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THE SCOPE FOR PAVEMENT PORTERS: ADDRESSING THE CHALLENGES OF LAST-MILE PARCEL DELIVERY IN LONDON

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ABSTRACT
The UK parcel sector generated almost £9 billion in revenue in 2015, with growth expected to increase by 15.6% in 2019 and is characterised by many independent players competing in an 'everyone-delivers-everywhere' culture leading to much replication of vehicle activity. With road space in urban centres being increasingly reallocated to pavement widening, bus and cycle lanes, there is growing interest in alternative solutions to the last-mile delivery problem. We make three contributions in this paper: firstly, through empirical analysis using carrier operational datasets, we quantify the characteristics of last-mile parcel operations and demonstrate the reliance placed on walking which can make up over 60% of the round time; secondly we introduce the concept of 'portering' where vans rendezvous with porters who operate within specific 'patches' to service consignees on-foot, potentially saving 86% in driving distance on some rounds; finally, we highlight the wider practical issues and optimisation challenges associated with operating driving and portering rounds in inner urban areas.

INTRODUCTION
The UK parcel sector generated almost £9 billion in revenue in 2015, a 6% increase on the previous year, with growth expected to increase by 15.6% to 2019 (*1*). With over 1.7 billion parcels being delivered domestically per annum (*2*), light goods vehicles (LGVs – up to and including 3.5 tonnes gross weight) have seen the greatest growth with 3.6 million licenced in the UK, a 23% increase relative to heavy goods vehicles since 1995 (*3, 4, 5*). The parcel distribution sector is characterised by many independent players competing in an 'everyone-delivers-everywhere' culture leading to much replication of vehicle activity (*6*). This in turn negatively impacts on congestion and the need to reduce emissions in cities, which is a central requirement of EU legislation (*7*).

The UK parcels market consists of three sub-sectors where transactions take place between different entities: business-to-business (B2B); business-to-consumer (B2C), and consumer-to-all-parties (C2X). In the UK, B2B accounted for 38%, B2C, 56%, and C2X, 6% of the parcel market in 2012 (*8*) with forecasts suggesting that volumes in the B2C and C2X sub-sectors will grow at approximately 4.5 to 5.5% per annum in the medium term (*9*).

Parcel carriers offer consignees a wide range of delivery options from immediate to same day, next day, to a delivery anytime within a set period of days. 'Express' usually refers to services with a specified day of delivery (e.g. next day or two-day) and time of delivery (e.g. before 09:00, before 10:00). 'Courier' services are usually the most time-sensitive, often guaranteeing same day delivery, or delivery before a certain time. The market for courier services is much more fragmented than for express and parcel services comprising many small owner operators. Data has suggested that next day services accounted for 56% of all UK domestic volumes in 2014-15 and 70% of total parcel revenues (*10*).

In order to meet customer needs, carriers have developed different logistics strategies and networks. Couriers offering immediate and same-day services typically operate a door-to-door service between the consignor and consignee. A parcel carrier based wholly within one city is likely to make use of a single depot from which multi-drop vehicle rounds are performed whereas a national or international carrier will typically make use of a hub-and-spoke network. In the case of the latter, central hubs and regional/local distribution centres may be operated, with large fully-loaded vehicles operating between the hubs and other distribution centres, and smaller vehicles performing multi-drop rounds for last-mile delivery operated from several local depots in the case of large cities. In addition to this, parcel carriers are using 'lifestyle' couriers (self-employed owner-drivers working on a freelance basis) to manage local last-mile deliveries, the handling of failed first-time deliveries and customer returns. With the plethora of different operators and services, it is estimated that the UK parcel market is approximately 20% overcapacity (*11*). Given that road space in urban centres is being reallocated to pavement widening, bus and cycle lanes (Barry, 2014), and with Transport for London predicting that traffic congestion in central London will increase by 60% by 2031 (*12*), there is growing interest in alternative solutions to the last-mile problem.

We make three contributions in this paper: firstly, through empirical analysis using carrier operational datasets, we quantify the characteristics of last-mile parcel operations and demonstrate the reliance placed on walking as an integral component in the last 100m transaction; secondly we introduce the concept of ‘portering’ as a potentially viable option for improving the efficiency of last-mile van operations using a case study example; finally, we highlight the wider issues and challenges associated with operating and optimising driving and portering rounds in inner urban areas.

QUANTIFYING PARCEL CARRIER ACTIVITY ON-STREET USING MANIFEST RECORDS

Researchers have previously used several approaches in an attempt to gauge the intensity of parcel operations on-street including individual business audits through ‘Delivery and Servicing plans’ (*13*), observational high street surveys (e.g., *14*) and driver activity studies (e.g., *15*). In this research, a new research approach was adopted in which manifest data from two major carriers were used in an attempt to understand last-mile delivery and collection activity within central London, operating primarily over the W1, WC1, WC2 and EC1-4 postcode areas between 1st October 2016 and 7th February 2017.

Approximately 90% of Carrier 1’s work was business-to-consumer (B2C) related across a mixed land use profile including retail, commerce and domestic customers while Carrier 2 specialised more in business-to-business (B2B) parcel movements. A total of 396 unique consignors were observed in the Carrier 1’s dataset, with major fashion, general retailers and on-line ticket companies (C2C) generating the greatest number of records (~110,000 in the case of Carrier 1). The manifest data included parcel identification numbers, delivery addresses, manifest numbers (which identify vehicle rounds) and various temporal and event based information detailing when a barcode was scanned and details of failed first-time deliveries. The database comprised 894,136 and 394,551 records for carriers 1 and 2 respectively with each record corresponding to a delivery/collection attempt. Consignments were generated by 405,811 and 112,785 unique recipients from the respective carriers.

To better understand the spatial distribution of deliveries, a smaller study area based around Oxford Street was chosen, representing around 2% and 3.2% of the overall datasets from carriers 1 and 2 respectively. The area is approximately 1.3km along the topmost edge (Seymour Street, A5204) by 400m along the rightmost edge (Regent Street), (~0.5km^2), and has a dense land use made up of shops, offices and private addresses containing 1172 distinct postcodes. For spatial analyses, heat maps were generated using GIS software (QGIS) based on latitude and longitudes obtained for each postcode. These enable the numbers of parcels destined for particular postcodes to be displayed, with a radius of 50m being drawn around each point to illustrate where overlap in delivery locations occurs.

Of the 1172 postcodes, 836 received successful deliveries with 336 postcodes recording a failed delivery attempt at some point over the analysis period. Carrier 1 reported that 38% of failures occurred between 12:00 and 15:00. Aggregate deliveries from Carrier 1 and Carrier 2 were mapped to reveal the distribution and delivery hotspots in the area (Figure 1). The locations receiving the largest number of deliveries are of particular interest as these locations are likely to receive the most vehicle traffic. Such mapping is useful when considering where and how kerbside space might be allotted to freight vehicles according to the greatest demand areas and considering how consignees might be ‘clustered’ into service patches by carriers (*16*).

Most of the activity hot spots appeared to be in areas of mixed land use with multi-tenanted offices, shops, restaurants and hotels, including those on Oxford Street, Regent Street and opposite Portman Square (Figure 1). Due to the data anonymization process, it was not possible to determine the extent to which personal deliveries were made to workplaces but this is of interest employers and transport authorities in London who would like to restrict such activity (*17*).

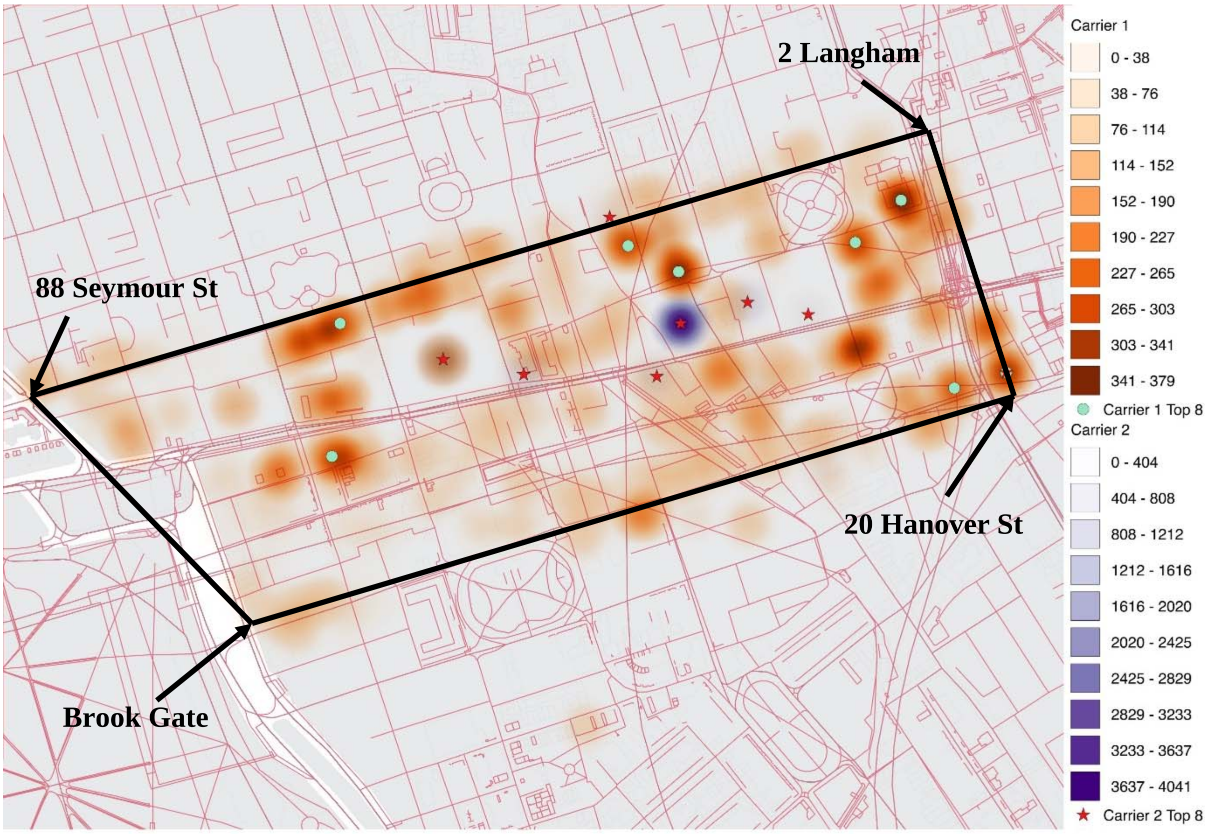

FIGURE 1 Total number of deliveries (Carrier 1 and Carrier 2) by location around Oxford Street between 1st October 2016 – 7th February 2017 (129 days) and Carrier 2 (Primarily B2B) covers 28th August 2016 – 5th November 2016 (69 days).

To illustrate the extent to which the busiest locations differed from the norm, the ‘top 8’ (0.9%) postcodes, corresponding to the three ‘hottest’ delivery activity bands identified in Figure 2 (i.e. those with over 522 aggregate deliveries from Carrier 1 and 2 over the period), accounted for 12.3 times the mean activity, or 29.1% of the total activity (Table 1). In addition, the ‘top 20’ (2.4%) and ‘top 45’ (5.4%) postcodes accounted for 42.4% and 58% of total activity, respectively, indicating the skewed nature of the spatial distribution, with a relatively small number of locations generating high levels of activity and many postcodes generating little.

TABLE 1 Comparison of ‘top 8’ and All Postcode Areas in Terms of Delivered Items: Data for Carrier 1 (Primarily B2C) covers 1st October 2016 – 7th February 2017 (129 days) and Carrier 2 (Primarily B2B) covers 28th August 2016 – 5th November 2016 (69 days)

	Number of deliveries - All postcodes (836) *(Top 8 Postcodes)*			
Activity *(days)*	Total	Average per postcode	Standard Deviation	Maximum
Carrier 1 *(129)*	14009 *(2348)*	16.8 *(293.5)*	40 (56)	379
Carrier 2 *(69)*	19218 *(8637)*	23 *(197.5)*	158 (140)	4041
All Deliveries	33227 *(9684)*	39.8 *(491)*	169 (163)	4041

Mondays and Tuesdays were the busiest day of the week for Carrier 1 and Carrier 2 respectively, with approximately 241 (Monday – Carrier 1) and 290 (Tuesday - Carrier 2) manifest entries per day in the Oxford Street area. For Carrier 1, the Monday peak was due to the very high proportion (49%) of failed first-time deliveries experienced on Saturdays that required subsequent re-delivery on the Monday, reflecting the number of offices closed on Saturdays. The majority of the activity related to deliveries, which outweighed collections by 18.6 to 1 in the case of Carrier 1. First-time delivery failure rates ranged from 7.4% (Thursdays) to 14% (Mondays) for Carrier 1 and 2.3% (Monday) to 4.4% (Thursday) for Carrier 2, both in line with national averages (*18*).

From an analysis of the delivery times, 69.8% took place between 11:00 and 16:00, peaking between 14:00 and 15:00 and 11:00 and 13:00 for Carriers 1 and 2 respectively, reflecting core office hours. It is important to note that the activity analysis presented in Figure 1 does not represent the total parcel activity across the area which may be around 15 times higher again, given that the carriers in question have an approximate 7% national market share (*8*). An activity survey on Regent Street in central London found that 21% of all motorised goods vehicles were parcel carriers and couriers (*15*).

CHARACTERISTICS OF MULTI-DROP OPERATIONS AND THEIR ON-STREET IMPACTS

A detailed study of 25 vehicle rounds operated by these parcel carriers making deliveries and collections across three postcodes in the West End of central London (WC1, WC2 and W1) was also undertaken. This was done over three days in October 2016 and involved: i) GPS tracking of both the vehicle and the driver, ii) surveyors accompanying drivers to verify round timings, parking places used, and delivery/collection locations served, and iii) analysis of the daily manifest data for each vehicle round.

All the vehicles used were light goods vehicles (vans) up to and including 3.5 tonnes gross, and a goods carrying capacity of approximately 1 tonne (6m^3 in volume). Parcels for delivery and collection were allocated to drivers each day based on pre-determined and largely fixed vehicle round structures. Parcel deliveries accounted for 94% of all activity with the transaction order being left to the driver's discretion. Drivers were responsible for selecting the route, parking locations and the clusters of consignees to service from each stopping point. The vehicle rounds studied took place in the 'West End' of central London in the area of Oxford Street, Regent Street, Covent Garden, Soho, Mayfair and Piccadilly. The area has approximately 2,000 shops, 2,500 restaurants and cafes, 3,000 licensed premises, 40 theatres, 20 cinemas, 30 museums and galleries as well as 40,000 residents, and accounts for 65,000 employees generating 15% of London's total gross value added (GVA), (*19*, *20*).

The rounds emanated from three depots which had stem mileages of: Depot A (2 km); Depot B (4 km) and Depot C (11 km). The average round duration, defined as the difference in time from leaving the depot and returning, excluding time spent in the depot, was 7.3 hours and the average distance driven within the delivery area (excluding stem mileage) was 11.9 km with a mean speed of 7 kmph (and 8.9 kmph including stem mileage). Of interest was the fact that 62% of the total round time was spent with the vehicle parked while the driver unloaded and sorted on average 126 parcels and delivered these on-foot to 72 establishments from 37 stopping places. The average distance walked per vehicle round was 7.9 km, which accounted for 28% of the total distance travelled from the depot (i.e. including distance driven), with 95% of vehicle stops taking place on-street at the kerbside. On average, the driver delivered/collected 3.8 parcels from 2.1 establishments per vehicle stop, with establishments receiving/dispatching 1.9 parcels per delivery/collection.

The mean drive time between stopping locations was 3.7 minutes, with an average 8.1 minutes dwell time observed at each vehicle stop, which was comparable with previous studies (*21*, *22*). Mean driving and parking times per parcel were 1.5 and 2.3 minutes respectively, with associated driving and walking distance of 202 metres and 72 metres. The walking distance per establishment served was 105 metres on average. The findings suggest that last-mile parcel operations are characterised by walking with the vehicle left stationary, often conflicting with a kerbside infrastructure legislated in favour of passenger transportation (*23*). In these circumstances, carriers are increasingly facing fines with UPS receiving penalty charge notices totalling over $17m from servicing clients in New York alone during 2016 (*24*). With the growth in parcel delivery set to continue (*25*), carriers are becoming increasingly interested in exploring new ways of working.

THE CONCEPT OF 'PORTERING' TO REDUCE LAST-MILE VEHICLE IMPACTS

Human carriage of goods has been an important means of commercial freight transport in our cities for centuries (*26, 27*). The advent of the railways largely resulted in the demise of the City of London porter and the use of barrows and hand carts for goods movement (*28, 29*) but this concept could be viable once again for parcel logistics in dense urban areas where kerbside parking is problematic. In this paper, we suggest that portering could take two separate forms, with the specific objective of reducing vehicle stopping times at kerbside:

Scenario 1 – In this case the van alights at the kerbside in the drivers preferred location, where a pre-notified porter is waiting to receive the parcels from the driver for local delivery on-foot (this could be referred to as 'drop-and-drive'). In this sense, the driver would still be making the same number of stops as if he/she were making the deliveries on foot and the time taken to make the deliveries by the porter would be the same. No porter facilities are required in terms of dedicated kerbside space or storage facilities but carriage provision for parcels would be necessary in terms of a hand cart. This scenario is akin to the notions of crowdshipping on a large scale (*16, 30, 31*) and would be most applicable in locations with extremely dense delivery networks or where substantial vehicle access and kerbside parking restrictions exist.

Scenario 2 – In this case, there would be a fixed number of portering reception points (substantially less than the current number of vehicle stopping locations per round) which could be reserved kerbside spaces, small permanent facilities/buildings, or temporary mobile depots which are delivered to the location each day (*32, 33, 34, 35, 36*). These portering reception points would cover a greater delivery catchment area compared to Scenario 1, and therefore drivers would drop off a larger number of parcels destined for more consignees at each stop. The porters would make deliveries from these points either on-foot, possibly using handling equipment, or using cargo cycles (depending on the size, weight and number of parcels to be conveyed and the distances involved).

The key benefit to carriers of adopting such portering services is the reduction in vehicle stopping time at the kerbside and overall distance travelled. This would have the potential to make rounds more efficient and vehicles more productive in terms of their carrying capacity. These gains would be traded against the additional cost of the porters, the carrying equipment and the telematics systems needed to manage the last-100m transaction to the consignee. For urban authorities in central London, reductions in vehicle stopping times at kerbside would help to reduce traffic congestion, as currently vehicle demand for the kerbside outweighs supply.

Quantifying the potential benefits of a portering service

Using the data collected from the 25 vehicle rounds studied in detail, an attempt was made to understand the likely vehicle time and distance savings from both the drop-and-drive scenario (scenario 1) and the use of a reduced number of vehicle stopping points (scenario 2). For each of the rounds, estimated round times (T_{new}) for the drop-and-drive element were calculated (Table 2) as:

$$T_{new} = T_{actual} - \text{Total parked timed (before)} + \text{Number of stops x Y minutes per stop}$$

In scenario 1 it was assumed that the same number of stops were made, using a conservative estimate of 3 mins per stop (Y) to unload, scan and transfer parcels from the driver to the porter based on surveyor observations. Replicating the same round orders using mapping software, the results suggested that an average time saving of around 4 hours per round (55% of the total round time) could be possible (Depot 1: 5,12 hours saved; Depot 2: 3.03; Depot 3: 4.28) which would have significant implications on driver and vehicle utilisation. The estimated time savings for each of the 25 individual rounds ranged from around 2 to 6 hours, which reflected the variability in observed parking times (from 1.9 hours across 14 stopping points to 6.3 hours across 72). Parking times were mainly influenced by the total workload in different 'hot spot' areas and the individual driver's preference between moving the vehicle frequently to minimise walking or to walk between groups of customers to avoid driving and finding parking places.

To demonstrate the likely portering workload that could be involved with scenario 2, one of the surveyed rounds was studied in detail (Figure 2). This round involved 138 items being delivered to 54 consignees, (including 7 time guaranteed deliveries and 6 collections) for which the driver used 52 stopping locations across the 1.3km^2 area. The van covered 16.8km over 7.3 hours during the round (excluding stem mileage), recording a mean speed of 8.8 km/hr. Sixty one percent of the round involved the vehicle being parked (5.3 hours, 87% at on-street locations) with the driver making deliveries on foot.

To illustrate how portering 'patches' might be allocated, the 54 consignees were separated into 9 defined delivery patches made up of 350m squares (Figure 2) with two outlying customers to the south East (patch 9). Previous relevant work focussed on where to site 'mini-hubs' in Seville based on 200m spheres of influence (*37*). Clearly, the size of the delivery patch has a direct influence on the amount of walking that may be entailed. This has been demonstrated in that the length of the optimal tour over a given patch is proportional to the square root of the size of the area (*38*), with implications for vehicle routing problems (*39*). The geographical scale of walking patches would depend on the package generation characteristics of the surrounding land use and the consequential ability of the porter to physically man handle the packages.

Within each delivery patch, a shortest path walking tour between all the customers was devised and approximate walking times and distances quantified using mapping software (Table 2). Handover times in each patch were adjusted to reflect the number of parcels actually delivered. This was achieved by assuming 30s to park the van, access packages for the specific patch and then book them over to the porter (10s per parcel), being consistent with the average of 3 minutes per stop. This produced a range of van-to-porter handover times from 61s to 586s (Table 2) where delivery patch (1) received considerably more parcels (n=54) than the others, mainly due to one customer receiving 32 parcels. The walking and handover times totalled 1.69 hours across all the patches with porter walking distances within each patch ranging between 44m to 1107m. The major benefit to the carrier is in the time and distance savings from only having to service one handover point in each patch. If in this example, the vehicle traversed patches 7-5-3-1-2-4-6-8-9 in order, stopping in each to drop packages to a porter, the vehicle driving distance could be approximately 2.2 km, a reduction of 14.6 km (86%) over the current system.

TABLE 2 Estimated Workload for Roadside Porter in Example Round (Figure 2)

Delivery patch (no. consignees)	Walking time (s)	Walking distance (m)	Parcels	Handover Time for driver (s)	Collections
1 (6)	602	849	54	586	0
2 (8)	527	741	10	133	0
3 (6)	559	790	15	185	0
4 (4)	475	662	4	71	3
5 (9)	792	1107	15	185	2
6 (3)	445	627	6	92	0
7 (5)	458	647	13	164	0
8 (11)	565	791	11	143	1
9 (2)	31	44	3	61	0
Total	**4454**	**6258**	**131**	**1620**	**6**

Any portering system would have to cater for instances where single consignees were receiving multiple parcels as it would make logistical sense to service large receivers directly from the van, or situate the drop site as close as possible to them where they featured in a given patch. There would also be the issue of how collections would be managed given the driver-porter transaction is one-way at each rendezvous point. It would be feasible for porters to work across multiple patches and hand back parcels to the driver at another location, e.g., moving across after completing the 9 deliveries and picking up 2 collections in patch 5 and then moving to 6 to wait for the driver, hand over the 2 collections and pick up the 3 deliveries for that patch. To operate effectively, this concept would require careful consideration and optimisation of both the driving and walking tours to account for things like dynamic collection requests during the round, failed deliveries and potential re-delivery attempts, extended portering time associated with servicing high-rise buildings, carrying capacity limitations of the porters. Carrying capacity is a key issue which will differ between parcel carriers depending on their market specialism (e.g. Amazon states that 86% of its delivered products weigh 2.3kg of less (*40*) whereas 54% of Carrier 2 parcels weighed under 5kg).

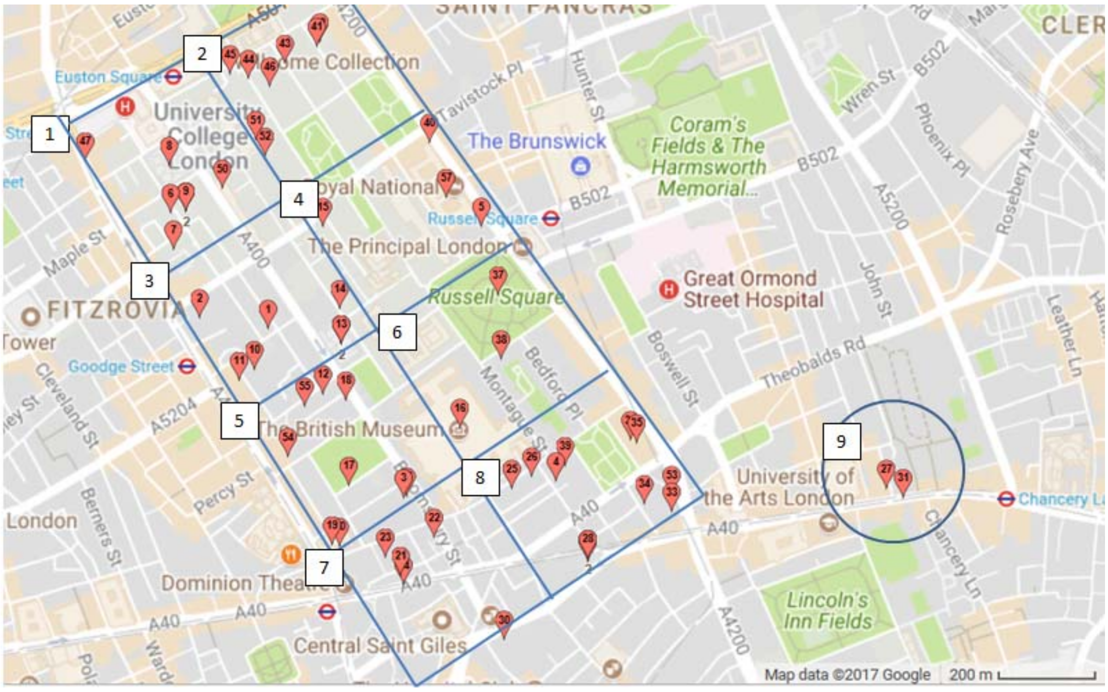

FIGURE 2 Customer locations on example round and proposed 'drop-and-walk' delivery patches.

THE OPTIMISATION CHALLENGE ASSOCIATED WITH PORTERING

Last-mile parcel delivery problems are generally studied under city logistics systems (*41*), where the corresponding optimisation problems are modelled using two-tier distribution structures. The first tier usually involves vehicles with relatively large carrying capacities off-loading goods at rendezvous points, for the second-tier to undertake the last-mile transaction.

The optimisation of plans involves deciding on the routing and scheduling of vehicles across both tiers, the demand locations to be served, the locations of the van-porter rendezvous points, and the capacities of any reception facilities to be used. In our context, we envisage two cases i) fixed cluster case, where the delivery patches have been identified (as in the case of the nine patches shown in Figure 2) prior to the routing and scheduling, ii) unknown clusters where the delivery or collection points have not been grouped into patches. In either case, vans would operate in the first-tier and porters in the second. We discuss two cases below in further detail:

Fixed Cluster: The first case gives way to generalised vehicle routing problems where the aim is to route vehicles over a given set of clusters that correspond to the delivery patches. Although this class of optimisation problems has been studied in sufficient detail (*42*), the generalised vehicle routing problem and its variants do not explicitly consider the way in which intra-cluster deliveries are performed. Assuming Scenario 1, where there is no need for a reception facility for handing-over of parcels, there are at least two ways in which deliveries within clusters can be done. Depending on the total weight and size of parcels handed over, the porters could perform direct deliveries in a so-called 'hotelling' mode, back and forth from the van, or, assuming they have sufficient carrying capacity, would operate a smaller tour from consignee to consignee using consolidation. The combined use of hotelling and consolidation within a cluster is another possibility.

Deciding on the location of the hand-over point will be a key part of the optimisation problem, which may be limited to one of the delivery points. In addition, the consolidation poses an additional challenge of finding an optimal tour over the delivery points within a cluster. If there are no additional constraints present in the problem, then the optimal assignments for both the hotelling and the consolidation options can simply be pre-computed for each possible selection of the rendezvous point without forming an integral part of the optimisation problem. Such pre-processing will reduce the solution complexity, assuming that each cluster is feasible with respect to the porters' ability to carry the parcels. However, if there are additional constraints related to the time-sensitive nature of the deliveries, then this pre-processing may no longer be possible.

Unknown clusters: If the delivery patches were not pre-defined, then the optimisation problem would have to involve decisions pertaining to the formation of clusters along with the routing and scheduling decisions. The interdependent nature of both sets of decisions means that they will have to be taken in conjunction. In the case of Scenario 1 where a porter is available to receive the parcels, the corresponding optimisation problem would be akin to the truck and trailer routing problem (*43*) where, in our context, the trailer would correspond to the van performing first-tier deliveries and the porters would act as the trucks in the second-tier for the last-mile deliveries. The problem would involve additional constraints for time-sensitive deliveries as well as the capacity of the porter in terms of the total weight and size of the parcels they are able to carry. An additional set of constraints would also be needed to synchronise the timing between the van(s) and the porter(s) for a timely hand-over such that neither will stay idle waiting for the other at rendezvous points.

ISSUES TO CONSIDER WHEN DEVISING AND IMPLEMENTING PORTERING SYSTEMS

This paper has shown how walking is a key component in last-mile parcel deliveries and that portering could be a viable alternative to reduce kerbside van activity. In devising and implementing a portering system for central urban areas, there is a range of issues that would require further consideration.

- **Geographical coverage and influence of major consignees:** The larger the catchment area for portering, the more likely the need for handling equipment such as trolleys or cargo cycles in addition to porters manually carrying parcels and packages. Understanding the major demand origins across an area, as well as the postcodes that attract the most deliveries and generate the most first-time failures, returns and collections is also very important when devising the scale of portering patches and where the optimal drop locations for vans would be.
- **The location and type of portering infrastructure necessary:** This will depend on the geographical area served, the portering infrastructure requirements associated with the land use needs and the availability of space. Portering infrastructure could include a reception facility, with or without storage space, for incoming and outgoing parcels, overnight storage for handling and transport equipment used by porters, scanning and computing equipment to track and trace goods passing through the facility, recharging facilities for any electric equipment such as cargo cycles, and off-street parking space for vehicles/drivers delivering to or collecting from the portering facility. In future, autonomous vehicles of varying types are likely to be deployed in urban freight operations. Despite the development of early prototype robot technology to carry out the movement of parcels (*44*), the deployment of efficient and affordable technology to carry out this last leg is far further away, given the complexity of crossing roads, climbing stairs, using lifts, and communicating with consignees. It is likely to remain far more efficient and cost-effective to use humans to carry out this last leg of the supply chain to and from the road vehicle, at least in the foreseeable future.

- **Financing the portering service:** This could be provided by the public (the local authority) or private sectors (based on contributions from freight operators and receivers), and as the portering scheme will potentially provide commercial, traffic and environmental benefits, it is reasonable to expect a mixed financial model. Freight operators using the scheme would enjoy vehicle/driver time and distance savings, whereas consignees and consignors would potentially benefit from having fewer goods vehicles operating outside their premises and from receiving fewer deliveries/collections from multiple carriers. The local authority and its residents would benefit in terms of traffic (both in terms of road space, reduced numbers of goods vehicles and vehicle dwell times) and environmental improvements from reduced air pollution, noise and safety concerns resulting from reductions in goods vehicle activity. Aligning the costs and benefits of the portering scheme with the financial contributions is likely to be important in its success, as is the case with Urban Consolidation Centres (UCCs). As in UCCs, public sector financial support may well be necessary in terms of meeting the capital costs of any buildings and other infrastructure required.
- **Operational management:** This could be public or private sector led. Experience from UCCs suggests that, even if the public sector is involved in the financing and development of the portering scheme, the day-to-day operations are best led by a private operator (*45*). As with public sector-backed UCCs, this is likely to be best achieved through a tendering process. If the portering scheme is a private sector-led initiative, this could be achieved through a single company (either a market entrant/start-up company specialising in providing this service or an established freight operator diversifying into this service) or it could be a joint venture formed by several collaborating parcel carriers who will each use and benefit from the scheme. One could envisage a last-mile crowd-sourced operator such as Deliveroo (www.deliveroo.co.uk), Uber Rush (www.uberrush.com), or Amazon Flex (www.amazonflex.com) providing a porter smartphone-based interface to integrate with the carriers. The scheme could be mandatory in challenging urban areas where the public sector would take a more active role in its operation.

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