

An Initial Assessment of the Potential for Urban Distribution Centres in Dublin

Clare Finnegan
Centre for Transport Research
Department of Civil, Structural & Environmental Engineering
Trinity College Dublin
Dublin 2
Tel: + 353 1 6082537
Fax: + 353 1 6773072
Email: finnegc@tcd.ie

Hugh Finlay
Centre for Transport Research
Department of Civil, Structural & Environmental Engineering
Trinity College Dublin
Dublin 2
Tel: + 353 1 6082534
Fax: + 353 1 6773072
Email: finlayh@tcd.ie

Margaret O'Mahony (**CORRESPONDING AUTHOR**)
Centre for Transport Research
Department of Civil, Structural & Environmental Engineering
Trinity College Dublin
Dublin 2
Tel: + 353 1 6082084
Fax: + 353 1 6773072
Email: margaret.omahony@tcd.ie

Word count: $5007 + 8(250) = 7007$

ABSTRACT

Urban distribution centres (UDCs) /consolidation terminals form an important component of the concept of 'city logistics'. UDCs can fulfil a number of functions including warehousing, transshipment and consolidation of loads. At the terminal, shipments destined for delivery are sorted into routes, and dispatched with a single truck serving all premises along one route.

The aim of the paper is to present the first stages of a feasibility analysis and an estimation of the potential for using UDCs in Dublin, the objective of which would be to improve freight distribution in the city. The paper commences with a review of relevant studies and this is followed by the design of a survey of freight deliveries to a large university in the city centre. The aim of this survey is as the first phase of the project and it leads into a second survey of businesses in the city centre, which is currently underway.

Two geographical zones in the city showed a high origin output in terms of deliveries to the university campus, indicating potential for location of an urban distribution centre. These findings will require validation in the larger survey. A breakdown of the vehicle types indicated that 64% of the deliveries were made in vans. 18 incidences of multiple deliveries by the same company on the same day were uncovered. The reasons behind this will be further investigated to see if 'just-in-time' delivery is the justification or if better coordination to reduce trips is an option.

INTRODUCTION

Urban distribution centres (UDCs) /consolidation terminals form an important component of the concept of 'city logistics'. City logistics can be defined as 'the process for totally optimising the logistics and transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy' (1). The aim of city logistics is to globally optimise logistics systems within an urban area by considering the costs and benefits of schemes to the public as well as the private sector (1)

UDCs can fulfil a number of functions including warehousing, transshipment and consolidation of loads. At the terminal, shipments destined for delivery are sorted into routes, and dispatched with a single truck serving all premises along one route. The trucks also pick up outbound shipments and return them to the terminal where they are sorted for collection. Such centres are designed to meet the requirements of an urban freight transport system using advanced information systems (AIS). These systems help implement algorithms and heuristics to develop more efficient routing and scheduling systems for deliveries in an urban centre. This helps to optimise the number of trucks required to provide the same or even a higher level of service to customers compared with a regular delivery system (2).

UDCs can also facilitate the implementation of cooperative freight transportation systems. These systems involve a number of freight carriers and shippers jointly operating the distribution centres to reduce their own costs and to provide higher levels of service to their customers. Taniguchi et al. (3) concluded that adopting cooperative freight transportations systems could reduce truck traffic.

The aim of the paper is to present the first stages of a feasibility analysis and an estimation of the potential for using UDCs in Dublin, the objective of which would be to improve freight distribution in the city. The paper commences with a review of relevant studies and this is followed by the design of a survey of freight deliveries to a large university in the city centre. The aim of this survey is as a pilot to a much larger survey of businesses in the city centre, which is currently underway. Some interesting results are available from the survey – already some areas of Dublin are indicating potential for having a UDC.

BACKGROUND

Planning the size and location of facilities are traditional problems associated with consolidation terminals. Young, Ritchie and Ogden (4) 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 have the greatest impact. Sites with good access are both attractive to the industry and are desirable locations from the public point of view simply because they minimise the amount of travel on local streets. Ogden (5) also 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

Optimisation problems relating to the location of the centres have been combined with the routing of goods in academic papers. Taniguchi et al. (2) focus on optimisation in designing public logistics terminals, taking into account traffic conditions on the road network. A mathematical model was developed using queuing theory and non-linear programming. In the Taniguchi model, a distinction is made between two types of goods movement: line-haul, which is long-haul transportation by large trucks and local pickup/delivery, which is transportation by smaller trucks over short distances.

The model was applied to an actual road network in the Kyoto-Osaka area to determine the optimal size and location of logistics terminals. This network is planned for the year 2016, and 16 possibilities for logistics terminals are outlined along several planned expressways. The network has two centroids for line-haul trucks in East and West Japan and 36 centroids for pickup/delivery trucks and passenger cars in the Kyoto-Osaka region. Predicted O-D traffic volume levels for 2010 were used in the model.

Other studies using the UDC concept include the Heathrow Airport Retail Consolidation Centre. 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, the airport initiated a project to develop a new warehousing and distribution service for retailers at Heathrow (6). 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

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. To date the new operation has resulted in a reduction in vehicle movements for retailers and suppliers to the four Heathrow terminals by 61%.

Case Studies Using Eco-Friendly Vehicles and UDCs in selected European Cities

La Rochelle, France, a city of 135,000 inhabitants 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 (7).

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 heavy goods vehicles (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).

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 (electric vehicle city distribution) project, a European initiative, (7) 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 6.00 and 7.30 am was enacted.

A mid-term evaluation by external consultants appointed by the Directorate General for Transport and Energy at the European Union has found that (7):

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 parcels 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 electric vehicles (EVs)
7. Effective collaboration between the city council, local businesses and 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 customer (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 initial 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.

Other cities, which have used the UDC concept, include Rotterdam, Stockholm, Milan, Brussels and Paris (7). A brief description of the Rotterdam and Stockholm examples follows:

Rotterdam

Rotterdam, a large port city of 600,000 inhabitants is a major European transport hub. The city authorities wish to facilitate the role of the city as a major intermodal gateway while ameliorating the impacts of traffic (7). The 3 main logistics service providers, who account for 70% of all parcels and package deliveries in the city, operate from their own UDCs on the edge of the city. The 3 main carriers purchased a fleet of 7 large EVs (Mercedes) to substitute for the equivalent 3.5 GVW diesel vans. A van has to serve 100 or more addresses per day in one single trip. All 7 vans are in operation at the 3 transport companies. The range of the large EVs was

found to be sufficient (max 70 km and 100 drops per day – this takes drivers from 5 to 7 hours to complete).

The high capital costs are problematic however because the vehicles are treated as prototypes by the manufacturers. While more definitive information is awaited in response to enquiries, the capital costs of the larger EVs and HEVs are some orders of magnitude greater than those of conventional vehicles of similar capacity.

A report by KPMG consultants examines the effectiveness of UDCs in 13 cities in the Netherlands (9). The Dutch approach is one of extensive consultation and collaboration with all the interested parties with a view to achieving a balanced solution broadly acceptable to all.

The negative aspects of UDCs are:

1. The perceived loss of control of goods in transit and problems with liability or damaged goods
2. The creation of monopolies and the exclusion of smaller companies
3. Extension of the lead-times due to the introduction of an additional step in the supply chain
4. Lack of co-operation by companies who already enjoy in-house transport facilities

In the case of Rotterdam the three main logistics service providers already had their own UDCs in place for the delivery of parcels and packages and these were easily adapted to take on board the EVs and hybrids. The application of ICT related logistics software ensures a high degree of loading and optimum deliveries per run (up to a 100 per vehicle).

The project suffered from unduly long delays in the procurement of the EVs due to changing policies by the suppliers and the project was extended for a year. The first cost of these 7 prototypes vehicles will remain prohibitive until Mercedes or other suppliers can be persuaded to plan longer production runs for large EVs.

Stockholm

The heart of Stockholm covers 5X7 km where 250,000 people live and 280,000 work. The city has developed extensive traffic policies to help improve the quality of life in the area (7). Access to the city centre by diesel trucks and buses over 3.5 tons is restricted while zero and low emission vehicles are favoured. Under the ELCIDIS programme, 6 hybrid trucks (gross vehicle weight (GVW) 12 t) and 3 small EV vans were tested as a replacement for conventional vehicles. Four major companies servicing the city have been using the six hybrid trucks. Rosters include the delivery of fruit, vegetables and ice cream to restaurants, necessitating on-board CO₂ tanks for refrigeration. General cargo (parcels as well as pallet loads), clothes and bread deliveries are also made. Mercedes Benz was persuaded to supply the uniquely large hybrid trucks for city distribution. The hybrids have an average driving distance of between 50 and 100 km per day. The share of the daily distance driven on the electric or “silent” mode is 30 – 40% depending on the routes designated.

SURVEY

In the case of Dublin, the aim is to determine the pattern of freight deliveries to the city centre. Two surveys were undertaken, one covers one week of deliveries to a large university campus in the city centre and the second will collect data on one day's deliveries to a number of businesses in the city centre. The results from both

surveys will be integral to identifying freight distribution trends in Dublin City Centre. The paper reports on the results of the first survey.

Consultation meetings were held with a range of different participants having a vested interest in freight transport. The parties who provided input 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)

The 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 nighttime deliveries.

Delivery service providers (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. 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.

Objectives of the Survey

Prior to the construction of the survey form, the project team compiled a list of essential data requirements. It was also considered important to construct the survey form in a manner that would minimise the burden of completing it as much as possible. The structure of a number of other similar questionnaires was examined including those of Allen et al. (10). The survey form used by Allen et al. was of particular interest because it was used in a research project carried out by the Transport Studies Group, Westminster as part of the Sustainable Cities Programme in the UK.

Using the Westminster study as background, the survey form used for the Dublin study required the following 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 survey was then used in a weeklong survey of deliveries to Trinity College Dublin (TCD). Vehicles making deliveries were stopped as they entered the gate of the campus and the survey team noted the answers to the survey questions. The purpose of the 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 occupies some 47 acres of land in Dublin City Centre, has a staff of over 1,700, a student population of nearly 15,000. As such it is uniquely placed as a sizeable delivery destination in Dublin's city centre.

RESULTS

The specific areas of interest for analysis of the data include:

- 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 post code and by Dublin Transportation Office (DTO) transportation model zone)
- Breakdown of vehicle types
- Correlations between certain key variables
- Companies making multiple deliveries in the same day

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

Figure 1 shows the frequency of deliveries by time of day. Thursday and Monday emerged as the busiest days for deliveries to the College with each day having 106 and 91 deliveries respectively. The peak hour for deliveries occurred between 10:00 and 11:00 with an average of 14 deliveries arriving in this hour. The next busiest hour occurs between 11:00 and 12:00 with an average of 13 deliveries arriving in this hour. Overall, the time period from 11.00 – 15.00 seemed 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. The morning period (7:00 – 11:00) is the second busiest period overall, 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). Specifically, for the periods 15:00-16:00, 16:00 – 17:00 and 17:00 – 18:00, only 26, 13 and two deliveries were recorded respectively for the entire week.

Figure 2 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.

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 presented in Table 1. Catering, stationery, laboratory supplies and courier parcels make up the bulk of the 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. 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%.

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 aim was to see if similar goods were packaged in the same way. Consistency of packaging of similar types of goods will be an issue in terms of a possible UDC, hence the interest in this particular aspect. The hypothesis tested was that there is a correlation between types of packaging and types of goods. Using Pearson's Product Moment Correlation Coefficient, also known as Pearson's r , a correlation coefficient of -0.126 was calculated. Cohen and Holliday (12) suggest that a coefficient of 0.19 or below represents 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 the same categories of goods are packaged.

Another aspect 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 transport modeling system. This system has 21 zones as shown in Figure 4. Table 2 details the zones where delivery trips began at the start of the day. Table 2 shows Zone 1 (city centre) 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. TCD itself is located in Zone 1. Zones 6 (includes areas such as Inchicore, Crumlin, Kimmage, Walkinstown and Cherry Orchard.) and 12 (including 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 located in Zones 6 and 12 and this may help to explain the higher number of origins for deliveries to the city centre. Given the high output of these two zones, they may be possible locations for UDCs although the generation level produced in this survey needs further validation.

Table 3 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.

Having analysed the proportion of deliveries originating in the various DTO zones, a statistical correlation exercise was then carried out, the purpose of which was to test the hypothesis that if the supplier's base is in zone 1 (city centre), then the stop before TCD is more likely to be in zone 1. Using the Pearson's measure, a correlation coefficient of 0.458 was calculated. Cohen and Holliday (11) suggest that a

correlation coefficient in the range of 0.40 and 0.69 is considered modest and the value calculated falls in this range.

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 i.e. 62%.

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 the demand for 'just in time' products. It could also demonstrate that deliveries to a particular entity are not coordinated as well as they might in terms of reducing trips to the city centre. From the survey data, it was ascertained that over the course of the week of the survey, 13 companies made multiple deliveries to the College 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 in fact courier companies. The apparent lack of coordination of deliveries will be followed up at a later stage of the project when it is planned to interview logistics companies.

Having now completed the TCD survey, the next stage is to repeat the survey of 150 businesses in the city centre. Government departments, shopping centres, retail, etc will be included. The data collection for this is currently underway on the streets shown in Figure 5. The results will be analysed to see if the trends produced in the TCD survey are replicated in the larger survey of businesses in the city centre and in particular to reinforce any findings in terms of suitable locations for UDCs.

CONCLUSIONS

The aim of the research is to conduct a feasibility analysis for the use of consolidation terminals in Dublin to help reduce the current high number of freight movements evident in the city. These terminals could help coordinate freight movements and reduce trips to the city centre. The paper reports on a survey of freight deliveries to a large university campus located in the city centre of Dublin; the aim of which is to provide information on the trends of such deliveries. Of particular interest is the location of the origin of the deliveries geographically, as an area of high generation in terms of trips to the city centre could indicate a useful location site for an urban distribution centre.

The conclusions from the research are as follows:

1. Monday and Thursday had the highest number of freight deliveries to the campus – between 90 – 110.
2. The average dwell time for deliveries was 23 minutes.
3. The types of goods delivered included catering supplies/beverages, laboratory supplies, stationery, construction materials, electrical goods, courier parcels and miscellaneous. Catering, laboratory supplies, stationary and courier parcels had the highest frequency of deliveries.
4. The way goods are packaged could have an impact on how loads would be coordinated in an urban distribution centre system. It was noted in the survey that there was low correlation between the type of good and the packaging, indicating a high degree of variability in the way similar goods are packaged.
5. Two geographical zones in the city showed a high origin output in terms of deliveries to the campus, indicating potential in both of those areas for location

of an urban distribution centre. These findings will require validation in the larger survey.

6. A breakdown of the vehicle types indicated that 69% of the deliveries were made in vans.
7. 18 incidences of deliveries made on the same day by the same company were noted in the results. The reasons behind this will be further investigated to see if 'just-in-time' delivery is the justification or if better coordination to reduce the number of trips made is an option.

REFERENCES

- (1) Thompson, R. G., Taniguchi, E., City Logistics and Freight Transport, Handbook of Logistics and Supply Chain Management, Handbooks in Transport, Vol. 2, pp 393-405. 2001
- (2) Taniguchi, E., Noritake, M., Yamada, T. and Izumitani, T, Optimal Size and Location Planning of Public Logistics Terminals, *Transportation Research Part E*, 1999, Volume 35, Issue 3, pp 207-222
- (3) Taniguchi, E., Yamada, T., Yanagisawa, T. Issues and Views on Cooperative Freight Transportations Systems. 1995. *7th World Conference on Transport Research*.
- (4) Young, W., Ritchie, S.G., and Ogden, K.W., Factors that influence freight-facility location preference, *Transportation Research Record* 1980. 747, pp71-77
- (5) Ogden, K.W, *Urban Goods Movement: A Guide To Policy and Planning*, Ashgate, Brookfield Vermont 1992
- (6) BAA. *Heathrow, delivering for London and the regions*. BAA, Heathrow Airport, London. 2002.
- (7) Vermie T., et al, City of Rotterdam Public Works. "ELCIDIS – Final Report", CEC, DG-TREN, Brussels, 2002, www.elcidis.org
- (8) KPMG Klynveld Management Consultants, "*Final Report-Urban Distribution Centres in Rijnmond*", ROM-Rijnmond project C.5.2., February 1994
- (9) Debauche, W. and Duchateau, H. Urban freight transport in Brussels. Presented in Loughborough (UK) during the PTRC in September 1998 within the framework of the "Policy, Planning and Sustainability: Urban Freight Transport" – Published in the proceedings of the PTRC.
- (10) Allen, J., Anderson, S., Brown, M., Jones, P. *A framework for considering policies to encourage sustainable urban freight traffic and goods/service flows: Report 1: Approach taken to the project*. Transport Studies Group, University of Westminster. 2000.
- (11) Cohen, L. and Holliday, M. (1982) *Statistics for Social Scientists*, Harper and Row

List of Figures

FIGURE 1 Frequency of deliveries by time of day for TCD survey

FIGURE 2 Mean dwell times by time of day for TCD survey

FIGURE 3 Pie chart illustrating frequencies of types of packaging used

FIGURE 4 Zone system

FIGURE 5 The locations for the business survey (streets marked in red)

LIST OF TABLES

TABLE 1 Breakdown into types of goods

TABLE 2 Origin of deliveries (supplier base)

TABLE 3 Location of deliveries immediately prior to delivery to TCD

FIGURE 1. Frequency of deliveries by time of day for TCD survey

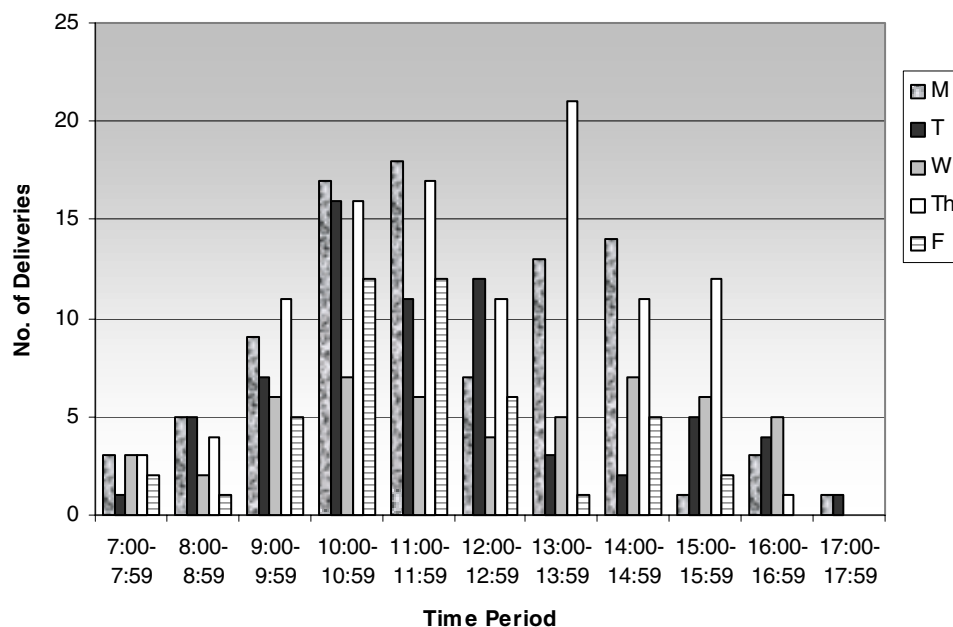


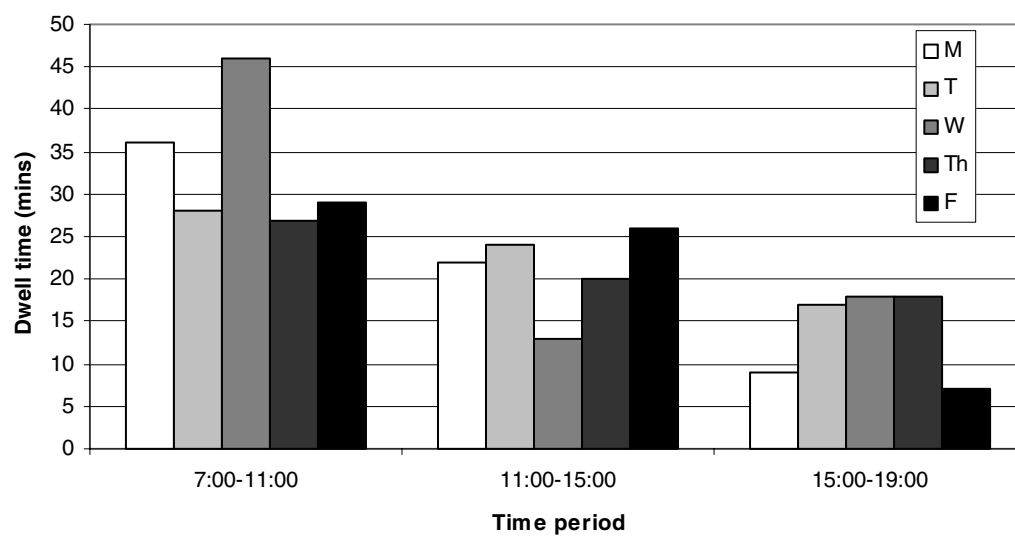
FIGURE 2 Mean dwell times by time of day for TCD survey

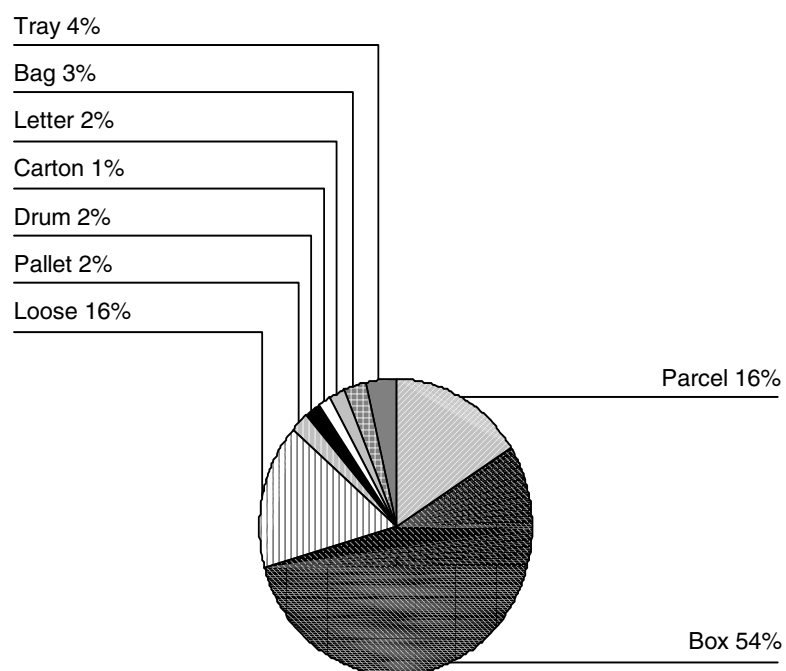
FIGURE 3 Pie chart illustrating frequencies of types of packaging used

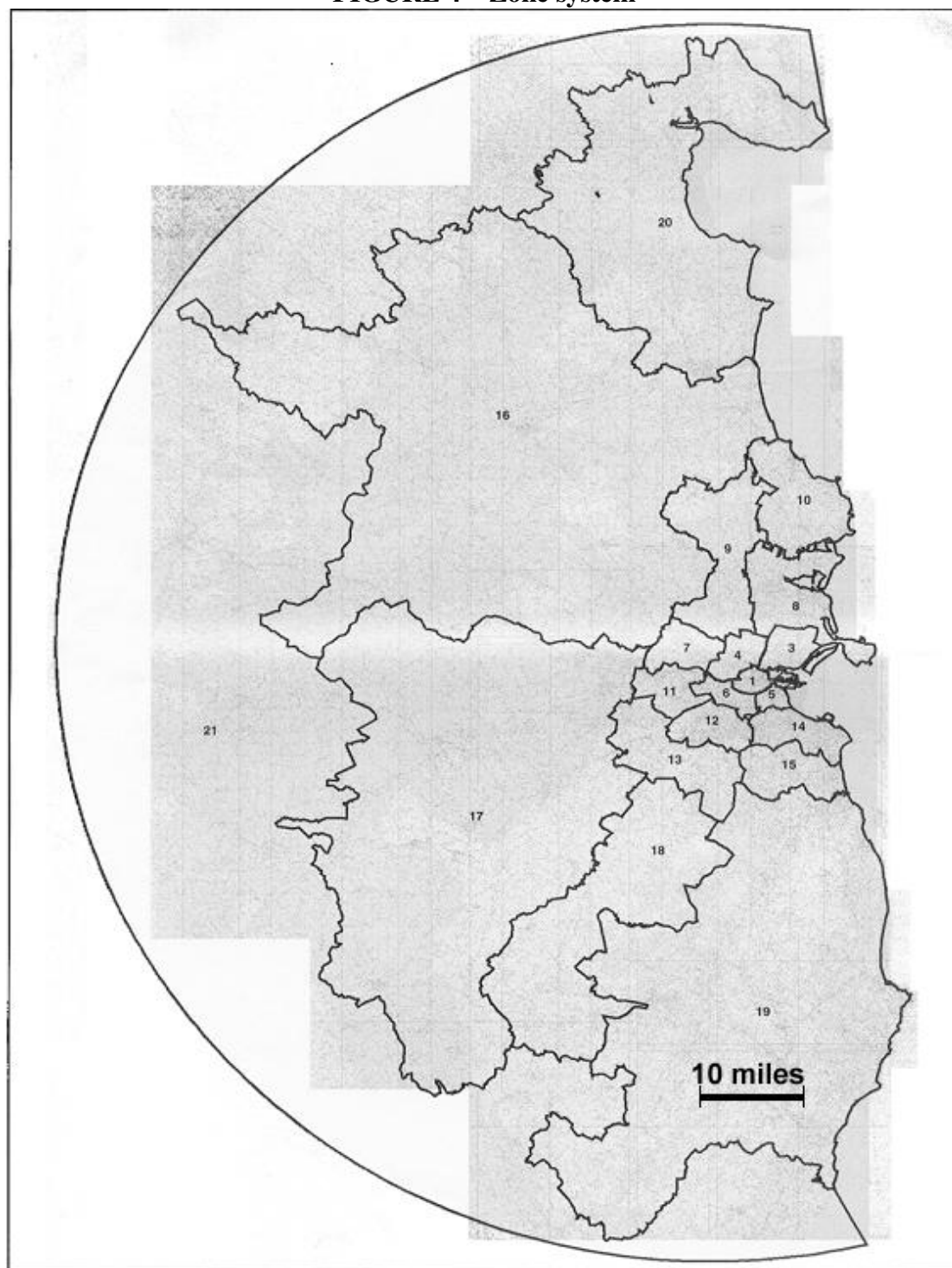
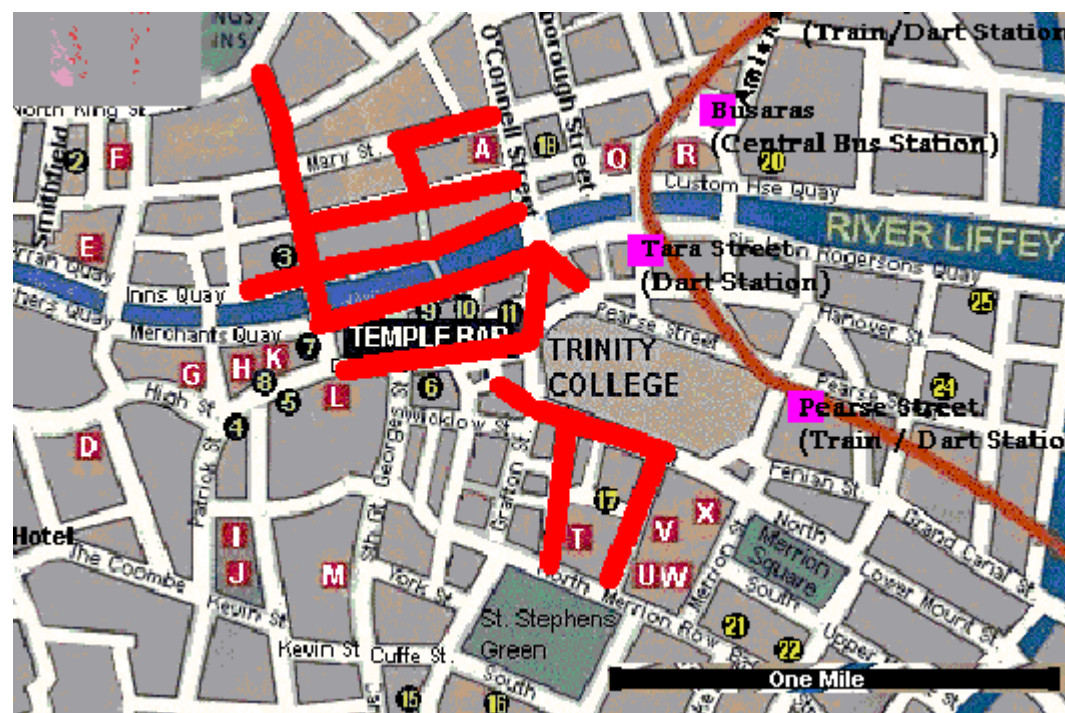
FIGURE 4 Zone system

FIGURE 5 The locations for the business survey (streets marked in red)



TABLES

TABLE 1. Breakdown into types of goods

	Frequency	Percent
Catering supplies, beverages	64	17.5
Laboratory supplies	72	19.7
Stationery/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
2 not defined		

TABLE 2. Origin of deliveries (supplier base)

Zone Area	Zone number	Frequency	Percent
City centre (Central Business District)	1	81	22.2
Dublin Port area	2	12	3.3
North east city	3	7	1.9
North west city	4	28	7.7
South east city	5	5	1.4
South west city	6	57	15.6
Fingal west	7	22	6.0
Fingal east	8	24	6.6
Fingal north west	9	0	0
Fingal north east	10	1	0.3
South Dublin (Lucan, Clondalkin)	11	0	0
South Dublin (Tallaght)	12	48	13.2
South Dublin (Saggart, Rathcoole)	13	3	0.8
Dun Laoghaire/Rathdown north	14	38	10.4
Dun Laoghaire/Rathdown south	15	3	0.8
Meath	16	6	1.6
Kildare	17	5	1.4
West Wicklow	18	0	0
East Wicklow	19	9	2.5
Louth	20	6	1.6
Externals	21	9	2.5
1 missing		1	0.3
Total		365	100

TABLE 3 Location of deliveries immediately prior to delivery to TCD

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
Fingal north east	10	1	0.3
South Dublin (Lucan, Clondalkin)	11	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
East Wicklow	19	5	1.4
Louth	20	5	1.4
Externals	21	7	1.9
Total		365	100