailers (with ambient box type trailers).

It is anticipated that in a similar fashion to other MSVC distribution centres, the Kilcock operation will allow suppliers to deliver full loads to the centre where they will then be consolidated with products from other suppliers to ensure that the company delivers full loads. It is expected that the average volume (in cases) for all sixteen shops will increase by 80% in total (from 4775 to 8617). On average, the number of cases delivered to each store by MSVC will increase by 90%.

In terms of the average mileage for the proposed routes for the city centre once Kilcock is fully operational, Table 5.1 below illustrates the extent of delivery distances travelled.

Day	Total Mileage	No. of Delivery Routes	Average Mileage
Monday	448	6	75
Tuesday	593	4	148
Wednesday	593	5	119
Thursday	547	4	137
Friday	976	7	139
Saturday	534	4	134
Total	3691	30	123

Table 5.1 Average Mileage for Proposed Routes

At first glance these distances may appear quite high, however it is important to remember that delivery rounds include trips to stores outside of Dublin as well as city centre stores. In other words, city centre stores may be serviced on routes that also service stores outside of Dublin.

Another important benefit associated with the Kilcock Distribution Centre is that it will further assist in the process of "backhauling", which is currently a priority for the Musgrave Group as part of a policy of reducing the environmental impact of company's transport fleet. Backhauling involves the use of MSVC trucks, which have been emptied after deliveries to collect produce from suppliers on the return trips to the distribution centre. This process helps to eliminate replica journeys by the company's suppliers when dispatching goods to the warehouse (Musgrave Group, 2002b). The effectiveness of backhauling is enhanced by the high levels of co-ordination that the distribution centre will provide through its comprehensive logistics system. MSVC estimate that backhauling currently saves around five million kilometres of transport for the Group and its suppliers every year (Musgrave Group, 2000). Ultimately the practice of backhauling increases the efficiency of a company's transport fleet. It results in fewer trucks on the road and consequently fewer emissions.

From the point of view of retailers in Dublin, deliveries via Kilcock are beneficial from an administrative perspective and from a customer service perspective. Dealing with MSVC for a range of products on a single order eliminates a great deal of paper work, which is time consuming and cumbersome. Furthermore, it is hoped that the system will reduce the possibility of stock outs and help increase the range of goods retailers keep at their stores.

5.3.5 Environmental Benefits of the Kilcock Distribution Centre

It is assumed that typically, a HGV on entering the canal cordon, will complete a round trip within the cordon of 11 km per round in order to make a delivery run to the 16 selected franchise stores located within the city centre.
On this basis the travel distance avoided by taking 500 HGVs out of circulation in the city centre would amount to 500X11vkm = 5,500 vkm per week. The additional travel avoided between Kilcock and the approaches to the city centre at the canals is not

taken into account in our calculations because we are concerned with the area within the canal cordon.

Generalising from the UNITE Berlin case study, the environmental costs shown in the Table 5.2 below may be used for estimating the impacts of the Kilcock UDC scenario. In calculating the value of noise mitigation it is assumed that all the deliveries occur at night using conventional HGV combinations.

Location	**Exhaust emissions *(PM 2.5)* €cent/vkm**	**Greenhouse gases €cent/vkm**	**HGV- night time Noise €cent/vkm**
Berlin	10.19	3.29	23.33
Dublin	10.19	3.29	23.33

Table 5.2 Costs due to Emissions, Global warming and Noise in €cent/vkm

Applying these values to calculate the benefits of removing 500 HGVs per week equivalent to 5,500vkm per week, from the city centre, the following external environmental benefits can be estimated, illustrated below in Table 5.3.

Location	**Exhaust emissions €**	**Greenhouse gases €**	**Night time Noise €**	**Total €**
Dublin City Centre	560.	181	1,283	2,024

Table 5.3 The Value of the Environmental Benefits Accruing in € per week

On this basis the value of the environmental benefits of mitigating delivery trips to the city centre would amount to €2,024 per week or to € 105,245 per annum.

There would also be considerable fuel cost savings accruing to the operator from the trips avoided within the canal cordons. Assuming an average fuel consumption of 8 mpg or 2.86 km per Litre @ €1 per litre, then 5,500 vkm per week avoided within the city centre would save € 1,923 per week or approximately €100,000 per annum. To conclude, the environmental or " marginal external cost" benefits accruing to society from the UDC solution would amount to € 2,024 per week or to € 105,245 per annum. In addition there are considerable logistical benefits to the operator. Fuel savings alone of € 1,923 per week or €100,000 per annum would accrue from the trips avoided within the canal cordon alone.

5.3.6 Logistics Technology

With regard to the IT systems in place for the Kilcock Distribution Centre, Paragon Software Systems will provide the vehicle routing and scheduling system. The Paragon Package can handle operations ranging from just 10 vehicles based at a single site to hundreds of vehicles operating from several sites. The standard Paragon vehicle routing and scheduling system allows the user to calculate effective transport schedules for both single depot and more complex multi depot operations. The system allows for distribution involving routes that return to the base depot, haulier 'out only' routes, multi-drop or single drop trips, multi trip routes, multi day routes, daily or weekly scheduling, deliveries and collections, multiple driver's shift details and

drivers' hours regulations (Paragon, 2004). Paragon Software Systems have provided vehicle routing and scheduling to a number of other high profile supermarkets particularly in the UK including Tesco, Sainsbury, and Safeway. Tesco Distribution uses a total of 26 systems for daily planning of 4000 drops made by 1400 vehicles to over 700 stores in the UK and Ireland. The Paragon system enables users to allow for constraints relating to different products. For example, the system can accommodate goods that must be delivered within a given time window and incorporate this added constraint into the overall transport plan. In the case of MSVC, it is a priority to deliver to city centre stores before 7:00am. Indeed delivery times for most of these stores are largely between 5:30am and 7:00am. This occurs for two main reasons: firstly the operation of bus lanes in the city centre, which restricts unloading conditions, and secondly city centre stores often form part of a wider route that includes deliveries outside of the Dublin area. For these routes it is important to depart from the city centre very early in the morning in order to make other drops on schedule.

5.4 OPPORTUNITIES FOR REPLICATION

From the data, potential for replicating an initiative similar to the Kilcock Distribution Centre exists in particularly high delivery generating zones such as Zone 6 (South West of the city) and Zone 12 (South Dublin). Table 5.4 below illustrates that 46% and 47% of the goods originating from zones 6 and 12 respectively are food related.

	Zone 1	**Zone 4**	**Zone 6**
Food/Beverages/General Catering Supplies	31%	47%	46%
Electrical Goods	.05%	6%	4%
Clothing/Shoes	6%	5%	4%
Household/Hardware Goods	6%	6%	7%
Stationary/Books/Newspapers	7%	13%	8%
Pharmaceutical Goods/Cosmetics	2.5%	11%	5%
Alcoholic Beverages	28%	5%	19%
Post/Parcels	8%	2%	2%
Miscellaneous Retail	11%	5%	5%

	Zone 12	**Zone 21**	**Outside Ireland**
Food/Beverages/General Catering Supplies	47%	26%	12%
Electrical Goods	0%	0.5%	7%
Clothing/Shoes	2%	18%	31%
Household/Hardware Goods	5%	21%	19%
Stationary/Books/Newspapers	10%	10%	18%
Pharmaceutical Goods/Cosmetics	20%	2%	3%
Alcoholic Beverages	13%	16%	2%
Post/Parcels	0%	0.5%	1%
Miscellaneous Retail	3%	6%	7%

Table 5.4 Breakdown of Types of Goods Originating from High Delivery Generating Zones

Therefore, food consolidation activities such as those undertaken by MSVC may be possible in Zone 6(Walkinstown, Kimmage, Crumlin, Kilmainham, Inchicore) and Zone 12(Tallaght, Clondalkin,Templeogue, Rathfarnham, Firhouse). Prominent food and beverage suppliers located in Zone 6 include Avonmore, Glanbia, C&C, Coca Cola, United Beverages and Strathroy.

Figure 5.7 emphasises the level of industrial activity throughout Dublin. There is a clear concentration of industrial estates in South West Dublin where Zone 6 is located and this is reflected in the survey results where it was found that 20.4% of deliveries originated from South West Dublin.Young, Richie and Ogden (1980) found that the four main influences affecting the location of freight facilities were:

- Proximity to arterial roads, freeways and services
- Proximity to customers and other facilities operated by the same firm
- Site availability
- Labour availability

Of these factors, the first was found to be most influential. A UDC located in South West Dublin would benefit from proximity to Dublin's C-Ring Motorway, the M50, along with a number of national roads facilitating good access to customers.

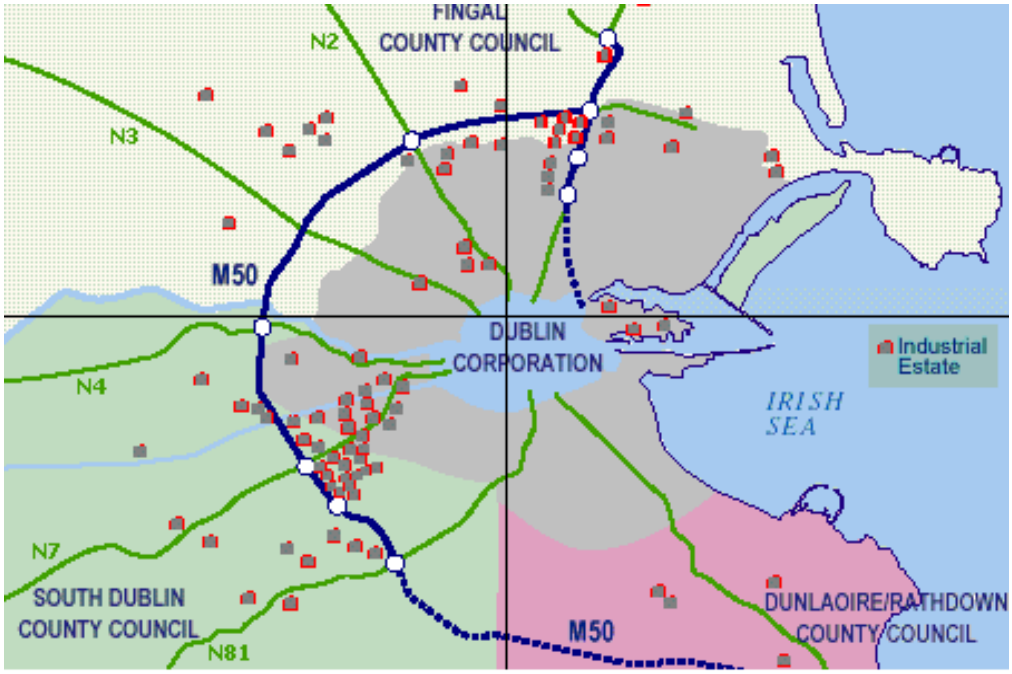

Figure 5.7 Map of industrial site locations and major roads in the Dublin Area

Further potential for UDCs lies in pharmaceutical goods and cosmetics. These goods primarily originate in Zones 4, 6 and 12 (15%, 21%, 40% of total respectively). Zone 12 contains companies such as United Drug, Pemberton, Intropharm and Unipharm. Cahill May Roberts and Boileau and Boyd are both located in zone 6, while the Boots Warehouse, TP Whelehan and Allegro are all found in zone 4.

Since zone 12 accounts for the largest proportion of pharmaceutical goods origins, this is the zone that offers the greatest potential for consolidation of the goods. Three trucks and sixteen vans were recorded in the data as originating from zone 12 to deliver pharmaceuticals. Ten vans also originated from zone 6. Therefore potential also appears to exist to consider consolidating and transporting pharmaceuticals from zone 6 in to the city centre.

5.5 FEASIBILITY OF AN UDC FOR DUBLIN

Two key areas involved in evaluating the feasibility of an urban distribution centre:

1. Planning the size and location of facilities
2. Ownership of the UDC

In relation to the planning the size and location of freight facilities Ogden (1992) describes the factors that influence specific site location. These include the following:

- Adequate site area of suitable shape and terrain
- Adequate local street and road capacity
- No restrictions on truck operations in the area
- Permitted access by largest vehicles allowed on line-haul (long distance transportation by large trucks on expressways) routes
- No adverse noise or zoning restrictions which might inhibit 24 hour terminal operations
- Safety and security considerations

With regard to the south west of Dublin, it has already been highlighted that a UDC in this area would benefit from proximity to national roads (N4, N7, N81) as well as the M50 motorway. Access to the M50 motorway is particularly important in the light of the development of the Port Tunnel.

In terms of ownership of a UDC, Ogden (1992) points to three possible scenarios:

- Ownership by a single private corporation, perhaps owned in turn by one or more freight or transport companies
- A cooperative venture in which each freight company using the facility contributes to its operation expenses and/or receives income from it
- A public corporation, usually owned and operated by the municipality of the area concerned

The first two ownership scenarios incorporate commercial interests and are therefore more likely to focus and produce long-term viability and competitiveness of a scheme. Furthermore, given current limitations on spending by local authorities, it is unlikely that a large-scale consolidation platform would be established and operated by the authority itself.

With regard to the extent of the role of local authorities in implementing and operating a UDC, the approach suggested by the LEAN (1998) and REFORM (1999)

projects is to examine each scenario on a case-by-case basis. These projects recommend that local authorities give active support to promoting co-operation between UDC potential stakeholders. This support may take the form of facilitating regular meetings of the stakeholders. Furthermore, local authorities can assist in the process of implementing a UDC by identifying suitable sites at an early stage and secure them by adopting appropriate land use planning measures. They can also help shape the framework conditions of the transport market using appropriate regulations. If urban freight is found to impose unacceptably high costs on society, authorities have the option of introducing measures such as road pricing or city access regulations. Since location is identified as one of the potential key success factors, and location is influenced to a large extent by transport infrastructure, authorities should be encouraged to provide the necessary transport infrastructure in order to guarantee efficient access to and from a UDC.

5.5.1 Possible Costs of a UDC in South West Dublin

In order to determine the possible capital infrastructure costs involved in setting up a distribution centre in South West Dublin, it was necessary to ascertain the current market cost of land in the area (per acre) and the current market building cost (per square metre). Building costs (for warehousing and offices) in South West Dublin are approximately €1500 per square metre. Costs of land in the area are in the range of at least €750,000 per acre. These costs are a reflection of the demand for business space in a prime industrial area of the city. Therefore, if a large scale urban distribution centre (a similar scale to the Musgrave Kilcock centre consisting of 150,000 square feet on 21 acre site) was established in South West Dublin to cater for consolidation of goods prior to entering the city centre the following capital costs are likely to be incurred illustrated below in Table 5.5.

Building Cost of 150,000 Square Feet
150,000/10.75 (to convert to metres) = 13953 13953 metres X 1500 (cost per metre) = €20,929,500
5.5.1.1.1 Land Cost of 21 Acres
21 X 750,000 (cost per acre) = €15,750,000

Table 5.5 Building and Land Costs in South West Dublin

In addition to the land and building costs, which already provide a combined cost of 36,679,500 there are also costs involved in site development. Site development includes the provision of hard standing surfaces for HGVs, building internal roads, ensuring adequate lighting is provided and building a secure boundary around the site. All of this additional infrastructure could cost in the region of €5 million. This brings the total capital cost of any potential UDC development in South West Dublin of the scale of the Musgrave Kilcock Centre to €41,679,500.

However, this figure is merely an indication of the capital costs of a large-scale urban consolidation operation. Clearly, a smaller scale distribution centre would involve less capital investment. The implementation of such a scheme is likely to require the participation of a number of companies as well as local authorities. While the

development of an entirely new distribution centre in South West Dublin is one long-term option, there are other alternatives for consolidation schemes. The first option involves the utilisation of a proposed transport and logistics centre in Portlaoise. The second option involves enhancing current levels of consolidation at company level.

5.5.2 The Portlaoise Interchange Economic Development Plan

The Portlaoise Interchange Economic Development Plan proposes the establishment of a 250-acre transport and logistics centre, motorway services and retail warehousing on a site bordering the M7 motorway interchange and the Dublin-Limerick railway line, outside Portlaoise. This scheme offers the potential to become the country's main hub for warehousing and distribution. Therefore large-scale goods consolidation opportunities are possible at the interchange. The scale of the proposed development (requiring a €250 investment) is an indication of the importance of goods transportation and logistic services to the economy as a whole. Benefits of locating such a development in Portlaoise include the proximity of the area to a number of major centres and cities and the fact that site costs, development levies and freight forwarding costs are less in Portlaoise then in Dublin and many other areas. The progression of this proposed scheme should be monitored with a view to examining the extent of consolidation activities possible for Dublin related deliveries in line with the development of any definitive freight strategy for the Greater Dublin Area.

However, it must be acknowledged that participation in the operation of a public UDC could be perceived as involving a reduced level of control for a company over their supply chain. This is something that is likely to affect overall participation rates in a public consolidation centre initiative. Other potential barriers for companies using a publicly run consolidation centre include fears of the disclosure of company information regarding products, logistics management and commercially sensitive information on business practices.

5.6 THE POTENTIAL FOR CONSOLIDATION AT COMPANY LEVEL

Superquinn is another leading Irish food industry retailer, which in the past number of years has also moved towards a centralised distribution delivery system. Superquinn has 19 retail outlets in Ireland and sales estimated at 9% of total grocery spend (Celerity, 2003). An 180,000 square foot distribution centre was built at Blanchardstown Corporate Park in Dublin in 2001. The purpose of the facility is to handle the warehousing and distribution of both chilled and ambient grocery goods for the Superquinn chain of supermarkets. Wincanton Logistics, a third party logistics company, manages the distribution centre. It is anticipated that the new distribution centre will significantly reduce the number of deliveries to Superquinn from 400,000 annually to less than 100,000. Looking at deliveries on a daily level, it is expected that 960 of 1300 trucks that arrive at Superquinn shops will be taken off the road (Superquinn, 2001).

Two years into centralised distribution, the company state that the system has brought about enhanced levels of customer satisfaction, largely due to the fact that Superquinn have improved the availability of products on its shelves. Superquinn now has 98% of

products available at any given time compared to a European average of 93% (Sunday Business Post, 2004).

With regard to the costs incurred through the implementation of centralised distribution, it is estimated that the operating costs could be met from the savings obtained through more efficient distribution. However, the full return on the original investment will probably take around seven years (Sunday Business Post, 2004).

Cash and carry group Barry's of Mallow, County Cork are another example of the trend towards centralised distribution of food products in Ireland. In April 2004, the company announced that it is to develop a ten million euro chilled and frozen food distribution centre with a total size of 60,000 square feet. Construction of the first phase of the project will begin in May, and is due for completion in October. It is estimated that up to 75 jobs will be created in the process. The distribution centre is described as being of "strategic importance" to the future growth and development of the company (Checkout, 2004).

The move by Irish companies such as Superquinn and Barrys to centralised distribution shows that potential exists at individual company level to optimise consolidation opportunities, especially when the company concerned (such as Musgrave and Superquinn) delivers goods to a large number of businesses.

5.7 CONCLUSIONS

From the international case studies described and the Musgrave Centralised Distribution example, it is clear that the transport industry, the public and the consignee alike can benefit from UDCs. For the transport operator, specialised city distribution can offer efficiency gains. This is largely because city distribution is often less profitable than long distance haul. The public in general benefit from UDCs through the reduction of traffic, resulting in less noise and air emissions. For example in the case of La Rochelle, although transhipment costs associated with the project are high, lower emissions in the Medieval Town Centre are an asset for tourism. UDCs also help to facilitate the process of backhauling, which serves to reduce the number of unnecessary trips. Finally, the consignees benefit from shopping streets being more attractive to customers, thereby encouraging more business.

On the other hand UDCs also impose costs, particularly on the transport companies involved but also for example on the residents in the areas surrounding the platform (increased traffic). Also, every additional transhipment carried out increases transport costs substantially. According to REFORM (1999) 1/3 of distribution costs are caused by transhipment. Transaction costs incurred through UDCs can include information exchange and also fear of losing competitive advantages.

Given the costs and benefits of UDCs, it is clear that each individual case must be evaluated on its own merits. However a number of factors that offer potential for the successful implementation of a UDC have been identified by BESTUFS (2002):

1. **Freight Consultation Forum**

Ann informal relationship should be established that brings together all stakeholders involved (transport industry, retailers, community members, local and national authorities) to explore how UDCs could be used more effectively to reduce transport demand.

2. **Technology:**

Co-ordination i.e. information sharing among partners is integral to the operation of a UDC. Information technology such as the Paragon System used by the Musgrave Group offers strong potential for increased efficiencies in terms of consolidating and routing activities.

3. **Local Know-How:**

Local know-how includes a clear knowledge and understanding of local conditions, the transport network, obstacles and delivery conditions. It can be an invaluable source of information that can make the set up and operation of a UDC run more smoothly.

4. **Location:**

Consolidation and distribution costs depend heavily on the location of the distribution centre. Therefore the location of the platform is critical for its success. As mentioned previously, the Musgrave Distribution Centre is located close to a good road network.

5. **Intermodal Access:**

This is a less important factor in the case of Ireland due to the limited role rail plays in freight distribution although if a shift in policy towards rail freight occurred this could be revisited. However in other countries such as France and Germany, rail can play an important role for efficient access to an urban freight platform

6. **Share of Own-Account Transport:**

Generally, own account transport (company transports its own goods from one place to another) offers more potential for consolidation, whereas professional transport operators often already consolidate their goods received from different shippers. Thus, the higher the share of own-account transport in the city, the higher the success potential for a UDC.

In the long term, UDCs will only be successful if all participating partners benefit from the schemes. In other words UDCs must be commercially viable and socially beneficial to form a realistic management strategy for urban freight distribution.

6 INTERNAL CONSOLIDATION: MANAGING THE LAST MILE

6.1 INTRODUCTION

Deliveries to customers located in congested city centre locations can cause considerable congestion and nuisance when this is done by conventional commercial vehicles. Solutions for taking delivery trips out of peak times and for mitigating the need for kerb-side deliveries have been demonstrated by several European cities.

Innovative solutions for managing the "last mile" distribution of goods in congested urban areas are reported in the DG-TREN sponsored city freight thematic network (BESTUFS, 2003). In the case of parcels and mail, the Deutsche Post World Net Group (owners of DHL) has been to the forefront in these developments. In German cities the Deutsche Post group has demonstrated the use of managed down-town fixed platforms, and of unmanned but secure "pack stations", which are facilitated by the application of advanced ICT tracking and customer alerting systems.

The down town "platform" concept is a means of managing distribution within designated areas such as large office complexes, and public institutions such as colleges or hospitals, which tend to be located in congested city centre areas. The platform concept can offer logistical efficiencies such as consolidation at a local level which reduces distribution trips within the designated area; holding additional buffering inventory which lessens the need for multiple trips from outlying depots to the city centre; and the opportunity for suppliers of servicing the platform at off peak times.

In this chapter a number of case histories are described, one involving the delivery of mail by walking couriers from a platform located in the Dublin 2 business district. A possible scenario for managing the "last mile" deliveries within the large TCD campus is also evaluated.

DHL has operated a platform successfully for some years at Sandwith Street to service the main city centre business district and the operational characteristics and benefits are reported.

On the basis of the comprehensive data gathered in our survey work, a justification can be made for replicating the platform concept on a larger scale on the TCD campus. The possible operational characteristics and potential benefits are examined.

In addition to the innovative approach developed by DHL, the logistical practices of carriers such as SDS, FasTrack, and the "Irish Times" newspapers are briefly described because they are regarded as sustainable examples for managing deliveries.

The possibility of replicating the "platform" model at the large Department of Education & Science campus in Marlborough Street is considered as an example of how this could be done for a large delivery destination entity.

6.2 BACKGROUND

Three examples have been selected from European cities, which describe how the platform concept can be managed.

6.2.1 The "MERCi" Project in Genoa

The Italian city of Genoa began to operate an interception platform in March 2003 close to the historic centre. The "MERCi" project is funded by the Ministry of the Environment in collaboration with the municipal authority and the local traders. A wide variety of goods are handled by the platform and final deliveries are made by a fleet of eight dedicated electric vehicles.

Aim
To achieve goods distribution through zero emissions environmental impact in the historical centre of Genoa.

The characteristics of the city centre are:

- The roads are very narrow
- Traders have very limited storage space
- The historical centre is almost completely closed to automotive traffic except to couriers and to electric vehicles (EVs).

Solution

- A hub or platform was established in March 2003
- The hub of 1,100m^2 is located 5 km from the historic centre and 1.5km.from the motorway
- 150/300 packages/day are delivered
- 5/8 delivery operations /day occur
- 8 electric vehicles are deployed and can cover 12 – 20 km for each delivery round
- The EVs are "FAAM-JOLLY 600/1200" units having a capacity of 5 to 9 cubic metres and a range of 50 to 60 km.
- Distribution excludes fresh foods, drugs and cash deliveries
- Advanced logistics software is used to optimise planning, operations, control and customer alert in "real time".
- This pilot action is financially supported by the municipal authorities and the appropriate restrictions and permitting are enforced.

Results

- Significant reductions achieved have been achieved in mitigating vehicle access, emissions and nuisance
- The project is to be extended to other parts of the city

6.2.2 Vehicles & Logistics in the Information Age" – Deutsche Post

A variation of the city centre platform can be seen in Germany where Deutsche Post/DHL has introduced unmanned "PACKSTATIONS" for parcels deliveries and collections in high-density locations such as office complexes, universities and

institutions (BESTUFS, 2003b). A "PACKSTSION" is a machine-based parcel and mail retrieval system that enables registered customers to retrieve and to send small consignments. Customers are notified by text message or by e-mail when a delivery arrives. Parcels are collected by customers with the appropriate cards and PIN codes 24 hrs per day (DHL, 2004).

Following three years of trial, PACKSTATIONS were established at Dortmund, Mainz and Cologne in June 2003. By the end of 2004 the facilities will be extended to Hanover, Bremen, Darmstadt, Wiesbaden with further stations planned for Hamburg, Berlin and Potsdam. A total of 500 stations are planned and 320 are already in operation.

Aim

To respond to new demands & pressures for better customer service; to showcase advanced ICT technologies and the automation of the conventional procedures & operations for delivering mail and parcels, thereby achieving greater logistics efficiencies.

Solution

- The introduction of secure locker rooms/pack stations and drop points where the density of customer premises and offices can justify the investment. Examples include large office complexes; universities and filling stations located in high-density business districts.
- The experimental pack stations/locker banks are owned and managed by Deutsche Post
- Up to 500 lockers are planned for installation– at present 320 are placed in direct "living areas" where they can be easily observed to ensure security.
- The exploitation of the advanced ICT applications systems and logistics software that are now becoming available

Results

- Logistical efficiencies have been achieved in terms of better deployment of vehicles & manpower
- Demonstration of what advanced ICT can achieve and a contribution to systems and e-commerce development for mail and parcels deliveries in the Deutsche Post/DHL Group
- The re-scheduling of vehicle movements to enhance sustainability by reducing congestion and nuisance at peak times – a greater independence from set and restricted collection and delivery times giving flexibility in route scheduling
- It was found necessary to ensure that a critical mass of customers can be persuaded to sign up – every location is unique in terms of its customer density and make up
- The additional investments must be justified by the operational savings accruing in terms of better consolidation and the reduction of delivery trips to the city centre, particularly at congested peak times.
- Unnecessary trips are avoided when recipients are not at home – customers can control when they wish to collect their packages.

- Different approaches for overcoming organisational & operational barriers can be explored – advanced consultation with all the parties affected is critical for success
- While the experiments in Germany are regarded as very successful, a pilot scheme in Amsterdam has failed because of security problems in a poorly unsupervised location (BESTUFS, 2003b).

6.2.3 Improving City Transportation & Distribution Networks in Portugal

Aim
To Improve Urban Distribution by developing an innovative logistics regime for the historic city of Evora (Innovagency, 2003).

Solution
- Managing the demand side more efficiently by better consolidation in at platforms immediately outside the walls of the historic city.
- Streamlining the supply side by promoting shared distribution facilities and integrated ITS systems
- The city authorities are developing innovative access control mechanisms, incentives and regulations to encourage the new regime and collaboration by the distributors.

Results
- A logistics systems has been developed to minimise the inward and outward flows of goods and to improve the traditional supply chains to the city
- Comprehensive origin & destination surveys have been completed to help identify opportunities for achieving greater logistical efficiencies in the supply chain
- A set of medium term goals have been agreed with the parties concerned
- A public consultation process has been completed to agree a new mobility management and monitoring regime for the city
- It yet remains to be seen whether the targets can be achieved

6.3 IRISH CASE STUDIES

The Irish case studies described below for managing the last mile of deliveries include DHL, Fastrack and the Irish Times.

6.3.1 DHL - The Dublin Platform Experiment

DHL is a major logistics service provider in Dublin city. Since 2003 DHL have become part of the Deutsche Post World Net group who are a leading player in the European domestic mail services, international express airfreight, global freight logistics and the related financial services. 250 aircraft operate worldwide for DHL, 36 global hubs for sorting and a fleet of 60,000 vehicles service destinations in all continents.

Deutsche Post World Net serves 5 million customers and has 276,000 employees. The DHL division employs 150,000 of which 500 are based in Ireland. Express service

centres are located in Dublin, Cork, Shannon, Waterford and Athlone. The group encourages innovation and development.

Beginning in Dublin in 1993, DHL experimented with the concept of a mobile platform or "Super Bus". The Super Bus or Mobile Station operated in the central parts of the city from which walking couriers were deployed for local distribution. Supported by a small number of sweeper vans, the super-bus proved to be an effective and productive means of servicing customers. The Super Bus had the advantage of being able to move around the city centre dropping off and collecting walking couriers to make their deliveries.

Over the last two years however, because congestion and parking had become problematic for such a large vehicle, it was decided to replace the mobile bus with a fixed, premises-based platform located at Sandwith Street. in the South inner city. The hiring and retention of walking couriers also proved difficult to manage from a mobile base.

DHL kindly afforded the opportunity of reviewing the operation of the fixed platform, which has proved to be an innovative and sustainable solution for managing the last mile for the delivery of documents and mail. In examining the operations of the DHL fixed platform the following questions and issues were considered in relation to how to best to manage the last delivery mile:

1. Is the transfer of documents from regional hubs outside the city to smaller platforms located in selected city centre business districts operationally feasible, acceptable to customers and economically justifiable?
2. What are the resources required and how are these to be managed?
3. What contribution can this arrangement make to developing a more sustainable transport solution for the city in terms of:
   (a) Minimising the need for trips to the city centre
   (b) Contributing to peak separation by taking commercial traffic out of peak commuting times
4. The impacts on customer service
5. Do the benefits for the logistics service provider offset the costs of introducing an additional step into the supply chain
6. The criteria necessary to justify establishing a platform
7. The potential for replication

6.3.2 The Platform in Operation

Since 2001, DHL has managed a substantial operations platform within the south inner city to service customers in a key strategic business district that are within a 1km. radius of Sandwith Street. The platform serves a dual purpose, as a base for walking and cycling couriers and as a drop off and collection point for customers.

The platform is serviced in the early morning from the main DHL hub at Dublin airport cargo terminal. The "last mile" deliveries are made by walking and cycling couriers or alternatively, parcels can be collected by customers. Advanced ICT systems help to track consignments and to alert customers by e-mail. The platform handles letter post type light documents – the heavier parcels are delivered directly to

customer premises during the day by DHL vans because they would be unsuitable for delivery by walking couriers.

To understand how the platform operates the upstream and downstream flows to and from the platform were tracked for a typical busy weekday. Details of the upstream flows of goods from the main DHL hub at Dublin airport to the city centre platform for a typical day can be seen below in Table 6.1.

Numbers of vehicles deployed	1 LGV for servicing the platform
Type of vehicle	Ford Transit van
Number of round trips from airport to platform by LGV	2 Round Trips per day
Time of departure from airport	7.00 – 7.30 am
Trip duration	30 minutes
Dwell time at platform	60 minutes
Volume of units delivered to platform	800 – 1,000 per day
Distance travelled per round trip	20 km
How are other parts of the city served?	Directly from airport and from parcels depots at Swords and the Naas Road.
Where does local sorting take place?	At Sandwith Street. – each load takes 30 minutes to sort

Table 6.1Details of Flows of Goods from Dublin Airport to DHL City Centre Platform per day

600 businesses are served within a 1 km. distance of the platform where the density of customers is high. The area encompasses the main commercial, retail and government districts around Grafton Street, College Green and the International Financial Services Centre.

Details of the flow of goods from the platform to customers for a typical day can be viewed below in Table 6.2

Operating hours – receivership & local distribution	7.00 am to 6.30 pm
Number of consignments received	1,000 items inbound
Origin of goods	Airport cargo terminal – DHL flights
Number of items dispatched from the platform	1,000 items
Rhythm of departures by couriers	X 2 cycles, am and pm
Area serviced	Streets and institutions within 1 km
Number of businesses served	800 companies
Technologies used	ICT systems developed by DHL
Residence time for consignments	30 minutes for sorting of the LGV load at the platform
Staffing at platform	1 supervisor + 1 operator
Number of couriers	16 – 18
Type of platform	Converted domestic residence

Table 6.2Details of the Distribution of Goods from the City Centre Platform to Customers

Under current arrangements at the fixed platform, 16 to 18 walking and cycling couriers are deployed at Sandwith Street. The split between the walking and cycling couriers is 75% in favour of the walkers. A Ford Transit LGV provides a shuttle service to and from the airport cargo terminal twice a day. While the main purpose of the platform is to facilitate local distribution, it also serves as a walk-in customer drop-off point for express mail and this mail is collected on the return trips to the airport. The deployment pattern for the couriers can be seen below in Table 6.3.

Number of couriers per shift and per day	16 - 18
Number of rounds per courier per day	2 - Starting at 8.00am
Number of rounds per courier	2
Average duration of rounds	4 hrs (4 + 4 hrs split shift)
Number of drops per courier per day	60 - 80
Average number of consignments per drop	1+ items
Average dwell time at premises	2+ minutes
Area covered per round	Radius of 1 km
Distance walked per round	4 km

Table 6.3 Deployment Pattern for Couriers

6.3.3 Possibilities for Deploying "Eco-Friendly" Vehicles

DHL are mindful of the desirability of minimising vehicle emissions, particularly in the city centre and they have deployed a dedicated LPG fuelled Ford Transit van in their fleet configuration. Because most of the deliveries and collections need to be made during the day, the EU noise directive, which relates to night deliveries, would not affect their operations. More vehicles could be converted to cleaner LPG fuel if price or tax incentives and a better spread of refuelling facilities were available. As described in chapter 7, the incentives for using LPG are currently much less attractive than was the case a decade ago (when LPG was 40% cheaper than petrol) because of the virtual disappearance of the price differential compared with diesel and petrol.

6.3.4 Restrictions and Incentives

The platform operator would welcome better provisions for loading such as a dedicated drop zone. Loading and unloading is currently carried out on the kerb side in front of a period building. The appropriate incentives by the municipal authority could help to encourage the replication of the platform solution in other parts of the city where customer densities are sufficiently high.

The company may in future consider the feasibility of such an operation by demonstrating the unmanned "pack station" concept whereby parcels can be delivered to a secure drop point for subsequent collection by customers. The extent to which customers in Dublin can be persuaded to accept this type of service for time sensitive items needs to be established.

6.3.5 Potential Costs and Benefits of a City Centre Platform

The rental of the Dublin DHL platform premises amounts to about € 2,500 per month. Manning levels at the platform comprise 20 persons - a supervisor, one dispatcher and

from 16 to 18 walking and cycling couriers. Sources of cost are outlined below in Table 6.4.

Rental of platform premises	€ 2,500 per month
Hiring of walking couriers, supervisors	18-20 couriers employed + 2 platform operatives
Fit out of platform premises	Additional costs incurred (confidential)
Security at platform	Additional costs incurred (confidential)
Lack of a dedicated loading bay	On-street delivery at the platform is undesirable – causes difficulties for traffic flow and for the operator

Table 6.4 Sources of Cost for a City Centre Platform

Benefits of the platform on the other hand include operational efficiencies, enhanced levels of customer service and positive environmental implications and may be viewed below in Table 6.5.

Reduction in the number of commercial vehicles accessing the city from the airport	12 trips per day to city centre is avoided
Significant reduction in delivery drops by LGVs on congested city streets in vicinity of platform	1,000 items per day now delivered by walking couriers instead of by van blocking the kerb sides
Operational efficiencies achieved in replacing vans by couriers	Couriers are found to be more productive than vehicles & drivers; Fuel savings
Reduction in nuisance by delivery vans on city centre congested streets	Less noise nuisance & emissions
Improved customer service & reliability	No significant loss of time is incurred by introducing an additional step in supply chain, reliability is improved, an express drop-off facility provided for clients
Potential for replication in other parts of the city where customer densities permit	Dept. of Education complex TCD campus Government Buildings
Potential for introducing clean vehicles	LPG fuelled Ford Transits would be suitable provided that the appropriate fuel price incentives were available

Table 6.5Benefits of the City Centre Platform

6.3.6 Fastrack

The Fastrack subsidiary of Iarnrod Eireann operates an express interregional and intercity express courier service whereby deliveries are made to the mainline rail stations by scheduled service trains for onward delivery to customer premises. In Dublin, the hub is located at Heuston Station and the "final mile" deliveries are made by a combination of either LGVs and by motorbike couriers.

While the volume of parcels delivered to the city centre is small (100 items per day), the platform at Heuston is a welcome example of a sustainable rail to road inter-modal transport in action. Other significant players in the parcels and mail courier business in Dublin such as Pony Express, Inter Link, and FedEx might be interested in exploring the "platform" solution.

6.3.7 Irish Times Newspaper Deliveries to City Centre Shops

The delivery of newspapers in the early morning is a major logistical exercise and is now handled by the "Irish Times" in a sustainable way. Since June 2002 the newspaper has changed its distribution methods. This has entailed dividing the city into 4 hubs that are supplied by HGV tractor and trailer combinations from the main printing works in City West.

Newspapers are sorted at the hubs for onward distribution by smaller LGVs to designated sectors of the city centre where they are dropped into boxes located on the pavements outside the shops. The replenished boxes or cages are received into the shops when the premises are opened later in the morning. For example, the hub at Islandbridge is served from City West by two HGVs and the deliveries are then sorted into smaller LGVs. Each LGV makes about 58 drops during each 2 hour run

The Irish Times solution avoids trips to the city centre by large HGVs. The 4 hubs located closer to the city ensure greater logistical efficiencies in terms of optimum fleet deployment and consolidation.

6.4 POTENTIAL FOR REPLICATION

The criteria necessary to justify a replication of the platform solution are:

1. Identifying the carriers and distributors who have a high volume of deliveries to the city centre
2. Establishing the density of customers within selected areas that could justify the deployment of walking or cycling couriers
3. Easy vehicle and customer access - preferably off-street parking
4. Availability of secure premises for the platform

Analysis of the survey data of deliveries to city centre businesses would indicate the potential for establishing platforms in at least at two locations. The data from the five-day gate surveys of (a) the TCD campus and (b) of the Department of Education & Science complex at Marlborough Street shows high volumes of deliveries and points to considerable nuisance caused by unrestricted access by commercial vehicles. Other possibilities may include government buildings and the House of the Oireachtas as well as hospitals and other similar institutions. Possible scenarios are developed in the following section.

6.5 PLATFORM FOR THE TRINITY COLLEGE CAMPUS

The college campus occupies 47 acres in the historic city centre and is a place of study, research and employment for 2,700 staff and 15,000 students. This concentration of people in a compact and densely populated site generates as much

commercial traffic as a small town. In recent years the free access enjoyed by delivery and service vehicles is causing increasing congestion and nuisance within the campus. The aim of this investigation is to see if this traffic can be managed in a more sustainable way, both internally on campus and in the vicinity of the college.

We have examined several innovative solutions that have been demonstrated for "managing the last" in other European cities (BESTUFS, 2003). We have also assessed the down town platform and walking courier arrangements currently operated by DHL for delivering local mail to the south inner city business district.

As mentioned in Chapter 3, a pilot gate survey was carried out at TCD to help us to perfect our survey methodology. The gate survey monitored the patterns of deliveries to the campus during the course of "College Green Week" which was held from 10th to 16th February 2003. The TCD gate survey data was analysed to see whether a case could be made for establishing an interception point or platform on the periphery of the campus in order to mange the last mile deliveries to premises in a more controlled and sustainable manner. This aims to benefit both internal traffic on campus and traffic in the vicinity of the college.

The data was examined to determine what proportion of vehicles carrying non-urgent consignments could be intercepted at the proposed platform and following sorting and consolidation, the goods would be subsequently distributed by in-house personnel. The benefits of this arrangement in terms of reducing congestion on campus and of mitigating the need for suppliers to make multiple deliveries to the city centre was evaluated.
In parallel with this exercise, the Purchasing Department in the college had started to explore the opportunities for more bulk purchasing which has the potential for cost savings. Bulk purchasing also reduces the need for suppliers to access the college from their outlying depots.

Critical questions to be answered are:

1. Can an Interception Platform be justified in order to manage deliveries on campus in a more sustainable way?
2. What restrictions and arrangements are acceptable to control access to the campus?
3. Can we quantify the likely benefits accruing in terms of a reduction in traffic congestion on-campus and in the vicinity of the college; better customer service levels; additional storage; improved security and control?
4. What are the likely additional resources and costs required?
5. How does the proposal fit in with the existing practices at TCD?

6.5.1 The Operation of the Interception Platform

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The scenario for tracking the flow of deliveries inwards to the platform and onwards to the campus is described as follows:

- The carriers arrive at Lincoln Place Gate
- Vehicles are categorised into urgent & non-urgent deliverables
- Non-urgent deliverables are directed to the Interception Platform

- Unloading and logging of the non-urgent goods for temporary storage at platform takes place
- Sorting, consolidation and controls take place
- Loading to an in-house vehicle(s)
- Final delivery is made to departments and premises on campus.

In order to distinguish between the urgent and non-urgent deliveries at the entrance gates, it is proposed that departments would be requested to advise their suppliers to clearly tag all urgent deliveries so that drivers could access the campus quickly. All goods and packages not specifically identified would be directed to the Platform on the assumption that they are non-urgent. Access to the campus proper would be by exception only. At the platform the deliverables would be codified into an input/output management system and put into temporary storage and sorted for subsequent dispatch. Schedules for onward distribution within the campus would be decided in accord with the current practices for mail deliveries and in order to avoid traffic peaks in the mornings.

Final mile deliveries would be made by an existing in-house van or by acquiring a "clean" vehicle. The Irish LPG Association advise that a conversion to auto-gas could be made for €1,500 or that a dedicated second hand LPG vehicle could be readily acquired from the UK. It should be mentioned that a trial some years ago of an EV using heavy lead acid batteries was found it to be impractical for use on the cobble stoned pavements. The possible availability of "clean" and eco-friendly vehicles is dealt with in Chapter 7.

In order to estimate the possible scale of operations for the platform it is necessary to (a) identify the number and busiest drop points on the campus and (b) to classify deliveries as between urgent and non-urgent. An analysis of the pilot gate survey data as reported in Chapter 3 was made as shown in Table 6.6 below.

Number of drop points on campus	120 addresses
Most important destinations	9 principal, 120 in total
Total number of deliveries/week	365
Number of urgent deliveries	121
Number of non-urgent deliveries	244
Proportion of vehicles permitted to access the campus by college security	33%
Proportion of total deliveries that can be potentially diverted to the platform	67%

Table 6.6 Proportion of Total Deliveries that Might be Diverted to the Platform

In examining the data relating to the 365 deliveries to campus, it was established that the categories that might merit classification as non-urgent are the routine laboratory supplies, stationery and office supplies, books, electrical goods, dry goods and novelties for the college shops, water and beverages, furniture, routine supplies for the building and maintenance departments. Where deliveries to any particular department or laboratory are by special courier or where goods are destined for a construction company working on campus, direct access is permitted.

The biggest generators of traffic are the dental hospital and the laboratories based in the Hamilton and Parsons buildings. The restaurants and canteens have separate arrangements for receiving and storing perishable and chilled goods and use a special entrance off Pearse Street for servicing the dinning hall and buttery. This particular data was not reported in the Gate Survey.

The proposed interception of deliveries of laboratory and cleaning supplies such as industrial gases and solvents, would facilitate tighter controls by the college authorities of the consignments of hazardous materials currently entering the campus.

Following interception, logging and consolidation of the incoming loads at the platform, the distribution on campus would be organised as follows using in-house vehicles. The internal deliveries by an in-house vehicle would take place during the off-peak periods during the morning and afternoon. It is expected that two rounds would be made every day to any number of 120 drop points, although 9 destinations is likely to account for most of the deliveries. Loadings per round will vary from 15 to 50 deliveries of boxes and parcels. The onward distribution of the non-urgent goods delivered to the platform would be carried out by one of the three existing vehicles in the college fleet.

At present a dedicated mail van distributes the post internally which loads at a central point and completes 2 rounds per day. It is proposed that these rosters would be expanded to include the internal distribution of the non-urgent consignments diverted to the platform. Another van that distributes stationery and office supplies from central stores twice a day would also be available for delivering the incoming goods diverted to the platform. A third in-house vehicle used for housekeeping rounds could also be deployed for additional work. Theses vehicles are all diesel-fuelled which would make conversion to cleaner auto-gas more expensive than would be the case with spark ignition engines. A synopsis of the operational scenario for the platform can be seen below in Table 6.7. below.

Opening hours	Monday to Friday
No. of suppliers & carriers using the platform	20 – 70 per day
Storage capacity required	200 m2
Stocking facilities	Stacking, sorting bins, lift-gates, dollies, roll cages
Controls & IT systems	Signing delivery notes, IT software and inventory management systems, security cameras
No. of collections per day from platform for onward internal distribution	2 during the off-peak late morning and early afternoon periods
No. of units delivered per round	50 parcels/boxes
Manning levels – drivers, operatives	8 existing + 2 additional, the drivers to be given the additional task of distributing consignments from the platform
Vehicle requirements	The existing in-house vans (3 available) would be deployed

Table 6.7 Proposed Operational Scenario for TCD Platform

The proposed arrangements are based on operating platforms that are supported by the municipalities of La Rochelle and Genoa and by DHL in Dublin. On this basis it would be reasonable to propose two additional staff, a supervisor/dispatcher and a stacker/loader

It is interesting to note that the La Rochelle Platform case study referred to in Chapter 5, describes the use of 4 Citroen Berlingo EVs (< 3.5t gvw) to deliver up to 600 parcels per day within the city walls (ELCIDIS, 2002). Because of the smaller volumes of deliveries involved at TCD, it is assumed that the one of the three existing in-house vans would be sufficient for each delivery round.

It was found from the survey data that up to 100 deliveries to college can occur on the busiest days – Mondays and Thursdays. Assuming that these particular parcels and boxes were dispatched for internal distribution on the subsequent Tuesdays and Fridays, then two rounds would be required, each with an average loading of 50 items per round.

Assuming an average dwell time of 23 minutes and typically 9 different drop points per round (Hamilton, Parsons, Smurfit, Dental Hospital, Shops, Arts, Library, Building Services, Museum), then each round would take 3hrs and 27 minutes to complete. Because drops would now be made by college personnel rather than by strangers unfamiliar with the geography of the campus, it is assumed that the dwell time could be substantially reduced to say 12 - 14 minutes. This is in line with the average dwell time for deliveries to premises in the city centre as reported in our survey of businesses.

On this basis each round would be concluded in 1 hr and 45 minutes during the busy periods and within 1 hrs at the less busy times. Extensions to the current rostering hours for the college drivers might possibly be accommodated by the existing staff compliment of 8 operatives and drivers, but this would need to be considered and agreed by the parties concerned. As vehicles presenting at the Lincoln Place Gate or the proposed new goods entrance at Westland Row will be interrogated and logged by college security.

An examination of the survey data shows that there are 10 companies that are exceptionally active in making multiple deliveries of laboratory and other supplies to college departments. This presents an opportunity for persuading these particular suppliers to consolidate their deliveries externally in order to help minimise the need for trips to the city centre. It has been seen from the previous table that laboratory supplies account for 72 trips or 19.7% of the total and that office supplies accounts for 61 trips or 16.7% of the total of 365 deliveries to college during the survey week.

As part of a drive by Purchasing Department to effect savings through bulk buying, it might be possible to persuade the top ten suppliers to consolidate their deliveries more efficiently. This has the potential of reducing the number of trips to the city centre from their depots on the periphery from 76 per week to 10 or less, assuming that only one delivery per week per supplier is encouraged. This would give a saving of 66 trips per week. (The most active suppliers are Fannins, Tipperary, AGB, Lennox, BOC, Coca Cola, Bewleys, Dunwoody & Dobs, Radionics, MPS)

There are a total of 69 deliveries per week by couriers amounting to 18.9% of the total deliveries to college. There is the possibility of persuading the top four most active couriers (DHL, SDS, Securispeed, UPS) to mitigate their need for multiple deliveries and to agree to reduce their need to access the college to once a day. The top four couriers between them currently access the campus 36 times per week making an average of 9 deliveries each. By restricting the access of each of the top four carriers to once per day (20 trips in all) there is a potential for saving up to 16 trips per week to the college precincts and within the campus. The bigger couriers might be persuaded to rationalise their activities to facilitate a major client.

6.5.2 Benefits of the Platform

Table 6.8. below outlines the potential savings in trips to the precincts of TCD by the college suppliers in terms of fewer deliveries.

Savings due to bulk purchasing and external consolidation by 10 major suppliers	66 trips per week
Savings due to the rationalisation of multiple deliveries by the 4 major couriers	16 trips per week
Total trips saved to precincts of TCD from outlying zones	82 trips per week

Table 6.8 Possible Mitigation of Trips to City Centre by Top Suppliers and Couriers

6.5.3 Costs of the Platform

While the platform is likely to produce benefits in the form of a reduced number of trips, there are additional operational costs involved in the establishment of the initiative. Likely costs are given in Table 6.9.

Acquisition of the Platform & off street loading bay	Upgrade of the existing stores & new entrance and loading bay is part of the ongoing building programme
New equipment for the platform - bins, stacking, trolleys, IT systems	€ 1,000
Additional supervisor and stacker	€40,000 per year
Acquisition of a clean LPG vehicle – assume 2nd hand purchase from Northern Ireland.	€ 1,500

Table 6.9 Additional Costs of TCD Platform

The possibility of acquiring a 2nd hand LPG vehicle from Northern Ireland when a fleet replacement vehicle is due could be considered. All TCD vehicles tend to be 2nd hand because the very low mileage incurred. The additional cost may amount to €1,500 compared with conventional LGV (Irish LPG gas Association, 2004). The auto-gas fuelling tank would be provided at their own expense by either Calor or Flogas, in order to encourage the market.

6.5.4 Implementation of the Platform

The project could be implemented on a phased basis starting with the monitoring and tagging of three categories of deliveries, laboratory supplies, office supplies and electrical goods. The biggest challenge will be to convince the individual purchasing departments and research teams to respect the regime proposed for urgent deliveries as this will require the individuals concerned to alert their suppliers to the procedures in force. The platform could be established in late 2005 as part of the campus re-development planned for the northeast corner. The project could be operational by the end of 2006 with the platform fully equipped and the new logistics controls and bulk-purchasing regime in place to cover all categories of goods with the exception of certain catering supplies. Efficiency targets and performance indicators would be set in order to measure:

1. The impacts for traffic congestion on campus of optimising the opportunities for internal consolidation of diverted goods at the platform to cover > 60% of all deliveries
2. The levels of external consolidation achieved by the major suppliers on behalf of TCD
3. The impacts of restricting access by the main mail & parcels couriers to once a day
4. The benefits of reducing the average dwell time on campus from 23 to 13 minutes

6.5.5 Environmental and Social Benefits

As described above, the proposed interception platform on the periphery of the college would reduce the access to the campus by 67% or by 244 commercial vehicles per week. This is equivalent to a reduction of 100 "van hours" per week. Assuming an average speed whilst transiting the campus and searching for the correct address of 5 km/hr, the total kilometres saved per week by the "avoided" vans would amount to 500vkm (vehicle kilometres).

The "UNITE" methodology described in Chapter 4 is used to estimate the possible economic value of the environmental benefits of removing significant numbers of commercial vehicles from the campus. Generalising on two relevant case histories reported by "UNITE" (the Berlin and the Strasburg-Neubrandenburg evaluation), the estimated economic value of the reduced emissions and noise accruing from the avoided 500 vehicle kilometres per week can be seen below in Table 6.10.

UNITE Location reference	**Exhaust emissions €cent/week**	**Greenhouse gases €cent/week**	**Noise Day time €cent/week**	**Total savings to TCD €cent/week**
Berlin	5,095	1,645	3,825	10,565
Strasburg-Neubrandenburg	3,730	1,640	1,520	6,890

Table 6.10 Environmental Savings Accruing from proposed TCD Platform

It can be seen from the above that the environmental and noise abatement benefits accruing form the proposed platform at TCD would range from € 69 to € 106 per

week .On an annual basis the savings range from € 3,588 to € 5,512. Added to this would be the fuel savings for the mileage avoided on campus by the external carriers. The mileage avoided would amount to 26,000 km per annum (500 km per week X 52 weeks). Assuming a fuel consumption of 10 mpg or 16.093km per gallon = 16.093 km per 4.546 Litre = 3.54 km per Litre @ € 1 per Litre , then 26,000 km/yr would save €7,345per annum for the carriers.

Based on the above assumptions, the environmental and fuel savings combined would amount to €12,857 per annum. While the emission and noise abatement benefits alone would not offset the cost to the authorities of operating the platform, the college would enjoy other less quantifiable benefits arising from reduced congestion and nuisance, more security and less collision damage by vehicles to the fabric of the historic buildings. The carriers and suppliers would benefit from the fuel savings of avoided travel within the campus and they would also avail of the mitigation of delivery trips from their outlying depots to the city centre brought about by the reductions in multiple deliveries and by more efficient off-site consolidation which bulk purchasing would encourage. The overall benefits are summarised below in Table 6.11.

Reduction in the numbers of supply vehicles accessing the campus due to interception by the platform	244 per week or 67% of the current total
Reduction in need for suppliers to access the precincts of TCD due to external consolidation & bulk purchasing	66 accesses to college per week
Reductions in multi - trips within the campus by top 4 couriers due to rationalisation	16 trips per week
Reductions in trips to the city centre precincts of TCD by the main couriers	16 trips per week
Reduction in dwell time on campus due to more efficient distribution by in-house staff & less occupation of road spaces by external vehicles	23 minutes reduced to 13 minutes (a saving of 10 minutes is targeted)
Total time saved in the occupation of spaces on campus (total dwell time) by removing non-essential delivery vehicles i.e. non-urgent supplies & better consolidation by the top couriers	(244+16) X 23 = 5980 minutes = 99hrs.40 minutes per week , equivalent to 100 "van hours" per week. (To offset this, some time will be spent at the externally located platform by the carriers when making deliveries)
Improved controls, security of access & safety on campus	IT monitoring & logistics software
Reduction in emissions	€ 5,512 per annum
Fuel savings	€ 7,354 per annum
Better control of hazardous materials	
Improved customer service resulting form controls by the platform	More reliable deliveries by in-house staff and the availability of buffer stocks of essential supplies

Table 6.11 Summary of Benefits of the Platform

In conclusion, the additional costs for operating the platform would be about € 40,000. (The capital costs would be absorbed in any event as part of the planned expenditure for the transfer of the existing stores to a new location fronting on Pearse St., which would now double up as a platform). The setting up costs could be incorporated in the general upgrade for the stores and goods entrance that is proposed for the college building programme. These costs would be off -set by substantially less congestion on campus, by better control of access by third parties and by the mitigation of commercial traffic on the main access routes to TCD. The main logistical efficiencies described such as better vehicle deployment and fuel savings would accrue to the logistics service providers. While the environmental benefits in terms of reduced emissions and noise would not be substantial (from €3,600 to €5,500 per annum) there would be other less quantifiable but perhaps more important social and security advantages.

6.6 THE DEPARTMENT OF EDUCATION AND SCIENCE

The volumes and configuration of deliveries to the Department of Education & Science complex at Marlborough Street, Dublin 1, are such as to merit an examination of the case for a platform solution. The authorities there would like to mitigate congestion and nuisance and to control access to the campus.

The Department is located in a busy city centre complex that includes offices for 550 civil servants, a model school and crèches. Day to day business is conducted with 4,000 primary schools and with the main regional office based in Athlone. This gives rise to multiple deliveries of documentation and printed materials.

Like TCD, delivery vehicles have free access to the campus and this causes considerable nuisance. Storage space is very limited. The campus was recently refurbished as a public park by the Office of Public Works and the authorities would now like to see commercial deliveries and collections managed in a more sustainable way. Parking is very restricted in the streets adjoining the campus although there is a small loading bay on Talbot St. A platform facility would intercept non-urgent deliveries, provide badly needed additional storage space, and help to minimise multiple deliveries from the main suppliers. The platform in conjunction with a bigger loading bay could form a part of the proposed developments for the site and provide more secure off-street parking and controls.

During the week beginning Monday the 24th March 2003, the Department kindly arranged for their security staff to monitor all deliveries to the campus. Deliveries were logged by day of week; by time of day; by dwell time; by types of goods; by type and quantities of packages; by vehicle type; by origin of the supplier; and by the delivery points within the complex.

In order to determine the potential for diverting traffic to the proposed platform and for mitigating access, the following analysis of the data was carried out as described below in Table 6.12.

Types of Goods	Mon	Tues	Wed	Thurs	Friday
Catering	1	2	6	4	4
Stationary/books	3	5	1	3	
Courier – letters & parcels	9	5	14	12	7
Furniture	1				
Other		3			
Total	14	15	21	19	11

Table 6.12 Breakdown of Types of Goods by Day of Week for Dept. of Education

A total of 80 deliveries were received by the Department during the survey week. Most of these, 47 (59%) were courier deliveries of letters and documents; 16 (20%) were supplies of food and beverages and 12 (15%) comprised stationary and books. Wednesday was the busiest day and deliveries were most frequent between 11.00 and 15.00 hrs.

Vans, trucks and cars accounted for 46 of all deliveries and the remaining 34 was by cycling, motorbike or walking couriers. Of the 47 deliveries of letters by the courier services (DHL, SDS, Pony Express, Interlink), only 12 arrived by van, the rest by bicycle or on foot.

6.6.1 Benefits of a Potential Platform for Receiving Deliveries in the Department of Education

If all deliveries with the exception of those from the courier services were regarded as non-urgent and directed to the platform, then 34 commercial vehicles a week could be removed from accessing the campus. The average dwell time was approximately 8 minutes, the longest dwell times being caused by the deliveries of catering supplies, office supplies and furniture. The non-motorised walking and cycling couriers completed their deliveries in a little over one minute.

On the assumption that 34 commercial vehicles a week carrying non-urgent deliveries could be diverted to the platform, a total of 4 hours 32 minutes of occupation time by commercial vehicles of the restricted space on the campus could be freed up. This mitigation in traffic would also benefit the general public who enjoy access to the campus.

As with the proposed platform at TCD, additional storage and secure loading space at the Marlborough St. platform would facilitate bulk purchasing by the Department and cut down on the need for multiple deliveries by their main suppliers to the city centre.

While the potential benefits to the Department of Education arising from a platform are on a smaller scale than those accruing to TCD, security and environmental factors may justify a similar solution. The number of commercial vehicles accessing the campus could be reduced by almost half and the availability of additional on-site storage at the platform could help to minimise the need for multiple trips by suppliers. The existing security and messenger personnel could be deployed to operate the platform and for the internal distribution of the non-urgent deliveries during the off-peak.

6.7 SDS/AN POST

SDS operates the Naas Rd. as a hub and spoke for servicing the regions, Dublin city and Dublin port. A secondary facility is located at Kilbarrack to service the North side.

The consolidation process takes place in an upgraded €40 million mechanical sorting facility of 50,000 square feet. The origin of parcels is 70% from the city and 30% from the country. Deliveries from the hub are also 30% to the city and 70% to the country.

Volumes of up to 40,000 units per day are handled. The origin and destinations of consignments are determined by bar codes at the sorting phase. Consignments are tracked by GPS and mobile communications – this service is available to customers on the SDS web site. While most consignments comprise parcels and documentation, stationary, books, medicines and miscellaneous retail goods are also handled.

Roster planning begins at 6.00 am. All network vehicles are radio controlled and tracked by satellite. The SDS fleet comprises 150 vehicles of which 40 are HGVs and 80 are long-wheel based high roofed Ford Transits. The LGVs and car-vans service the city centre.

Table 6.13 below profiles delivery operations on a typical day in October 2003.

No. of round trips per day from depot	100
No. of vehicles deployed	80 LGVs & car-vans
Delivery window	8 hrs per day, 8am - 6 pm
No. of drops per LGV and per trip	70 per day
Average duration of round trips	3 hrs
No. of round trips per vehicle & driver	2
Distance travelled per vehicle per day	50 – 60 miles to city centre & return
No. of parcels delivered per round	100 packages
Ave. no. of units delivered per drop	1.27 parcels
Dwell time per stop	4 – 6 minutes
Ave. parcel weight	5 kg.

Table 6.13 Profile of Parcels Deliveries on a Typical Day

From the data provided by SDS, deliveries to the city for a typical day was profiled in terms of the numbers of round trips made; numbers of drops made; average dwell times; average number of packages delivered per drop and per round trip; types of premises served; distances travelled. The main types of businesses served are offices, miscellaneous retail stores, newsagents and hotels. Table 6.13 above profiles delivery operations on a typical day in October 2003. (SDS ceased to exist as a separate entity in early 2004 but some of the services are continued by An Post).

6.7.1 Benefits of a Potential SDS/An Post City Centre Platform

The data available on the SDS operations would suggest that the concept of the downtown fixed platform could be replicated by the company in high-density city

centre business districts. If it was found possible to follow along the lines of the DHL platform model and assuming that 2,000 units (parcels rather than mail) could be delivered by walking or cycling couriers or by small electric carts rather than by van, this could have the effect of removing 24 LGVs and car-vans from the city centre during business hours.

In terms of eco-friendly solutions it was also established that the particular SDS configuration and rosters for parcels deliveries to and from the city centre would suit the technical capabilities of the small Citroen Berlingo Electric car-vans. These have been deployed in significant numbers by the postal services in La Rochelle, Milan and in Sweden. As will seen in Chapter 7, this particular EV option is now longer commercially possible because the Peugeot Citroen Group has ceased production of the Berlingo after a run of 14,000 units and the withdrawal of supports by governments and municipalties.

6.8 CONCLUSIONS & RECOMMENDATIONS

6.8.1 Conclusions

1. The concept of the platform or local mini-UDC for managing the "final mile" deliveries in densely populated cities has been successfully demonstrated on the continent. In the cities of La Rochelle, Genoa, Evora and Rotterdam the authorities have worked in partnership with the commercial logistics service providers to develop innovative and sustainable solutions. The relevant case histories reported.
2. A platform of this type currently operates profitably in Dublin. In the main business district of the south inner city centre, DHL has established a down town platform whereby 1,000 deliveries per day are made by walking couriers. This takes 12 LGVs out of the congested city centre during the working day. The company is satisfied that the introduction of an additional step into the supply chain and the costs of employing a team of 20 couriers and platform operatives are justified by the overall logistical savings achieved and by the enhanced customer service enjoyed by 800 business clients.
3. Courier companies such as SDS and Fastrack consolidate their loads externally before distribution to the city centre. This is done by SDS at their UDC on the Naas Road. Fastrack can be described as an example of a sustainable inter modal courier service that involves the transfer of parcels from rail to road for final delivery by light vans and couriers to city centre premises. Consignments arriving from the regions are consolidated at the depot located at Hueston station.
4. The "Irish Times" has developed an innovative logistical exercise whereby the final deliveries of newspapers to lock-ups located at newsagents are made by vans operating from four consolidation hubs which service different parts of the city. These hubs are in turn serviced by large HGVs combinations that deliver newsprint from the main printing works. This solution avoids the need for the newsprint HGVs to access the city in the early morning.
5. It is estimated that the platform solution proposed and developed for the TCD campus would achieve substantial reductions in traffic congestion, both on campus and in the city centre precincts. Access by delivery vehicles to the campus could be reduced by up to 67% or by 244 vehicles per week, by diverting all non-urgent deliveries to the platform.

6. The potential exists for the four more regular couriers to reduce multiple daily trips to the college. It is estimated that this would save 16 vehicle trips per week to the college
7. Current plans by the college authorities to effect cost savings through bulk buying and by encouraging the main suppliers to consolidate more efficiently in advance at their supply depots, could reduce deliveries to the college and its precincts by a further 66 trips per week.
8. By combining these possibilities, the total time saved in the occupation of the limited road spaces on campus by non-essential commercial vehicles could be reduced by the equivalent of 100 "van hours" or by 4.2 "van days" per week.
9. The estimated reductions in congestion would substantially reduce the nuisance caused by the "free for all" access to the campus that assorted delivery vehicles currently enjoy. The benefits to the quality of the college environment of a saving of 4.2 "van days" days per week were quantified in terms of less noise and emissions.
10. The proposed platform operations might be fitted into the current in-house arrangements for distributing mail and supplies internally without recourse to additional drivers.
11. A total of 82 trips to the city centre could be avoided by persuading the main suppliers and couriers to rationalise and to consolidate their deliveries externally beforehand at their depots (66) and to minimise the need for multiple deliveries (16).
12. The internal distribution of non-urgent deliveries from the platform by experienced in-house staff would make it possible to reduce the currently long dwell times for deliveries on campus (23 minutes). It was observed that much of this inordinately long dwell time is caused by courier van drivers looking for directions may not be optimal.
13. The additional costs of the TCD platform would be about € 40,000 assuming the hiring of two extra new staff - a controller/IT person and a stacker.
14. The extra costs would be offset by the fuel savings, lower emissions, security, and other sustainable benefits accruing. These benefits would reward both the college and the main carriers and would mitigate traffic not only within the campus, but also on the congested streets in the vicinity of TCD.
15. The environmental benefits in terms of reduced emissions and noise would not be substantial (€3,600 - €5,500 per annum) but other benefits such as greater security and control and less danger to pedestrians and buildings would be significant. Significant fuel savings would accrue to the main suppliers currently servicing TCD. The proposed platform solution therefore has merits as a justifiable part of the colleges re-development plans for the northeast corner currently under consideration.
16. The potential for replicating the platform solution at the Dept of Education and Science complex in Marlborough St. also merits consideration.
17. The platform concept has the potential to be replicated in other parts of the city by other courier companies (SDS/An Post as proposed) where the density of customers is high, e.g.– government office complexes, hospitals and colleges and institutions.
18. As an alternative to a manned platform, DHL may wish to evaluate the possibility of introducing the "Pack Station" concept in other parts of the city. This would comprise an unmanned but secure platforms having shared access by groups of signed up customers. The pack station would accommodate both mail and parcels

and be replenished at night or during the off-peak. Experience in Germany would indicate that the availability of advanced ICT alerting and tracking systems and logistics software facilitates the low cost operation of down town platforms, whether manned or unmanned.

6.8.2 Recommendations

1. The possibility for establishing platforms at TCD and at the government offices at Marlborough St. is promising and should be progressed.
2. The potential for replicating a platform type solution merits consideration by other logistics service providers other than the companies who have collaborated with the project.
3. Possible special incentives by Dublin City Council such as privileged access and special permitting for the vehicles servicing the platforms; and free and managed loading spaces merit examination
4. Dublin City Council may wish to consider evaluating the relevance the public private partnership models that have worked in other cities whereby the commercial logistics service providers are invited by the authorities to develop sustainable city freight solutions.
5. The feasibility of demonstrating an unmanned “pack station” solution for final mile deliveries merits consideration for certain niche applications in areas such as high-rise buildings that are occupied by multiple customers.

7 THE ADOPTION OF ECO-FRIENDLY TECHNOLOGIES FOR DELIVERIES TO THE CITY CENTRE

7.1 INTRODUCTION

This chapter looks at two ideas: firstly, the potential for night time deliveries taking on board noise restrictions and the strategies required to deal with those restrictions and secondly the use of eco-friendly vehicles to reduce both fuel consumption and air pollution. The chapter is presented as follows: a review of the current state-of-the-art of silent technologies, followed by another review in terms of eco-friendly vehicles and concluding with proposals for how both strategies could be used in Dublin to improve management of urban freight in the city.

In recent years, night deliveries are seen by traffic engineers and by the logistics service providers as a way of achieving peak separation by taking commercial traffic out of peak commuting times and as a way of achieving efficiencies in the deployment of drivers and vehicles.

The implications of night deliveries concern many players – the local authorities, national governments, the EU Commission, businesses, carriers and the local communities. These concerns and the need to achieve consensus between the different interest groups were highlighted at the recent workshops held in a number of cities under the auspices of city freight thematic network, BESTUFS during 2003 (BESTUFS, 2003).

The European Commission through its directives on noise (CEC Directive 2002/49/EC) and air quality (CEC, Directive 96/62, 1996) is driving the national and municipal authorities to develop and encourage more sustainable solutions for managing traffic.

In relation to night deliveries and noise nuisance, developments in low noise technologies in a number of countries were examined and it was concluded that the results of the Dutch "PEAK" programme are of particular relevance. This is because the focus was on modifying conventional diesel vehicles and ancillaries rather than resorting to alternative fuels and systems (PEAK, 2002).

The noise standards initially set by the Dutch government for night deliveries were found to be very stringent and would be difficult to achieve, at the present state of technical development, at an acceptable economic cost to businesses. The information and advice provided by the Dutch authorities has enabled us to put forward a possible approach for promoting night deliveries in Dublin in a way that would minimise noise nuisance in accordance with EU and evolving national policies.

In relation to air quality, the state of development and the availability of low emission alternative fuels such as natural gas, liquid petroleum gas and electricity are also examined. Clean transport can benefit the environment during the busy daytime, particularly in pollution hot spots. As a part of their air quality management plans, the municipal authorities may in the future be required to restrict conventional diesel vehicles in congested city centre areas and for this reason the use of clean fuels merits consideration (EPA, 2004).

7.2 BACKGROUND

In the first instance, developments in the areas of low noise night deliveries are reviewed with the aim of finding possible solutions for managing deliveries in Dublin city centre in a more sustainable manner. Secondly, the vehicles and fuel options that could help to improve air quality in the congested pollution hot spots are assessed.

7.2.1 Noise and Night Deliveries in other European Cites

Night deliveries are becoming a growing feature of city freight logistics in many continental cities (BESTUFS, 2003c). This is driven by a number of factors:

- The desire by the authorities to promote peak separation by taking commercial traffic out of the commuting peaks and to minimise the need for trips to the city centre during the day
- The desire of the logistics service providers to optimise their operations by deploying their vehicles and drivers more efficiently by avoiding congestion bottlenecks
- The trends in retailing towards longer opening hours which increase the capability of stores to accept early morning and late evening deliveries
- The desire of businesses to free up customer access to their premises during the day time and to discourage the disruption caused by deliveries
- The development of "silent" technologies and practices (vehicles, ancillaries and logistics locations) that can make night deliveries more acceptable for urban residents and for the municipal authorities.

Experience shows that significant benefits can be gained by shifting transport demand to the night. Simulation models developed by a consortium led by IVECO indicates that moves to night deliveries gives significant benefits to traffic management in terms of (Distribution Forum, 2001):

1. Better use of infrastructure
2. Better peak separation leading to reduction in traffic volumes
3. Improved quality of logistics services in terms of customer service, reliability & efficiency
4. Increase in vehicle speeds
5. Reduced fuel consumption
6. Reduced emissions
7. More efficient deployment of vehicles & drivers

On the other hand, additional and unexpected costs and difficulties were found to arise in relation to:

1. Noise nuisance
2. Changes and restrictions to working conditions for drivers
3. Extra staffing costs for goods receivers
4. The poor availability and the additional costs for acquiring low noise vehicles
5. The limited availability and costs of low noise ancillaries – roll cages, non-slam doors, tail-lifts, sites, modified pavement materials etc. traffic safety and insurance considerations

Today the municipal authorities are faced with a growing intensity of commercial traffic and with having to cope with the unexpected new rhythms and patterns affecting deliveries and collections, that are driven by factors such as internet shopping and the e-society. There is an increasing tendency by suppliers to spread deliveries and pick-ups over the whole day and at weekends (BESTUFS, 2003c).

In response to the resulting increased congestion and nuisance created, city authorities are experimenting with new regulatory and permitting arrangements to manage the situation in a better way (BESTUFS, 2001).

As discussed earlier, our analysis of the survey data from 160 city centre premises identified niche applications whereby city freight might be managed in a more sustainable manner by moving to night deliveries. The larger supermarket and department stories and the smaller grocery and convenience stores in the major Musgrave Super Valu Centra (MSVC) franchise chain can accept night or early morning deliveries. It is the policy of MSVC to have the distribution to their city centre stores completed before the morning peak.

Through TCD's participation in the BESTUFS EU city freight thematic network, case studies were identified which are relevant for Dublin. Following an examination of the reported experiences of cities located in France, Italy, Hungary and the Netherlands, it was felt that an appropriate model to follow is that developed by the Dutch authorities under the "PEAK" programme. This is because the Dutch have resorted to modifying conventional diesel HGVs and LGVs to achieve low noise emissions rather than to pursuing alternative fuels which would require new and expensive re-fuelling infrastructure (BESTUFS, 2003b). The relative merits of a number of alternative fuels are assessed and compared in a later part of this chapter.

Based on the Dutch model, we have tried to match a conservative low noise technological solution to a niche application involving the early morning deliveries of both dry and chilled groceries from depots on the periphery of the city, to city centre stores.

7.2.2 Night Deliveries in Dublin

Our analysis of the survey data shows that a significant proportion of goods deliveries to city centre stores originate in the early morning mainly from zones outside the canal cordon. According to Dublin City Council and to the main distributors interviewed, the noisy nature of this activity, particularly when refrigerated goods are carried, gives rise to complaints by city centre residents. Contact was therefore made with the main Irish distributor to franchised grocery and convenience stores, namely the Musgrave Group (MSVC) to explore the possibility of developing more sustainable solutions based on the Dutch "PEAK" model.

Newspaper deliveries and refuse collections has also emerged as significant early morning activities on city streets that could also potentially benefit from a more "silent" approach. Low noise CNG trucks have been demonstrated for these niche applications in the London Borough of Merton (Cleansing Department) and in the Dutch newspaper industry (London Borough of Merton, 2002).

7.2.3 The Legal Situation - EU Noise Policy

The EU Commission's policy on noise is driving the national authorities to take action to ameliorate the traffic nuisance in urban areas. As a part of its policy to "integrate sustainable development into transport policies", DG-TREN has developed an important initiative and line of action – namely the European Directive on the Assessment and Management of Environmental Noise published in June of 2002 (CEC, 2002).

According to research carried out by the EC, exposure to excessive noise caused by traffic, confronts the majority of its citizens. For example during the day 40% of the population are exposed to road traffic noise exceeding 55dB and 20% are exposed to noise levels exceeding 65dB. At night 30% are exposed to noise levels exceeding 55dB.

The Directive on the Assessment and Management of Noise provides a common basis for tackling the noise problem across the EU. The aims of the Directive are to:

1. Define a common approach to combat the harmful effects of exposure
2. Harmonise common noise indicators and common methods to measure annoyance
3. Develop strategic noise maps
4. Prepare action plans and integrate these into strategic planning policies
5. Communicate with the public

The Directive requires that all cities with more than 250,000 inhabitants create strategic noise maps and action plans by mid-year 2007. National governments will be required to set limits for both daytime and night time deliveries and collections in the relevant urban areas. These standards are to be set by national authorities, in accordance with the principal of "subsidiarity". The levels of noise nuisance that are likely to be acceptable to residents are indicated by the research conducted by the EU and by certain member states, notably Italy, the Netherlands, and France.

The challenge for the authorities is to set noise limits that can be achieved without too much disruption to the economic life of the city. It will be important to ensure that the appropriate noise abatement techniques can be adopted at a reasonable cost. As discussed earlier, we have identified the approach by the Dutch authorities as a possible model to follow where the suppliers of vehicles and of ancillary equipment were invited to demonstrate what might be technically and economically feasible (PEAK, 1995).

Although Ireland has not so far designated all of the urban areas, motorways and railways that might be affected by the EU Directive, Dublin City Council (DCC) has prepared noise maps for the city centre. The DCC strategic noise-mapping project will form the basis for implementing the EC Noise Directive (DCC, 2002).

Compliance with the new noise guidelines and the mitigation measures to be set by the authorities in the spirit of the EU directive will involve additional costs - the acquisition of "low noise technologies" by the carriers, possible extra working time

by retail staff, and the ongoing expense of monitoring and of policing the standards agreed.

7.2.4 Response to the EU Noise Directive by DCC

In compliance with the EC directive, DCC started in April 1999 to prepare a strategic noise map of the inner city area between the North and South Circular Roads. This activity feeds into the DG-TREN "CALM" thematic network and database that monitors the progress of noise research at national and EU levels (CALM Network, 1999).

In its assessment of noise, DCC used a proprietary noise model called "Predictor". Using this methodology and suitable software, the DCC has developed noise maps which are linked to land use, population, and to traffic data (Noise Mapping Project – Interim Report, DCC, 2002). DCC collected and modelled noise data within the canal cordons and the related DCC databases for land use, population and traffic flow densities were taken into consideration.

The investigations show that fewer than 7% of the resident population in the mapped region is exposed to noise levels above a generally acceptable level of 68dB(A) during the day. The noise map also shows that 19% of the residents are exposed to average nighttime sound levels above a level of 55dB(A).

7.3 NATIONAL PROGRAMMES THAT PROMOTE SILENT AND CLEAN TECHNOLOGIES

In reviewing developments in the field of silent technologies, the following are examples of the current state-of-the-art (BESTUFS, 2003d).

7.3.1 The Netherlands

The sustainable physical distribution of goods and services in urban areas in the Netherlands where 89% of the inhabitants live, features high on the Dutch political and economic agenda. In urban areas, it is estimated that commercial distribution accounts for 6 – 10% of all traffic movements.

In order to promote a public private partnership in sustainable logistics, the Dutch Forum for Physical Distribution in Urban Areas (PSD) was established in 1995. The forum has evaluated the possible access regulations and permitting measures which help to promote sustainable solutions (PSD, 1995 – 2004). The PSD forum serves as a networking organisation for all the parties involved in the supply chain and it has helped to place city freight distribution high on the public policy agenda. The forum facilitates the exchange of information on developments in 290 different municipalities. The forum encourages a uniform approach for establishing a vehicle entry regime in the Dutch municipalities for vans and trucks of 3.5 tonnes and upwards. The regulatory regimes are of sufficient duration (5 to 7 years) to encourage the development and implementation of innovative solutions.

7.3.1.1 The Dutch "PEAK" Programme

In the Netherlands, an Environmental Retail Trade & Traditional Crafts Decree, promulgated in 1998, brought the question of alleviating peak noise during loading and unloading into the spotlight. This order affects 65,000 Dutch companies and covers distribution activities in urban and residential areas.

To overcome the difficulty of complying with the stringent noise level standards proposed for governing loading and unloading, the authorities responded by setting up the PEAK programme - "Places – People – Products – Solutions for night distribution". The programme aims to encourage the market to adjust to the noise decree and to examine the quality of life and the economic and technical feasibility issues involved (PEAK, 1995).

The PEAK programme has developed a range of technical modifications that are necessary for delivery vehicles and related ancillary equipment to achieve an acceptable level of acoustic nuisance. The programme is led by the Ministry of Housing, Spatial Planning & Environment and conducted by the Dutch research institute, NOVEM (De Gooijer, 2003). The targeted noise levels in respect of the retail trade was set at 65dB(A) for the evening and at 60dB(A) for the night time and the early morning hours as can be seen below in Table 7.1.

Period	**Peak noise level**
07.00 – 19.00 hrs	No level applies
19.00 – 23.00 hrs	Peak level of 65 dB(A)
23.00 – 07.00 hrs	Peak level of 60 dB(A)

Table 7.1Dutch Legislation for Noise Levels During Evening & Night in Urban Areas (PEAK, 2002)

The programme comprises projects which focus on the:

1. Transfer of knowledge
2. Promoting quiet behaviour
3. Assessing loading and unloading locations, pavements, architecture
4. Developing "silent" vehicles of < 7.5 tons gvw
5. Modified low noise vehicles of > 7.5 tons gvw
6. Quiet refrigerated units
7. Portable forklifts
8. Silent roll containers & pallet trucks
9. Shopping trolleys
10. Electric accessories – reversing beep etc.

The solutions demonstrated by the PEAK programme were evaluated in terms of their technical and economic feasibility. For vehicles > 7.5 tonnes gvw, a HGV diesel tractor unit was modified by DAF to try to comply with the low noise standards set by the authorities. The body and exhaust systems of smaller LGVs > 7.5 tonnes were also modified.

Modified low noise on-board ancillaries comprised non-slam doors; silent reverse and signalling. Refrigeration units were also designed to comply with the required acoustic standards. External ancillaries such as roll cages and trolleys that cause high noise levels (>65dB(A)) were also modified. Electric hand operated carts were found to be suitable for the final-link distribution on pavements and laneways. It was also necessary to ensure that the pavement designs, materials and the general architecture at the unloading sites facilitated low noise activities.

Measurement methods for peak noise during loading and unloading were designed by the technical consultancy, TNO. The effects of various noise reduction measures were quantified and comparisons made between different products (TNO, 2002). Noise measurement protocols were developed for the all the activities that occur during loading and unloading – these activities are described later.

The low noise vehicles, ancillaries and systems developed in the Netherlands are deemed to be relevant for the night delivery scenarios which we have put forward - the deliveries of both dry and chilled goods to grocery stores. The proposed showcase demonstration would involve technology transfer from the PEAK programme.

7.3.2 France

Research conducted by GART, a consortium of French municipal authorities concerned with traffic management, has found that (Dablanc L.,2003)

1. There is room for greater peak separation between the patterns for people movement and for goods movement
2. Delivery and pick up rhythms vary according to the field of activity and types of businesses being served
3. The frequency of deliveries is increasing
4. In French cities, night deliveries are not very common place
5. Receivers of goods are generally not available before 10:00 am and many shops close between 12:00 and 14:00 hrs.
6. Time management is a cause for conflict between customers and carriers
7. The typical 15 minutes maximum dwell time on the street can be a major congestion problem particularly if the designated loading bays are blocked.
8. The EU working hour directives restricts driver flexibility and to work at night carriers require two or more drivers to share the same vehicle.

Despite these constraints, some French municipalities see night time deliveries as a worthwhile and viable solution for easing congestion and are strongly encouraged by the authorities in Dijon, Orleans, Marseilles and Paris. On the other hand, cities like Lille and Rennes reject night deliveries because of the noise nuisance and the anticipated complaints by residents. It is recognised by the French authorities that high noise levels are often caused by factors independent of the vehicle operations – goods handling, the opening and closing of doors, pavement noise.

The GART view tends to favour the establishment of city centre relay centres or shared drop points that can be quickly replenished at night and having local distribution organised during the day. The extension of the time limits for morning

deliveries and the incremental development of low noise technologies and systems are seen by GART as realistic near term solutions.

7.4 EMISSIONS TO AIR - THE PRESSURES FROM TRANSPORT

According to the Environmental Protection Agency, pollution from rapidly increasing road traffic is now the primary threat to the quality of air in our towns and cities (EPA, 2004). The current rates of car ownership and the volume of road traffic have already reached the levels predicted for 2010, contributing to congestion and to major increases in energy usage and greenhouse gas emissions.

The exceptional economic growth of recent years has caused the numbers of cars on Irish roads to increase by 82% between 1990 and 2002 while the numbers of goods vehicles has increased by 63% in the same period. Freight traffic on the roads has also increased in line with economic development. According to the National Roads Authority, total non-urban travel for goods vehicles has increased by 55% from 3,870 million km in 1990 to 6,010 million km in 2001 (NRA/TRL, 2002)

According to Sustainable Energy Ireland (SEI), transport has been the biggest contributor to the large increase in total energy demand since the early 1990's. While the total primary energy requirement increased by 56% between 1990 and 2002, the energy consumption in the transport sector more than doubled during this period. This is due to the unprecedented increases in the sales of petrol and diesel in the period. The share of primary energy consumed by transport grew from 22% of the total in 1990 to reach 30% of the total by 2001 and is now approaching the levels of primary energy required for generating electricity (36%,) and heat (34%) (SEI, 2003).

Motorised traffic is a major cause of air pollution in the form of carbon monoxide (CO), nitrogen oxides (NOX), volatile organic compounds (VOCs) and fine particulate matter fractions (PM10 and PM2.5). These pollutants expose the public to risk in the urban areas that are subject to heavy traffic.

While in the case of petrol vehicles the use of catalytic converters and other advances in petrol cars have successfully reduced CO and VOC emissions the situation with regard to green house gases, mainly CO2, however is not so promising. According to the EPA, the proportion of CO2 emissions from transport in the national total rose from 9.5% in 1990 to 17% in 2002 - equivalent to 11.5 million tonnes of CO2 (EPA, 2004).

Vehicle numbers, energy use by transport and the emissions of nitrogen oxides and green house gases have all increased between 1990 and 2000. According to Sustainable Energy Ireland, on a business as usual basis, emissions from the transport sector are projected to increase by 180% above 1990 levels by 2010 (SEI, 2003). Energy use by transport closely tracks economic growth. Transport energy intensity which is the ratio between consumption (kg of oil equivalent) and GDP (in €) has remained at about 1.05;1.00 for the last decade. (SEI, 2002). The key challenge for policy makers is to try to decouple this relationship and to arrest the growth of green house gas/CO2 emissions (CEC, 2001).

According to the EPA, road traffic remains the most significant threat to air quality in the larger congested urban centres. Concentrations of nitrogen dioxide and fine particles or PM10, which are emitted by diesel engine buses and commercial vehicles, are the pollutants of most concern. High concentrations are observed at the DCC monitoring stations in the parts of central Dublin affected by large volumes of traffic, for example College Street, and Winetavern Street.

The new Irish Air Quality Standards derive from the framework of the EU Council Directive (CEC, Directive 96/62, 1996) and daughter directives. The Air Quality Standards Regulations 2002 has transposed the EU directives into Irish law (DELG, 2002). Standards have been set for SO2, NO2, NO, Pb, PM10, CO and benzene.

The EPA advise local authorities on the measures needed to ensure compliance with the new standards and to develop suitable air quality management plans. These standards will come into force for different pollutants in 2005 and more stringent limits will follow in 2010. The proposed air quality management plans may have to curtail motorised traffic in the congested parts of the city.

According to the EPA, particulate PM10 and NOX emissions that derive from diesel engines will be the most problematic pollutant to alleviate in terms of the stringent limit values embodied in the new air quality standards. The EPA foresees that the necessary air quality management plans will present a major challenge to the municipal authorities because they are likely to involve restricting traffic in the areas deemed to be pollution hot spots. These restrictions may impact significantly on the operations of diesel-fuelled commercial vehicles.

For this reason the feasibility of substituting commercial diesel delivery trucks with cleaner eco-friendly fuels such as LPG, CNG and electric vehicles, which could enjoy privileged access, is examined below.

7.5 A REVIEW OF THE CURRENT STATE OF DEVELOPMENT OF ECO-FRIENDLY FUELS AND SILENT VEHICLES

7.5.1 Types of Eco-Friendly Fuels

There are a number of alternative eco-friendly transport fuels currently available and others still commanding attention in international R&D. According to Sustainable Energy Ireland, formerly the Irish Energy Centre, (Crowley et al, 1996), the alternatives, which have a potential application in Ireland are:

1. Gaseous fuels such as propane or butane in the form of liquefied petroleum gas (LPG)
2. Methane in the form of compressed or liquefied natural gas (CNG and LNG).
3. Bio-fuels derived from indigenous agricultural substrates
4. Electric vehicles and electric hybrid vehicles (dual mode – electric combined with diesel or petrol) are also of interest because of their zero emissions and "silent" mode of operation.

According to an International Energy Agency report on Climate Change (IEA, 1993) , the technical and commercial status of the alternative fuel technologies can be summarised as follows in Table 7.2.

Type	Technical Development	Commercialisation
CNG(conversions of existing vehicles)	Mature	Niche markets
CNG(direct from manufacturer)	Demonstrated	Production lines planned Commercial availability uncertain
Bio-fuels	Demonstrated	Limited production & availability
LPG	Mature	Significant niche markets
Hydrogen	Developmental	Medium- term prospects
Electric Vehicles	Developmental	Limited niche markets, commercial availability uncertain
Electric Hybrid Electrics	Developmental	Niche applications- still at prototype stage

Table 7.2 Status of Alternative Fuel Technologies

7.5.2 Comparing the Fuel Options

7.5.2.1 Compressed Natural Gas (CNG)

To help identify the vehicles and fuel types that could be suitable for low noise and low emission deliveries in Dublin, the conclusions arrived at by two major DG-TREN funded reviews of alternative fuels were examined, namely the "ZEUS" and "UTOPIA" RTD programmes (CEC, 2000; UTOPIA, CEC, 2001).

Compressed natural gas technology is well developed and can be substituted for petrol in spark ignition engines. The range of CNG vehicles is restricted by the weight and the volume penalties associated with the "on-board" storage of the compressed gas in tanks. Distribution to filling stations is by means of low-pressure spur lines from the main gas transmission lines. The gas is then compressed from about 4 bar to 200 bar into on board fuel tanks.

The conversion of a diesel engine to burn CNG is expensive give a value because it involves a change from compression ignition to spark ignition. CNG offers significant environmental benefits in terms of low emissions and noise. There are at present over 380,000 CNG fuelled vehicles in the EU, mostly in Italy, comprising buses, HGVs, refuse trucks and taxies. Because of the significant investment needed in new refuelling infrastructure, CNG is really only suited for use in large depot based fleets where a large throughput can be guaranteed (ZEUS, - Refuelling Infrastructure, CEC, 2000).

In the UK government incentives help to meet the additional costs for converting to CNG. There is currently a fleet of 300 commercial vehicles in the UK that run on

natural gas. Liquefied rather than compressed gas is preferred because the payload and range limitation penalties are less significant (CHIVE, 2004). Applications include early morning deliveries to supermarkets (Marks & Spencer), mail deliveries in East London and refuse collection in the London Borough of Merton (PowerShift/TransportEnergy, 2003).

Following discussions between Bord Gas Eireann and Dublin Bus, and a successful application for EU support under the Thermie programme, a three year trial of a CNG fuelled bus was organised. The trial started in April of 1998 and the vehicle was deployed on the No. 3 route from the Donnybrook garage to Sandymount. The bus was fuelled by BGE at Sir John Rogersons Quay. The bus was a single deck vehicle with a dedicated spark ignition engine supplied and serviced by Volvo. The performance was compared with a standard diesel bus (Dublin Bus, 2004).

The aim of the project was to evaluate the technical and economic feasibility of deploying a CNG bus in fleet operation. Fuel and air quality emissions were also closely monitored. Results are outlined in Table 7.3.

Particulars	**NG Bus**	**Diesel Bus**
Total annual km	38,400 km	64,000 km
Daily range per fill	307 km	480 km
Fuel consumption	2.30 g/s	1.86 g/s
Fuel cost/mile	15pence	11.3 pence
CO2	1,471g/km	1,423 g/km
Hydrocarbon	2.04 g/km	0.85 g/km
NOx	7.20 g/km	15.68 g/km
CO	1.41 g/km	2.39 g/km
Availability	89%	+95%

Table 7.3 Comparison of CNG Bus with Diesel Equivalent (Dublin Bus, 2004)

It was found there was a 28-30% increase in fuel consumption in energy terms and a 20% increase in cost terms after considering the differences in cost between natural gas versus diesel in Ireland.

In terms of emissions, NOx, hydrocarbons and CO were about half as low for the CNG bus as compared with the diesel. On the other hand CO2 emissions per km are higher for the CNG vehicle. Particulate emissions were observed to be minimal and noise was significantly reduced but these parameters were not quantified. Dublin Bus found that the range limitations created scheduling problems and that the regular cleaning of the gas injection system every four weeks imposed an additional maintenance burden.

It was concluded that CNG buses are more expensive to run than diesel due to the lower efficiency of the gas engines. Due the large volume of the roof mounted gas tanks (5 times bigger than the diesel) the range of the CNG vehicles is considerably reduced. CNG buses would therefore be unsuitable for use on high mileage high capacity routes, particularly on double deckers where tanks could not be roof mounted. Dublin Bus concluded that extensive fleet operation would require major investment in compressors, storage and safety equipment and sensors. There would

also be significant additional ongoing electricity and maintenance costs associated with the fuelling bay.

The ZEUS programme has addressed the issue of providing a refuelling infrastructure for alternative fuels. Because of the costs and economies of scale involved, this is a significant barrier to fuel switching. For example, the Dutch experience in cities such as Groningen and Velsen shows that market forces would require substantial government inducements to put in place the scale of the NG refuelling infrastructure needed to ensure a wide uptake of CNG (Gobits and Vermie, 1998).

The demonstration projects supported by the UK Department for Transport and the Energy Savings Trust under the Power Shift programme were also reviewed. Again it is clear that market forces alone without government inducements will not ensure a wide uptake of natural gas by fleet operators at this time (PowerShift, TransportEnergy, 2003).

CNG is regarded by the UK authorities as an attractive eco-friendly fuel which substantially reduces noise by 10 dB(A), almost halving the noise nuisance compared with diesel . Some big UK operators like the Royal Mail and M&S switched to NG specially to overcome time delivery curfews in London (PowerShift, TransportEnergy, 2003).

By contrast the Dutch authorities also considered CNG as an option for meeting their low noise requirements, but this was found to be unsatisfactory for a number of reasons (NOVEM, 2004). Gas engines must be run at much higher revs to achieve the same torque as the equivalent diesel. Conventional gearboxes are designed to match the characteristics of diesel engines and they cause excessive noise when aligned with high revving gas engines. This tends to defeat the low noise characteristics of the motive power unit.

- **a)** On board CNG fuel tanks can take up to half a tonne of valuable payload capacity, reducing it by up to a third
- **b)** A dedicated and parallel fuelling infrastructure is required for CNG. Because of the expensive involved and the scale effects, this arrangement could only suits large fleet operators.
- **c)** The range limitations of CNG reduce their appeal for fleet operators.
- **d)** While petrol fuelled spark ignition engines are relatively easy to convert to gas, diesel compression ignition engines are expensive to retrofit

Following our enquiries to the major commercial vehicle suppliers (IVECO, Mercedes) we have established that -

1. IVECO can supply the Daily LGV models from 3.5t to 6.5t gvw powered by a 2.8L 260 hp engine, the additional cost over the standard diesel being € 6,000.
2. Detailed specifications and prices have been received form IVECO for a choice of four dedicated gas LGVs ranging from 3.5 t gvw to 6.5t gvw. Prices range from € 25,900 to €33,5000 excluding Vat (IVECO, 2004)
3. EuroTech trucks at 18t (4X2) and 26t (6X2) are available with the IVECO 260 hp 9.5 L gas engine and carry an additional cost of €25,000 to €30,000.

4. The fuel efficiency of a gas engine cannot match a diesel and the economics of operation depend on a favourable duty regime. Natural gas engines consume 25% more energy than the diesel equivalent and take up 3 – 4 times more on- board storage space (IVECO, 2004; CEC, 2000).
5. In the UK, because of the very favourable pricing regime, the operating fuel cost savings amount to 25% with gas taxed @ 9p/kg versus diesel @ 46p/litre (1 kg. of gas = 1.32 litre of diesel).
6. Compressor station costs range from €90,000 to €300,000 assuming an increase in pressure from 4 bar at source to 200+ bar in the fuel tanks (CHIVE, 2004).

7.5.2.2 Liquefied Petroleum Gas (LPG)

Liquefied petroleum gas is regarded as a "clean" fuel alternative that is made up of propane and butane and is a by-product of the petroleum refining industry. LPG is extensively used in spark ignition vehicles that are often dual fired to run on both gas and petrol. LPG contains about a third less energy by volume compared with petrol and is stored on board the vehicles pressurised tanks.

LPG is promoted as an automotive fuel because of its low tail pipe emissions and low CO2 forming characteristics. EU sponsored evaluation studies has demonstrated its value in urban pollution hot spots (ZEUS, CEC, 2000). According to the European LPG Gas Association, automotive LPG is currently used by more than 2.6 million vehicles in Europe and by 8 million worldwide and market share in Europe is expected to reach 5% by 2010 (AEGPL, December 2001).

LPG is extracted from natural gas processing (60% of total supply) and from oil reefing (40% of total supply) and supplies could be easily expanded to service a market of 18 million vehicles according to European LP Gas Association (AEGPL, 2003). Many countries including the UK, France, the Netherlands, Italy and Austria have an extensive refuelling infrastructure in place at garage forecourts and the governments provide incentives as part of their policies to promote clean alternatives. Incentive schemes such as the UK "PowerShift" programme is described later (Energy Saving Trust UK, PowerShift, 2003).

In contrast to the drive by many governments and by the EU commission to promote clean and alternative fuels, the popularity of LPG in Ireland has decreased drastically from a high of 20,000 tonnes per year in 1982/83 to a current low of 1,000 tonnes in 2004 (Irish LPG Association, 2003). This major decline in the Irish market is due to the erosion of the price difference between petrol and LPG. For example LPG sold at 52% of the price of petrol in 1982 but the price had increased to 73% by 2003.

More recently (June of 2004) the price advantage of LPG compared with petrol and diesel fuel has improved a little. LPG is currently about 65% the price of petrol and 72% the price of diesel. The current price differentials are still too narrow however to off set the extra costs of vehicle conversion for most operators, unless high mileages are incurred (ILPGA, 2004).

According to the ZEUS review of the alternative fuel options for Europe, for niche applications in commercial vehicles, LPG small car-vans for parcels deliveries and as

service vehicles are particularly favoured in urban "pollution hot spots" (ZEUS, 2001). The major attraction of LPG is its relative cleanliness compared with petrol and diesel. As can be seen from the Table below, tail pipe emissions of greenhouse gases such as CO2 are significantly lower than for petrol and NOx and particulate emissions are less than for diesel. Exhaust gases show less smog forming potential and less carcinogenic components are formed such as butadiene, benzene and aldehydes.

Automotive LPG not only helps to reduce the toxic emissions that damage air quality and human health but it also significantly reduces the production of greenhouse gases by 12 to 20% compared with petrol vehicles (AEGPL, 2003).

Vehicle - type & number	**NOx (g/km) Nitrous oxides**	**HC (g/km) Hydrocarbons**	**CO (g/km) Carbon Monoxide**	**Particulates**	**CO2 (g/km) Carbon Dioxide**
Petrol Euro 4 (593 vehicles)	0.032	0.054	0.427	-	209.8
Diesel Euro 4 2 vehicles)	0.210	0.010	0.140	0.022	156.5
CNG Euro 4 (18 vehicles)	0.019	0.065	0.464	-	174.5
LPGEuro 4 (42vehicles)	0.025	0.039	0.531	-	178.7

Table 7.4 Calculated Average Emissions of Regulated Pollutants of Type Approved EURO IV Vehicles (AEGP, 2003)

In respect to noise nuisance it should be noted that where vehicles such as car-vans and small service vans have spark ignition engines (which are half as noisy as compression ignition diesel engines), switching from petrol to gas does not offer any noise benefits.

According to the Irish Bulletin of Vehicle & Driver Statistics there were 33,000 HGVs and 200,000 LGVs (< 3.5t unladen definition) registered in the country for the year 2002. (Dept. of Environment, 2003).

Diesel is now the dominant fuel type for all commercial vehicles in the Ireland including vans with small engines of < 2 litres capacity. At present right hand drive petrol driven commercial vehicles can only be acquired by special imports from Northern Ireland and Britain. A fleet operator converting to LPG would suffer a delay of from 8 to 12 weeks in sourcing a suitable spark ignition vehicle from the UK. Conversion costs in the Ireland would amount to € 1,500 . Alternatively the fitting-out of a suitable new or used vehicle can be carried out at source by the major UK suppliers such as Ford, DAF and IVECO (ILPGA, 2004).

Ford supply two types of bi-fuel LGVs. For example the bi-fuel 2.3 litre Ford Transit is available for Stg.£ 14,500 and incurs a premium of £ 750 compared with the diesel equivalent. There is a reduction of 18% in the payload capacity to make way for the on-board storage tanks (gvw is 2800 kg and the payload is 965 kg). The bi-fuel 1.8 litre Ford Transit Connect is at Stg£ 11,080 some £ 800 more expensive than the standard diesel and suffers a payload penalty of 11% (the gvw is 1,970 kg and the payload is 557 kg).

The dominance of diesel vehicles in the Irish market greatly reduces the potential for easy conversions to LPG. The situation here is different to that in many continental countries and in the USA where not only small but even large spark ignition engines are readily available (> 6 litres). Relatively heavy LPG fuelled vehicles such as buses and refuse trucks have been shown to provide a clean and low noise solution in a number of congested EU cities including Dublin where an LPG bus was demonstrated as described below (ZEUS, 2000).

There are strict ISO and EN standards in force for the use of LPG reflecting the importance which the authorities and the CEC attach to safety. Normally no additional insurance penalties are imposed for LPG (NSAI, 2004). On site LPG storage and re-fuelling facilities are supplied by the gas suppliers, namely Calor Gas and Flo Gas . There are six refuelling stations currently in operation in Dublin.

The current narrow price differentials and a lack of incentives for vehicle conversions compared to those available in other countries, is against a recovery of the Irish LPG market at the present time. The dominance of the commercial vehicle fleet by diesel engines for all categories of vehicles does not facilitate an easy or inexpensive conversion to spark ignition fired LPG fuel. Nevertheless suitable right hand drive LPG vehicles in most categories can be sourced from the UK.

Historically there are safety concerns and perceptions about handling LPG. While auto gas is denser than air, therefore requiring additional precautions, recent years has seem considerable development work in all aspects of LPG safety and there are five special Irish Standards for LPG vehicles and components now in force (NSAI, 2004). These developments should help to ally poor public perceptions.

Dublin Bus LPG Demonstration

In October 1999 Dublin Bus introduced a dedicated LPG single deck bus on the No. 3 route in Dublin for a trial period of six months (Dublin Bus, 2004). This DAF bus covered 17,600 km in the period. The vehicle was fitted with two roof tanks (weighing 300 kg) giving a fuel capacity range of 480 kms. The fuel tanks were topped up each morning (3 minutes refuelling) from a 4,000 litre LPG tank at the Donnybrook garage.

Detailed emission and performance records were maintained and compared with the equivalent DAF diesel-engined vehicle. Substantial reductions in NOX, CO, CH, particulate and smoke emissions were recorded (seen below in Table 7.5). Engine noise was reduced by 30 – 50% as might be expected with the conversion from compression to spark ignition.

Particulars	LPG Bus (DAF "M")	Diesel Bus
Mileage km	17,600	--
Range km	480	--
CO2 (g/kWh)	1.0	1.1
CO ,,	0.6	1.5
NOx ,,	0.4	6.8
Hydrocarbons (PAHC)	1.0	10.0
Particulates (g/kWh)	< 0.01	0.15
Smoke	0.00	1 m-1

Table 7.5 Emission Characteristics of LPG Bus compared with Diesel (Irish LPG Association, 2004)

It was concluded that the mechanical integrity of the bus was satisfactory and the advantages of LPG as a clean and reliable fuel was clearly demonstrated. The price difference between the low cost diesel fuel especially available to the CIE group, and the current cost of LPG auto gas does not provide an incentive for further replication at this time.

7.5.2.3 Bio-Fuels

The most widely known fuel derived from renewable resources is alcohol produced by the fermentation of agricultural substrates. Ethanol derived from potatoes, sugar beet and cereals can be used as a fuel extender or substitute for gasoline. Ethanol gives cleaner tail pipe emissions than petrol but this fuel type is not a commercially available option at the present time and would in any event be limited for use in spark ignition engines (ZEUS, CEC, 2000).

The technology of rapeseed oil production is well developed and the product can be used directly with little engine modification or as a fuel blend. This fuel has been extensively investigated in Ireland by Cork County Council in collaboaration with Teagasc(Cork County Council, 2001).

Vegetable oils, however do not offer any benefits over conventional hydrocarbon fuels in terms of lower emissions or less noise pollution. The main advantages are that bio-fuels are derived from a renewable resource and that the plants needed to produce rapeseed oil absorb CO2, thereby helping to offset the vehicle emissions.

Under an EU contract for DG-XVII, Cork County Council carried out a comparative analysis of a number of vehicles in their fleet converted to bio-diesel, with their conventional vehicles running on mineral diesel (Cork County Council, 2001). The purpose of the trial was to investigate the technical performance of bio-diesel in a typical local authority fleet, to determine the costs, and to assess the impact on the environment.

Four sets of 3 vehicles were used in the trial - 12 in all. Each set consisted of one vehicle fueled by Rape Methyl Ester (RME), one by Sunflower Methyl Ester (SME) and one by mineral diesel oil. The project involved a preparatory period of 7 months, a 12-month trial and a period to monitor and to evaluate the results, 23 months in all. The project started in July 1998 and the trial vehicles were Ford Transit pickups. Of the total of 12 vehicles, 8 were run on 100% bio-fuels and these covered some

153,000 miles during the trial period. Considerable data was collected on the feasibility of using bio-diesel fuels in Ireland and on its performance in day-to-day fleet use.

The CEC has considered proposals for developing common standards for the "eco-labeling" of vehicles. Vehicles would be ranked according to fuel economy, CO2 emissions, tail pipe emissons and noise. It remains to be seen how this approach will develop and how it can best link into the development and designation of low emission zones in European cities (ALTER , 2004*)*

To conclude from the results of the EU Thermie programmes and of the trial by Cork County Council, it is not apparent that bio-fuel vehicles, using compression ignition engines, would be any quieter than conventional gasoline or gas fired vehicles or could significantly reduce tail pipe emissions in city centre areas. (CEC, UTOPIA, 2001; CEC, ZEUS, 2000).

7.5.2.4 Hydrogen

Hydrogen is advocated as a transportation fuel for a number of reasons including as a means of dealing with fossil fuel scarcity and a way for improving environmental quality. Governments in Europe and the US see hydrogen as the favoured long-term alternative to the conventional hydrocarbon based economy when the world's supplies of petroleum-based fuels become restricted. Current research points to the fact that the introduction of hydrogen fuel would entail a dramatic change for society. Vehicles that use hydrogen fuel are likely to cost significantly more than current vehicles (Farrell et al., 2002). This is attributable to the complex fuel storage networks required and to the more expensive prime movers in the form of fuel cells.

Vehicles operating on hydrogen have very low emissions, approaching zero for fuel cell powered vehicles. Farrell et al (2002) suggest that the immediate environmental benefits of introducing hydrogen may be more visible in the heavy-duty freight vehicles.

Realistically however, the auto-motive industry estimates that hydrogen vehicles are at least a decade away from a programme of comprehensive demonstrations, with widespread public and commercial fleet use even further away (Ricardo et al, 2002). A more recent review by Wald published in the Scientific American questions whether a convincing economic or environmental case can ever be made for the proposed hydrogen economy (Wald, 2004). An energy analysis is conducted by Wald on the conversion efficiencies likely to apply in each step of the total hydrogen fuel producing chain and its translation to motive power by on board vehicle fuel cells. The final "well to wheel" efficiencies achieved may only be a third as that for conventional petroleum fuels. In addition the clean emissions achieved at the tail pipe may be more than off-set by the green house gases emanating from the coal fired electricity plants needed to produce the hydrogen fuel by electrolysis of water, unless nuclear power is used. Therefore, for the purpose of this project, hydrogen fuel is not a realistic option.

7.5.2.5 Electric Vehicles

When we started the project it was hoped that electric vehicles and electric hybrid would offer a sustainable and realistic solution for commercial deliveries in the congested city centre and we therefore devoted significant time to examining the EV option. We have found that despite considerable worldwide R&D, electric commercial vehicles, unlike the passenger cars such as the Toyota Prius, have not made an impact on transport and are limited to niche applications. High energy density batteries, which would allow EVs to substitute for conventional commercial light to medium sized commercial vans, are not available at a reasonable cost (Chan et al, 2002). We have examined many case studies involving the use of EVs, many of which were funded during the past 15 years by the EU (DG-TREN) and assessed in the ELCIDIS Final Report (CEC, 2002).

There are many variations and options in the detail of possible electrical system technologies. These relate to the following:

1. Motor type: Induction. permanent magnet and switched reluctance
2. Voltage level: 42V. HV
3. Semiconductors: MOSFET, IGBT
4. Battery type: Lead Aid, Nickel Metal Hydride, Lithium-Ion,

The most successful traction batteries will have to optimise a combination of the following factors (Chan, 2002):

1. Durability and long cycle life
2. Cost
3. Operability over a wide range of temperatures
4. Ability to accept high charge and discharge rates
5. Low weight, high energy density and small, flexible package size
6. Charge retention
7. Regenerative breaking

The continuing rise in the sales of the Japanese passenger petrol electric hybrid cars on the global markets would indicate that an optimal combination of these factors is within reach. The Ricardo report (Ricardo, 2002) commissioned by Britain's Department for Transport concludes that progressive electrification and hybridisation of the vehicle fleets offers significant CO2 reducing benefits at a manageable level of risk. Improvements to the batteries and related hybrid power electronic control systems are needed to improve reliability and to reduce costs, particularly for the larger commercial vehicles. According to Ricardo (2002), the two battery types that are likely to share the HEV market over the next decade are the Nickel Metal Hydride and the Lithium Ion.

7.5.2.6 Hybrid Electric Vehicles

A hybrid electric vehicle embodies a dual fuel system, a conventional spark ignition or compression engine to generate power for the electric traction motors via storage batteries, or to give direct drive to the wheels as appropriate. Developments in modern

power electronics have made possible the use of sophisticated control and energy managements systems (Chan, 2002).

Unlike EVs, which are constrained in their travel range by the capacity of the traction batteries, HEVs are not so distance limited and can carry out very similar duties and rosters to conventional commercial vans. Case histories involving the use of HEVs in the "ELCIDIS" group of cities are mentioned later.

7.5.3 Developments of Eco-Friendly & Electric Vehicles in the UK, US and EU

7.5.3.1 UK

Currently, the UK has an ambitious programme under way to promote energy efficiency and clean transport. The Energy Saving Trust has established the Transport Action Initiative (Energy Savings Trust, 2001) to develop market-oriented schemes, described below, that have the potential to deliver real environmental benefits in terms of saving energy and lowering harmful emissions.

As part of an overall Stg.£69m three-year package, significant incentives are available through two schemes - "PowerShift" and "CleanUp" (TransportEnergy, 2003). PowerShift aims to stimulate a sustainable market for clean vehicles and to promote hybrid and fuel cell vehicles. The CleanUp campaign encourages the retrofitting of emissions control equipment to the worst polluting vehicles-buses, delivery trucks and taxis operating in the country's nine worst pollution hotspots.

Supported by the Energy Savings Trust PowerShift programme, the Royal Mail has demonstrated the use of both small and medium sized EVs for postal work (Energy Saving Trust, 2003). In Essex and North London the requirement was to carry around 15 full mailbags over a total distance of 60 miles per day. The payload was 1 tonne and the volume, 11.5 cubic metres. The vans specified were a long wheelbase version of the Convoy van. Trip statistics of the Royal Mail EVs is outlined below in Table 7.6.

Typical Distance per Day	50km
Average Trip Distance	14km
Utilisation	3 to 5 trips per day
Payload	1 tonne weight, 11.5m^3 volume
GVW	4050kg

Table 7.6 Royal Mail Trip Statistics (Energy Saving Trust UK, TransportEnergy, 2003)

The roster allowed for periods during the day when advanced fast-charging technology known as "Wavedriver" could be used, quickly restoring vehicle range for further operations within 30 minutes. In London, the daily utilisation often exceeded the single charge range. On very busy days the vehicle was operated four or five times per day with recharge breaks in between.

The "Wavedriver" charging system mentioned above is a compact integrated EV management system. It controls power delivery to the electric motor in response to driver commands, reclaims energy from braking to recharge the batteries

(regenerative breaking) and also serves as an on-board fast charging system. When connected to the standard industrial 3-phase 415 V supply, it can restore 80% of the vehicles range in one hour or 50% in 30 minutes.

Grants are available to companies from "Transport Energy UK" to help acquire eco-friendly commercial vehicles. These are listed in Table 7.7 below.

Fuel	Vehicle Type	New/Conversion	Grant
LPG	Vans up to 3.5 GVW	New conversion	50-70% 30-50%
	HGVs over 3.5t GVW	New conversion	40-75% 40-75%
Natural Gas	Vans up to 3.5t GVW	New conversion	50-75% 40-75%
	HGVs over 3.5t GVW	New conversion	40-75% up to 75%
EV Hybrids	All cars vans	New New New	75% £1000 -

Table 7.7 Grants Available from Transport Energy UK

The Energy Saving Trust has reported on a case study that started in the summer of 2001 (TransportEnergy, 2003). The firm of C&H (hauliers) Ltd employs a fleet of 50 HGVs, of which 10 are fuelled by liquefied natural gas or LNG. The company makes deliveries to newspaper printing works in and around London.

The aim was to achieve the high environmental standards demanded by its main customer Stora Enso, Europe's largest producer of newsprint. Each LNG fuelled HGV is expected to make 25 deliveries a week amounting to 550 tonnes of paper per year. This is similar to what the conventional trucks will do.

The LNG trucks each manage to cover a distance of 45,000 miles per year for the local London deliveries. The range of these vehicles is 310 miles compared with 560 or more for the diesel equivalent but this reduced range can be accommodated by the scheduled returns to the depot at Barking where refuelling takes place. It takes less time to re-fuel with LNG than with diesel but operators need to be mindful of the cold temperatures associated with liquefied gas.

The carriers, C&H (Hauliers) Ltd. received a 75% grant of Stg.£ 275,000 from the Transport Energy Power Shift scheme towards the additional cost of the 10 new LNG vehicles. An LNG fuelling facility was installed at the main Barking depot. The 6 tonne fuel tank is topped up once a week.

LNG was chosen instead of CNG because LNG stores 2 to 4 times more energy than an equivalent volume of CNG. This permits smaller on-board tanks and minimises the payload penalty. The in-service operational experience is proving satisfactory for the operators and the lower in-cab noise levels (50% reduction) appeals to the drivers and to customers and residents in urban East London.

7.5.3.2 Development of Electric Vehicles in the US

Research in the US into EVs intensified in the 1990s. Key to the development of EV use in the US has been the 1990 ratified US California Zero Emission Mandate and its more recent update, the Memorandum of Agreement (March 1996). In 1990, the Californian Air Resources Board (CARB) obliged the leading US and Japanese manufacturers on the Californian automobile market to start the sale of electric vehicles in the state in 1998 (Schmitt, 1998). This move has been taken on board by other states and has resulted in a wider acknowledgement of pollution problems (U.S Department of Energy, 2003).

However, the automobile industry as a whole did not accept this measure and instead negotiated a "two steps forward, one step back" policy. This compromise produced several joint, contractually protected, mandatory concessions from the automobile industry. The positions of the Californian environment authorities and the automobile industry were formalised in a letter of intent forming a common strategic policy (U.S. Department of Energy, 2003).

More recently, the Hybrid Electric Vehicle (HEV) programme was initiated in 1993 as a five year cost-shared partnership between the US Department of Energy and the "Big Three" American auto manufacturers; General Motors, Ford and Daimler Chrysler. Participants committed to produce first generation prototypes by 2000 and market-ready HEVs by 2003 (US Deptment Energy, 2003).

The overall goal was to develop feasible HEVs that achieved twice the fuel economy of similar gasoline vehicles with comparable performance and costs. Despite these initiatives, American manufacturers have yet to launch market-ready HEVs. Users must rely on imported passenger cars such as the Toyota Prius, Honda Insight and a new model of the Honda Civic. Significant tax incentives are available in the US for individuals who purchase 'clean' vehicles from both the federal and state legislatures (U.S. Department of Energy, 2003).

EVs on the other hand, are more readily available in the US. Manufacturers such as SHERPA supply small electric commercial vans of 5,000 lbs. load capacity that use conventional lead acid batteries (Electric Vehicles International, 2003).

The Transportation Technology R&D Centre at the Argonne National Laboratory monitors developments in HEV and EV technologies under contract from the with the U.S. Department of Energy (Argonne National Laboratory, 2003). Frequent publications on their web site by the Argonne National Laboratory together with an overview paper by Chan (Chan, 2002) gives a good overview of developments worldwide and particularly in the U.S.

7.5.3.3 Development of EVs in Europe

The introduction of EVs in France is based on a centralist approach (Schmitt, 1998). Electricité de France declared strong support for the development of EVs following heightened environmental pressure and a contractual declaration from the state. The production and sale of EVs started and this was followed up by fleet tests in several French cities including La Rochelle as described in this report. The state offered

depreciation rates and supported the purchase of electric vehicles. However in spite of efforts by local authorities to install charging stations, to inform and to train interested drivers, the enthusiasm of private drivers was only moderate.

The German federal transport and environmental authorities refused to recognise the EV as a major environmental improvement (EPTR, 2002), because it is claimed that unless EVs reduce individual motorised traffic, public money could be more effectively invested in an extension of the public traffic system infrastructure. The German automobile industry, battery industry and the Association of German Electric Power Plants explained in 1994 that the EV is only a long-term alternative to fossil fuel. Deutsche Post and Deutsche Telekom, on the other hand are more positive about EVs and declare the electric vehicle to be a prospective alternative for low emission road traffic (EPTR, 2002).

DG-TREN in 1998 sponsored the "ELCIDIS" (Electric Vehicle City Distribution) programme to demonstrate how clean vehicles can be used to minimise the nuisance of urban distribution (Municipality of Rotterdam, Elcidis co-ordination office, 2003) .The project has deployed a total of 55 electric and hybrid vehicles, 39 battery only (EVs) and 16 hybrid diesel-electric (HEVs). The final ELCIDIS report (Vermie et al. 2002) gives an overview of the market applications, availability and performance of commercial electric vehicles in the EU.

The six participating cities (Rotterdam, Stockholm, Milan, Erlangan, La Rochelle and Erlangen) set out to demonstrate that by organising urban distribution using quiet and clean EVs and HEVs in conjunction with an efficient logistics organisation (using existing or new central distribution centres), that an improved living climate could be achieved, all at an acceptable cost to businesses. Companies would be expected to pay a premium price for deliveries, by EV or HEV, for which in return they would benefit from more frequent deliveries by eco-friendly vehicles enjoying privileged access to restricted areas and out of town additional storage space, thereby freeing up premium retail space at their city centre premises . It was hoped that in this way the number of journeys by HGVs in the city centres could be decreased and that less congestion and greater accessibility to city centres would accrue.

The cities of Rotterdam and Stockholm focused on large EVs (payload 1000 – 15000 kg) while La Rochelle deployed small EVs with a payload of 500 kg. Larger hybrid electric vehicles (HEVs) are deployed in Stavanger, Milan and Erlangen (Vermie et al, 2002).

The most popular vehicle featuring in the ELCIDIS programme is the small electric Citroen Berlingo/Peugeot Partner van. This vehicle is regarded as a mature commercial product, with several thousands (14,000) having being produced to date. The other EVs and HEVs deployed are not in serial production and are expensive prototypes requiring significant backup services.

The EV models demonstrated are the small (a) Citroen Berlingo, the larger (b) Mercedes Sprint and the (c) IVECO pallet truck. Details of the models are provided in Table 7.8

Payload	500kg
GVW	1950kg
Volume	3 Cubic Metres
Range	80 km
Max Speed	90 km
Batteries	Nickel Cadmium

Table 7.8 Citroen Berlingo/Peugeot Partner Details

The larger EV Mercedes Sprint is very much a prototype. For example the EV vans used in Rotterdam differ in specifications according to requirements of the carrier company. The TNT vehicles have the following specifications (Table 9).

Payload	1250 kg
GVW	3500kg
Volume	12 Cubic Metres
Top Speed	90km/hr
Range	75 km/hr
Batteries	Sodium nickel chloride (ZEBRA)

Table 7.9 Mercedes Sprint Details

For pallet loads, IVECO supply an EV fitted with a tailgate for loading pallets with the following details (Table 10).

Payload	900kg
GVW	3300kg
Volume	8 Cubic Metres
Range	50km
Battery	Lead Acid

Table 7.10 IVECO Details

With regard to HEVs, two types are evaluated by ELCIDIS, the Mercedes ATEGO and the Audi Duo.

Mercedes ATEGO vans are employed in Stockholm for goods deliveries and have the following characteristics (Table 11).

Payload	2300kg
GVW	12000kg
Volume	30 Cubic Metres
Top Speed Diesel	110 km/hr
Top Speed Electric	70 km/hr
Range Electric	30-40 km
Batteries	Lead Acid

Table 7.11 ATEGO details

In the city of Erlangen, Audi supplied 13 of prototype HEVs. These were tested over a period of 30 months, the details of which are presented in Table 7.12 below.

Payload	400kg
GVW	2000kg
Volume	2 Cubic Metres
Top Speed Diesel	170 km/hr
Top Speed Electric	120 km/hr
Range Electric	35 km
Batteries	Lead Acid

Table 7.12 Audi Details

The CEC final evaluation report of the ELCIDIS programme sees a continuing role for EVs and electric hybrids in niche applications. Substantial reductions in costs and improvements in the technical performance of the more advanced higher energy density traction batteries are needed even though reliability is much improved.

The high capital costs for EVs and particularly for commercial sized HEVs, continues to be a major impediment and any significant reductions must await much longer production runs, according to both Chan (Chan, 2002) and to Vemie (Vermie et al, 2002) who compiled the CEC sponsored evaluation report on ELCIDIS. This report calls for a greater diversity and choice in the market place, particularly for the larger payload class of vehicles of 1,000 to 1,500 kg.

The two hybrid electric vehicles examined in the ELCIDIS programme are experimental one-off prototypes and do not therefore compare favourably with the smaller EVs in terms of capital costs or reliability. The HEVs are expensive to manufacture because of the dual fuel systems employed. Annoying breakdowns have been experienced due to control malfunctions. These have involved charger breakdowns and malfunctioning switching gear when changing from the electricity to the diesel mode (Vermie et al, 2002). These operational problems are referred to later in the section on case histories in the selected ELCIDIS cities.

The larger EVs and HEVs which are needed for payloads of more than 500 kg are not on offer on the catalogues of the European suppliers. It seems evident that the hand-made prototypes used in the ELCIDIS demonstrations having payloads of 1,000 to 1,500 kg. could only be acquired by means of substantial subsidies from the city or state authorities and with help from the suppliers themselves (Vermie et al, 2002).

The true costs of acquiring the prototype vehicles and the level of subsidies granted by the authorities in the ELCIDIS and BESTUFS cities are not adequately reported. In order to obtain more accurate cost data, enquiries were made with potential suppliers such as IVECO and Peugeot Citroen (PSA). The latter are no longer prepared to supply new EVs or a back up service at this time and have ceased EV production following a run of 14,000 commercial car vans.

The case histories examined demonstrate that EVs and HEVs are operationally suitable for accessing restricted areas and for discharging out-of-time deliveries. Zero emissions, silent running and better overall energy efficiencies can contribute to promoting sustainable transport solutions in historic and fragile city centres.

Nevertheless the market does not support volume production of commercial EVs and HEVs and the potential suppliers are awaiting government and EC intervention to kick start production.

7.6 SUMMARY OF FUEL COMPARISONS

Evaluations by the EU point to natural gas, either in compressed (CNG) or liquefied (LNG) as the favoured fuel for the larger trucks, e.g. for HGVs and for the heavier LGVs and rigid vehicles, LPG is recommended as a suitable and economically attractive clean fuel for cars and smaller vehicles as is already the case in many European countries.

Electric vehicles (EVs) and hybrid electric vehicles (HEVs) offer significant environmental advantages in terms of zero emissions and low noise. Although they have benefited technically from long standing development programmes, they have proven to be prohibitively expensive to acquire and to operate in commercial fleets.

In response to our enquiries we have ascertained that one of the main developers of EVs, the French PSA group have ceased production of the once popular car-van Citroen Berlingo EV model of which 14,000 units were produced. PSA are no longer willing to supply or to service an EV. The Dutch "PEAK" programme evaluation has also concluded that electrically powered commercial vehicles are not a viable alternative at the present time.

Hybrid diesel electric technology for LGVs and lorries offers many environmental attractions when travelling on the electric mode in congested city centres, but commercial HEVs are unlikely to see volume production for many years to come unless substantial government incentives are forthcoming (CEC, 2001) .

The "UTOPIA" final report gives a detailed assessment of 50 demonstration projects on alternative fuels that were completed in the EU during the past 25 years (UTOPIA, CEC, 2001). While these assessments commissioned by the EU (DG-TREN) are primarily concerned with evaluating the reductions in emissions and with calculating the energy substitution benefits, a reduction in noise pollution is also a benefit. An up to date view of the availability and the operational feasibility of the different fuel options is given in the ZEUS and UTOPIA reports.

From an urban perspective, four important outputs have resulted from the UTOPIA evaluation report:

1. An assessment of the most promising applications for cleaner and low noise vehicles and the required supporting measures
2. A good practice guide for setting up and running pilot projects aimed at the potential "project champions".
3. Recommendations on policy actions at EU and national levels to help promote market introduction
4. A software framework, which provides an evaluation methodology to support local initiatives by city transport planners and to pre-screen the options available.

The policy options necessary to promote alternative fuels are evaluated and these could serve as a useful model for any initiatives to promote low noise and clean vehicles in Dublin. These policy options include:

1. Pricing policies – preferential parking charges for cleaner vehicles;
2. Incentives for purchase, retrofit and scrappage
3. Taxes – differential fuel and vehicle taxes; energy and carbon taxes
4. Regulation – zone access control; preference for clean and silent vehicles; safety standards; public procurement mandates
5. Urban planning measures – low emission zones (LEZs); changes in urban delivery restrictions; sitting of refuelling stations; provisions for night deliveries
6. Investment supports for RTD, refuelling infrastructure, public private contracts
7. "Green procurement" – forming purchasing consortia
8. Information and public awareness – "greener" fleet guides; best practice campaigns

The UTOPIA project suggests that in the period to 2020, bio-diesel, CNG and electricity are the most likely short to medium term alternatives to petrol and diesel. The policy actions needed to encourage the market include vehicle and fuel tax incentive schemes, preferential urban road pricing and parking restrictions and privileges. It is concluded that significant privileges would need to be guaranteed for a significant period of from 5 – 10 years to encourage investor interest.

While CNG and EVs are favoured by the EU to help tackle "air quality hot spots" in city centres, these particular vehicles, because of their low noise characteristics, are also favoured by some municipal authorities for night duties. Case material involving the deployment of low noise vehicles for the delivery of groceries to supermarkets (CNG in London) , parcels to business premises (EVs in La Rochelle and Genoa) and refuse collection (CNG in London) is reported by BESTUFS for cities in the Netherlands, UK , France and Italy (BESTUFS, 2003c).

7.7 POSSIBLE SCENARIOS FOR DUBLIN WHERE ECO-FRIENDLY SOLUTIONS MIGHT APPLY

In trying to match the development and availability of low noise and clean technologies with the requirement to reduce the impacts of night deliveries and to reduce emissions in pollution hot spots during the day, three different elements are considered –

- The vehicles and fuel types available
- The "quiet" ancillaries required
- The management of the delivery logistics at the unloading destinations

The characteristics of the different eco-friendly vehicles and the fuel options that have merited considerable international RTD investment have already been examined.

For the scenarios for night deliveries that have been identified from our analysis of deliveries to Dublin city centre, the available options for ameliorating the noise nuisance are

(1) To deploy modified or "hushed" diesel engines.
(2) To use compressed natural gas engines
(3) To substitute EVs or HEVs

Walking and cycling couriers are also a practical solution for the "final mile" distribution of mail from a city centre platform and this niche application is described in a case study in Chapter 6.

7.7.1 An Examination of Night Deliveries to Grocery Stores – MSVC Case Study

From an analysis of the data collected, the deliveries of groceries to convenience stores in the early morning points to a need to deploy more sustainable low noise solutions. The two categories of groceries examined are

- Deliveries of ambient dry goods to grocery stores by HGVs and LGVs
- Night deliveries of chilled and frozen goods by HGVs

Arising from our survey of retail shops we found that one of the leading distributors, the Musgrave Super Valu Centra Group (MSVC) is currently examining the future implications for their operations of evolving national and EU noise policies. The group is aware of complaints made by residents to Dublin City Council concerning the noise nuisance created by early morning deliveries to their city centre franchise stores.

The early morning delivery operations that are affected by these concerns are as follows:

1) Dry goods from the Ballymount depot
2) Chilled and frozen goods from Fonthill
3) From January 2005, ambient goods from the new UDC at Kilcock

In the Dublin area, deliveries to stores located in the city centre are made from two major outlying depots at Fonthill, Clondalkin and at Ballymount situated near the Naas Road. Fonthill supplies frozen and chilled goods to the city centre and suburbs while Ballymount looks after the supplies of ambient goods.

At present deliveries for the city centre depart by HGV from 4:30 am onwards and most shops are served before 7:30 am. Schedules and loadings are planned in advance. Deliveries are made six days a week and up to 30 stores are served in the city centre area. Factors that drive the need for early morning deliveries include increasing congestion and the access restrictions.

In considering the possible integration of low noise HGVs and ancillaries into the day-to-day operations of MSVC in the city centre, the following potentially suitable configurations emerged from the data provided.

Table 7.13 below describes a typical delivery roster for ambient goods from the Ballymount depot in December 2003. (From January 2005 distribution will take place from the new UDC at Kilcock and this operation is the subject of a case history of a UDC operation described in Chapter 5).

Types of vehicles	HGV combinations, gvw 25 – 40 t
No. of vehicles	30 HGVs , 11 trailers + LGV sweeper
No. of round trips from depot	11
Frequency of departures	4.30 am start, return by 10.00 am
Ave. no. of drops in city centre	4 in city centre, additional outside
No. of round trips per driver	X 2
Average distance travelled per day	50 – 100 kms
No. of units delivered per round trip	2,400 cases packed in 48 cages
No. of units delivered per stop	4 to 6 roll cages
Dwell time per stop	15 to 30 minutes
No. of shops in city centre	30

Table 7.13 Deliveries of Ambient Goods on Typical Day

Table 7.14 below describes the arrangements for the delivery of chilled and frozen goods to the city from the Fonthill depot.

Types of vehicles	HGV combinations & rigids
No. of vehicles	50+
No. of round trips from depot	x
Frequency of departures	5.30 am, return by 10.00 am
Ave. no. of drops in city centre per trip	3- 4
Ave. distance travelled per day	50 – 90 km
No. of units delivered per round trip	45 roll cages (including the suburbs)
No. of units delivered per stop	5 – 6 cages
No. of deliveries per shop per week	X 3
Dwell time per stop	15 + minutes

Table 7.14 Deliveries of Chilled and Frozen Goods on a typical day

At present MSVC stores typically receive 3 deliveries per week of frozen goods and 1 of dry goods. The frequency of ambient goods deliveries by MSVC own account vehicles will increase when the Kilcock UDC comes on stream in 2005.

Early morning deliveries are a cause of nuisance, particularly the movement of frozen and chilled goods, which employ diesel driven refrigeration units. A HGV will carry up to 45 roll cages and each shop will typically accept 5 or 6. On arrival the chilled goods are immediately loaded into refrigerated storage.

The impact of deploying low noise vehicles and ancillaries on the particular configurations as described in Tables 7.13 and 7.14 above, would be to make night time deliveries a more acceptable solution to city centre residents.

The possibility and feasibility of integrating a low noise vehicle and ancillaries into the MSVC fleet as a demonstration project is explored in Chapter 11. This would show-case the PEAK developments and applications in Dublin and encourage wider replication.

7.7.2 An Examination of Drugs Deliveries to the City Centre during the Day

Certain categories of goods must be delivered during daytime business hours. For example, deliveries of drugs to city centre pharmacies takes place during daytime business hours, some located in heavily congested and polluted streets.

The deployment of clean LPG fuelled LGVs on these runs would mitigate emissions because the commercial traffic created by this category of business is significant. The city centre is populated by 80 pharmacies and they are serviced twice a day.

We found that the configuration of deliveries operated by the United Drug company from their new €40 million depot at the Magna Business park at Citywest, D.24, would be suitable for LPG fuelled vehicles.

At the Citywest United Drug facility supplies are sourced from overseas through Dublin port and then sorted for onward dispatch to city centre pharmacists. State-of-the-art IT logistics and GPS tracking systems are used to promote efficient logistics.

The delivery patterns for a typical day (30/09/03) are profiled in Table 7.15 below.

Types of vehicles	LGVs, 3.5t unladen
No. of vehicles	25
No. of round trips from depot	2 per van; 50 in total per day
Frequency of departure	All LGVs are loaded and dispatched by 9.45hrs
Ave. distance travelled per round	30 – 50 km
No. of round trips per vehicle/per driver	2
Duration of round trips	6 hrs in the am, 3 hrs in the pm
No. of stops per round & per vehicle	30 - 40
No. of units delivered per round	130 totes
Av. no. of units delivered per stop	3 totes
Dwell time	5 minutes

Table 7.15 Deliveries of Drugs and Medicine on a Typical Day

As described earlier the use of LPG vans for this category of goods deliveries would substantially reduce tail pipe emissions and particulates compared with diesel vehicles (refer Tables 7.4 and 7.5).

Possibilities for follow up demonstrations involving low noise equipment and unloading procedures and low emission vehicles are explored in Appendix A.

7.8 CONCLUSIONS

1. Possible operationally and technically feasible solutions have been identified for introducing more sustainable clean and low noise delivery practices into Dublin.
2. The availability and likely costs of different clean and low noise vehicle, fuel and ancillary equipment options have been determined and compared.

3. In the case of night deliveries we have concluded that a combination of modified diesel vehicles and related ancillaries offers the most realistic and cost effective solution.
4. In proposing possible standards for noise limits in Dublin, the Dutch PEAK programme indicates that 65 dB(A) is a feasible limit for night time deliveries.
5. There would be major difficulties in trying to achieve a lower limit of 60 dB(A), particularly for large HGV combinations, and also for effectively controlling the unloading activities at the delivery sites.
6. Managing the loading and unloading operations in the city centre to minimise noise is equally important to the operations of the vehicles. While it is possible to control this activity at dedicated off-street sites, kerb-side deliveries are problematic. It is proposed to carry acoustic materials on board the delivery vehicles and to provide training for the operatives.
7. As a practical demonstration it is proposed to show case a modified 17t gvw and related ancillaries in fleet operation for the delivery of dry and chilled groceries to the MSVC franchised stores.
8. The project is intended to introduce best practice and technology transfer and from the Dutch PEAK programme and to introduce the noise evaluation methodology developed by NOVEM and TNO.
9. The conventional diesel refrigeration units fitted to HGVs cause particular irritation. Electrically driven low noise refrigeration units are recommended for the delivery of chilled and frozen goods.
10. An appropriate permitting framework and incentives to reward good behaviour and to encourage the carriers to manage their logistics activities in a more sustainable way is recommended.
11. The additional costs of modifying a rigid HGV and ancillaries as proposed for the MSVC demonstration project, would amount to € 8,000.
12. A period of 5 years may be needed for carriers and for receivers to adapt to change and to encourage the suppliers to reduce the costs of modified equipment.
13. While CNG has the attraction of significantly reducing both noise and emissions, the additional costs of (a) setting up a parallel re-fuelling infrastructure (b) the performance penalties involved and (c) the current uncertainty about pricing policies for gas in Ireland, does not make CNG an attractive option for Irish fleet operators at this time.
14. While EVs and HEVs may offer an elegant technical solution for niche applications such as for parcels deliveries and as service vehicles, this option cannot be recommended at the present time. An underdeveloped market, diminished enthusiasm by the major auto suppliers and low residuals are major disincentives for commercial fleet operators.
15. LPG is a favoured fuel in many European cities for the smaller car-vans because they offer a clean solution for "urban pollution hot spots" during the day time and therefore fit our definition of an eco-friendly fuel.
16. Incentives to promote LPG vehicles may form a part of the measures which the EPA expect the local authorities will be obliged to take to help minimise traffic generated emissions in urban pollution hot spots in order to comply with the new air quality standards coming into force from 2005 onwards.
17. The safety issues relating to LPG have merited considerable attention in recent years and a special Irish Standard for auto-gas has been developed.
18. The current Irish price differential between petrol and auto-gas is currently much too narrow to encourage fuel switching and the market has consequently

collapsed. Tax incentives as proposed to government by the ILPG Association will be needed to revive the market.

19. Publicity, promotion and training will be necessary for the success of the sustainable low noise and low emission solutions proposed.

8 CITY ACCESS CONTROL

8.1 INTRODUCTION

The OECD (OECD, 2003) links sustainable urban goods transport to "continuing economic growth while protecting the environment and ensuring a better quality of life for future generations". As an unavoidable consequence of economic activity, the challenge facing national and local government is to strike a balance between the need for urban goods transport to fulfil commercial purposes and the impact of goods transport on the communities being served.

In the case of Dublin, a specific challenge facing authorities is to optimise the use of the Dublin Port Tunnel (DPT) for Heavy Goods Vehicles (HGVs). However as highlighted in the Interim DELCAN Report (DELCAN, 2004), it is not a foregone conclusion that all HGV traffic will use the DPT. Most notably, the DPT may not provide an efficient route for those commercial vehicles whose trips have an origin and destination within Dublin (in other words for trips that are not port related). Also, given the fact that it was found in the overall survey that only 3% of trips originated in Zone 2, which accounted for Dublin Port, it is clear that a system is needed for managing commercial vehicles.

Regulating city access for all types of goods vehicles is one means of managing commercial vehicles. The purpose of such regulations is to reduce the negative effects of goods vehicles in city areas such as congestion problems, safety problems and environmental problems. However formulating city access regulations involves finding a balance between the interests of the stakeholders involved and therefore it is necessary to maintain that balance between supporting economic growth while mitigating the unsavoury aspects of road freight transport.

This review of city access regulations will firstly involve an examination of international case studies in Denmark, the UK, Slovenia, Spain and Sweden. Secondly, the effect of three possible time restriction measures on the survey is analysed. Finally the case for a permit system based on time restrictions in Dublin is discussed.

8.2 INTERNATIONAL CASE STUDIES

8.2.1 Copenhagen

Copenhagen, like many other European cities is increasingly faced with problems associated with freight distribution including pollution, compromised accessibility and urban congestion. These problems have been exacerbated by the narrow winding streets of the Medieval City. The Medieval Centre has an area of 1 km^2 and 6000 vans and lorries enter the area each day. This area has the largest pedestrianised area in Denmark and is the city's main shopping, leisure and cultural centre. It was found that only 15% of vehicles driving into the area have loading greater than 60% of capacity and indeed more than half of the vehicles have loading less than 20% of capacity (OECD, 2003).

On 1 February 2002, the Mayor of Building and Technical Departments of Copenhagen, Soren Pind launched the obligatory trial initiative, "City Goods Ordinance" for the medieval section of the city. Permission for conducting the trial ordinance was provided by the Traffic Ministry in accordance with traffic law §92d.This initiative was prompted by a pilot project on city logistics carried out from 1998-2000. The overall objective of the Ordinance in 2002 was to make the narrow streets of the city centre more accessible, increase traffic safety and improve the city environment through:

- Better use of the capacity of all vehicles
- Establishing of loading and unloading zones
- No stopping policy in the restricted area without a certificate

The City Goods scheme covered a mandatory trial period of 21 months and meant that vehicles and lorries supplying goods that were over 2,500 kg total weight could not stop in the medieval city without a city goods certificate. Lorries over 18,000 kg required a special certificate. The area where the City Goods Ordinance applies can be seen in Figure 8.1 below.

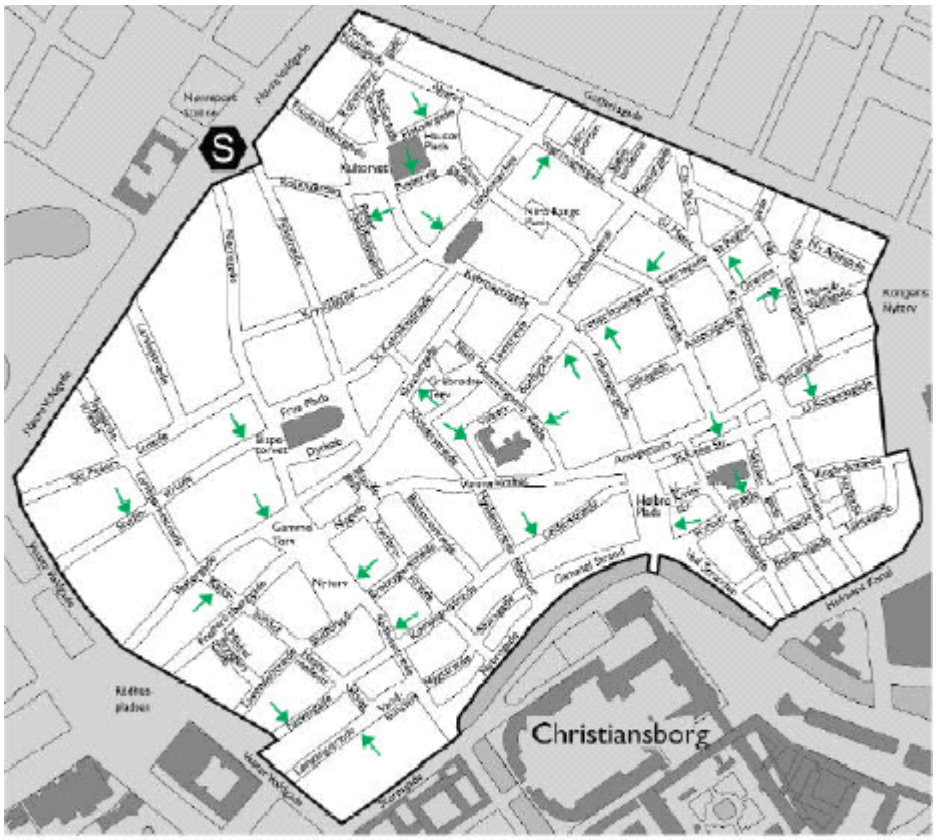

Figure 8.1 The Certification Zone (Area of 1 km^2)

A certification system was used in Copenhagen and three types of certificates were used in the initiative:

1. **Green Certificate**

- Obtained by filling out an application form
- Engine of the vehicle should not be older than 8 years
- On average, 60% vehicle capacity utilisation should be achieved over 3 month periods
- Capacity utilisation achieved must be reported every 3 months to the municipality
- The vehicle's total permissible weight must be in the interval of 2,500 kg and 18,001 kg.
- Exclusive access to 26 attractively located loading zones
- Cost of certificate: 260 Danish Kr. (approx. €37) and valid for entire trial period

2. **Yellow Certificate**

- An option for those who cannot make the Green Certificate's Restrictions
- Special application form used
- Engine of the vehicle should not be older than 8 years
- Vehicle is not longer than 6 metres and/or does not exceed a total weight of 3,500 kg
- Cost of certificate: 260 Kr. (approx. €37) and valid for six month period

3. **Red Certificate**

- An option for infrequent visits to Copenhagen inner-city
- Cost of certificate: 40 Kr. (approx. €6) and is valid only for 1 day
- No application is needed. The certificate can be bought at petrol stations leading to the inner city.
- Does not give access to dedicated loading zones designated for the scheme

In order to facilitate haulage contractors, an amnesty was granted to everyone who could not meet the demands of the certificates in the first year (1 February 2002 - 31 January 2003). It is important to note that truck drivers did not require a certificate to drive through the city. Furthermore in relation to enforcement of the certification system, vehicles over 2,500 kg total weight that stopped on the public street areas in the certification zone were fined by way of a parking ticket for non-compliance. Vehicles without a valid Green City Goods Certificate were fined a parking ticket if they stopped in the loading zones during the times 8.00-12.00, Monday through Friday. Parking fines totalled approximately €70 per ticket.

Other conditions of the certification system included the fact that the issued certificate could be revoked without reimbursement in the event of missing or incorrect information on the application and/or report form or if any additional violations of conditions and duties associated with the ordinance were committed. Moreover, if the carrying capacity condition was not met (i.e. if average carrying capacity was less than 60%), only the Green Certificate was revoked. It was still possible to apply for a yellow certificate for the relevant vehicle. One project manager and 1-3 project

employees in the City Goods Secretariat carried out administration of the City Goods initiative (City Gods, 2003).

Vehicles that were exempt from the City Goods Ordinance included cars for personal transport, electric vehicles, hybrid vehicles, public transport vehicles (with particle filters), rescue vehicles, ambulances, fire engines, road sweepers, tow lorries and TV inspection vehicles.

8.2.1.1 Results of the City Goods Arrangement

Prior to the implementation of the City Goods Ordinance, an extensive information campaign was carried out to ensure high levels of awareness among the public, businesses in the affected area, haulage contractors and other interested parties. This involved advertisement of the scheme in the printed and electronic media along with presentations at conferences, fairs and other business events. It was found from the results of a questionnaire sent out to all haulage contractors in the City Goods database in April 2003 that approximately 50% knew about the arrangement from advertising, while a further 25% learned about the arrangement from signposting. In the same survey, when asked if they experienced any affects of the City Goods arrangement, over 50% of the haulage contractors said they had experienced no effects, 10% found it easier to drive through the city and found better opportunities for unloading (City Gods, 2003).

In March 2003, a public hearing concerning the scheme was held involving residents and firms of the medieval town along with other relevant organisations. It was found that the City Goods arrangement was largely well received by all parties with the exception of trade and services. Trades people expressed their desire at the hearing for further relaxations in the scheme or indeed complete exemption for trade and service purposes.

By the middle of September 2003, approximately 3,000 vehicles were recorded as possessing a City Goods Certificate. Over the first six months of the project, 25% of certificates were green, while 75% were yellow. In 2003, 33% were green with 67% yellow. Vehicles over 3.5 tonnes with an engine older than 6 years could no longer obtain yellow certificates by the end of the amnesty period (1/2/03). Approximately 50% of the green certificates were issued for vans between 3 and 3.5 tonnes. Just 6% of green vehicles were issued for vehicles under 3 tonnes and it was also found that the number of green certificates issued for vehicles over 3.5 tonnes increased from 36% in the first six months of 2002 to 45% in 2003. A breakdown of the goods transported by vehicles with green certificates revealed that 25% involved the transport of general goods, 14% transported pallets, 10% were involved in parcel delivery, refrigerated goods and repairs and trade. The remaining approximately 20% covered other kinds of transport. Repairs and trade on the other hand, covered more than 50% of transportation using yellow certificates while the transport of building materials was responsible for 11% of the total (City Gods, 2003).

Up to September 2003, approximately 37,000 red certificates were sold; this represents an average of approximately 100 per working day over the course of a year. However, since no application form is required for the red certificate, there is an

absence of data available regarding the types of businesses and vehicles using this certificate.

Compliance and enforcement of the arrangement were carried out in two ways. Firstly, fines were imposed both on vehicles that stopped in the certification zone without certificates, and also on vehicles stopped illegally in the loading zones. A stop zone is provided at entrances into the restricted part of the city. Guards check lorries and vans for their certification and load utilisation at these entrances. Approximately 13,500 fines were imposed over the course of the scheme (this corresponds to around 20 fines per day). Secondly, the City Goods Secretariat carried out around 40 audits during spring 2003. This involved a manual examination of the daily registrations, invoices and application forms. Almost half of the haulage contractors did not present the required documentation and inconsistencies were discovered in 50% of cases from the other half of the applications. The inconsistencies were largely blamed on an ambiguous understanding of the reporting procedure.

8.2.1.2 Overall Assessment of the Arrangement

In the Progress Report for the City Goods Experiment (City Gods, 2003), it is noted that the vast majority of vehicles between 2.5 and 18 tonnes stopping in the certification zone possessed City Goods Certificates. However, it is also important to note that many of these vehicles used Red Certificates. This meant that although the vehicle was charged for accessing and stopping in the inner city, there was no onus on the vehicle owner to fulfil the criteria (relating to capacity and engine age) necessary for the green and yellow permits.

A traffic census carried out four times over the period 1999-2003 indicated that the number of vehicles in the range 2.5 to 18 tonnes only decreased slightly. This may be attributable to the fact that a proportion of vehicles did not meet the criteria for the City Goods Arrangement and purchased red certificates. Furthermore, it has been acknowledged that more vehicles passed through the certification zone than was anticipated at the beginning of the scheme. This makes the task of analysing the effect of the scheme on the urban environment even more complicated.

Overall it was found that for vehicles with Green Certificates, average utilisation achieved is approximately 70%. This is one promising result of the initiative, however again it is important to bear in mind that comparison of utilisation of vehicles prior to the scheme is not possible due to a lack of data. Another promising result has been the support of residents in the city and their view that the urban environment has improved as a result of the initiative. Moreover, the 26 designated loading zones have proved a popular feature of the arrangement amongst transport companies.

Ultimately the obstacles that impeded the success of the Copenhagen City Goods Experiment lie in four main areas:

1. Difficulty in verifying the data provided by companies on capacity utilisation.
2. The possibility of exemption from the ordinance by buying a red certificate (and thus avoiding capacity utilisation and engine age conditions).
3. The levels of through traffic passing through the Certification Zone (also exempt from the ordinance).

4. A lack of quantifiable success criteria that would clearly illustrate the effects of the arrangement.

However, in spite of these difficulties the arrangement is a good starting point for the application of innovative solutions for urban goods transport and provides valuable lessons for other cities like Dublin who are examining new approaches to urban freight. In particular, the continued consultation and co-operation between the transport companies and the Municipality of Copenhagen throughout the trial period ensured constant feedback from the companies. Indeed it is stated in the Progress Report for the City Goods Experiment that "among firms and the representative of the transport services, the support has been remarkable" (City Gods, 2003).

8.2.2 Stockholm, Gothenburg, Malmo and Lund

Another way of restricting traffic for certain types of vehicles in specific areas in cities is through the implementation of Low Emission Zones (LEZ) (also called Environmental Zones or Clear Zones). Watkiss et al. (2003) define a Low Emission Zone as " a defined area that can only be entered by specified vehicles meeting certain emissions criteria or standards". A LEZ also prohibits older vehicles operating within the given area and in this way encourages a more rapid fleet turnover.

The biggest cities in Sweden –Stockholm, Gothenburg, Malmo and Lund have introduced LEZs in the centre of each city. Although the LEZ regulations are not harmonised with European Union emission standards, they have been made possible through Swedish law under the Road Traffic Act, April 1992 (LEDA, 1999). The first LEZs were implemented in Sweden in 1996 in Stockholm, Gothenburg and Malmo, with Lund following suit in 1999. The size of the environmental zones for Stockholm, Gothenburg, Malmo and Lund respectively are $35km^2$, $15km^2$, $9km^2$ and $4km^2$.

It was decided to follow a similar template for the operation of the LEZ in all four cities. The environmental zones programme applies to trucks and buses with a diesel engine and a gross vehicle weight of greater than 3.5 tonnes. The basic requirement for entering the zones is that these vehicles must not be more than eight years old (as determined from the first date of registration). Older vehicles, depending on their age can either be exempted or banned completely from the LEZ. Vehicles older than 15 years are banned, while vehicles aged between 9-15 years old must be retrofitted with an emission control device in order to enter the zone. The required emission reductions for retrofit equipment can be viewed in Table 8.1 below.

Emissions	Demand Level B	Demand Level C
Particulates	-80%	-80%
Hydrocarbons	-80%	-80%
Oxides of Nitrogen	No Increase	-35%
Noise	No Increase	No Increase

Table 8.1 Required Emission Reductions From Retrofit Equipment

Demand Level B= Subsequently installed catalytic converter with particle filter.
Demand Level C= Equipment for reducing oxides of nitrogen (NO_x).
Source: Feychting et al.

In total, there are four sets of circumstances where exemptions for the LEZ regulations may apply (City of Göteborg, 2002):

1. Vehicles with extra low emissions
Vehicles with the potential to be certified according to Euro IV or better may be permitted to operate in the zone for additional years.

2. Vehicles equipped with after treatment device
Vehicles more than eight years old may enter the LEZ for additional years of they are equipped with an appropriate after treatment device

3. Vehicles with "special bodywork" and approved after treatment device
Vehicles with special bodywork older than eight years and equipped with exhaust emission control will be provided with an exception that allows them to travel in the zone

4. Change of engine
If the vehicle has been equipped with a new engine of at least Euro III standard, the vehicle may enter the zone for some additional years.

Permission to drive in the LEZ must be proved by displaying a permit sticker on the vehicle windscreen. The sticker shows the period of validity, the first registered year of the vehicle and the registration number of the vehicle. The permit stickers are available from the relevant municipalities and are valid in the other environmental zones (LEDA, 1999). General exceptions from the scheme are given to freight vehicles used for international road transport. This has led to complaints from Swedish carriers since it is felt that the LEZ is not administered on a level playing field when certain vehicles are exempt from zone regulations.

8.2.2.1 Results of the LEZs in Sweden

Calculations for the Göteborg LEZ, show that after a five-year period the direct environmental gains cover 80% of the costs (i.e. investments made by transport companies). There are also other gains, which are more difficult to put an economic value on, such as the speeding up of technological development (in terms of fleet turnover) (LEDA, 1999). The main impact of the LEZs is the reduction in emissions from heavy vehicles. An evaluation of the program carried out 1 year after its introduction showed the following emission reductions from heavy-duty vehicles shown in Table 8.2 below (LEDA, 1999).

Reductions in Emissions from Heavy Vehicles	
Particles	15-20%
HC Emissions	5-9%
NO_X Emissions	1-8%

Table 8.2 Reduction in Emissions Following Year 1 of the LEZs

Furthermore it is estimated that 3,000 vehicles have been retrofitted with emission control systems over the first three years of the program duration (DieselNet, 2002).
A specific evaluation of the Stockholm Environmental Scheme was done using traffic data sets and modelling systems used by the Stockholm Municipality. Emission and

concentration modelling work was carried out using the AIRVIRO system (Rapaport, 2002). Two scenarios were used for the evaluation of the Stockholm Environmental Zone- no zone scenario and environmental zone in place scenario. In addition, two time periods were used for the study - 1995, the base year and 2001, the year when the difference between emission levels was estimated to be at its highest. Results from the evaluation are summarised in Table 8.3 below. The Environmental Zone appears to be most effective on emissions and concentrations of particles and to a lesser extent on nitrogen oxide. For the year 2001, a 25% difference in particles was noted along with a 5% difference in nitrogen oxide emissions. The highest levels of nitrogen (according to the model) should decrease by 32% with the Environmental Zone and by 29% without the zone. This implies that the 4% difference is attributable to the zone. However, the zone appears to have little impact on Volatile Organic Compounds (VOC), carbon monoxide and dioxide.

In all, the key benefit of the Environmental Zone lies in the fact that it imposes new, more environmentally friendly technology on the market by encouraging the purchase of cleaner vehicles or upgrading of vehicles.

Year	**1995 (Base Yr. Tons/yr**	**2001 (Without environmental zone tons/yr)**	**2001 (With environmental zone tons/yr)**
CO			
All other traffic	13290	5154	5154
Heavy traffic	94	88	78
Percent	0.70	2	2
NO_X			
All other traffic	652	344	344
Heavy traffic	172	138	120
Percent	26	40	35
VOC			
All other traffic	2186	1038	1038
Heavy traffic	43	41	37
Percent	2	4	4
Particles			
All other traffic	11.8	8.07	8.07
Heavy traffic	5.37	4.12	2.08
Percent	46	51	26
CO_2			
All other traffic	253469	245490	245490
Heavy traffic	26210	25993	25868
Percent	10	11	11

Table 8.3 Estimates of Air Pollution Emissions from Traffic for the Years 1995 and 2001

8.2.3 Barcelona and Maribor

Barcelona is another example of a European city that has implemented zone access restrictions in the city centre. There are three controlled entry points to the restricted zone, which is located in the centre of Barcelona. Restriction measures were first implemented 20 years ago despite initial apprehension of businesses in the affected area. The primary motivation for establishing the zone was to ease the traffic in the historical area of the city, thereby improving the quality of life in the area. Rising bollards and gates protect the restricted zones. Entry to the zones is only possible at certain times - it is not permitted for vehicles to access the zone between 11am and 3pm and between 5pm and 8pm. Therefore deliveries and other commercial visits must be made outside of these hours. Entry to the zone is controlled by the use of swipe cards or by telephoning the control centre at one of the three gates and obtaining access (Transport Benchmarks, 2004).

Among the new accession countries to the European Union, there has also been a move towards managing urban freight distribution, particularly in the city centres. Maribor in Slovenia is the second largest city in the country and has 115,000 inhabitants. According to recent plans of the city's administration (BESTUFS, 2003e), a new approach to access to the central part of the city is being taken. Previously, access to the centre of the city was controlled through one entrance/exit point. Deliveries were allowed only during the night from 21:00 to 07:00 and deliveries that occurred during the day were only allowed in special delivery areas. However, frequent violations of the system combined with an increase in business units and business activity meant that a new approach was required. It is now proposed that vehicles enter the restricted city centre zone through controlled gates under certain conditions. Delivery times are from 6:00 to 9:00 and from 19:00 to 22:00 Monday to Friday and from 13:00 to 15:00 on weekends. Exceptions from these conditions are made for perishable goods deliveries, construction and maintenance works, security and taxis. Vehicles over 3.5 tons are obliged to possess a special permit, which requires paying an entrance fee. The entrance fee is paid for deliveries out of regular delivery times. Details of fees payable can be seen below in Table 8.4. Deliveries using vehicles over 3.5 tons are only permitted in the case of specific goods (in terms of weight, dimensions etc.) that cannot be delivered using a 3.5 ton vehicle.

One year entrance fee for vehicles up to 3.5 ton (perishable goods)	350 Euro
One day entrance fee for trucks up to 3.5 ton	50 Euro
One day entrance fee for trucks above 3.5 ton	210 Euro
One day entrance fee for passenger cars	5 Euro
Fine for each additional hour above allowed delivery duration (40 mins)	10 Euro

Table 8.4 Entrance Fees for City Centre Access in Maribor

In a similar way to the Barcelona access control system, entrance to the restricted zone in Maribor is controlled via rising bollards. In addition to the bollards, identification equipment is also used. On entering a zone gate, an ID card (which stores details of the card owner and vehicle) must be read by special equipment. The time of entry and the entry gate concerned are recorded. If the ID card is deemed

valid, the bollards sink and once an exit inductivity loop is passed the bollards return to their original upright position.

As a result of the new control access system in Maribor, it had been noted that there is decreased congestion at the entry/exit gates. Furthermore, the new system has ensured a greater level of control over vehicle access to the restricted area, thereby reducing violations of the scheme (BESTUFS, 2003e).

8.3 ILLUSTRATING THE EFFECTS OF CITY ACCESS CONTROL BASED ON TIME RESTRICTIONS USING SURVEY DATA

On the 1st of March 2004, Dublin City Council (DCC) launched a pilot scheme to improve traffic flow and road safety. The scheme involved the imposition of restrictions on allowable delivery times in the city centre. The restrictions involved the introduction of 9 ½ hour clearways on strategic routes. Affected streets can be seen in Figure 8.2.

Figure 8.2 Routes Affected by the DCC Clearway Hours

The clearway hours mean that no on-street deliveries are permitted on the highlighted streets indicated above on the map between 7:00am and 10:00am and between 12:30 pm and 19:00pm except where there are indented loading bays and/or paid parking. Normal deliveries are permitted between 19:00pm and 7:00am and between 10:00am and 12:30 pm Monday to Saturday and all day Sunday (Dublin City Council, 2004).

8.3.1 Scenario 1:Examining the Effect of the Application of the Clearway Delivery Hours Ignoring Loading Facilities Used

Using the data collected for the overall city centre business survey, it was feasible to examine the impact of a permit system based on the DCC pilot commercial vehicle delivery strategy allowable delivery hours. This examination involved a number of steps.

Firstly, arrival times in our survey dataset were examined and were classified individually as allowable delivery times or banned delivery times. It was found that at the time of the survey (Spring/Summer 2003) 54% of deliveries (492 in total) arrived during the "banned" delivery hours. Only 45% of the total of deliveries (409 in total) arrived during the allowable delivery hours. The remaining 1% was accounted for by missing data.

The second step in the evaluation involved assigning new delivery arrival times to those deliveries that occurred outside the allowable delivery hours. As a starting point, it was decided to use a random number generator to ascertain new delivery times. The times of the day were classified as minutes, so for example midnight was 0 minutes, 1:00am was 60 minutes 2:00 was 120 minutes and finally 11pm was 1380 minutes. The random number function in Visual Basic (VB) was used to produce 492 integers. The VB code can be viewed in Appendix G. A number of rules were incorporated in the code. Random numbers were only generated between 300 minutes and 1380 minutes (i.e. between 5:00am and 11:pm). This was a reflection of the trend found in the overall survey where almost all of the deliveries arrived between the hours of 5:00 and 11:00pm. In addition, rules were implemented that ensured that delivery times did not arise within banned delivery hours. The random number process was carried out fifteen times to produce fifteen separate sets of random numbers. The consistency of the random data sets was checked by obtaining the mean for each individual set and then getting the standard deviation of all of the means. A standard deviation of 17.09 was obtained. This represents 0.018% of the total mean of all the groups of random numbers. Standard deviation is a measure of the variance (spread of a set of data). As the variance of a sample of data is based on the sum of the differences between each value and the mean, it is larger when the values are further from the mean and the data are more spread out, and smaller when the values are closer to the mean. In other words, the standard deviation value obtained (17.09) indicates a level of consistency in the arrival times generated.

The third step in the evaluation involved selecting one set of random numbers from the set of fifteen. Again this was done on a random basis using the random function in VB. Having selected the random number group to be applied to the overall dataset, the random integers were converted into times, for example 1378 minutes was 22:58 and 692 minutes was 11:32. Once all the random numbers were converted into twenty-four hour time format, the new delivery times were randomly assigned to the 492 deliveries that had originally occurred during banned delivery hours. The impact of this was then analysed.

8.3.1.1 Traffic Implications of Scenario 1

Having applied the new delivery times, the first area of analysis is the pattern of new delivery arrival times. Figure 8.3 below illustrates the number of deliveries arriving each hour under a new system of time restrictions. It was found that if the DCC pilot clearway hours were introduced in the city centre this would lead to 22% of deliveries arriving between 10:00 and 11:00, 18% arriving between 11:00 and 12:00 and 8% arriving between 12:00 and 12:30. It was also found that 9% and 11% of deliveries would occur between 5:00 and 6:00 and 6:00 and 7:00 respectively. Between 19:00 and 23:00, a steady flow of deliveries was observed with 6%, 6.5%, 6.5%, 6.7% and 5.5% of deliveries occurring during these hours.

In the situation where no clearway hours exist, the busiest hour for deliveries is between 10:00 and 11:00 (16% of deliveries occurring in this hour). Therefore an increase of 6% in the number of delivery trips is observed at this time. There is also a 4% increase in the number of deliveries between 11:00 and 12:00. Furthermore an increase of 1% is observed between 12:00 and 12:30. However it appears that most of the deliveries previously occurring in "banned" times are accommodated in the hours between 19:00 and 23:00 where an average increase in the number of delivery trips of almost 6% each hour is observed.

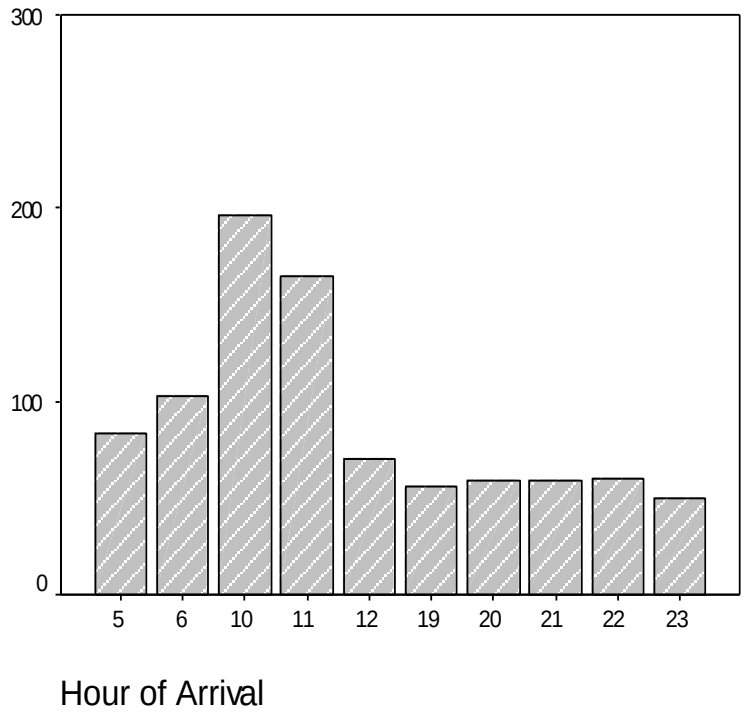

Figure 8.3 Frequencies of Deliveries Using Newly Generated Arrival Times

8.3.1.2 Noise Implications of Scenario 1

One particular cause of concern about the environmental effect of urban freight is truck noise. The approach used to quantify marginal external noise costs of forcing deliveries into particular time frames is again based on the UNITE Programme (Bickel et al., 2003) where a great deal of consideration was given to the area of

costing noise levels in different cities. If deliveries are forced into particular hours of the day or night, there are likely to be noise level repercussions on the areas affected. The costs due to noise from road vehicles outlined in the UNITE programme provide a framework for the analysis of the effect regulating allowable delivery times.

Because of their size and more powerful engines, trucks produce noise levels as much as 15dBA (A-weighted decibel scale). The principal causes of truck noise are exhaust, gears, fan, air intake and tyres. Engine exhaust noise tends to dominate for most operating conditions, particularly during acceleration (Ogden, 1992). Therefore, it was decided to focus on the noise effects of changing the delivery times of trucks.

Berlin and Stuttgart formed important case studies in the UNITE Report (Bickel et al., 2003) and the HGV noise costs obtained for these cities were used as a basis to estimate the environmental costs involved in designating allowable delivery times. The costs per HGV vehicle kilometre for day and night for the two cities can be seen below in Table 8.5.

Location	HGV- Daytime	HGV- Night Time
Berlin	7.67 cent	23.33 cent
Stuttgart	25.75 cent	78.25 cent

Table 8.5 Overview of Costs Due to Noise from HGVs in €cent/vkm

The first step involved in analysing the costs due to noise from trucks involved assigning the daytime and nighttime costs to our original survey data. In the UNITE project, nighttime hours were defined as from 23:00 to 07:00. The disturbance caused by trucks is greater at night because it may disturb people relaxing or sleeping. Therefore a higher cost is associated with vehicles operating during nighttime hours (as can be seen from Table 8.7). Deliveries occurring at nighttime are assigned the higher cost (23.33 cent in the case of Berlin and 78.25 cent in the case of Stuttgart). Deliveries during daytime hours are assigned the lower cost. The next step is to calculate the cost for the entire journey. This is done by multiplying the cost per kilometre by the distance travelled (in kilometres). So for example, if the cost per kilometre is 25.75 cent and the distance travelled for one particular delivery is 8.13 km, the total cost due to noise for that delivery is 2.0935. The noise cost of deliveries for all the deliveries made by trucks in the original survey data using this approach is in the range €831.62 (for Stuttgart) and €2790.35 (for Berlin). These figures represent the costs applied to the 354 truck deliveries identified in the survey for one day.

Once the cost of noise of the original survey data has been calculated, the next step is to calculate the effect of each scenario on noise costs. The difference between the original costs and the noise costs incurred with each scenario is then determined. Scenario 1 examined the effect of applying clearway hours (7:00-10:00am and 12:30pm-19:00) to all deliveries regardless of the type of loading facilities used. Once the deliveries occurring in the clearway hours are assigned new arrival times, the effect of the changed truck delivery times on noise costs is calculated. The approach used to calculate the cost of truck noise in the original survey is used to determine the effect of scenario 1. In this case, the noise cost of the scenario ranges from €1174.15 to €3939.69 using the Berlin and Stuttgart costs per kilometre. This represents a significant increase in the cost of noise due to trucks of 41.19% from the original dataset costs (€831.62 and €2790.35). This indicates that a scheme that restricts

deliveries without consideration of the loading facilities used is likely to increase the cost of noise considerably.

8.3.1.3 Air Pollution Implications of Scenario 1

The air emissions implications are also of interest when analyzing the potential effects of a new delivery management strategy. Again, the approach used to quantify marginal external exhaust emissions and greenhouse emissions costs of forcing deliveries into particular time frames is based on the UNITE Programme (Bickel et al., 2003). Costs per kilometre outlined in the programme for the cities of Berlin and Stuttgart were applied to the data gathered in the overall business survey. The costs can be seen in Table 8.6 below. The UNITE Programme provides details of costs for HGVs, diesel cars and petrol cars. For the purposes of this report, the costs for HGVs were applied to trucks and the costs for diesel cars were applied to LGVs and cars in the survey

Location	Greenhouse Gas Emissions-HGV	Greenhouse Gas Emissions-Diesel Car	Exhaust Emissions-HGV	Exhaust Emissions-Diesel Car
Berlin	3.28	0.31	10.19	0.73
Strasburg	3.28	0.31	7.46	0.38

Table 8.6 UNITE costs for Greenshouse Gas Emissions and Exhaust Emissions in €cent / vkm

In order to assess the impact of directly applying the clearway hours on the cost of air emissions, the UNITE greenhouse gas emission costing and exhaust emissions costings were applied to deliveries for each scenario that occurred between the hours of 9:00 and 17:00. These hours were selected because they largely represent "regular" working hours when most workers are present in the city centre and when most shopping activities take place. The environmental conditions during these hours affect the quality of life or "liveability" of the city. Air quality is usually incorporated in liveability ratings (Taniguchi et al., 2003).

Applying the Berlin and Strasburg costs to deliveries in the original survey, it was found that the cost of emissions ranged from € 694 per day (Strasburg costs) to €884 per day (Berlin costs). Over the course of year (260 days) this totals betweeen €180,440 and €229,840.

When the UNITE costs were applied to Scenario 1, it was found that there was a 31% reduction in the cost of greenhouse gas emissions and exhaust emissions between 9:00 and 17:00. It should be noted that while air quality is likely to improve during daytime hours, an overall reduction in the cost of emissions is not observed since Scenario 1 forces early morning and late night deliveries. Therefore the reduction in the cost of emissions during the day is offset by additional deliveries between 19:00 and 7:00 and between 10:00 and 12:30. However it must also be acknowledged that a reduction in the cost of greenhouse gas emissions and exhaust emissions during the day would have a substantial effect on the liveability of the city in terms of air quality.

8.3.2 Scenario 2:Examining the Effect of the Application of the Clearway Delivery Hours taking into Account Loading Arrangements Used

Table 8.7 below illustrates the loading arrangements used for all deliveries found in the dataset to occur in the DCC restricted times. On-street parking is used in 45% of cases while dedicated loading bays are used in 42.5% of cases.

		Frequency	Percent
Valid	on-street parking	222	45.1
	shared loading bay	59	12.0
	dedicated loading bay	209	42.5
	other	2	.4
	Total	492	100.0

Table 8.7 Loading Arrangements of Deliveries Occurring Within Banned Delivery Times

The next step in the evaluation of delivery restrictions by time of day is to directly apply the DCC pilot scheme. In other words, deliveries that occur in restricted times that do not use on–street parking are permitted. This means that 222 new arrival times must be generated. Again, the numbers are randomly generated using VB. This time however, deliveries made using shared loading bays or dedicated loading bays were added to the data set of allowable delivery times.

8.3.2.1 Traffic Implications of Scenario 2

Figure 3 below shows the distribution of deliveries using this scenario. It was found that when deliveries using shared or dedicated loading bays were allowed during the DCC restricted times the peak hour for deliveries still occurred from 10:00 to 11:00 (20% of total). This represents an increase of 4% in the number of delivery trips from the situation observed in the original survey result. The next busiest delivery hour was found to be from 11:00 to 12:00. However, outside of these hours, the number of deliveries per hour does not exceed 10% of the total. There is a relatively even distribution of deliveries from 5:00 to 9:00 and from 13:00 to 23:00.

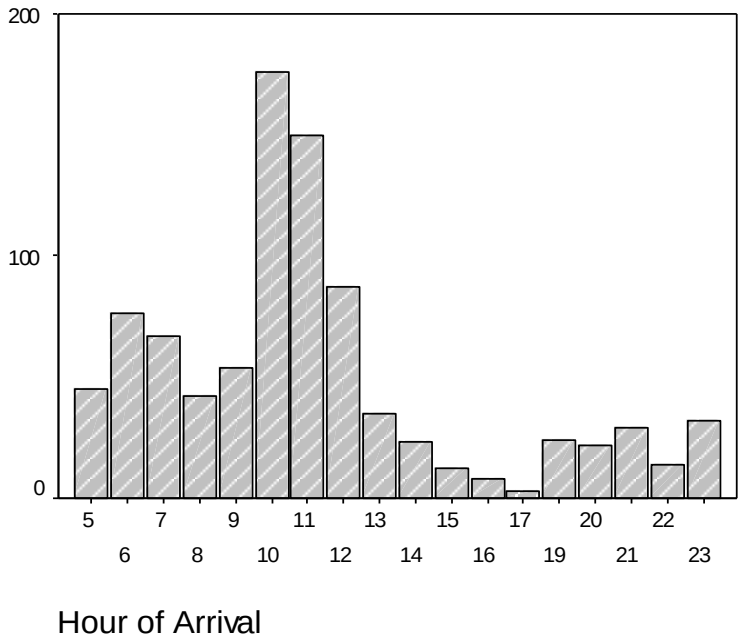

Figure 8.4 Frequencies of Deliveries Using Newly Generated Arrival Times Taking into Account Loading Arrangements Used

8.3.2.2 Noise Implications of Scenario 2

In Scenario 2, the clearway hours were applied to all deliveries except where either shared loading bays or private loading facilities were used. Deliveries that occurred in restricted times and used on-street parking were prohibited. Calculating new arrival times for these deliveries created a new dataset, which had repercussions for the noise costs incurred. Again the HGV daytime and nighttime costs per kilometre were assigned to each truck delivery and multiplied by the total distance in kilometres for each delivery distance to give a total cost. The total cost for Scenario 2 was in the range €831.46 (using Berlin cost figures) to €2790.82 (using Stuttgart cost figures). There is only a slight difference between the noise cost of the original survey data and the noise costs applying Scenario 2 (-0.02% for Berlin and 0.02% for Stuttgart). Therefore it may be concluded that in terms of noise, applying the clearway hours to all deliveries except those that do not use indented loading bays or paid parking will not have a significant effect on noise cost.

8.3.2.3 Air Pollution Implications of Scenario 2

The UNITE costs outlined in Section 8.3.1.3 were again used to evaluate the air emissions implications of Scenario 2 where clearway hours were applied to all deliveries except those with private or indented loading facilities. For this Scenario a reduction in the cost of air emissions of approximately 9% between the hours of 9:00 and 17:00 was found. Although 9% may be considered a reasonable reduction, it is still considerably less than the 31% reduction found in Scenario 1. This is largely because of the fact that Scenario 2 allows for certain deliveries during clearway hours (i.e those with private or indented loading facilities).

8.3.3 Scenario 3: Examining the Effect of the Application of a Restriction Involving the Prohibition of all Vehicles within the DCC Restricted Times Except Trucks using Dedicated Loading Bays

Scenario 3 involves an evaluation of the impact of restricting all vehicles within the DCC restricted times with the exception of trucks using dedicated loading bays. The motivation for examining this scenario lies in the fact that, trucks by the nature of their size occupy more loading space than other delivery vehicles. They also offer more opportunities because of their size to reduce the number of delivery trips to the city centre by increasing the consignment size. Therefore, accommodating large vehicles that do not provide an on-street nuisance during restricted times was a scenario that merited consideration. This scenario was carried out by ascertaining the number of deliveries that occurred within the restricted hours that involved a truck and a dedicated loading bay. It was found that 91 deliveries out of a total of 492 fulfilled the criteria. These deliveries were added to the dataset of deliveries occurring during allowable times of the day. The remaining deliveries (401) occurred during restricted times. Therefore, a corresponding number of new arrival times were randomly generated in VB. These new delivery arrival times were assigned to the 401 deliveries and the impact was then calculated.

8.3.3.1 Traffic Implications of Scenario 3

The effect of the strategy on the frequency of deliveries per hour can be seen below in Figure 8.5. Figure 8.5 illustrates a "bunching" effect resulting from the scenario. Between the hours 10:00-11:00, 11:00-12:00 and 12:00-13:00, 22%, 19% and 9% of deliveries arrive respectively. Very few deliveries occur between 13:00 and 19:00. This is due to the small number of trucks delivering in this time. In the overall survey it was found that 93% of trucks arrive before 14:00. Therefore, a strategy that focuses on allowing trucks deliver within restricted times is unlikely to have a far-reaching effect on the pattern of delivery arrivals to the city centre in general.

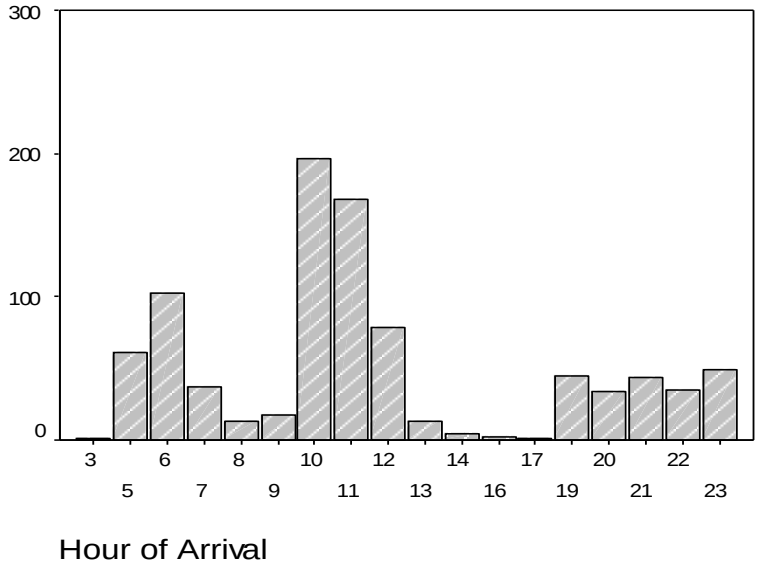

Figure 8.5 Frequencies of Deliveries when Trucks Using Dedicated Loading Bays are Permitted in Restricted Delivery Time Windows

8.3.3.2 Noise Implications of Scenario 3

In Scenario 3, the effect of prohibiting deliveries within clearway times with the exception of trucks using private loading bays was examined. New arrival times were calculated for deliveries that did not fulfil arrival time criteria (i.e. arrived within the clearway hours) or did not fulfil the vehicle mode and loading facility criteria (i.e. were not trucks using private loading bays). Calculating new arrival times can affect the cost of noise since different noise cost per kilometre is assigned to each delivery depending on the time of day in question. For Scenario 3, the cost due to noise from trucks was calculated to be between €915.34 (using Berlin cost figures) and €3072.15 (using Stuttgart cost figures). This represents an increase in cost of approximately 10.1% from the noise costs calculated from the original dataset.

Therefore, the scenario that produced the greatest impact on the noise cost was Scenario 1. This was the only scenario that did not take into consideration to any degree the loading facilities used for each delivery – may need to include other characteristics of Scenario 1 here as well. This finding highlights the importance of the type of loading facilities used for urban deliveries.

8.3.3.3 Air Pollution Implications of Scenario 3

For this Scenario, a reduction in the cost of greenhouse gas emissions and exhaust emissions of approximately 12% was calculated. Over the course of the year, the cost of emissions is estimated at between €158,860 and €202,020 (applying the Berlin and Strasburg emissions costs). Therefore this scenario ranks second among the three scenarios analysed in terms of air pollution implications.

8.4 CITY ACCESS CONTROL BASED ON RESTRICTED DELIVERY TIMES: THE CASE FOR DUBLIN

As highlighted in the opening section of this chapter, a comprehensive commercial vehicle management strategy in Dublin is necessary to deal with vehicles that will not use the Dublin Port Tunnel. This strategy should complement any HGV Management Strategy adopted by Dublin City Council in the future to ensure that commercial vehicles are dealt with in a manner that is as efficient as possible. In the Delcan Report (2004) the favoured option for a HGV management strategy for Dublin City is to restrict HGV access to the Canal Cordon to permit holders only. This option is based on the premise that HGV movements into the Canal Cordon are restricted to off-peak periods (such as 19:00 to 7:00) and only HGVs with a special permit can enter the area. However this permit is described as an "exception rather than the rule" with permits issued by the DCC only for compelling reasons to travel within the Cordon. Since the Delcan Report deals primarily with HGVs (where HGVs are classified as any truck that exceeds 17 tonne GVW), a need exists for a management strategy for smaller vehicles entering the city centre. It as identified in the survey that 55% of vehicles entering the city centre were vans. A permit system based on restricted deliveries times would provide a level of control over the extent of commercial vehicle access to the city centre.

When evaluating the potential for a permit system for commercial vehicles a number of key questions must be dealt with, namely:

- Why are access restrictions necessary for Dublin?
- Who are the stakeholders involved?
- What is the likely impact on the actors involved
- What vehicles would be affected?
- Where in the city would the system apply?

8.4.1 Why are Access Restrictions Necessary for Dublin?

The OECD (2003) describes freight transport as a "fundamental component of urban life" and as such it must be managed efficiently, particularly within an urban context. A number of undesirable externalities associated with road freight transport (environmental problems, safety problems, energy consumption) demand that measures should be introduced that serve to mitigate the effects of freight transport without impeding economic activity. According to the UK Round Table on Sustainable Development (1996):

"there is no magic solution to the many problems caused by present land transport patterns and trends. But there is much that a co-ordinated, sustainable transport strategy can do to minimise current and anticipated future adverse impacts and their associated costs, efficiently and equitably while continuing to deliver or improve on existing benefits".

Access restrictions are necessary specifically for Dublin as part of a set of overall traffic improvement strategies for the city. In particular, the opening of the Dublin Port Tunnel (DPT) requires a complementary strategy for deliveries to the city centre. City access regulations must be clearly outlined for vehicles whose trip does not involve the Port Tunnel.

8.4.2 Who are the Stakeholders Involved?

Several actors are directly and indirectly involved in urban goods distribution. The introduction of any access control system for commercial vehicles is likely to impact upon these actors in some fashion. Therefore, it is important to study the likely impact of restrictions on all parties involved. BESTUFS (2000) lists the main interest groups for urban goods distribution below in Table 8.8.

Actor	Interest in terms of urban goods transport
Shipper	Delivery and collection of goods at lowest cost while meeting the need of customers
Transport Company	Low cost, high quality transport operation, satisfactory service for shippers and receivers
Receiver/Shop Owner	Products delivered on time, at a short lead time
Inhabitant	Minimum hindrance caused by goods transport
Visitor/Shopping Public	Minimum hindrance caused by goods transport and a high variety of latest products in the shops
Local Government	Attractive city for inhabitants and visitors; minimum hindrance with an effective and efficient transport system
National Government	Minimum external effects from transport, maximum overall economic situation

Table 8.8 Actors Involved in Urban Goods Distribution and their Interests

One option for formalising the consultative process for the possible introduction of a new commercial vehicle management strategy is to establish Freight Quality Partnerships (FQPs). FQPs may be thought of as "a means for local government, businesses, freight operators, environmental groups, the local community and other interested stakeholders to work together to address specific freight transport problems. They provide a forum to achieve best practice in environmentally sensitive, economic, safe and efficient freight transport" (DfT, 2003a). The creation of an FQP would allow relevant local authorities such as Dublin County Council to approach stakeholder consultation for the introduction of any new urban goods distribution strategy in a structured manner. FQP members for a Dublin scenario could include:

- Dublin City Council (along with other local authorities in the Greater Dublin Area)
- The Department of Transport (Road Haulage Section)
- Dublin Transportation Office
- National Roads Authority
- Environmental Protection Agency
- Sustainable Energy Ireland
- Irish Road Haulage Association
- Various trade associations (IBEC, DCBA, RGDATA etc.)
- Dublin Chamber of Commerce,
- An Garda Síochána.
- Dublin Port Company

The key benefits of FQP for Dublin include the following:

1. Enhanced understanding between different stakeholders

The interactive nature of an FQP helps to provide local authorities with a clearer understanding of the operational need of businesses and the freight transport industry.

Conversely, businesses and freight operators gain a greater appreciation for local authority policies and the difficulties involved in developing an urban freight strategy.

2. Increased levels of knowledge
Up to this point, freight in Ireland has been an understudied area that has produced more problems than solutions. FQPs could serve as a briefing mechanism for local authorities on freight issues in Dublin.

3. Simulation of best practice principles
The exchange of ideas between the various parties of an FQP can lead to the development of clear principles on best practice for the implementation of new freight management initiatives.

FQPs have been widely used in the UK in recent years. The first partnerships were established in the mid-90's and by 2003, 31 FQPs were in place. They have produced agreements on routing, load sharing and town centre access, helping to reduce congestion, emissions and the number of vehicles in urban centres (DfT, 2003b). Approximately 30 local authorities in the UK have already put in place formal agreements and arrangement for a FQP. These include Hampshire, Southampton City, Surrey, Kent, Ripon, Northamptonshire, the West Midlands, Leicestershire and Nottinghamshire (Browne et al, 2003).

8.4.3 What is the Likely Impact on the Actors Involved?

Vehicle access time restrictions reduce the times during the working day that vehicle can enter designated areas to carry out freight work. Coupled with time restrictions imposed by customers and receivers, this can result in distribution companies having very little time in which to perform their work, placing their operations under significant strain. Options available to companies facing access restrictions in a city include the following:

- Attempt to continue delivering and collecting goods during the working day. This could be achieved by compressing the time in which deliveries take place, by operating a greater number of vehicle rounds
- Deliver and collect goods in the restricted area at night. This could involve the use of an urban distribution centre
- The company could continue to operate delivery trips at current times and then drivers could park the vehicles on the edge of the restricted area and deliver the goods by foot. This could involve last mile goods management
- Deliver in the prohibited hours and risk incurring penalties

Businesses receiving goods in a restricted zone may be forced co-ordinate out of hours deliveries with distribution companies as a result of vehicle access time restrictions. Many premises receiving deliveries do not currently allow out of hours deliveries. The main reasons for this are they either (1) do not have facilities to ensure the security of their premises if staff are not present at the time of delivery, or (2) are worried about the accuracy of deliveries if staff are not present or (3) do not want to have to pay their staff for out of hours work.

In order to estimate the possible additional staffing costs of the implementation of clearway hours (7:00-10:00 and 12:30 to 19:00) to small businesses that do not operate outside general opening hours, a case study of one particular shop on the south of the city was used. This shop, a newsagent opens daily from 9:00 to 18:00. A typical delivery day involves four deliveries. From the survey data it was found that three of these deliveries are received during time periods, which fall into clearway hour time zones. If the clearway delivery hours were introduced, deliveries would be forced to occur either between 10:00 and 12:30 or after 19:00. The owner stated her belief that given the small time frame for deliveries during the morning, it is likely that it would be necessary to ensure that 2 experienced adult staff were available at least twice a week for around two hours after closing time in order to receive deliveries.

Therefore additional personnel costs for this particular shop total the following:

2 (no. of staff) X 10.5 (minimum wage rate for adult employee + 50% shift premium for overtime) X 2 (no.of hours) = €42

If the shop is forced to accept deliveries after regular working hours twice a week, the total additional personnel costs over a year are €4368.

Local authorities are likely to have a strong involvement in the implementation of vehicle access time restriction measures. In particular, Dublin City Council is likely to be influential in both the planning and operation of any restrictive measures. Enforcement of the measures may entail some degree of Garda involvement.

8.4.4 What are the Likely Effects of the Measures?

Time restrictions could lead to distribution activities being compressed into a shorter period at the start or end of the day. A study of time restrictions carried out in Westminster University (Allen et al., 2003) suggested that bunching of deliveries would have negative impacts on the distribution operations of companies affected in terms of increases in vehicle rounds, total distance travelled and could also result in more queuing at the receiver's premises. The environmental impact of vehicle activity would also be expected to increase if companies respond to time restrictions in this manner. This bunching effect was seen in scenario 3 where trucks using dedicated loading bays were allowed to access the city centre during restricted hours.

However the study also points out that if time restrictions result in more distribution companies operating at night then this could be beneficial from both a commercial and environmental prospective. Commercial benefits would depend on the trade-off between drivers' wages and improved driving speeds. This approach is dependent on willingness of senders and receivers of goods to accept night work. It is also an approach that could benefit from the operation of an urban distribution centre, which would allow greater levels of goods consolidation to be achieved.

8.4.5 What Vehicles Would be Affected?

A permit system in the city centre based on time restrictions would affect commercial vehicles from vans to HGVs.

8.4.6 Where in the City Would the System Apply?

The system would largely apply to the current DCC strategic routes outlined in Figure 2. Analysis of the effect of restrictive delivery hours on survey data largely concerned these streets. However, given future infrastructure developments, namely the Port Tunnel and the associated attempts to control the access of large goods vehicles to the city centre the area in which the control system would apply would require further evaluation and research.

8.5 CONCLUSIONS

The analysis of survey data to evaluate the potential impact of time-based access restrictions to the city centre showed the following:

- When vehicles were restricted to the DCC allowable delivery hours, the number of deliveries occurring at the peak time (10:00-11:00) increased by 6%. Deliveries were reasonably evenly distributed from 12:00 onwards.
- When vehicles were restricted to allowable delivery hours except those vehicles that used dedicated or shared loading bays, again the hours 10:00 to 13:00 proved the busiest times for deliveries. However, an increased level of business activity in the morning in comparison to the evening was also noted
- When vehicles were restricted to DCC allowable delivery hours except for trucks using dedicated loading bays, a degree of bunched delivery arrivals was noted in the data. Three main peaks for deliveries were observed, namely between 5:00 and 7:00, 10:00 and 12:00 and 19:00 and 23:00. This can be explained by the fact that it was found in the overall dataset that the majority of trucks arrive before 14:00 (93%). Therefore, there is only a limited number of trucks using dedicated loading bays that can be assigned to other times of the day

Furthermore, an environmental analysis of the scenarios based on the cost of noise illustrated that Scenario 2, which is based on the DCC pilot commercial vehicle delivery strategy produced the least additional cost. This illustrates the importance of taking into account loading facilities in the city centre when formulating a city delivery strategy. It was also found during the course of the environmental analysis that Scenario 1 produced the greatest benefits in terms of a reduction in the cost of air pollution.

The implementation of a time based permit system requires the evaluation of a number of scenarios such as those analysed in this chapter in order to quantify the effects of such measures. One important effect, which this chapter has highlighted, is the cost to small businesses of accepting deliveries outside regular trading hours. It was estimated that ensuring adequate staff for deliveries could cost small businesses over €4000 per annum.

The success of any system based on time restrictions is likely to depend on the goods receivers' willingness to receive after hours and nighttime deliveries. The roles of initiatives such as Urban Distribution Centres and City Centre Platforms for managing

the last mile of deliveries are likely to receive more attention in the future as complementary strategies for city centre restrictions.

9 PROJECT CONCLUSIONS

9.1 INTRODUCTION

The increasing levels of congestion that affect most cities including Dublin make a city freight regime difficult to manage efficiently and in a sustainable manner acceptable to all the many parties concerned. While policies and strategies to improve the mobility of residents, commuters and customers has merited considerable international research efforts, the management of urban freight has received much less attention. This research was prompted by the recognition that mobility and efficient goods distribution in particular, is crucial for the continuing economic and social viability of the city.

The survey of deliveries to city centre businesses has helped to create a picture of freight delivery patterns on the city's streets. The analysis of this survey, coupled with interaction with logistics service providers and with cities overseas, has assisted in the development of a number of scenarios. It is hoped that these scenarios would serve to mitigate congestion and help manage deliveries in a more sustainable manner. The primary focus of the project is on minimising the need to access the city centre, on taking commercial deliveries out of peak traffic hours and on promoting more eco-friendly and sustainable transport solutions.

It is hoped that this project will be followed up by a number of pilot actions and demonstrations of emerging technologies that facilitates more eco-friendly commercial transport.

9.2 COMPLETION OF THE WORK PROGRAMME

A research methodology was developed to determine how commercial deliveries in Dublin city centre might be managed in a more sustainable way acceptable to all the parties affected. The tasks as set out in the work programme were completed as follows:

9.2.1 Literature Reviews and International Best Practice

A comprehensive review of current international developments in urban freight policies and strategies by the OECD and others confirm the growing importance of city freight related research. The EU supported "BESTUFS" thematic network has encouraged cities to develop innovative solutions for managing city freight and to persuade others to share and to replicate theses experiences. Of particular interest were case studies from the "BESTUFS" cities that reported improved logistical efficiencies arising from the consolidation of deliveries destined for city centre premises, whether carried out externally at outlying supply depots, or managed internally at down town platforms. These measures were found to minimise the need for trips by HGVs and LGVs to the city centre. These measures also facilitated more out of regular trading hours deliveries and night deliveries, thus taking significant volumes of commercial traffic out of peak commuting times.

The deployment of "clean" and silent" vehicles fuelled by alternative fuels featured in many of the EU supported demonstration projects during the past decade. Different types of "eco-friendly" vehicles were developed to help minimise air and noise emissions in congested and polluted historic city centres. The potential of the different eco-friendly vehicle options currently available for deployment in Dublin was reviewed.

9.2.2 Collation and Analysis of Traffic Data

The data available from the CSO and other sources enabled us to track the growth in freight and other traffic during the recent decade. These data confirm the growth in the scale and intensity of traffic during the boom years of the Celtic Tiger economy.

Major freight strategy studies commissioned from external consultants by the DCC and by the DTO in relation to the new port access tunnel were examined. These external studies have helped to complement this research work and to put it in a wider regional context while justifying a focus the micro rather than on the macro aspects of freight traffic management strategy.

9.2.3 Delineation of a City Centre Area for Analysis

On the advice of DCC, the area bounded by the canal cordons was delineated as the area for our investigations. The DCC provided helpful details of the current and planned parking restrictions. The results of the ongoing DCC noise-mapping project indicated the city streets where congestion is likely to be most severe and these areas were selected for our survey of business premises.

9.2.4 Developing an Appropriate Methodology

A suitable methodology was developed to measure the flows and rhythms of commercial deliveries to premises located on the more congested streets. Our approach was influenced by work conducted by a French consortium of municipalities (GART) who have a well-developed expertise in this area.

Before we embarked on our street-by-street survey of retail premises and institutions, we organised a pilot study of the deliveries made to the TCD campus during the course of a typical week. This pilot study enabled us to perfect our methodology and tactics and also provided useful data that we could use in a case study.

A substantial body of research is devoted to understanding the external environmental impacts of transport. For purposes of this study we employed the UNITE methodology to calculate the likely benefits for air quality and for noise reduction of the scenarios that we have developed and evaluated.

9.2.5 Liaison and Interaction with Relevant Stakeholders

Interaction with the DCC and the DTO enabled us to take the relevant public policies and strategies into account and to benefit from the guidance offered. The businesses represented by the Dublin City Centre Business Association (DCCBA) wish to see the city centre prosper as an attractive retailing and business destination. The success of

major retail investment and property development projects currently in the pipeline will depend greatly on having efficient freight mobility systems in place and easy customer access to the city.

The goodwill of the business and trade associations was successfully canvassed and support was forthcoming from the DCCBA, RGDATA (Retail, Grocery, Dairy and Allied Trades' Association), the LVA (Licensed Vintners Association) and RAI Restaurant Association of Ireland. It was nevertheless found necessary to physically call on many premises to obtain a satisfactory response rate and to ensure that our detailed questionnaire was fully completed. It was concluded that the initial postal and telephone surveys gave poor results because of the high levels of "survey fatigue" evident among the Irish business community.

9.2.6 Survey of City Centre Businesses

Both the pilot survey and the overall business survey provided useful information regarding current freight distribution trends in Dublin City Centre. The survey helped to identify high delivery generating zones and the main types of goods delivered in the city. In the main survey, the top three delivery generating zones were found to be Zone 6 (South West of the City), Zone 1 (City Centre) and Zone 12 (South Dublin). It was interesting to note the high level of deliveries that originated in the City Centre both in the pilot survey (47%) and in the main survey (18%). High delivery generating zones indicate a high level of business activity in the area.

The main types of goods delivered in Dublin City Centre were found to be food/beverages, alcohol, clothing, household goods/hardware and pharmaceutical goods. However the predominance of food/beverages in a number of high delivery generating zones indicated the importance of the category in the general commercial life of the city.

With regard to the frequency of deliveries, it was found that the number of deliveries peaks between 10:00-11:00. Overall, the busiest time period for deliveries occurs between 9:00 and 12:00. It was also found that vans were the most common type of vehicle used, accounting for 55% of all deliveries. Trucks accounted for 40% of the total while cars and motorcycles accounted for just 6% of the total. Average dwell time for deliveries was another area of interest. The average dwell time for all deliveries was 14 minutes, but this was found to vary considerably according to business type.

Another key area of interest in the survey analysis was use of different loading facilities for deliveries. Worryingly, 39% of deliveries made by trucks used on-street parking. Given the average dwell time of deliveries made by truck (22 minutes), this finding is a source of concern due to the effects on city centre accessibility.

9.2.7 Identifying and Developing Sustainable Scenarios

Possible scenarios for sustainable city freight management were formulated based on information from the following:

1. The survey data was examined to help identify possible suitable niche applications for sustainable transport
2. An evaluation of the international case experience that might be replicated here
3. Collaboration with key logistics service providers who advised on the operational feasibility of different options and who gave us details of their current and planned operations.

The criteria for selecting potentially suitable solutions included an assessment of:

1. Whether the proposed solution is likely to minimise the congestion caused by deliveries and the excessive occupation of public spaces by large moving or parked vehicles
2. Whether the need for carriers to access the city centre can be minimised
3. The extent to which deliveries can be taken out of peak commuting times
4. Whether the proposed scenarios adequately take into account current trends in supply chain management in terms of just in time deliveries, the "24 hour/ 7 day week and e-commerce.
5. Whether the solutions proposed are operationally and economically feasible having regard to the technologies currently available
6. The environmental and social benefits likely to accrue to the city centre inhabitants and business customers
7. The likelihood of the parties concerned (the municipal authority, the logistics service providers, the business customers and the city dwellers) "buying in" to what is proposed

Four scenarios emerged from our analysis and from our interactions with the interested parties:

9. External consolidation at Urban Delivery Centres (UDCs)
10. Internal consolidation – "Managing the Last Mile"
11. The Adoption of Eco-Friendly Technologies for Deliveries to the City Centre
12. City Access Control

The conclusions arising from our development and analysis of the above scenarios are described below.

9.3 SPECIFIC CONCLUSIONS FROM THE SCENARIOS EXAMINED

9.3.1 External Consolidation at an Urban Distribution Centre

The concept of Urban Distribution Centres (UDCs) has continued to form part of the discussion on more sustainable freight distribution in urban centres. This is due in no small part to a number of international examples of UDCs that have helped to fuel and inform debate on whether the centres should form part of an overall strategy for managing city centre deliveries. International UDCs such as those in Kassel, La Rochelle, Leiden, Heathrow and Fukuoka have operated with mixed success. However the continued relevancy of distribution centres is demonstrated by the recent introduction of a pilot scheme of a consolidation centre in Bristol in May 2004. The scheme will serve retailers primarily located in Bristol's main retail area Broadmead.

The consolidation centre itself is located on the periphery of the city, close to a strategic road network to maximise consolidation benefits.

The benefits of external consolidation both for a company and for traffic in general are demonstrated in the case of the Musgrave Group Distribution Centre located in Kilcock. The motivation for examining this specific case study of external consolidation is largely due to the importance of deliveries of food/beverages in overall city life; one of the findings from our survey of deliveries to city centre businesses.

The key benefit of centralised distribution and consolidation at Kilcock is the reduction of trips that the centre allows for. Taking a sample of 16 city centre stores that Musgraves deliver to, it was found that the distribution centre removes the need for 17 suppliers to deliver direct to these stores. Since most of these suppliers deliver twice a week to these stores, 544 individual trips are eliminated from the supply chain (16 stores X 17 suppliers X 2 times a week). Since MSVC deliveries to the stores in question will increase from 17 to 60 the total reduction in the number of trips to the city centre is 501.

Further benefits of the Kilcock operation include the facilitation of the process of backhauling. This process involves the use of company trucks that have been emptied after deliveries to collect goods from suppliers on the return trips to the distribution centre. Backhauling helps to reduce the number of unnecessary journeys so the efficiency of the process is enhanced by the high levels of supply chain co-ordination that the distribution centre allows for. Backhauling therefore results in fewer trucks on the road and consequently a reduction in the negative environmental impacts of road freight transport.

In terms of quantifying the environmental benefits of the Kilcock distribution centre for the selected city centre stores, it was found that the savings in terms of exhaust emissions, greenhouse gases and night time noise would amount to €2024 per week, totalling €105,245 over the course of a year. In addition fuel savings from the initiative of €1923 per week or €100,000 per annum would result from trips avoided within the canal cordon.

9.3.2 Internal Consolidation – Managing the Last Mile

Deliveries to customers located in congested city centre streets causes congestion and nuisance when this is done by conventional commercial vehicles. The down-town "platform" or "pack station" concept has been demonstrated successfully as a practical way for managing the local distribution of mail and small parcels within designated areas where the density of customers is found to be sufficiently high.

A platform minimises the need for kerb-side deliveries to premises by commercial vehicles because "last mile" calls are made instead by walking or cycling couriers. Modern ICT applications make it possible to alert customers to come to collect their consignments from the platform. Bulk deliveries of mail and parcels can also be made to the platform in the off peak, thereby easing congestion.

We found that a platform for mail deliveries is currently operated by DHL in Sandwith St. to serve their customers in the main city centre business district. Last mile deliveries amounting to 1,000 per day, are made by a team of 20 walking couriers. This has the benefit of taking 12 LGVs out of the congested city centre during the working day.

DHL are satisfied that the introduction of an additional step into their supply chain and the employment of a team of walking couriers and operatives is justified by the overall logistical efficiencies achieved and by the enhanced customer service and reliability enjoyed by up to 800 of their important business clients.

We found that other courier companies, namely SDS and FasTrack consolidate and optimise their deliveries for local distribution at centres which have easy access to the city centre. This was done (up to recently) by SDS at their regional parcels depot at Newlands Cross. At FasTrack all consignments coming by rail from the regions are sorted for local delivery at Heuston station. The FasTrack operation is an interesting example of an inter-modal (mainline rail to road) transport hub in action in Ireland.

For the distribution of morning papers, the "Irish Times" has developed an innovative logistical arrangement whereby the final deliveries of newspapers to dedicated lock-ups attached to newsagents shops, are made by light vans operating from four consolidation hubs which service different parts of the city. These hubs, located near the city centre at Inchicore and other sites, are in turn serviced by large HGVs combinations that deliver the newsprint from their main printing works. This arrangement avoids the need for the large HGVs to access the city centre in the early morning.

The possibility of establishing an Interception Platform to control and manage deliveries within the TCD campus was examined in detail. This scenario was prompted by the heavy volumes of goods that the college generates and by an analysis of the comprehensive data that was gathered from the pilot gate survey conducted during College Green Week of February of 2003.

The project proposes to divert all non-urgent deliveries to the platform and to deny carriers free access to the campus in order to reduce the severe congestion and nuisance that is caused by the current fee for all.

The data was examined to determine what proportion of deliveries could be diverted to the platform and following sorting and consolidation, the categories of goods that might be distributed by in-house personnel.

The potential benefits of this arrangement were found to be considerable, in terms of reducing congestion on campus and in discouraging the practice of some suppliers to make excessive multiple deliveries.

We estimate that access by commercial vehicles to the campus could be reduced by 67% or by 244 vehicles per week. In addition there is the potential to reduce multiple deliveries to the college by at least 16 vehicle trips per week. The resulting reduction in delivery trips to the college, and from the outlying supply depots to the city centre, could amount to 66 trips per week.

By combining these possibilities, it is estimated that the reduction in the total time in which the limited road spaces on campus is occupied by commercial vehicles making non-essential deliveries, would amount to 4.2 "van-days" per week.

The potential benefit of the platform to the college campus would include reduced emissions and noise (valued at €3,600 - €5,500 per annum), greater security and safety, less danger to pedestrians and less risk of collision damage to the fragile fabric of the buildings. Fuel savings would also accrue to the suppliers servicing the college.

There would be additional off-setting costs to the college for operating the platform, even if it was treated as an integral part of the new development plan for the north east corner of the campus at Pearse St. (€40,000 per annum). Nevertheless in terms of greater security, sustainability and better customer service (better reliability and the availability of buffer stocks and tighter control of hazardous materials), the proposal has significant merits.

It was found that the platform solution has the potential to be replicated at the Department of Education & Science complex in Marlborough St., This is on the basis of an analysis of the comprehensive data supplied by the Department which tracked deliveries for a period of one week. It is likely that a sufficiently high density of customers may also be found in other parts of the city to justify the platform solution, for example in new and developing commercial districts, at other government offices, at hospitals and colleges.

An alternative to the manned platform is the unmanned "Pack Station" concept that is being successfully developed by Deutsche Post/DHL in German cities. The pack stations are replenished by Deutsche Post at night and customers in designated areas or large buildings have shared and secure access.. The availability of advanced ICT alerting, tracking and surveillance systems has helped to make the pack station a viable option and DHL may propose to explore this innovative solution in Dublin.

9.3.3 The Adoption of Eco-Friendly Technologies for Deliveries to the City Centre

Night deliveries is seen by municipal traffic engineers and by logistics service providers as a way of achieving peak separation by taking commercial traffic out of peak times, thereby reducing congestion and helping to deploy delivery vehicles and drivers more efficiently.

The difficulty with night deliveries is the noise nuisance it causes for city centre residents. The technologies and procedures currently under development for ameliorating the noise disturbance associated with out of time loading and unloading activities have been evaluated.

Operationally feasible solutions have been identified for introducing more sustainable clean and low noise delivery practices into Dublin. It proposed to do this initially on a pilot basis.

Because air quality in cities is also causing increasing concerns, the technologies that offer clean and low emission transport in pollution hotspots are favoured in a growing number of cities. We have therefore evaluated the suitability and likely costs of the different clean and eco-friendly vehicles and related ancillaries that are currently under development.

We have evaluated the availability and suitability of different clean and low noise vehicles, fuels and ancillary equipment options. These have included vehicles fuelled by gas (LPG and CNG), by electricity (EVs and HEVs) and modified conventional diesel engined HGVs and LGVs. For night-time deliveries, the availability of low noise ancillaries and acoustic materials was examined.

We have concluded that a combination of modified diesel vehicles is likely to offer the most realistic and cost effective low noise solutions in a medium sized city like Dublin.

We have concluded that the Dutch PEAK programme offers a realistic approach for managing night deliveries and that elements of experience this could be followed in Dublin. The Dutch experience indicates that a limit of 65 dB(A) can be fairly easily achieved for night-time delivery operations. There would however be major expenses involved in trying to achieve a lower limit of 60 dB(A), particularly for large HGV combinations. A proposal for a demonstration project involving MSVC and the incorporation of silent vehicles in their operations is included in Appendix A. This is put forward as a suggestion for further research in the area and has the added advantage of involving industry in future research.

Apart from "silencing" the commercial vehicles, managing the loading and unloading operations in the city centre to minimise noise is equally important. While it may be possible to control this activity at dedicated and modified off-street sites, kerb-side deliveries are more problematic. This can be tackled by having the delivery vehicles carry acoustic materials on board and to ensure appropriate training for the drivers and the other operatives involved.

It is estimated that the additional costs of modifying standard DAF truck and the related ancillaries for the proposed pilot project would cost between €8000 to €16,000. These costs would need to be substantially reduced over time in order to encourage the market. The Dutch authorities suggest that a period of 5 years may be needed for carriers and for receivers to adopt the modified vehicles and to encourage the equipment suppliers to reduce the costs of the ancillaries.

CNG is favoured in the UK, in Italy and in India as an eco-friendly low polluting and low noise alternative to diesel. While CNG is attractive as a relatively clean and silent fuel, we have concluded that (a) the additional costs of setting up a parallel re-fuelling infrastructure (b) the performance penalties suffered by the fleet operators and (c) the current uncertainty about pricing policies for natural gas as an automotive fuel in Ireland, does not make CNG an attractive or realistic option at this time.

Practical demonstrations of a CNG fuelled bus (No.3 to Sandymount) organised by Dublin Bus and of a fleet of car-van service utility vehicles deployed by Bord Gas were not continued.

It was found that the situation regarding the availability and the costs of operating electric vehicles to be disappointing in view of the major international R&D in this mode of transport. While EVs and HEVs may offer an elegant and eco-friendly solution for niche applications (parcels deliveries and as service vehicles) this option cannot be recommended for economic reasons at the present time. An underdeveloped market, diminished enthusiasm by the major auto suppliers, low residuals and the cost of replacing the traction batteries are major disincentives for commercial fleet operators.

The vehicle suppliers whom we contacted need long-term government incentives before they commit to volume production. Last year the French PSA group ceased production of their technically highly developed Citroen Berlingo car-van of which 14,000 were supplied to various municipalities, utilities and postal authorities.

LPG is favoured in many EU countries for the smaller LGVs and car-vans because it offers a clean and practical solution for accessing "urban pollution hot spots" during the day-time and therefore fit our definition of an eco-friendly fuel. However there are no noise reduction benefits gained by using LPG in spark ignition engines compared with burning petrol.

Incentives to promote LPG is a practical measure that is readily available for minimising traffic-generated emissions in the pollution hot spots that the authorities are required to designate under EU rules. Dublin City Council, in consultation with the Department of the Environment, are currently preparing proposals to comply with the new EU air quality directives and standards to come into force from 2005 onwards.

The auto-gas industry has addressed the safety concerns associated with LPG by developing better gas monitoring systems and a special Irish NSAI standard for LPG in cars is now in force.

We have found that the current Irish price differential between petrol and auto-gas is too narrow to encourage fuel switching and this explains why the market has collapsed. Tax incentives as proposed to government by the ILPG Association, will be needed to revive the market.

We found that the carriage of chilled and frozen goods causes significant nuisance because of the noise generated by the conventional diesel driven refrigeration units as fitted to LGVs and HGV trailers. Electrically driven refrigeration units have been developed by suppliers in the UK and cryogenic units have been demonstrated in the Netherlands. The electrically driven units would be suitable for night deliveries in the city centre.

Low noise vehicle bodies and ancillaries such as cages, trolleys, pallet trucks and acoustic materials for unloading sites have been developed as part of the PEAK programme. It would be possible to acquire these ancillaries for evaluation in fleet operation in Dublin.

The availability of low noise vehicles and ancillaries at an acceptable cost would facilitate the re-scheduling of day-time deliveries to the night-time and help to take

commercial traffic out of peak. During the day clean LPG vehicles would be welcomed in the congested pollution hot spots in the city centre.

9.3.4 City Centre Access Control

One method of managing urban freight distribution is to control access to the city centre at particular times of the day. The aim of such regulations is to reduce the negative effects of commercial vehicles in a city. However formulating city access regulations involves finding a balance between the interests of the stakeholders involved and therefore it is necessary to maintain that balance between supporting economic growth while reducing some of the negative effects of road freight transport.

Controlling access to the city centre is an approach that has been taken in a number of European Cities. Copenhagen in particular is notable for its innovative "City Goods Ordinance" initiative. This initiative required all vans and trucks over 2.5 tons total weight to possess a certificate in order to stop in the medieval part of Copenhagen. The compulsory certification scheme included stipulations regarding capacity utilisation and engine technology. The overall aim of the scheme was to reduce the number and/or size of vehicles and lower the visual intrusion from street traffic. Promising results from the initiative include capacity utilisation achieved for vehicles using a green certificate (the main type of certificate for cargo transporters). It was found that vehicles with this certificate were achieving average capacity utilisation of 70%. Another promising result has been the support of residents in the city and their view that the urban environment has improved as a result of the initiative. Moreover, the 26 designated loading zones have proved popular feature of the arrangement amongst transport companies.

However, there are a number of difficulties associated with the scheme, namely:

- Difficulty in verifying the data provided by companies on capacity utilisation.
- The possibility of exemption from the ordinance by buying a red certificate (and thus avoiding capacity utilisation and engine age conditions).
- The levels of through traffic passing through the Certification Zone (also exempt from the ordinance).
- A lack of quantifiable success criteria that would clearly illustrate the effects of the arrangement.

Despite these difficulties the arrangement is a good starting point for the application of innovative solutions for urban goods transport and provides valuable lessons for other cities like Dublin that are in need of new and innovative approaches to urban freight distribution.

In order to assess the possible impacts of time-based restrictions, three scenarios were established and the results were analysed. The time-based restrictions were based on Dublin City Council pilot clearway hours (7:00-10:00 and 12:30-19:00). The three scenarios were the following:

- Scenario 1: The Application of the Clearway Delivery Hours to all deliveries regardless of the type of loading facilities used

- Scenario 2: The Application of the Clearway Delivery Hours to all deliveries except those with private or shared loading facilities (indented bays)
- Scenario 3: The Application of Clearway Delivery Hours to all deliveries except those made using trucks and dedicated loading bays

Analysis of scenario 1 showed that when vehicles were restricted to the DCC allowable delivery hours, the number of deliveries occurring at the peak time (10:00-11:00) increased by 6%. Deliveries were reasonably evenly distributed from 12:00 onwards. An environmental analysis using the cost of noise showed that this scenario brought about an increase in the cost of noise of 41% compared to the cost calculated from the original dataset.

Analysis of the application of scenario 2 to the survey data showed that when vehicles were restricted to allowable delivery hours except those vehicles that used dedicated or shared loading bays, the time period from 10:00 to 13:00 proved the busiest time for deliveries. However, an increased level of business activity in the morning in comparison to the evening was also noted. With regard to the environmental implications of this scenario, it was found that this scenario produced that least additional cost due to noise.

Finally the application of scenario 3 (when vehicles were restricted to DCC allowable delivery hours except for trucks using dedicated loading bays) resulted in a degree of bunching in delivery arrival times. Three main peaks for deliveries were observed, namely between 5:00 and 7:00, 10:00 and 12:00 and 19:00 and 23:00. This scenario produced an increase in the cost of noise of 10% compared to the cost calculated from the original data set.

A further conclusion, which may be drawn from the section dealing with City Access Control is that small businesses that operate primarily during regular working hours are likely to incur additional personnel costs if they are forced to receive deliveries at times outside the normal working day.

Ultimately, the use of city access controls as a long- term measure to manage city centre deliveries may require complementary strategies such as the use of Urban Distribution Centres or Last Mile City Centre Platforms. Furthermore, the introduction of access controls for Dublin City Centre is likely to require input from a number of stakeholders. It is concluded that Freight Quality Partnerships (FQPs) such as those used in the UK are useful as a framework for formalising the consultative process for the possible introduction of any new commercial vehicle management strategy. FQPs provide a structured approach for consultation and discussion with relevant parties.

9.4 FURTHER PROJECT OUTPUT

A further output of this project will be a doctoral thesis examining the area of freight demand. The freight models described in Appendix B form relevant background literature research on the area for the thesis.

10 PROJECT RECOMMENDATIONS: TOWARDS A SUSTAINABLE SOLUTION FOR MANAGING CITY FREIGHT DELIVERIES

10.1 INTRODUCTION

It is recommended that the new analysis of the patterns of deliveries to the city centre and the sustainable solutions developed in this research project be used to inform developing transport strategies for the city.

It is has been demonstrated by Irish based distribution companies that a UDC located on the periphery of the city, and a down town platform for last mile deliveries, can offer an effective means for minimising congestion by commercial vehicles, particularly at peak periods. These models have the potential for replication.

Practical and low cost technological solutions for mitigation noise and emissions have been identified that are applicable for Dublin. These technologies facilitate night deliveries and can provide clean transport in pollution hot spots during the day. It is recommended that these technologies be demonstrated in fleet use by two logistics service providers, namely MSVC and DHL. Detailed proposals are presented in Appendix A. These pilot projects would require collaboration with Dublin City Council and the Dublin City Centre Business Association.

10.2 A SPRINGBOARD FOR CONTINUING RESEARCH

Recognising that an efficient and sustainable freight distribution system is crucial for the continuing economic and social vitality of the city and that research in this area needs considerable development, it is recommended that continuing progress be sustained.

Specifically this can be achieved by:

1. Following through on the demonstration projects and technology transfer opportunities that have been identified and developed
2. By building freight modelling capability into overall traffic modelling methodology
3. Strengthening the knowledge base and developing new data basis for freight transport
4. Strengthening the links with the relevant international city freight research networks such as TCD's involvement in BESTUFS 2 and any relevant new initiatives proposed under FP7.

10.3 A CITY FREIGHT CONSULTATION FORUM FOR DUBLIN

It is recommended that a City Freight Forum be established involving relevant stakeholders - the municipal authorities, the business community, the logistics service providers and urban residents. The forum would share experiences, identify areas of concern to members and identify best practice measures and principles for action by local government and industry to promote environmentally sensitive, economic and

efficient delivery of goods in town and cities. As in other cities, the forum could be chaired by the municipal authority and aim to win across the board support. There would be a focus on overcoming the institutional and human barriers to innovation and change. A City Freight Forum should help ensure freight and service transport receives the level of attention it deserves in Dublin.

10.4 FREIGHT MODELLING

It is recommended that a study be undertaken in the area of freight modelling with a view to developing a Freight Demand Model for the Greater Dublin Area. This is a long-term recommendation and one that is likely to require considerable data collection in order to build a comprehensive model that produces reliable results that predict the level of freight demand for the transport system. A comprehensive freight model will allow the assessment of activities such as infrastructure planning, traffic monitoring and traffic impact assessments of major developments. Without the availability of such a model development and continual evaluation of a long-term urban freight strategy for city will be difficult.

10.5 RECOMMENDATIONS FOR INDIVIDUAL SCENARIOS

10.5.1 External Consolidation at an Urban Distribution Centre

It is recommended that the development of an Urban Distribution Centre in South West Dublin should be viewed as a long-term approach to managing food related deliveries, which form such an important part of overall freight distribution in the city. Preliminary set up costs of land and buildings were estimated to be in the region of €41 million. However in order to quantify the benefits of the centre over the next number of years, it is recommended that a comprehensive cost/benefit analysis be carried taking into account both the financial payback, and both user and non-user benefits. Given the potential costs of developing a large-scale urban distribution centre in South West Dublin, optimised consolidation at company level offers the next most appropriate option for reducing trips to the city centre through efficient logistics management. It is recommended that companies wishing to optimise consolidation in so far as possible follow the Musgrave approach for centralising distribution and consolidation.

10.5.2 Internal consolidation – Managing the Last Mile

Possibilities for replicating the platform model in other parts of the city where customer densities are high should be encouraged. The survey data points to possibilities at the Department of Education & Science complex in Marlborough St., and at the Houses of the Oireachtas & Government Buildings. The major city hospitals and colleges also offer possibilities.

Where DHL has shown the way, other logistics service providers can also be attracted to adopting the platform model.

Special incentives by Dublin City Council are needed to support the platform model. These may include privileged access and permitting by the vehicles servicing the platform; easily accessible and supervised loading spaces adjacent to the platforms.

The DHL platform now operating in Sandwich Street would welcome a dedicated space at their premises.

It is recommended that a new interception platform be established in the vicinity of the TCD campus and that provision be made for this facility in the development plans for the north-east corner. The potential benefits accruing for sustainable transport on campus are significant.

DHL should be encouraged to demonstrate the unmanned "pack station" model in Dublin as has been done successfully in German cities for the distribution of mail.

Consideration should be given to promoting both the platform and pack station models in Dublin by means of public private partnerships involving the logistics service providers. Under this scenario the platforms would be operated by a commercial company such as DHL and suitable sites and loading facilities would be organised by the municipal authority.

10.5.3 The Adoption of Eco-Friendly Technologies for Deliveries to the City Centre Eco-friendly Technologies

It is recommended that a solution for managing night time deliveries, derived from the Dutch "PEAK" programme, be demonstrated in fleet operation by the MSVC group.

A detailed proposal for this is included in Appendix A.
Both dry goods and chilled and refrigerated food and groceries would be carried. For the refrigerated goods a low noise bi-temperature electric unit is specified.

The demonstration would include modifications to one or two selected loading sites in the city centre. The performance of different architectural configurations and of different acoustic materials would be evaluated and compared, possibly in collaboration with a third level college and NOVEM. .

Where deliveries to the smaller convenience stores are made on-street, the installation of fixed noise reducing measures at the kerb-side is not an option. The recommended trial will test the feasibility of using portable on-board rubber mats and other acoustic materials.

The training of drivers and operatives to respect a new low noise regime is regarded as an important part of the project.

A noise monitoring regime and cost effective measurement system based on the NOVEM and TNO monitoring methodology is recommended. A realistic standard of 65 dB(A) will be set for the demonstration because the incremental cost of achieving lower levels of noise approaching 60dB(A) would be prohibitive.

Because the demonstration would aim to show-case and develop cost-effective solutions which can make night deliveries to the city centre and to make these more widely acceptable, steps are recommended to encourage a significant level of replication. This would be done by means of publicity and through the City Freight Forum.

In order to reduce air emissions during the day, to respect the EU directives on air quality and the concerns recently expressed by the EPA relating to traffic related pollution, LPG is favoured as a clean and adaptable alternative fuel. Spark ignition petrol engined LGVs and the smaller car-van type vehicles can be easily modified to burn LPG. These should be favoured for deployment in “urban pollution hot spots”.

We recommend that the case put by the Irish LPG Gas Association to Government for widening the current small price differentials between conventional fuels and LPG, be considered sympathetically. In many European countries, tax incentives are regarded as necessary to revive and to stimulate the market for cleaner fuels such as LPG.

Permitting incentives and privileged access to designated city centre polluted zones are recommended to encourage “clean” low emission vehicles.

We have also consulted another leading logistics service provider, namely TDG, as to the practicality of developing more sustainable solutions for deliveries in the city centre. TDG have already undertaken substantial research into the area of 'Urban Logistics'.

Having reviewed the solutions developed in other European cities, TDG has advised that practical solutions for out-of-hours deliveries might be possible in respect of their operations in Dublin city centre. This would depend on the availability at reasonable cost of low noise conventional vehicles and related ancillaries, and the possible application of acoustic materials at loading sites. In return a response by the authorities in terms of providing additional loading bays, easier access and effective enforcement would be expected.

TDG would also consider the possibility of evaluating the deployment of "clean" vehicles should certain parts of the city be designated as "pollution hot spots" in the future. TDG are happy to collaborate with all the parties concerned in the development of sustainable solutions for managing city freight.

Fleet operators should be encouraged to favour low noise and low emission vehicles when renewing their fleets, particularly those distributors involved in night deliveries. The use of low noise ancillaries (trolleys, tail gates, reversing cameras, refrigeration units, insulated bodies and floors) is also recommended for out of time deliveries and the market should be encouraged to supply these at reasonable cost. Appropriate low noise architectural solutions involving the use of low noise acoustic materials at important unloading sites should feature in the new property developments planned for the city centre. Major new retail developments are planned for Abbey St., and for shopping malls such as the ILAC centre and these provide an opportunity to show-case best practice as demonstrated in the Netherlands.

A Best Practice Guide would also be helpful in providing guidelines and standards for operators.

10.5.4 City Access Control

It is recommended that the introduction of any new City Access Controls be accompanied by structured consultation with relevant stakeholders in the form of a City Freight Consultation Forum. City authorities have an important role to play in helping industry, through forging partnerships to progress and develop best practices in sustainable distribution systems, and to help find solutions to the issues of greatest concern.

In the light of any possible introduction of a time-based city access restriction, it is also recommended that city authorities review the findings of chapter 8 where a number of scenarios for city access control were analysed. These findings highlight the impact that loading arrangements can have on the traffic and environmental benefits derived from restricting access to the city centre.

10.6 FINAL NOTE

In conclusion, it is hoped that all of the recommendations described in this chapter can in some way contribute to a more sustainable fright distribution system for the city and further research on this topic. It is also hoped that the project will help to address gaps in knowledge, which previously existed regarding the nature of deliveries in Dublin City Centre at a micro-level.

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APPENDICES

A PROPOSED DEMONSTRATION PROJECTS FOR LOW NOISE & LOW EMISSION VEHICLES & RELATED ANCILLARIES

A.1 INTRODUCTION

In Chapter 7 a number of possible scenarios were identified where eco-friendly solutions might apply. One of these relates to the night-time deliveries of ambient and chilled goods to the MSVC stores located within the canal cordon. The other relates to the deliveries of drugs to city centre pharmacies during day time business hours.

In the case of night time deliveries, the requirement is to mitigate the noise nuisance caused to residents. In the case of day time deliveries, the concern is to minimise vehicle missions in urban pollution hot spots.

A.2 NIGHT-TIME DELIVERIES – 1ST DEMONSTRTION

We have matched the MSVC configurations for deliveries of groceries described in Chpater 7 (Tables 7.13 and 7.14) with the possible availability of a modified low noise DAF vehicle. Currently deliveries are made by a HGV tractor and trailer combination as described in Table A.1 below.

Type of Vehicle	HGV combination; gvw 25-40t
Value of vehicle	€ 75,000
Engine	430 bhp – diesel
Average mileage per route – includes drops outside city centre	100 km
Time of departure and return to depot	Depart 4.30 am; return 10.00am
No. of stores served	30
No. of scheduled stops per trip	2- 8
No. of roll cages per trip	38 – 40
No. of roll cages delivered per drop	4 – 8
Average dwell time per stop	14 minutes
Fuel consumption	8 mpg

Table A.1 A Typical Grocery Delivery Roster to the City Centre for a HGV

Because of the high costs involved in modifying a large HGV combination, it proposed to demonstrate a smaller 17t gvw rigid HGV. Low noise ancillary equipment is also essential whether carried on board the vehicle, in moving deliveries from truck to store or in fitting out the loading and unloading logistics sites.

Enquiries relating to the availability and likely costs of the following low noise ancillaries were made with Dutch and UK suppliers:

1) Silent fridge units
2) Silent roll cages
3) Non-slam doors & rolling doors
4) Low noise Tailboards
5) Forklifts

6) Electric handcarts
7) Modified shopping trolleys
8) Pavement design and absorbing materials at delivery sites
9) Materials for reducing collision noise for application to floors, bodies & walls
10) Reversing cameras

A.2.1 Acoustic Standards & Monitoring

Before considering the possible configuration and costs of the proposed pilot demonstration, it is instructive to review the acoustic standards and monitoring procedures that would apply.

In order to set realistic noise standards we have examined the experience of the Dutch PEAK initiative. TNO (the Dutch Standards Institute) has developed a methodology for measuring peak noise during loading and unloading. The methodology defines a set of measurement methods so that new equipment can comply with any limits set by government decree (TNO, 2003).

Noise levels are measured from all sources and activities during goods delivery. These activities include the arrival, departure and manoeuvring of the vehicle, knocking and banging sounds during unloading, removing and receiving goods on load hatches, roll cages and trolleys.

The methodology is designed to quantify the impacts of noise reduction measures and to determine whether the products specially developed, can meet the noise reception limits set by the authorities. Comparisons can therefore be easily be made between different products as they become available.

Measurement methods were developed by TNO for the following activities at 7.5m. distances from individual sources under controlled conditions –

1. Constant speed, acceleration and braking at low speed for trucks and vans
2. Doors, hatches, hinged and roller doors on trailers, bodies and cabs
3. Tailboards, body floors and the walls of trucks and vans
4. Shopping trolleys, goods carts and hand pallet trucks
5. Fork lift trucks
6. Refrigeration units

The impact of the loading and unloading operations that generate most noise were measured and the following dB(A) levels in Table A.2 were found:

Slamming door	74
Driving up/away	67 – 83
Load hatch	65 – 92
Cages/pallet truck over load floor	74 – 85
Refrigeration kicking in	70 – 78
Shopping trolleys	53 - 77

Table A.2 Peak Noise of Loading & Unloading Measured in dB(A) at 7.5 Metres from the Source at a Height of 1.2m. Above the Road Surface

The PEAK project examined the technical and economic implications of trying to develop vehicles and products to comply with the standards specified by the Decree and Order in Council (PEAK, 2003). This was initially set at 60 dB(A) but this was found to be difficult and expensive to meet. The higher 65 dB(A) level is a much more realistic standard.

A.2.1.1 Product Innovations

The product and vehicle innovations arising from the PEAK programme are summarised in Table A.3 below.

Project Title	Product Innovations to Reduce Noise
Optimise loading/unloading locations	Infrastructure Pavement – fixed and temporary Structural adjustments – acoustic insulation, awnings, curative measures guidelines
Vehicles < 7.5 tonnes	Engine, inlet, exhaust Differential & gearbox Compressed air system Brake system Warning reverse Tailboard Loading space Locking/doors
Vehicles > 7.5 tonnes	Motor, inlet, exhaust Differential & gearbox Compressed air system Brake system Warning Tailboard Loading space Locking/doors
Refrigeration	Refrigerated units & installations
Silent roll cages and hand pallet trucks	Roll cages Pallet trucks Ground surface
Shopping trolleys	Quiet trolleys

Table A.3 Low noise Vehicles & Products developed under PEAK

Many of the above products interact closely with each other – for example properly designed absorbent pavement materials will lessen the noise levels created by the passage of trolleys and cages and by collisions.

A.2.1.2 Operational and Economic Results

The PEAK programme examined the operational and economic feasibility of introducing a range of silent technologies and products to the market. New designs and prototypes were built and tested.

It was found that propulsion noise remains the biggest obstacle to satisfying the 60dB(A) limit where HGVs are concerned.

A.2.1.3 Awareness & Dissemination

The Dutch authorities have actively promoted an awareness of the range of "quiet" products and behavioural practices developed under PEAK among the affected players. Regional tours and workshops were organised.

It was found that provided that noise minimisation is treated as an integral part of the training for drivers and operatives, the additional costs were not too significant. Course material and acoustic best practice guidelines have been circulated to the Dutch cities to encourage quiet behaviour.

A.2.1.4 Architectural Solutions on Site

The costs of making modifications and taking curative measures varies from site to site. Making changes to new building developments at the design stage is much cheaper than retrofitting existing sites and buildings.

The noise produced when cages and pallet trucks are rolled over a surface can be reduced by between 10 and 20 dB(A). Awnings and screens can provide a further reduction of between 10 and 15 dB(A).

It was found that while restocking stores at night gives lower transport costs, these savings must be offset against possible higher wage bills for any extra staff required to receive the deliveries.

A.2.1.5 Refrigeration

Loud refrigeration units, whether mounted on a solo truck or on trailer units are very irritating. Peak noise emissions levels of 69 and 74 dB(A) have been measured by NOVEM on conventional refrigerated installations. It was found that noise pollution is most intense at bedroom level because refrigeration units are mounted high up on the vehicle/trailer bodies.

For conventional systems where the compressor is driven by a stand alone diesel unit, noise reductions can be achieved by decreasing the rotational speeds below 1,000 r.p.m., by optimising sound insulation and by reducing inlet and outlet noise.

Alternative systems that employ generator units and hydraulic units driven by the main lorry engine were found to be more promising. The main vehicle engine can still produces excessive noise that needs to be managed. The costs of the electrical and hydraulic versions on test range vary from €3,000 to € 4,000.

A cryogenic CO2 refrigerated system was developed by Thermo King that guarantees compliance with the lower 60dB(A) standard. This system has been demonstrated on a special semi-trailer unit. The cost of a CO2 refrigeration system is likely to cost from € 11,000 to € 15,000.

A.2.1.6 Roll cages and Hand Pallet Trucks

One of the aims of the PEAK programme was to reduce the noise created by the ancillaries such as the roll cages and hand pallet trucks when in motion and when handled. The noise from empty roll cages is particularly unpleasant.

In order to achieve a reduction of 20 dB(A),the following modifications were evaluated – (1) the use of elastic/soft wheels (2) reducing the play between the wheels and fork bearings (3) sound insulation between the metal parts to minimise rattling (4) rubber stoppers at contact points and for nesting (5) noiseless floors (6) fastenings for the cargo.

Because roll cages and hand pallet trucks have an economic life of about 5 years and the additional expense of acquiring and maintaining low noise versions is not readily recoverable.

A.2.1.7 Shopping Trolleys

By applying additional modifications to the standard trolley, either at the manufacturing stage or by retrofit, a reduction of 10 to 20 dB(A) was achieved. These modifications include (1) soft wheels and (2) adding rubbing strakes and coatings to minimise the effects of collision and nesting.

A.2.1.8 Site Modifications

According to CROW (the Dutch Institute for Road Infrastructure) the retrofitting of existing locations to meet low noise guidelines can be very costly. Fitting out an existing logistics site with acoustic paving, screens and materials can cost as much as €140,000. The additional costs involved for new developments would be considerably less because the low noise materials can be readily incorporated at the initial design stage.

A.2.3 Proposal for Showcasing a Low Noise 17t gvw Rigid HGV & Ancillaries in Fleet Operation for the Delivery of Frozen & Dry Goods to the MSVC Grocery Chain

The aims of the proposed demonstration are to:

1. Evaluate the operational and economic feasibility of deploying low noise vehicles & practices to achieve a more sustainable solution for night deliveries.
2. Assess the practicality and cost sensitivities of achieving a range of different limits on noise disturbance and to determine the feasibility of achieving levels of 65 dB(A) in the first instance.
3. Recommend practices acceptable to all the parties concerned – the residents, city council, retailers.
4. To show-case the transfer of low noise technologies developed in the Netherlands and to see how these might be adapted for Dublin
5. Promote the wider replication of low noise solutions

6. To encourage suppliers to bring to market low noise equipment and materials at a more acceptable cost
7. As an input by Dublin city to the EU noise policy and directive 2002/49 EC.

A.2.3.1 Partners & Funding

The partners would involved MSVC in collaboration with DCC, NOVEM and a third level institution. The possible duration would be 18 months

A.2.3.2 Methodology

The tasks would include the following:

1. Confirm routes and rosters for deliveries of dry, chilled and frozen goods from the MSVC depots (Fonthill, Ballymount, Kilcock) to shops (X30) in the city centre
2. Acquire a modified low noise 17t gvw rigid vehicle with capacity for 35 roll cages
3. Fit low noise refrigerator unit, e.g. bi-temperature electric (-18C and +01C)
4. Acquisition of low noise ancillaries – roll cages, pallet trucks, reversing beep/camera, non-slam doors and insulated floor and tail gate.
5. Modify a selected delivery site by installing "quiet" acoustic materials, asphalt, screens etc
6. For on-street unloading and kerb side deliveries, acquire portable paving and sound absorbing materials
7. Training of operatives and drivers
8. Set up a noise monitoring regime
9. Consultations with all affected parties to help overcome barriers
10. Dissemination of results & promoting replication
11. Monitoring & evaluation

A.2.3.3 Comparisons with the PEAK trial of a modified HGV

The experience with PEAK would suggest the cost schedule for the proposed demonstration as described in Table A.4 below.

Item	Supplier	Noise performance	Base cost	Additional cost
1.Modified chassis ex-factory, (for rigid 17.5t gvw)	DAF	65 dB(A)	€75,000	€ 7,000
2. Tail lift Ex-factory retrofit	Dhollandia	<60 dBA	€ 4,000	€ 300
3.Reversing beep	Groeneveld Sensors or Orlaco camera	<60 dBA	€ 300	€ 300
4. Trailer	retrofit to hatches & floors	<60 dBA		€ 200
5. Refrigeration	vehicle engine as electrical generator	<60 dBA	€ 3,000	0
6. Hand pallet truck	BT quietened truck	<60 dBA	€ 500	€ 200
7.Rolling containers X 30	Hoza	<60 dBA	€ -	€ 300
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Total additional cost				€ 8,300

Table A.4 The Costs of a Modified HGV & Ancillaries for Ambient & Chilled Groceries

A.3 LOW EMISSION LPG VEHICLES – 2ND DEMONSTRATION

A.3.1 Introduction

It is proposed to promote the use of low emission LPG Vehicles LPG for smaller vehicles of < 7.5 T g.v.w. Because LGVs and car vans are more commonly used for day time distribution and also for and newspaper deliveries in the early mornings, the options available for acquiring smaller more eco-friendly LGVs of < 7.5t gvw merits examination. Small LGVs and car-vans are also widely used as service and utility vehicles.

As discussed in Chapter 7, LPG offers much cleaner emissions than either diesel or petrol and meets the EU criteria for an eco-friendly fuel and is a suitable fuel for the smaller commercial vehicles (ZEUS, 2001).

As mentioned in Chapter 7, there are no significant price advantages for switching to LPG in Ireland at the present time and the auto gas market has accordingly collapsed (Irish LPGas Association, 2003). The EU directives on urban air quality and the concerns of the EPA may prompt government action to help bring about a revival in the auto-gas market as has happened in the other EU countries (EPA, 2004). .

IVECO has quoted for an LPG/petrol bi-fuel van as proposed for the delivery of drugs and mail in pollution hot spots during the day time. The additional costs (engine and chassis only) would be about € 800.

Because LPG vans would be limited to day-time operation, additional modifications to the body, floor and tail-gate would not be necessary. Fuelling facilities are normally provided by the LPG suppliers – the operating costs would be similar to that for conventional LGVs at current fuel prices.

A.3.2 Commentary

Under the PEAK programme, DAF were able to comply with a noise limit of 65dB(A) but a lower limit of 60 dB(A) would be problematic, particularly for large HGV trailer combinations..

Because the proposed demonstration would involve a modified rigid 17t gvw vehicle rather than a HGV combination and would aim to meet a less realistic target of 65 dB(A), the costs of the modifications would at €8,000+, be more acceptable.

For refrigeration a relatively cheap electric bi-temperature for both the chilled food and frozen foods compartments (-18C and +01C) of the vehicle body can be supplied by FRIGOBLOCK (UK). It is proposed to consider this type of €3,000 unit for the MSVC demonstration.

An important part of the demonstration project will be to select suitable unloading sites that can be adapted to minimise noise disturbance and to monitor performance.

Because most deliveries to the smaller shops take place on-street, installing fixed noise-reducing measures will be not be possible. The feasibility of using portable on-board rubber mats and other materials will be examined.

This monitoring methodology proposed will measure all types of noise nuisance – constant speed; acceleration and braking; opening and of closing doors and hatches; tailboards; body floors and walls; trolleys and cages; collisions; cooling and refrigeration units.

A.4 CONCLUSIONS

The proposed demonstrations are designed to evaluate the likely benefits and costs of introducing low noise and low emission vehicles in fleet operation.

Performance indicators will relate to -

1. The cost/noise reduction relationships in mitigating nuisance at the selected city centre sites
2. Realising the potential for encouraging night deliveries and peak separation in a more sustainable manner
3. Promoting the development of sustainable freight delivery management strategies for the city
4. Facilitating the more efficient logistics operations of the major distributors
5. A better understanding benefits and costs involved for all the parties concerned if expected to comply with the proposed new noise and emission targets currently being considered by the authorities.

B FREIGHT MODELLING

B.1 INTRODUCTION

During the course of the project, it became clear that the evaluation of urban freight requires an examination of the area of freight modelling. This chapter deals briefly with the general area of freight modelling and focuses particularly on urban freight modelling

Mathematical models are an important component in the process of estimating future travel demand and impact analysis. Planning authorities need to forecast future transport needs for both people and commodities in order to ensure that the appropriate infrastructure and human resources are in place to facilitate movement. The private sector requires forecasts of demand for transportation services to anticipate future financial requirements, equipment acquisition and labour requirements (Regan & Garrido, 2001). While passenger modelling is a well-established field, its freight counterpart is still at an earlier stage of development (Ortúzar and Willumsen, 1994) and consequently is an under studied field (DfT, 2002a). This may be attributable to a number of factors including the following: (Garrido, 2001)

- A lack of relevant modelling data (sometimes as a result of the private sector's opposition to disclosing information with competitive commercial value)
- Multiple dimensions to be considered. In passenger transportation there is only one unit of demand i.e. the passenger who is the primary decision maker. In freight transportation there are multiple dimensions (weight, volume, trips) and multiple decision makers (drivers, dispatchers, freight forwarders)
- Lack of efficient methods and tools to solve large-scale problems

B.2 BACKGROUND TO FREIGHT MODELLING AND TYPES OF FREIGHT MODELS USED

The multiple dimensions that can be used for freight demand modelling (weight, trips and volume) have given rise to two major modelling platforms: commodity-based and trip-based modelling. Commodity-based freight models focus on modelling the amount of freight in tons (or any other unit of weight). They are based on the premise that freight transport is primarily concerned with the movement of goods and not vehicles. Therefore, freight modelling must commence with an evaluation of commodities- their generation (by site or firm etc.), markets (by land use, location etc.) and logistics management (warehousing, transport, etc.). The state of the art for commodity based urban freight models is based on the traditional sequential modelling approach (generation, distribution, modal split and assignment). An alternative is to use a direct estimation approach combining the generation, distribution and modal split into a single step. In both approaches, truck trips are then derived from commodity movement via a vehicle-loading model and the output of the model is the assignment of truck trips to the road network (Ogden, 1992).

Trip-based freight models focus on estimating truck trip activity directly. Three approaches may be taken in trip-based models- sequential modelling approach, direct

estimation approach and truck traffic generation approach (which estimates the number of truck trips generated by a site or area). There are three main components associated with sequential modelling approach- trip generation, trip distribution and traffic assignment. Since the focus is on vehicle trips, it is assumed that the model selection and vehicle selections were already carried out and therefore trip-based models do not require mode split or vehicle loading models (Holguin-Veras & Thorson, 2000)

In addition to models based on commodity movements or vehicle movements, freight models may also be categorised according to the nature of the data required and geographical area concerned (Regan and Garrido, 2001). In terms of spatial considerations freight models can be classified into three distinct categories: global (international), intercity, and urban. From the perspective of this project, the most important types of models to be examined are intercity and urban in particular. However a brief description of global freight transport models is also provided.

B.2.1 Global Freight Model

The aim of a global freight model is to model the goods movement between different countries. This type of transport has experienced phenomenal growth in the past ten years, largely due to the operations of multinational firms where goods are manufactured in different locations and require transport to another location to be assembled and shipped abroad again. Haralambides and Veenstra (1998) identify three main approaches to model international demand for freight. The first approach follows the standard theory of international trade. This theory is deals with the pattern of trade between two or more nations based on the economic principle of competitive advantage and allows the indirect inclusion of transportation costs. The second approach relies on an aggregate cost function for a particular industrial sector, from which a demand function for shipping is derived. The main disadvantages of the approach relate to the considerable data requirements and computational complexities of the solving process. The third approach involves the use of spatial interaction models to estimate trade flows. The most widely used model in this approach is the gravity model (Garrido, 2001). This approach models vehicle movements directly, unlike the previous two approaches.

B.2.2 Intercity Freight Model

Intercity freight models are the most widely addressed in literature (Garrido, 2001). These models can be classified as either aggregated or disaggregate based on the nature of the data used. With an aggregate model, the basic unit of observation is the aggregated share of a freight mode at a certain geographic level. Disaggregate models on the other hand, use the individual decision maker's choice of a freight mode for a specific shipment as the basic unit of observation. Within disaggregate models, two further classes are observed- behavioural and inventory models. Behavioural models focus on the mode choice decision made by the consignee or the shipping firm, whereas inventory models analyse freight transport demand from an inventory manager's point of view.

B.2.3 Urban Freight Model

Given the focus of this project on Dublin, particular emphasis is given to urban freight models. Although commodity flows are at the core of freight transport demand, most of the literature available focuses on vehicle flows, particularly truck flows. This is primarily due to the fact that vehicle flows are easier to measure than commodity flows.

Models for analysing the demand for urban freight transport may be classified into three groups- gravitational models, (similar to those used in passenger travel analysis) input-output models, and finally models using the spatial equilibrium of prices (Russo & Comi, 2002). Using data on inter-zonal commodity flows in Melbourne, Ogden (1978) developed gravity models for the distribution of commodities between zones. Other similar, more recent studies include those by List and Turnquist (1994) and He and Cranic (1998). The input-output model by Harris and Liu (1998) predicts purchases and sales for different types of commodity categories both within and outside the city boundaries. However, the model outputs are expressed in currency units instead of quantities, which places limitations on the usefulness of its application. An example from the third group of urban freight models, which uses the spatial equilibrium of prices can be seen in the work of Oppenheim (1993).

B.3 SIMULATION MODELS

Simulation models provide a powerful tool for modelling traffic and transport systems. Two prominent models discussed in the next section are the GoodTrip Model and the MOSCA model.

B.3.1 GoodTrip Model

The GoodTrip Model developed in the Netherlands Research School for Transport, Infrastructure and Logistics (TRAIL) is a tool used to estimate goods flows, urban freight traffic and its impacts. The model serves to evaluate urban freight distribution from both a societal and economical point of view using geographical, economical and logistical data (Boerkamps & Van Binsbergen, 1999). GoodTrip is a commodity flow based simulation model and is based on the structure of supply chains. It consists of four key components - spatial organisations (where facilities are located, where goods are produced and consumer, and where people live and work), goods flows, traffic flows and infrastructure. Based on end-user (consumer) demand, the model calculates the volume per goods type in m^3 in each zone. The goods flows are determined by the spatial distribution of activities and the market shares of each activity type- e.g. consumer, supermarket, hypermarket, distribution centre etc. This goods attraction constraint starts with consumers and ends with producers or at the city borders depending on the modelling purpose (Boerkamps et al., 2000). Next, the flows of each goods type are combined using groupage probabilities. Each combination of goods type is considered a different goods flow. The flows of combined goods types are then assigned to vehicle tours. The type of origin and destination determine vehicle-loading factors such as vehicle size and delivery frequency. The origin's activity type is the most influential factor on choice of transport mode, vehicle capacity, maximum loading factor and the maximum number of stops per trip. The destination's activity type has the biggest influence on the

determination of the minimal delivery frequency. The vehicle-loading algorithm results in origin-destination matrices and a list of trips per mode. The model also produces indicators of tour characteristics. The tours per mode are assigned to infrastructure networks. Network loads are then used to determine vehicle mileage per mode. Finally, the emissions and energy use per mode are calculated, based on vehicle mileage and network loads (Boerkamps et al., 2000).

In terms of the application of the model, GoodTrip has been used to compare the logistical performance and external impacts of three types of distribution systems- the traditional system, the use of urban distribution centres (UDC) with vans and urban underground logistics systems (ULS) in the Dutch city of Groningen. The later two systems involve the use of a transhipment centre just outside the city. In the case of Groningen the effect of the different distribution systems was analysed for the food retail supply chain in the city. For each distribution system, the goods volumes and traffic flows to all 49 supermarkets in the city were estimated based on average consumer shopping expenditure. The weekly goods volume to the city ($8000m^3$) was divided into four categories- frozen, chilled, non-perishable and daily goods such as newspapers. The model has been calibrated and validated for the food retail sector using the case study results, data from a traditional four-step traffic model and empirical data of the traditional distribution system.

Results from the application of GoodTrip to Groningen illustrated that the use of urban distribution centres in conjunction with vans leads to a decrease of emissions in the city centre. However, it was found that overall emissions in the city increased. Underground transport was found to eliminate all emission inside the city centre and reduce wider emissions impacts in the city. Therefore using the model allows comparisons of distribution alternatives to be quantified. Quantities carried, distances travelled, logistical performance and the impacts of the alternatives can all be ascertained by the model.

B.3.2 MOSCA Model

The primary objective of MOSCA, a project co-funded by the European Commission Information Society Technologies (IST), was to find new ways of supporting transport planning and management in cities and agglomerations. This involved providing a set of tools for improving the efficiency of door-to-door transport of goods in urban areas by collaboratively providing demand and supply side information in one single system (MOSCA, 2003). MOSCA stands for Decision Support System for Integrated Door-to Door Delivery: Planning and Control in Logistic Chains. The motivation behind the project lies in the belief that all organisations, institutions and citizens affected by urban traffic benefit from sharing knowledge. The MOSCA model itself consists of a number of modules that provide both demand and supply side information in an overall system. The list of user requirements defined in the project can be seen below in Table B.1.

Supply Side	Demand Side
Freight transportation models and analysis of the traffic system	On-trip control
Optimisation of freight transport	Carrier-customer information exchange
Customer services	Customer access: problems found when approaching the point of service
Integration of information	City access: administrative regulations of city access with freight transport vehicles
Impact measurement (Freight) transport and social cost	
Location planning	

Table B.1 User Information Requirements

Once defined, these user requirements were translated into the functional and technical specification of the MOSCA system. From a technical point of view the MOSCA system consists of a number of modules, each of which help to fulfil the various user requirements. The project involved the testing of these modules in European cities and is described in the next section.

B.3.2.1 MOSCA-FREIGHT

Integral to the development of the MOSCA system is the integration of freight transport in available urban transport models. The MOSCA-FREIGHT module allows the calculation of business traffic and freight transport demand matrices of a city or region. The module can be integrated in an overall model structure including a passenger transport demand model (using the software program VISEVA) and a network/assignment model (VISUM). This module is not a stand-alone solution, and instead uses the structure of the VISEVA model (which is dedicated to the generation of demand matrices for passenger transport) as a framework. Therefore MOSCA-FREIGHT is compatible with passenger transport and a complete transport model can be generated.

This module was tested in the city of Chemnitz in Germany. The main goal of testing was firstly to develop a consistent business traffic and freight transport demand model for the city and secondly to successfully assign all passenger transport, business traffic and freight transport matrices using VISUM. Testing of the model showed that developing a demand model for urban business traffic and freight transport is both possible and useful (MOSCA, 2003). It was found that data collection activities in Chemnitz were exhaustive. However it was also noted that an aggregation of the industry sectors used could reduce the efforts required to collect data. Overall the MOSCA–FRIEGHT module was found to work well in Chemnitz.

B.3.2.2 MOSCA-SUSTAIN

This module allows the calculation of noise emissions and the associated social costs. It operates using both a traffic network model and a noise computation program. The module is a user-friendly database, which can be used by traffic and city planners for the assessment of different traffic scenarios. For the testing of MOSCA-SUSTAIN,

half of the city centre of Stuttgart and the main circular road around the centre were chosen. In total the test area included 80,000 inhabitants, 600 blocks of houses and 250 roads. Data collected from individual site inspections or brought in from the authorities was imported into MOSCA-SUSTAIN (an MS Access database) and re-organised with additional information (particularly output from the transport model). SoundPLAN, a noise computation programme was then applied to the dataset. In the database the results of the noise computation were assessed with predefined cost-rates (e.g. health costs, property costs) along with the distribution of inhabitants. For the tests scenarios were defined as follows in Table B.2 (MOSCA, 2003):

Scenario	Description
Scenario 0	Current situation without any measures
Scenario 1	In a large area around the city centre, a speed limit of 30 km/h is implemented and the changes in the traffic flows in the test area are measured
Scenario 2	Access restriction in the city centre for all HGV with more than 7.5 t (total weight
Scenario 3	Close down one important main road for all HGVs
Scenario 4	Passive noise reduction: Noise decreasing paving for the entire city

Table B.2 Five Scenarios Examined

The use of health and property costs to calculate noise exposure facilitates an examination of the extent of noise reduction, which can be achieved in the different scenarios. Noise reduction can be shown as noise building maps or as calculated table sheets. Differences between the scenarios can be displayed as ratios for each part of the city or the entire test area. MOSCA-SUSTAIN can accurately calculate the noise exposure for each house in the city centre of Stuttgart and therefore fulfils the noise map requirements of the EU noise Directive (2002/49/EC) for cities with more than 100,000 inhabitants.

B.3.2.3 MOSCA-SHORT

MOSCASHORT is a demand side module that focuses on the provision of trip information to users. It involves the use of an algorithm to find a robust path within a city if variable traffic conditions are provided. MOSCASHORT can calculate convenient paths between two points in a dynamic urban traffic network where travel times along the network arcs are not known in advance with certainty.

This module was tested in Stuttgart, Lugano and in Padova. Overall, it was found that the heuristic algorithm for the shortest path is suitable for application to real world problems. The results of the tests suggest that the algorithm used is the fastest available at present to solve robust shortest path problems on road networks.

B.3.2.4 MOSCA-TOUR

This module is an algorithm to plan delivery tours for a vehicle fleet given variable traffic conditions. It is embedded into logistics application software, which must invoke it providing data of the orders to be services, the objective function and the

characteristics of the vehicle fleet. Distances and travel times are provided either by MOSCA-SHORT or by a traffic model. Customer time window and location information is input from MOSCA-NET. Once all of the necessary input data is acquired, the algorithm calculates the most efficient vehicle routes. The result is a set of optimised routes that is fed back into the logistics application software.

Testing of MOSCA-TOUR was carried out in the city of Padova using different customer data sets as test cases. Nine test problems from a sample of 60 unique customers were used as scenarios to be tested. The performance in the module was measure in total travel time. The test showed that MOSCA-TOUR optimised the total travel time needed to serve all customers requiring a delivery. The main features of the model are a time dependent vehicle routing problem (TDVRP) integrated with robust shortest path (RSP) algorithm to deal with a complete graph represented by the data available. It was found that the time dependent VRP is suitable for application to real world situations.

B.3.2.5 MOSCA-LINE

MOSCA-LINE is an algorithm to plan online deliveries taking into account new customer requests or traffic jams. The module is capable of reorganising the next stops on a delivery route on the basis of available information such as the current location of vehicles and the road network situation. The module can also gather information about the traffic conditions from the incoming communications from vehicles. This real-time information can be used to produce more efficient delivery plans, taking into account new traffic situations.
The tests carried out on MOSCA-LINE in Lugano confirmed the applicability of the module for real problems. The architecture of the module operates by dividing the working day into time-slices, and new orders received during a time-slice are postpones until the end of it. Tests were carried out to ascertain the optimum number of time-slices to guarantee the best possible performance on a case study. Results obtained suggest that a number between 10 and 50 represents the best compromise between too short a run for the heuristic algorithm and not enough up to date information (MOSCA, 2003).

B.3.2.6 MOSCA-SHOP

MOSCA-SHOP is a web service to schedule the reservation of ramp access for urban freight deliveries. It provides information on free dock access and allows booking of access time slots. It is used by carriers to plan their service using enhanced information regarding waiting times at the shops' loading facilities. The carrier enters shipment data and requests loading bay access. Shops give their accessibility information and instructions for carriers to MOSCA-SHOP. Loading bay reservations and delivery instructions are then passed on to the carrier and incoming requests are sent to the shop. A level of service feedback function incorporated in the module allows carriers to assess the extent to which shops adhere to their access guarantees and also allows shops to assess the quality of the service of the carriers.

Results from testing the module in Stuttgart that it is carriers than derive the most benefit from the system. This is because they can increase their rate of successful first-time deliveries as well as decreasing their waiting time at shop premises.

B.3.2.7 MOSCA-NET

MOSCA-NET like MOSCA-SHOP is a web service. It is used to manage preferred delivery locations for recipients of freight consignments. It receives information about delivery locations, delivery profiles and time windows from private customers. Customers store the information on the module's database using a user interface while being connected online to it. The primary object of the module is to act as an information centre for delivery data, accessed by private customers and logistics service providers.

Results from the testing of MOSCA-NET in Stuttgart indicated that people seem to be reluctant to specify time-patterns form more than one week.

B.4 DATA NEEDS FOR FREIGHT MODELLING

The development of a freight model is dependent on the quality and extent of data available. Reliable data on the movement of freight are needed to inform public policy decisions on issues such as congestion mitigation, transportation security, air quality improvement, economic development, and land use. Reliable, high-quality freight transportation data are also needed by the private sector to inform a range of strategic investment decisions relating to topics such as equipment utilization, new market opportunities, and business relocation (TRB, 2003).

B.4.1 Major Reasons for Needing Freight Data

- Promote transportation efficiency and mitigate congestion
- Improve regional and global economic competitiveness
- Enable effective land use planning
- Inform investment and policy decisions about modal optimization
- Enhance transportation safety and security
- Identify transportation marketing opportunities
- Reduce fuel consumption and improve air quality
- Understand economic geography
- Reduce incremental operating costs for all users
- Provide information for national accounts

B.4.2 Current Freight Related Data Available

In terms of freight data available for models, there are a number of European initiatives dealing with freight transport. COST is a framework for scientific and technical cooperation and coordinating national research at a European level. There are nearly 200 COST Actions in total. The two COST Actions relevant for freight transport data are COST 310, Freight Transport Logistics, and COST 321, Urban Goods Transport (COST, 2003).

COST 321 took place over three years and involved the following countries: Finland, France, Germany, Ireland, Italy, Norway, Portugal, Spain, Sweden, Switzerland, The Netherlands, the UK and the former Yugoslavia. The aim of the research was to present a forward-looking analysis of freight transport logistics in Europe and to make

recommendations for the development of an integrated European freight transport network.

The final report gives the main characteristics of freight transport, current status of the transport system and logistics, transport demand and environmental factors. COST 321 involved four years research with the aim of studying the design and operation of innovative measures to improve the environmental performance of freight transport in urban areas. This particular Action served to increase public awareness of the problems associated by urban goods movement and the need for international cooperation in the field.

BESTUFS (BESTUFS, 2003) is an EC funded thematic network in the fifth framework program. As part of the work of BESTUFS, a city inquiry on "issues, requirements and innovative measures for transport and delivery of goods in urban areas" was carried out. The BESTUFS consortium in collaboration with POLIS carried out the European Survey on Transport and Delivery of Goods in Urban Areas. The survey has been sent to important European cities in order to identify their major problems, requirements and initiatives concerning urban freight transport. The results will help to focus on major aspects of urban freight transport and to highlight areas that merit further attention and research. They give a good indication of the current problems and issues to be dealt with concerning the movements of goods in urban areas and the situation in urban freight transport planning in city administrations.

General conclusions drawn from the BESTUFS survey results included the following (BESTUFS, 2001):

- Most of the European cities questioned in the survey have problems concerning urban freight transport, which affect the attractiveness and quality of life of the city.
- For most of the cities, the important issues concerning urban freight are dealing with cooperation among all local actors, coordinating urban freight policy, information, statistical data/data acquisition and use of innovative vehicle technology for city distribution.
- Not all of the cities are aware of the ongoing changes in logistics and city distribution (e.g. e-commerce, ITS) and know about new operational and technical possibilities (e.g. traffic management, enforcement support, etc.) to improve the situation.
- More than half of the cities do not even deal with urban freight transport planning.
- In most of the cities there is a lack of statistics and data concerning urban freight transport. The data availability is poor compared to passenger transport.

The chief sources of information in Ireland relating to freight are the Central Statistics Office (CSO), Dublin City Council (DCC), Dublin Transportation Office (DTO) and the National Roads Authority (NRA).

The CSO (CSO, 2003) compiles an annual survey of goods moved by road by tonnage carried and collates statistics on port traffic. The CSO road freight survey provides an origin-destination matrix of tonnes carried. The data relates to tonnage

carried rather than to vehicle kilometres. Each year the CSO collects data for one weeks transport activity for a random sample of goods vehicles in the country. The sample is grossed up to the level of the national fleet to provide estimates for freight activity by all goods vehicles for the year in question. Registered vehicles with an un-laden weight of 2 tonnes and over come within the scope of the survey.

The Statistics of the Port Traffic Survey carried out by the CSO (CSO, 2003b) collects quarterly data from 22 ports and harbours around the country. The statistics gather detail the movement of goods in sea going vessels by type of cargo and region of trade in addition to the type and size of the vessels used to carry out the transportation.

In relation to Dublin port, a government task force on ports established under the auspices of the Department of the Marine reported in 2002 on the volumes of traffic entering and leaving the port (Department of the Marine, 2002). This data helps to build a picture of how port related traffic affects congestion in the city centre.

Traffic counts on the canal cordons are carried out annually by Dublin City Council. The most recent traffic counts (December 2003) specifically focused on goods vehicles at 17 key road links crossing the canal cordon. Goods vehicles were classified according to the axle configuration. Previous cordon counts did not focus on the classification of goods vehicles and only looked at vehicles entering the cordon (and not exiting). Therefore, a thorough comparison of vehicle counts of recent years is not easily facilitated.

B.4.3 Data Required for Freight Models

Data needs for freight modelling are generally dependent on the specific modelling techniques used. However some common data requirements can generally be identified. In the case of urban freight models, Ogden (1992) identifies five key areas for data collection.

1. Vehicle Fleet

Data is required on the number, type and size of vehicles as well as their ownership pattern (for-hire operations, owner-drivers, and private operations. This information should be gathered at a disaggregate level. This type of information is contained in the CSO Road Freight Transport Survey and the database of Irish Registered Vehicles. However, only goods vehicles with an unladen weight of 2 tonnes and over are within the scope of the CSO survey. Therefore a gap in knowledge exists regarding vehicles less than 2 tonnes. This is something that should be addressed if a citywide freight model is to be developed.

2. **Vehicle Flows**

Information regarding vehicle flows is critical in terms of future infrastructure planning and current infrastructure management. Vehicle flows are also significant for the identification of freight activities in different locations and temporal variations of activities within a city. Although vehicle cordon counts take place annually in Dublin,

the pattern of goods vehicle movements is not clear since origin and destinations of non-port related trips through Dublin are unknown.

3. Commodity Flows

Unlike vehicle flows, commodity flows are the direct effect of consumption and therefore are a crucial piece of information for any comprehensive freight model. Obtaining commodity flow data often requires some form of interview. For each load being moved origin destination land use or industrial activity and commodity classification data should be collected, as well as load size (weight and/or volume), type of packaging and handling, ownership and responsibility of transport (shipper, forwarder, carrier etc.) and method of dispatch (depot, radio, phone, EDI, Internet etc.) (Garrido, 2001). Clearly this type of information is costly to acquire both in financial and in human terms. The CSO Road Freight Survey gathers a certain amount of relevant data regarding the commodities transported including weight and goods classification (using the Standard Goods Classification for Transport Statistics of the European Union). However, again a major problem for commodity flow analysis lies in the exclusion of vehicles with an unladen weight of less than 2 tonnes.

4. Major Freight Generators

Information regarding the major freight generators is essential for modeling the economic impact of freight movement. Ogden (1992) points to two approaches for the analysis of freight generators. The first approach (a metropolitan-wide analysis) includes both freight related data (volume and type of freight generated and associated vehicle trips) and economic data (income, population density) to establish relationships between explanatory variables. The second approach examines the impact of specific freight generators, such as an airport, port or industrial site. Useful information about these facilities includes origins and destination of truck movements and accessibility (e.g. delays, routes etc.). More specific data may include weight by commodity by origin destination, type of freight, numbers employed at site and the size of the site.

5. Major Freight Corridors

The identification of major corridors for the movement of goods within a metropolitan area is necessary for transport planning purposes. The identification of corridors can be done when truck and commodity flows have been ascertained. Once the major corridors have been identified, the next step is to uncover the commodity types being moved and the prominent vehicle types.

B.4.4 Data Sources in the UK

As part of an overall study of freight modelling, the Department of Transport (DfT) in the UK reviewed the relevant data sources available (DFT, 2002b). In order to obtain information on the broad spatial pattern of road goods transport the DfT carries out three continuing freight surveys:

- CSRGT – the Continuing Survey of Road Goods Transport
- IRHS – the continuing International Road Haulage Survey
- RoRo – the quarterly Roll-on/Roll-off Enquiry

The CSRGT is a statutory survey of heavy goods vehicles over 3.5 tonnes gross vehicle weight in the UK and is similar to the CSO Road Freight Survey. The CSRGT is the only national survey of road haulage activity. The IRHS is a statutory survey of the international work undertaken by UK hauliers using heavy goods vehicles over 3.5 tonnes gross vehicle weight. Finally, the RoRo is a voluntary enquiry of the number of road goods vehicles (RGVs) and unaccompanied trailers (U/Ts) travelling from the UK to mainland Europe and Ireland via Roll-on/Roll-off ferries and the Channel Tunnel. However the DfT review points to the fact that despite the data potentially available it is not always feasible to make best use of this data due to inconsistencies in definitions, methods of collection, incompatible geographic resolution and difficulties in access. It is stated that problems tend to be greatest when matching data from different agencies since each dataset is typically collected to meet the specific needs of the agency concerned and so it may not necessarily adopt the particular definitions that are pertinent to the requirements of freight modeling. This is also true of data available in the Greater Dublin Area where as mentioned previously in Section B.4.2 a number of agencies (including CSO, DCC and NRA) collect freight relevant data.

B.4.5 A Practical Example of Data Collection

The extent of the data required for freight modelling can be seen in the case of the Lower Mainland Vancouver Truck Freight Study. The study involved two main data collection components:

- Origin/destination surveys
- Vehicle volumes and classification survey

Regional truck surveys were carried out in order to obtain quantitative information regarding demand for light and heavy truck trips in the Lower Mainland. Data gathered included the number of trips made in a day, origins and destinations of these trips, and land use at the trip end. A clear distinction was made between light and heavy trucks where trucks under a GVW of 20,000 kg (20 tonnes) were classified as light and trucks over 20,000 kg were classified as heavy. As gross vehicle weight can be difficult to ascertain visually, the number of axles present was also used to distinguish between light and heavy trucks. Trucks with two axles were considered to be light trucks and those with three or more axles were classified as heavy vehicles. In order to obtain a clear picture of truck demand, three different types of truck surveys were carried out- internal trips, external trips and special generator trips.

Internal trips account for truck journeys originating and terminating within the study area. Trip diary surveys were mailed out to fleet managers of 13,600 trucks based on a random sample of trucks from a vehicle registry database. In total, 1740 surveys were completed accounting for 8100 trips. This represented a response rate of 13%, which was considered high when compared to other similar surveys (Bickel et al., 2003).

Special generator trips are those trips originating or terminating at facilities or locations that are major truck traffic generators. They include port terminals and the airport. Truck demand for these facilities was gathered using roadside interviews at six key sites. Information gathered manually was supplemented by additional input from the various facility operators.

External trips on the other hand, are those trips that originate or terminate outside of the study area. Through trips (originate outside the study area and pass through the region without stopping are also included in this category. Data relating to external trips was gathered mainly by carrying out roadside interviews. These interviews were conducted at seven entry/exit points to the region.

The second main component of the study was the vehicle volumes and classification survey. This involved a major vehicle classification count program in the region with 255 separate traffic-counting activities. Vehicles were classified into 10 different categories including light and heavy trucks at 75 of these locations. This comprehensive counting program was useful in a number of ways:

- Completed the 'snapshot' of truck activity on a typical day
- Established a reference point for comparison to historic counts, and to support monitoring truck movements in the future
- Presented insight into route selection and identification of major truck routes and
- Provided a basis for calibration and validation of the truck demand forecasting model and provided the vital link between the estimated (model) and observed truck traffic.

B.5 CONCLUSIONS

From the Vancouver case study it is clear that the development of a truck demand model/freight model requires considerable and deliberate data collection. Fitting existing data to any future freight models that are built may be convenient in the short term. However, some considerable data deficiencies exist, particularly the availability of information regarding non-port related trip origins and destinations in Dublin. Furthermore, as pointed out in the Delcan Report (2003) the disparity in the definition of a HGV vehicle in various studies carried out to date also poses some difficulties for vehicle classification in any future freight model. Also, as mentioned previously the CSO Road Freight Transport Survey excludes vehicles less than 2 tonnes. This means that nationwide O/D information for these vehicles along with weight carried, distance travelled and other commodity information is lacking. Data collection programs should have clear objectives and aims in order to ensure that useful data is collected and time and effort are not expended collecting data, which is never used. Any major data collection exercise must be carefully planned so that it Ogden, 1992):

- Collects information relevant to specific policy or planning needs
- Is efficient in the use of survey resources
- Produces reliable and verifiable results
- Easily facilitates survey analysis
- Facilitates subsequent monitoring of the freight system

Undoubtedly there are costs involved in developing a freight model for Dublin. Roadside surveys are costly to implement while postal surveys (used in the Vancouver Case Study) are subject to low response rates. The Lower Mainland Vancouver Freight Study was funded by eight agencies ranging from federal government to port authorities. A notable feature of the study was the successful inter-

agency collaboration throughout the project, from funding negotiations to project delivery (Bickel et al., 2003). A large-scale freight model for Dublin is likely to require input and co-operation from various agencies and authorities. Given their existing role in the development and maintenance of the Dublin Transportation Model, the DTO are likely to play a key role in the development of a freight model for the city.

Despite the likely costs of development and maintenance, a dedicated freight demand forecasting model for the Greater Dublin Area would be beneficial in terms of assisting activities such as major infrastructure planning, traffic monitoring, traffic impact assessments of major developments, pavement management systems and air quality modelling, all of which are important for commercial and social development of the city. Examples of specific policies whose evaluation would be aided by the availability of a freight model include:

- Consolidation and break up of shipments at the edge of a city or town
- Sensitivity of commercial traffic to different tolling regimes
- Changing carbon emissions targets
- A possible charge on embedded miles in goods (similar to a carbon tax)

Ultimately, enhanced levels of knowledge regarding freight distribution trends in Dublin provided by a comprehensive freight model will influence the strategic long-term transportation development of the city.

C LETTERS OF SUPPORT

DUBLIN CITY BUSINESS ASSOCIATION

DCCBA Ltd.
21 Dawson Street
Dublin 2
Tel: 01 - 662 2995
Fax: 01 - 662 2284
Email: info@dcba.ie
Website: www.dcba.ie

February 27, 2003.

«Title» «Initials» «Last_Name»
«Company»
«Address1»
«Address2»
«Address3»

Dear «First_Name»,

I would be very grateful if you would kindly facilitate a team from Trinity College (Clare Finnegan and Hugh Finlay) to compile data for an important new project on sustainable transport, which is of interest to members.

This involves a survey of deliveries to city centre business premises within the canal cordons on *a typical day during the week of 10th to 16th March.*

This exercise, which is being sponsored by the Department of Transport, will fill a crucial gap in the association's current understanding of the movements and behaviour of goods vehicles on our busy streets.

As you may be aware, our association sees an urgent need to persuade all the parties concerned to begin to manage deliveries in a way that will accommodate and maximise customer access. Indeed this concern will feature in the association's new "Mobility Plan for the City", currently under discussion.

Attached you will find diary sheets to be completed and returned by fax or by post to the address below for *a typical day, (preferably the 12th March)* in the week beginning the 10th March.

The completed diaries should be returned to following address or fax number before March 19th:
Clare Finnegan
TSRG
Department of Civil, Structural & Environmental Engineering
Trinity College, Dublin 2
Fax: 01 6773072; Tel: 01 6082537

If you have more than one outlet, please copy the diary sheet and circulate to each premises in the group.

A summary of the survey will be e-mailed back to respondents and I hope that this will provide useful feedback to members. Individual respondents will not be identified.

Thanking you for your kind co-operation.

Yours sincerely

Tom Coffey
Chief Executive

LVA
LICENSED VINTNERS ASSOCIATION

Anglesea House,
Anglesea Road,
Ballsbridge,
Dublin 4.

Tel: 668 0215.
Fax: 668 0448.

Chief Executive Frank Fell.

27 March 2003

TO ALL MEMBERS OF THE ASSOCIATION

Dear Member

I would be very grateful if you would facilitate a team from Trinity College (Clare Finnegan and Hugh Finlay) to compile data for an important new project on sustainable transport (particularly in relation to deliveries) of interest to members.

This involves a survey of deliveries to city centre business premises within the canal cordons during *a typical day during the week of 7th to 12th April.*

This exercise, which is being sponsored by the Department of Transport, will help to fill a crucial gap in the LVA's current understanding of the movements and behaviour of goods vehicles on our busy streets.

Attached you will find diary sheets to be completed and returned to the address below for *a typical day (say Wednesday the 9th April)* in the week beginning the 7th April.

The completed diaries should be returned to the following address or fax number, by the 16th April if possible.

Clare Finnegan
TSRG, Department of Civil, Structural & Environmental Engineering
Trinity College
Dublin 2
Fax: 677 3072
Tel: 608 2537/608 2534

A summary of the survey results will be made available to respondents and I hope that this will provide useful feedback. Individual respondents will not be identified.

Thanking our for your kind co-operation,

Yours sincerely,

FRANK FELL
CHIEF EXECUTIVE

TCD Daily Delivery Survey

Company Name _____ **Contact Person** **Type of Business** _____ **Business Address**

Phone Number

Fax Number

Day of the Week _____ **Date** _____

Time of Delivery Arrival	**Time of Delivery Departure**	**Type of Goods**	**How Packaged** (pallets,boxes parcels,loose,etc)	**Quantity of Packages**	**Type of Delivery Vehicle** (truck,van,car motorbike)	**Who supplied the Goods**	**Where is your Supplier Located**	**Where does loading/unloading occur?** (on-street parking, shared loading bay, dedicated loading bay,other)

Please answer the following questions when you have completed the delivery diary

1.) Would you consider the number of deliveries today

- Less than usual ☐
- Greater than usual ☐
- Typical of an average day ☐

2.) If the number of deliveries is more or less than usual, please indicate whether there were

1 to 5 less	☐	1 to 5 more	☐
6 to 10 less	☐	6 to 10 more	☐
11 to 15 less	☐	11 to 15 more	☐
greater than 15 less	☐	greater than 15 more	☐

3.) Please provide details of deliveries which are normally scheduled for today and did not arrive

Name of Supplier	Type of Goods	Expected Delivery Date

Please return this form to Clare Finnegan by fax (6773072) or by post to TSRG,Dept of Civil Structural &Environmental Engineering, TCD, Dublin 2

E AREAS IN EACH COARSE ZONE

Zone Area	Zone number
City centre (Central Business District)	1
Dublin Port area	2
North east city	3
North west city	4
South east city	5
South west city	6
Fingal west	7
Fingal east	8
Fingal north west	9
Fingal north east	10
South Dublin (Lucan, Clondalkin)	11
South Dublin (Tallaght)	12
South Dublin (Saggart, Rathcoole)	13
Dun Laoghaire/Rathdown north	14
Dun Laoghaire/Rathdown south	15
Meath	16
Kildare	17
West Wicklow	18
East Wicklow	19
Louth	20
Externals (Outside Greater Dublin Area)	21
Outside Ireland	
Total	

F MUSGRAVE UDC DISTANCE MODEL

	Current						Future					
Location	Current Freq	Average Vol - Current	Distance Delivery	Distance Delivery and return	Trunk Mileage	Total Delivery Dist	New Frequency	Average Volume - Future	Distance Delivery	Distance Delivery and return	Trunk Mileage	Total Delivery Dist
Rialto	1	566	4	8	312	320	5	846	20	40	0	200
Cathal Brugha St	1	175	5	10	312	322	3	338	21	42	0	126
Dame St.	1	380	5	10	312	322	3	703	21	42	0	126
Camden St	1	303	5	10	312	322	4	520	21	42	0	168
O'Connell St	1	380	5	10	312	322	5	647	21	42	0	210
O'Connell St	1	262	5	10	312	322	4	594	21	42	0	168
Talbot Street	2	156	5	10	312	644	4	405	21	42	0	168
Dorset Street	1	389	5	10	312	322	4	724	21	42	0	168
Capel St.	1	146	5	10	312	322	3	328	21	42	0	126
Westmoreland St.	1	372	5	10	312	322	5	768	21	42	0	210
Nth King St	1	164	4	8	312	320	3	359	20	40	0	120
Millennium Mall	1	167	5	10	312	322	4	374	21	42	0	168
Charlemount Street	1	301	5	10	312	322	4	565	21	42	0	168
Phibsboro	1	252	5	10	312	322	3	387	21	42	0	126
Nassau Street	1	413	5	10	312	322	3	585	21	42	0	126
Stoneybatter	1	349	4	8	312	320	3	474	20	40	0	120
	17	4,775				5,468	60	8,617				2,498

G VISUAL BASIC ARRIVAL TIME GENERATING CODE

```
Public Function RandomNumber()
' Generates a random whole number within a given range

' Declare Variables

  Dim counter As Integer
  Dim Found As Boolean

  Range("o3").Select

  For counter = 1 To 492

  RandomNumber = Int(Rnd * (1439 + 1 - 0)) + 0
  'Randomize
   Do
  Do While Not RandomNumber >= 300 And RandomNumber <= 1380
   RandomNumber = Int(Rnd * (1439 + 1 - 0)) + 0
  Loop

     If RandomNumber >= 420 And RandomNumber < 600 Then

        'RandomNumber = Int(Rnd * (1439 + 1 - 0)) + 0
        counter = counter - 1
        Exit Do

        ElseIf RandomNumber >= 750 And RandomNumber < 1140 Then

        'RandomNumber = Int(Rnd * (1439 + 1 - 0)) + 0
        counter = counter - 1
        Exit Do
       Else
        Found = True
        ActiveCell.Offset(counter, 0).Value = RandomNumber
        Exit Do

        End If


      Loop


 Next counter

End Function
```