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Before-after assessment of a logistics trial with clean urban freight vehicles: A case study in London

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Abstract

The paper addresses the potential role that can be played by clean vehicles especially cycles in conjunction with urban consolidation centres (UCCs) in reducing freight traffic and its environmental impacts in towns and cities. A trial is presented in which a major stationery and office supplies company making deliveries to customers in central London replaced their diesel vans with electrically-assisted tricycles and electric vans operating from a urban micro-consolidation centre located in the delivery area. The results show that the total distance travelled and the CO2e emissions per parcel delivered fell by 14% and 55% respectively as a result of this delivery system. The trial proved successful from the company's perspective in transport, environmental and financial terms and it has therefore decided to officially launch and continue the operation.

Keywords: Clean vehicles; urban freight; urban consolidation centre; impact assessment; before-after survey

1. Introduction

This paper focuses on the potential for clean vehicles including electrically-assisted cycles and urban consolidation centres (UCCs) to alleviate local environmental and traffic problems within urban areas. The paper begins with an overview of using cycles for urban freight and their potential advantages and disadvantages. It then considers the role and purpose of UCCs and their potential benefits. The results of a UCC trial that took place in the City of London between 2009 and 2010 are then presented. This involved the use of a consolidation centre in the delivery area from which electrically assisted tricycles and electric

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vans were operated for delivery to receivers. The traffic and environmental impacts of the operation before and after the introduction of the UCC and electrically-assisted tricycles and electric vans are quantified.

2. Using cycles for urban freight transport

Cycles have long been used for the distribution of goods in urban areas. For instance, in the early twentieth century it was common for them to be used in towns and cities in the UK for the delivery of consumer goods from local shops to customers' homes (such as bakers, butchers, newsagents and grocers). They also became commonly used at this time for the sale of ice cream during warmer months. In addition, many postal services have traditionally used bicycles for urban postal delivery work. However, there was a marked decline in the use of bicycles for urban deliveries from the mid-twentieth century due to factors including: the greater availability of cars and vans (due to falling purchasing and running costs), the comparatively lower operating costs per unit carried of cars and vans (due to their payload advantages over cycles), and the growing suburbanisation of urban areas (which reduced the viability of cycles given the lower population densities and greater travel distances involved).

Recent developments in cycle technology have helped to make cycles feasible for urban freight transportation once again. These developments include: the lightweighting of materials from which cycles are manufactured, the design of cycles with larger carrying capacities (in terms of both weight and volume) which includes the development of trailers, and the introduction of electric motors which assist the rider, especially when travelling uphill. Freight cycles range in payload from approximately 25 kg for conventional two-wheeled machines with a front basket or tray to approximately 250 kg for three and four wheeled cycles with rear-mounted boxes, cages or trailers. Electrically-assisted cycles have a typical speed of approximately 15 kilometres per hour in free-flow conditions.

A recent literature review of the uses of cycles for urban freight transport identified them as having been used either currently or during the last decade in countries including France (Paris, Bordeaux, Dijon and Rouen), the Netherlands (Arnheim, Locheim, Nijmegen and Apeldorn), Belgium (Antwerp), the UK (including London, York, Nottingham, Cambridge) and the USA (New York, Santa Cruz and other Californian cities) [1]. In addition, cycles are widely used for the delivery of goods in towns and cities in developing countries [2]. In these locations in which cycles are currently being operated for urban freight transport they are being used to carry a range of products including documents and letters, parcels, groceries, and non-food retail goods, fresh cut flowers, sandwiches. They are used for both business-to-business deliveries and business-to-consumer deliveries (i.e. home deliveries), and are operated both on an in-house (own-account) and third party basis.

The advantages offered by freight cycles for urban distribution work include:

- They require less kerbside loading space than a motor vehicle.
- They are easier to manoeuvre in heavily congested situations than motor vehicles.
- In some cities they have dedicated lanes and can also use bus lanes (unlike motor vehicles)
- They can potentially access urban locations closed to motor vehicles at certain times of day
- They do not emit greenhouse gases and are producing very low noise levels
- They have lower purchase and running costs than motor vehicles
- They have smaller space requirements for overnight storage than vans and other goods vehicles
- They are not usually subject to on-street parking charges or parking fines
- They are not subject to the charges imposed by the London Congestion Charging Scheme
- Cyclists do not require driver licensing
- The public has a positive public perception of cycles especially as a result of them having a far lower environmental impact than motor vehicles

- They are likely to be safer in areas with high pedestrian activity than motorised goods vehicles
- City authorities are generally increasing the amount of transport infrastructure provided for cyclists.

Freight cycles are generally viewed as less intimidating and safer than vans and other goods vehicles in a busy urban area with limited space. The public perception of both vans and van drivers tends to be rather negative. Survey work suggests that a similar tricycle freight and micro-consolidation centre scheme in Paris was supported by the majority of the general public due to its environmental credentials and 92% of respondents felt that this kind of trial should be supported by the local authority [3].

The disadvantages associated with freight cycles include:

- The limited payload weight and volume they offer for the carriage of goods compared with motor vehicles. This limits the type of goods they can carry and the type of supply chains they can be used in.
- They have lower travel speeds than motor vehicles in free-flow conditions - this can result in longer journey times when traffic conditions are good. This makes cycle delivery most advantageous in central or inner urban areas.
- Their lower speeds in free-flow conditions limit the distance over which they can feasibly make deliveries.
- Existing supply chains often involve distribution centres located on the edge of, or outside, the urban area. It can prove difficult to operate cycles for urban deliveries from such locations given the distances involved and the lower speed of cycles in outer urban areas.
- Supply chain reconfiguration can be necessary to facilitate urban deliveries by cycle – ideally this requires the implementation of a distribution centre located in the delivery catchment area. Such distribution centres bring additional costs, especially when located in areas in high land values therefore such centres need to be as small and “no frills” as possible.

The advantages of cycles over vans and other goods vehicles therefore have to be balanced against the limited weight and volume that a cycle can carry, which typically results in greater distances being travelled per item delivered. Cycles are also limited in terms of the distance they can realistically be used to deliver over, and can result in the need to reconfigure supply chains.

Given the advantages and disadvantages of cycle freight, it would appear that they are most suited to being used for the distribution of products with a relatively low bulk-density and size that do not have complicated storage or handling requirements. In addition, cycles achieve their greatest advantages in comparison with motorised goods vehicles in congested, inner and central urban areas but typically require a centre in the delivery catchment area from which to operate. This needs to be as low-cost and “no frills” as possible in order that the supply chain remains as financially competitive as possible.

3. The role and benefits of urban consolidation centres

A UCC is a logistics facility that is situated in relatively close proximity to the urban area that it serves, be that a city centre, an entire town or a specific site such as a shopping centre, airport, hospital or major construction site. Goods destined for these locations are dropped off at the UCC. The UCC operator sorts and consolidates these loads dropped off by logistics companies and makes delivers to the final destinations, often using environmentally friendly vehicles such as electric and gas-powered goods vehicles, and electrically-assisted tricycles [4].

By improving the lading factor of goods vehicles making final deliveries in congested locations, UCCs reduce the total distance travelled by delivery vehicles in urban areas, as well as reducing greenhouse gas emissions and local air quality pollutants associated with these journeys (both through reductions in the total distance travelled, and through the use of low emission vehicles) [5]. In addition the total kerbside time and space occupied by vehicles making on-street deliveries can be reduced through consolidation, further reducing the impact of freight operations on traffic congestion. Other social and environmental advantages can include noise reductions through the use of quieter vehicles, reductions in conflicts between goods vehicles and other road users, and greater pedestrian safety [6] [7].

The logistics companies dropping their loads at the UCC benefit by avoiding the need to enter congested urban areas and thereby saving time and costs. Those receiving goods from the UCC benefit in terms of delivery reliability. In addition to consolidation and final delivery, a range of other value-added logistics and retail services can also be provided at the UCC including off-site stockholding, consignment unpacking, preparation of products for display and price labelling. These can benefit receivers by reducing their on-site space requirements, saving time by reducing the tasks that have to be performed on-site, and enhancing productivity and sales in core activities.

Initial research into UCCs as an urban freight initiative commenced in the early 1970s and has continued ever since with levels of interest in this approach increasing during the last decade (see for example [5]; [8]; [9]; [10]; [11].

4. Background to the trial

In 2009 a major supplier of stationery and other office supplies to businesses in the UK made the decision to trial a new urban delivery system in the City of London in order to reduce the environmental impacts of their delivery operation. This decision was taken as part of the company's corporate social responsibility and environmental efforts [12]. However, it was also necessary for the new scheme trialled to produce a cost-effective service which met their customers' needs if it was to be implemented on a permanent basis [13]. The trial involved the use of an urban micro-consolidation centre together with electrically-assisted cargo tricycles and electric vans. This centre, located in the City of London delivery area, was used as a transhipment facility for the transfer of parcels from the suburban depot onto the electric vans and tricycles for final delivery. The trial of the urban micro-consolidation centre and the deliveries made from it were operated by a new company specialising in green urban freight deliveries. The trial therefore implemented two major logistics and technological changes simultaneously. First, the use of a micro-consolidation centre adjacent to the delivery area in an attempt to reduce the total stem mileage and greenhouse gas emissions travelled by vehicles to and from the suburban depot and the delivery area in the City of London. Second, to substitute electric vans and tricycles for diesel-powered vans for making deliveries in the customer catchment area.

The customers to whom deliveries were made were all located in the City of London which is the historic core of London with an area of 2.9 km^2. It contains London's business and financial centre. The City of London lies within the Clear Zone Partnership which is used as a testing ground to research, trial, monitor and set best practice for new transport technologies, innovations and physical measures, to be implemented on a local or regional scale. Since 1999 the London Borough of Camden, the City of London and the City of Westminster have worked jointly to achieve this. This resulted in the London Borough of Camden making a small financial contribution towards the trial. All the other costs were met by the office supplies company, which expected the new delivery system to have similar costs to their existing system. The system was trialled in the City of London as it comprises a high density of the company's delivery locations. This results in a relatively short travel distance between delivery locations [13].

The trial was the first of its kind in the UK combining an urban micro-consolidation centre and electric vans and tricycles, with the exception of some far smaller inconsequential pilots [1]. Similar electrically-assisted cargo tricycles are also being operated for urban freight deliveries in other countries, the most notable example being La Petite Reine in France [3].

The trial was of particular interest as the company's existing delivery system prior to the trial already involved a high degree of product consolidation and hence high vehicle lading factors. It did not therefore typify the types of operation in which UCCs are usually considered beneficial – namely systems with poor load consolidation. The trial represented the first attempt to fully evaluate the transport and environmental impacts of using a UCC in conjunction with electric vehicles in such a supply chain.

5. Operation before the trial

Prior to the trial the office supplies company operated a distribution system for deliveries in the City of London that involved using 3.5 tonne gross weight diesel-powered vans that were despatched from a warehouse located 29 kilometres away in the London suburbs. Seven vans carried out multi-drop delivery journeys to customers in the City of London. A total of approximately 1,200 parcels were delivered per day, all to business addresses. The delivery area has very heavy traffic flows in the morning peak and comprises a mix of very narrow roads and wider roads on which no stopping is allowed. Vans were loaded at the warehouse overnight and drivers arrived to start their delivery journeys at 06:00. The vans had a payload capacity of 1.3-1.6 tonnes and 9-10 cubic metres. Each van journey to the City of London consisted of 140-180 parcels. Some addresses received a single parcel while others received several. At some stops the driver was able to make deliveries to several addresses due to their close proximity to one another. In these cases the driver returned to the van to collect the parcels for each delivery in turn. In total the drivers made 20-25 stops per journeys, with a typical driving distance in the City of London of 10 km making these deliveries. The vans typically returned to the depot by lunchtime. Up to two additional afternoon delivery journeys to the City of London were also made by vans from the depot.

6. Operation during the trial

During the trial the office supplies company's delivery operation continued to serve the same clients with the same volumes of product as before the trial delivered. The key changes in the delivery operation were:

- A new urban consolidation centre was established close to the Tower of London in the City of London. This consolidation centre was used as a transhipment facility for the transfer of parcels from the suburban depot onto electric vans and tricycles and for overnight storage of the electric vans and tricycles. Because the centre itself was small (approximately 20 metres by 8 metres) it was referred to as an "urban micro-consolidation centre". The urban micro-consolidation centre and the deliveries made from it were operated by a new company specialising in green urban freight deliveries, on behalf of the office supplies company.
- An 18-tonne goods vehicle was used to transport parcels from the Office Depot warehouse in the suburbs of London to the micro-consolidation centre in the City of London (a distance of 30 kilometres – only 1 kilometre of which was in the City of London). The delivery was made overnight from the office supplies company's suburban warehouse to the consolidation centre in the City of London.
- Electrically-assisted cargo tricycles and electric vans were used to make parcel deliveries from the urban micro-consolidation centre to customers in the City of London. The operation of these vehicles did not result in any fossil fuel consumption or greenhouse gas emissions as the electricity they used was produced from renewable sources.

Fig. 1 and Fig. 2 provide an illustration of the differences in the delivery system and vehicle operations before and during the trial.

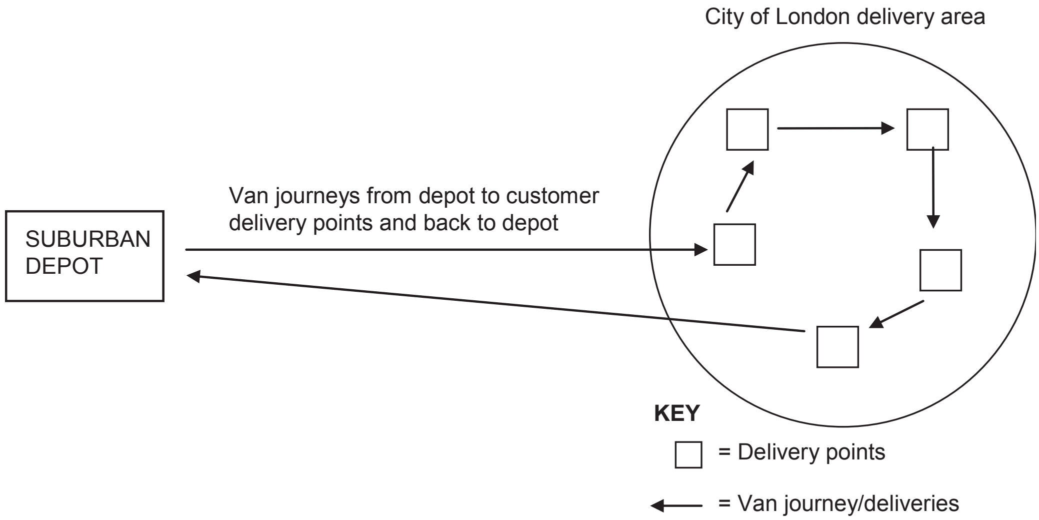

Fig. 1. Logistics system for deliveries by diesel vans from the suburban depot

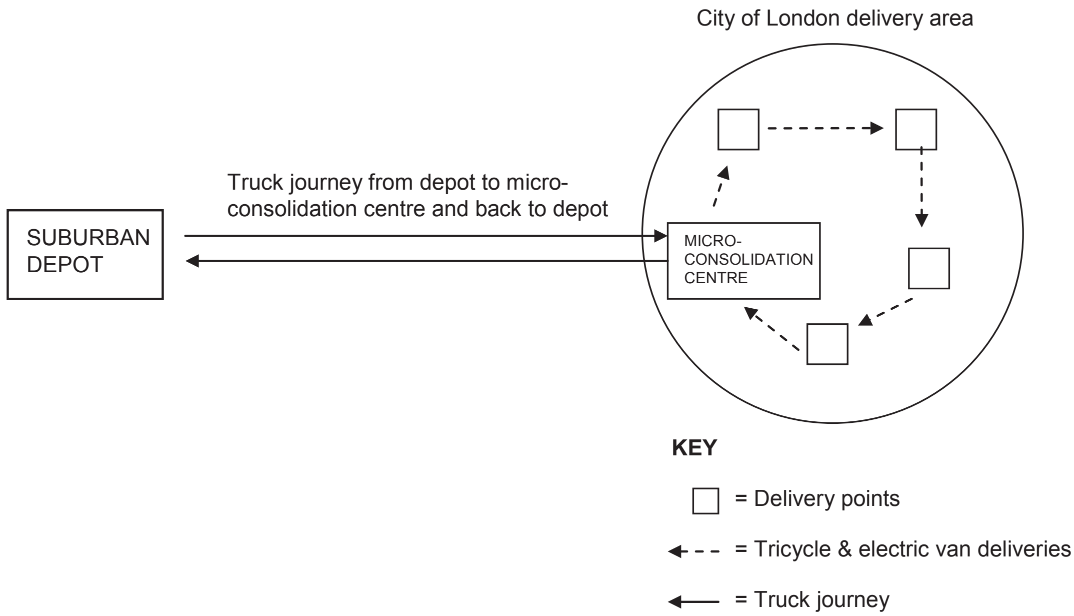

Fig. 2. Logistics system for deliveries by tricycles and electric vans via the micro-consolidation centre

The electrically-assisted cargo tricycles were manufactured in France by La Petite Reine. The empty weight of the tricycle is 110 kg, including the two batteries (i.e. without the driver and load weight). It can carry a load of up to 180 kg and has a load space of 1.5 cubic metres. It has a typical speed of approximately 15 kilometres per hour in free-flow conditions. The tricycle requires a four-hour recharging overnight. Aixam Mega electric vans were used in the trial. They had a load capacity of 445 kg and a load space volume of 3 cubic metres. The vans require an overnight recharging [14].

The City of London trial began in November 2009. Data collection commenced in December 2009 and continued until July 2010. During the trial the proportion of the office supplies company's parcel traffic delivered via the micro-consolidation centre was gradually increased, as were the number of tricycles and electric vans used. The tricycle delivery journeys started at 08:30, with the tricycle returning to the micro-consolidation centre for reloading at the end of each journey. Each performed 2-4 delivery journeys per day with a maximum of 8 operating hours per day. The variable range of parcel sizes and weights made it unviable for all parcels to be delivered by tricycle. The electric vans were used to deliver larger parcels from the micro-consolidation centre, also performing a similar number of journeys per day.

By July 2010, 6 tricycles and 3 electric vans were being operated each day from the micro-consolidation centre. One diesel truck was used to transport goods from the suburban depot to the micro-consolidation centre. All diesel vans deliveries direct to customers from the suburban depot had ceased and been replaced by electric van operations from the micro-consolidation centre.

7. Analysis of the before and after situation

7.1. Comparing vehicle weight and volume attributes

Table 1 shows the weight and volume capacity attributes of the three vehicles used to deliver parcels. The diesel van has the greatest weight and volume capacity, and the tricycle the least. The volume to weight ratio indicates that the diesel van is capable of carrying slightly more weight per unit of volume than the electric van and approximately 30% more than the tricycle. The diesel van is therefore better suited to carrying goods with high bulk density. It would simultaneously reach its volume and weight capacity limits when carrying goods with a bulk density of 160 kg/m^3 whereas the tricycle would reach this limit with goods with a bulk density of 120 kg/m^3.

Table 1. Volume and weight attributes of vehicles used before and during the trial (Source: own survey 2009-2010)

	Diesel van	Tricycle	Electric van
Weight capacity (tonnes)	1.4	0.18	0.45
Weight capacity index (diesel van = 100)	100	13	32
Volume capacity (cubic metres)	9	1.5	3
Volume capacity index (diesel van = 100)	100	17	33
Volume to weight ratio (tonnes per m3)	0.16	0.12	0.15

The survey work has found that the average parcel handled by the office supplies company for delivery in the City of London has a weight of 5.65 kg and a volume of 0.0375 m^3. This means that the average parcel has a bulk density of approximately 150 kg/m^3, and this bulk density is more suited to the electric and diesel van than the tricycle in terms of maximizing the load carried on each vehicle. When carrying parcels with this average bulk density the tricycle will reach its weight limits before being fully loaded in terms of volume. By comparison the electric van is fully loaded in terms of both weight and volume when carrying parcels with this average bulk density. The diesel van will reach its volume limits before being fully loaded in weight terms.

7.2. Comparing operational data before and during the trial

Table 2 provides data of the vehicle operations before and during the trial. It compares the diesel van operation from the suburban depot to customers in the City of London (i.e. before the trial) with the electrically-assisted tricycle and electric van delivery operations from the urban micro-consolidation centre to customers in the City of London. These results are based on detailed surveys and observations of the journeys. The diesel van carried a far greater load than either the electric van or tricycle and delivered more parcels per stop. As the diesel van operates from a suburban London depot this has implications for the proportion of total journey time spent travelling between stops and stopped while making deliveries. The operation of the tricycle and electric van resulted in no fossil fuel consumption or greenhouse gas emissions as the electricity they use has been produced from renewable sources.

Table 2. Data from the observed operations before and during the trial (Source: own survey 2009-2010)

Operational features	Before trial (trunking & deliveries)	During trial (deliveries from UCC only)	
Vehicle type	Diesel van	Tricycle	Electric van
Deliveries per journey			
Number of stops to make deliveries	20	17	14
Number of parcels delivered during journey	168	33	42
Parcels delivered per stop	8.4	2.0	3.0
Time use (as % of total journey time)			
"Stem" driving time from depot to first stop	21%	10%	12%
Time running on the road between first and last stop	21%	28%	26%
Time unloading between first and last stop	48%	54%	52%
"Stem" driving time from last stop to depot	10%	9%	10%
Total journey time (hours and minutes)	03:41	02:42	02:15
Driving speed			
Average driving speed in the City of London (km per hour)	8	8	8

7.3. Distance travelled and greenhouse gas emissions

The results show that by May 2010 the use of the micro-consolidation centre together with the complete replacement of the diesel van fleet by electrically-assisted tricycles and electric vans led to a reduction of 20% in the total distance driven by all vehicles per parcel delivered between the suburban depot and the customer delivery locations. The total carbon dioxide equivalent (CO_2e) emissions were calculated for the delivery system before the trial (CO_2e includes carbon dioxide, nitrous oxides and methane emissions). The total CO_2e emissions per parcel delivered was 54% lower in May 2010 than in October 2009 before the trial. This was due to the reduction in the total distance travelled per parcel and the use of electric vehicles using fuel generated from renewable, carbon-free sources in the City of London.

The distance travelled between the suburban depot and the City of London per parcel delivered fell by 82% due to the use of a single truck to transport goods between the suburban depot and the micro-consolidation centre in the City of London. However, within the City of London the total distance travelled per parcel delivered increased by 349% by May 2010. This is due to the lower carrying capacity of the electric vans and tricycles compared to the diesel vans together with the guaranteed delivery times that have to be met, thereby resulting in the need for more delivery activity per day. In terms of CO_2e emissions, these fell by 49% per parcel delivered between the suburban depot and the City of London, and by 83% per parcel delivered within the City of London compared with the situation before the trial.

Fig. 3 shows the results in terms of distance travelled per parcel, while Fig. 4 shows the results in terms of CO_2e emissions per parcel. Both of these figures show the results in the City of London where the deliveries are made, in the rest of London (as the parcels are transported from the suburban London depot to the City of London), and in London as a whole (i.e. the sum of both of these activities). The results indicate the improvements in total distance travelled and CO_2e emissions per parcel, and the reduction in the distance travelled per parcel in the rest of London when the operation using a micro-consolidation centre and only electric vehicles. The results also highlight the increase in the distance travelled per parcel and the reduction in CO_2e emissions per parcel within the City of London delivery area as a result of this new distribution system.

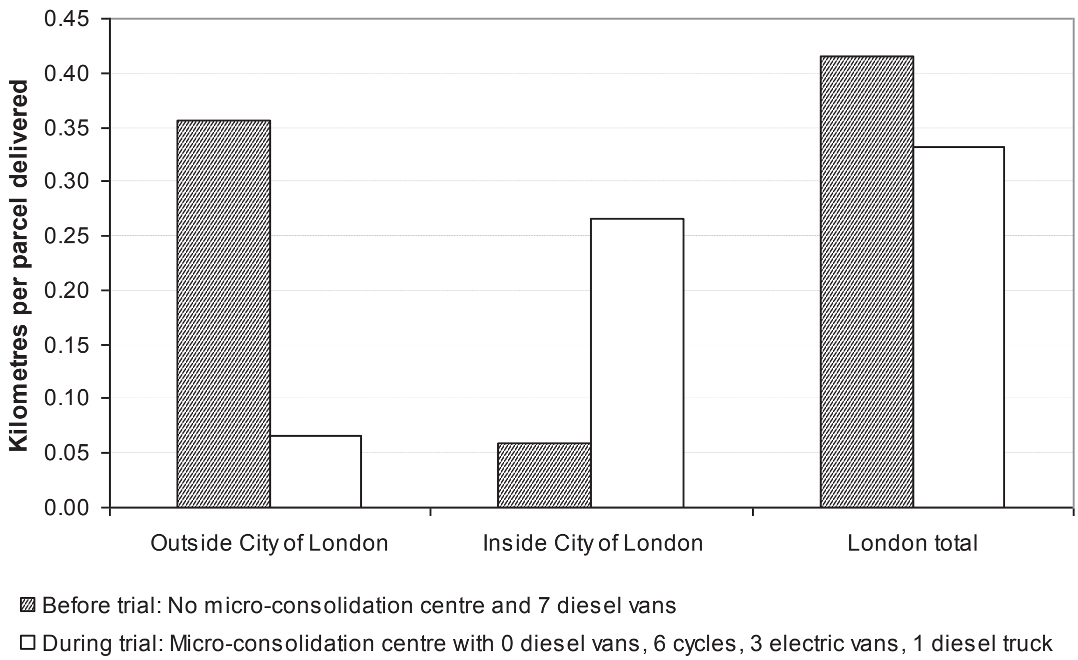

Fig. 3. Distance travelled per parcel before, and during the trial (Source: own survey 2009-2010)

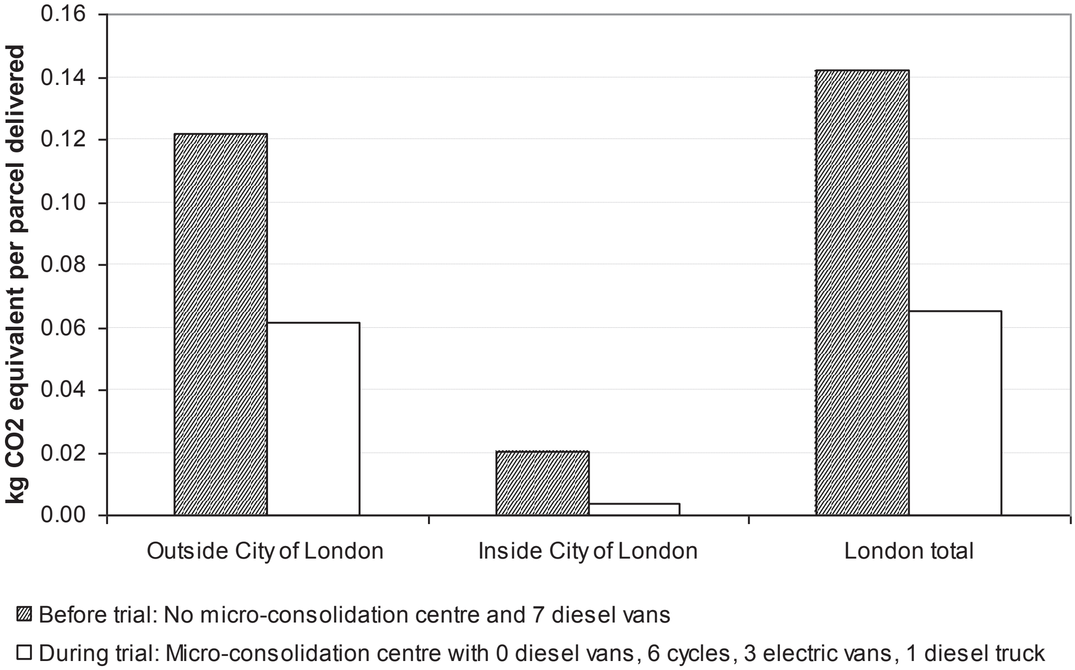

Fig. 4. CO2 equivalent emissions per parcel before and during the trial (Source: own survey 2009-2010)

8. Discussion and feedbacks during the conference

Two points were discussed immediately after the presentation at the conference and in the corridors. The first is about the expected future developments of this type of logistics concept. The second is on the eventual compensation of the achieved benefits through other businesses, since the diesel vans previously used continue to drive on the streets and deliver freight in London.

The current development seems to raise the expectation that the future market will be growing for cycle freight and electric vehicles concepts based on the utilization of an urban consolidation centre. The observation of the situation in London however, will need to be completed with similar evaluations in other cities and countries, before general lessons can be drawn on the economic profitability. It would seem probable that an extension of this relatively small business to a larger industrial business solution could give similar beneficial results. After the trial, the political support is stronger and the city logistics concept can be considered as feasible.

There is a possibility that the diesel vans that were previously used for deliveries would continue to travel in London, and this effect would need to be accounted for in a global balance assessment. Before the trial, the company was using partly own account and partly subcontractors for the deliveries in the observed area. The own account vans were still in use during the trial but in other area. The deliveries in the Central London area that we are observing were not made using these vans. Therefore we can exclude these vehicles entirely and these are considered to be off the limits of the system of the observed supply chain. This is even more the case for the subcontracted van drivers. Their market has been entirely overtaken by the Clean Vehicle Company.

9. Conclusion

This paper has considered the use of cycles for urban freight transport and how they can be utilised effectively within commercial supply chains. One method by which this can be achieved is by implementing a urban micro-consolidation centre within the target delivery area and trunking goods to this centre at which they can be cross-docked onto cycles for final delivery. In the trial evaluated in this paper which utilises these techniques (i.e. electrically-assisted cycles and urban micro-consolidation centre – as well as electric vans) the total distance travelled and the CO_2e emissions per parcel delivered fell by 20% and 55% respectively as a result of this delivery system.

However, the evaluation has also indicated that the distance travelled per parcel rose substantially in the City of London delivery area as a result of the electric vehicles having far smaller load limits in both weight and volume compared with diesel vans. But, at the same time, the trial system was able to virtually eliminate CO_2e emissions per parcel delivered in the City of London. The results therefore reflect the trade-off between total distance travelled and greenhouse gas emissions associated with the use of clean electric vehicles in place of diesel vehicles that have greater size and volume payloads.

The trial demonstrated that even in a supply chain in which goods are already highly consolidated there is still the potential to achieve further benefits in terms of further reductions in total distance travelled and greenhouse gas emissions through additional consolidation efforts and the use of clean electric vehicles. This is especially true in logistics systems that involve substantial stem distances between depots and delivery areas.

The office supplies company was pleased with the success of the trial in transport, environmental and financial terms. Due to confidentiality, the exact financial benefits of the trial were not quantified. The company decided to continue the operation beyond the end of the trial. The scheme was officially launched in 2010 [13].

Acknowledgements

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