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Last mile urban freight in the UK: how and why is it changing?

Future of Mobility: Evidence Review

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Last mile urban freight in the UK: how and why is it changing?

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I. Urban last-mile freight transport is growing

What is last-mile freight transport?

The domestic movement of freight can be divided into three broad functions: long-haul, regional, and urban distribution.

- Long-haul road movements largely occur along motorway and trunk routes or major rail corridors, between ports, factories, and national distribution centres.
- Regional distribution consists of shorter and more disaggregated journeys, often from national to regional distribution centres and out-of-town retail sites.
- Urban and last mile distribution connects regional distribution centres with urban retailers and consumers, resulting in smaller and more frequent deliveries.

Last-mile delivery is defined as the movement of goods from a transportation hub to the final delivery destination. The final delivery destination is typically a personal residence (Datex).

Last-mile delivery is driving some of the growth in the freight transport industry in terms of the increasing number of LGV (light goods vehicles) on the UK's roads (Braithwaite, 2018).

Heavy goods vehicles (HGVs – over 3.5 tonnes gross vehicle weight) still dominate, moving 88% of the overall amount of freight lifted by road, rail and water (DfT, 2015). The number of **light goods vehicles** (LGVs) has grown over the last two decades. There was a 48% increase in the number of LGVs licensed between 2000 and 2015, and a 47% increase in vehicle kilometres travelled by LGVs annually over this same period (DfT, 2016a; DfT, 2016b). LGV traffic growth has been more rapid than for any other vehicle type both nationally and in London. LGV use is for more than freight. They are used for everything from servicing (e.g. repair and maintenance of equipment), to carriage of equipment, providing transport, and goods delivery (for more detail see overleaf) (DfT, 2009; RAC, 2014). The increase in

number of registered LGVs likely reflects growth in all of these categories, combined with the good economic value that a van represents (Braithwaite, 2017).

Smaller operators dominate in last-mile freight

The majority of HGVs are owned by companies, (Sewells, 2014, FTA, 2016) but in the case of LGVs approximately 51% were registered to private individuals in 2015 (DfT, 2016c). In this regard, a key issue with last-mile freight operations is the **proliferation of smaller players and independents in the market**, duplicating the same activity, spatially and temporally. In 2014 there were 11,765 parcel companies registered in the UK (Keynote, 2015) of which 47% were classed as 'small' with annual turnovers of less than £50,000. This is further highlighted by the fact that the 200 largest UK van fleets account for only 9% of all LGVs (Sewells Research and Insight, 2014 quoted in FTA, 2016).

Servicing activity will continue to make up a significant proportion of van activity, currently accounting for 58% of the total distance travelled by all LGVs – twice the total distance travelled by those used for the delivery/collection of goods (29%) (DfT, 2009). Related to this is the fact that the proportion of LGVs licensed in Britain as 'heavy vans' (2.5–3.5 tonnes gross weight) has grown at the expense of smaller car derived and medium vans (up to 2.5 tonnes gross weight).¹ These longer LGVs have a greater load space, making them more useful when operated as a substitute for a small HGV (CfIT, 2010).

¹ The proportion of 'heavy vans' in the total LGV fleet rose from 23% in 1990 to 54% in 2015, while that of car-derived and medium vans (up to 2.5 tonnes gross weight) fell by 34% in the same period. (SMMT, 2016; McKinnon et al., 2015).

Why is last-mile growing so much?

Several factors will continue to contribute to the growth in LGV use over the last mile, namely:²

- Increasing demand for smaller, more frequent collections and deliveries to companies (just-in-time distribution)
- The rise in e-commerce: greater demand for online shopping and home delivery services, express and parcels services
- The continued outsourcing of service functions to specialist companies
- The use of more complex technology and communications equipment by businesses that requires specialist installation, planned servicing and emergency repairs
- The installation and maintenance of new telecommunication networks
- The increase in rapid response servicing (e.g. computer repairs, etc.)
- The growth in the UK construction industry
- The less stringent regulatory regime for LGVs compared with HGVs in relation to licensing and drivers' hours
- The shortage of HGV drivers compared to LGV drivers (Braithwaite and LCP Consulting, 2017; CfIT, 2010).

² List derived from Allen et al, 2016a.

2. Forecasts for the UK urban freight transport system: the last mile

Last-mile freight transport and e-commerce

This section focuses specifically on last-mile freight transport operations that support e-commerce as this is the sector of goods transport that has displayed, and will continue to display, the greatest change. Estimates suggest that Business-to-consumer (B2C) and Consumer-to-all-parties (C2X) parcel deliveries currently account for almost two-thirds of UK parcel volume, with Business-to-business (B2B) making up one-third (Royal Mail, 2016). Royal Mail has forecast that UK parcel volumes in the B2C and C2X sub-sectors will grow at approximately 4.5 to 5.5% per annum in the medium term, while it predicts that B2B volume growth will either track or be slightly above GDP growth (Royal Mail, 2016). The shift towards the growing importance of B2C and C2X sub-markets will result in the need for greater parcel handling capacity and delivery work, and will require carriers to invest in expanding their delivery networks, depot infrastructure, vehicle fleets and supporting technologies (Allen et al., 2016b).

Research has indicated that the following **factors are likely to play an important role in the future growth of e-commerce** (European Commission, 2012):

1. new demand through an internet-connected population – due to a growing proportion of older people who are familiar with the convenience of internet ordering, and young people who learn from birth;
2. physical shops (bricks-and-mortar) reducing in number due to competition from online shopping;
3. the growing use of smartphones to purchase goods online will continue making shopping at home and on the move ever-more convenient and easy; and

4. the importance of e-commerce for certain goods, which currently only have a relatively small online demand, will increase due to the previous factors.

Consignee control mechanisms

Thanks to the rise in e-commerce, mechanisms allowing the consignee to take more control over where and when they receive their goods, and how they return items. will become more widespread within our society. Some of these mechanisms, and their impact on freight transport, are described below.

1. **Click & Collect services** are proving popular with store-based online retailers as they help them avoid often loss-making last-mile deliveries while encouraging consumers to undertake even more shopping in-store while collecting goods. Online sales that made use of Click & Collect services in 2016 accounted for 25% of all online clothing and footwear sales in the UK (Verdict, 2016a). A survey of UK online retailers operating Click & Collect in-store found that approximately 90% offered free deliveries to consumers using the service (Oracle, 2016). Some store-based online retailers with Click & Collect facilities are opening them up to online-only retailers, generating a new revenue stream for store-based online retailers. Boots the Chemist has allowed its stores to be used for ASOS consumer collections, whilst Argos provides a similar service for eBay consumer collections (Retail Week in partnership with Metapack, 2016). Click & Collect will continue to grow as more partnerships develop between pure online and bricks-and-mortar stores to host collection outlets for customers. This could see more freight delivery and private car activity into certain postcodes where outlets are hosting such facilities.
2. **Collection points** are proving popular with convenience retailers as they provide an additional source of revenue. In terms of collection points, Royal Mail has a network of 11,500 Post Offices and delivery offices from which recipients can collect their parcels; Hermes, around 5,000 collection points located in independent shops and local convenience stores for parcel deliveries and collections; DPD, 2,500 shop-based collection points across the UK

(Herson, 2015). Collection points and locker banks are currently less widely used compared to Click & Collect services due to the delivery charges levied, accounting for only 1% of total online sales in the UK in 2016 (Verdict, 2016a).

3. **Personal deliveries to the workplace** are chosen as a delivery option by some who would not otherwise be at home during the working day. While this helps to reduce delivery failure rates, it can have other negative consequences including the detrimental impact these deliveries place on companies' loading bays, internal building logistics and post-rooms. It can also add to the total number of vehicle visits made to the building, where in central London, personal parcel deliveries can represent between 40–60% of parcel throughput in medium-larger sized multi-tenanted offices, (increasing to 90% of parcel throughput during the Christmas peak; Allen et al., 2017). As a result of these issues, around 8% of offices are now banning staff from receiving personal deliveries at the workplace (Transport for London, 2015) with the London Assembly calling for more companies in London to follow suit (London Assembly, 2017). Given that approximately 13–14% of all online shopping deliveries arrive either late or when the customer is not at home (IMRG, 2014a), there could still be wider environmental and transport benefits of having deliveries made to a workplace. Over the next 20 years, we may well see the adoption of such strategies to reduce wasted mileage during the working day.
4. **Try-and-buy outlets** aim to reduce the costs associated with managing returned products. A Czech online-only retailer, ZOOT, has implemented an approach in which clothing ordered by customers can be delivered to a 'Try & Buy' store which the customer visits to try on items and decide if they are suitable. Half of all orders are delivered to the Try & Buy facility within 24 hours of the order being placed and some deliveries take as little as three hours. Consumers only have to commit to buy the goods after trying them on (Mintel, 2016c).

Other trends in urban logistics

Other potential ways in which urban logistics may alter in the coming years in response to the changes in shopping patterns, among other factors, are discussed below. Some of which these changes require assistance by policy makers.

1. **Increased collaborative working between logistics providers** is envisaged to reduce infrastructure requirements and enhance the efficiency of their operations. Parcel carriers have traditionally viewed each other as competitors and have not countenanced such concepts, except when making deliveries to and collections from very remote, rural locations that are difficult to serve such as the Scottish Highlands and Islands, and the Isle of Man (Allen et al., 2016b). Such collaborations can also be adopted to address the difficulties posed by the cost of acquiring suitably located depots in central urban areas. **Gnewt Cargo**, operating in central London, is classed as a 'carrier's carrier', receiving parcels from carriers and suppliers in single HGV loads at its centrally located depots and carrying out the last-mile transaction on their behalf using a fleet of electrically powered LGVs (Allen and Browne, 2016). This approach reduces the number of LGVs having to deliver parcels in a given area, as well as reducing CO₂ and air pollutant emissions.
2. **Mandatory use of Urban Consolidation Centres (UCCs)** could become a reality if local authorities are to realise real reductions in freight vehicles entering urban areas, but question marks remain over the economic viability of some of these schemes without public subsidy (Allen et al., 2012b). Research by Cherrett et al. (2017) suggested that consolidating parcel carrier deliveries to university halls of residence in Southampton, UK, could reduce the current 13,000 annual observed courier visits to 300 for an annual service cost of approximately £18 per student.
3. **The introduction of Logistics hotels** where a municipality works with industrial partners to create multi-user logistics depots in central urban areas. The **municipality of Paris** is developing these as part of two key mixed-use developments in order to reduce freight vehicle journey distances in the urban

area and also provide the opportunity to transfer goods to cleaner, alternatively fuelled vehicles for final delivery. This approach is being implemented at Beaugrenelle (a 3000m² parking facility turned into a parcel cross dock facility), and at Chapelle International (a rail-connected site).

4. ***Use of shared drop zones*** which are areas on-street, reserved for collection and delivery activity. In several French cities, an approach called 'Espace de livraison de proximité' (ELP or in English, 'nearby delivery areas') was introduced and operated. Goods destined for customers in busy urban areas were instead delivered to an urban transshipment platform at which dedicated ELP staff loaded the goods onto trolleys, carts, bicycles and electric LGVs for the last-mile leg to shops and offices in the surrounding area (Browne et al., 2012; Huschebeck, 2012; SUGAR, 2011). In a district of Paris, the parcel carrier **La Tournée** established a 'virtual exchange point' system where its delivery staff received parcels which they sorted and then delivered locally on foot using a trolley (Ducret, 2014).

5. ***The introduction of 'mobile city hubs' and 'micro-consolidation centres'*** by last-mile delivery companies. A mobile city hub can include an LGV, a trailer or a barge, used as transshipment point / storage facility that can be easily moved around the urban area as required. Delivery staff collect their parcels from these mobile hubs and then make the deliveries using bicycles or LGVs, or on foot, returning to the hub to collect more parcels and carry out further delivery rounds. Examples include **Vert Chez Vous** on the River Seine and the HGV trailer-based '**Mobile Depot**' trialled by TNT in Brussels (Ducret, 2014). Micro-consolidation centres (also called **E-fulfillment centres**) are fixed depots located in inner and central urban areas to reduce the stem mileage between depot and centrally located customers; they can also support the use of environmentally friendly vehicles including electric LGVs. These can be difficult for last-mile delivery companies serving more traditional parts of the sector to acquire, due to the high rental values in such locations.

6. ***The continuing growth in 'Crowdshipping'*** will increasingly become a viable means for reducing the vehicle activity required for parcel deliveries. This

involves enlisting people who are already travelling from points A to B to take a package along with them, thereby creating new informal logistics networks (US Postal Service, 2014). Such crowdshipping services have emerged over the last five years and are provided via a range of online crowdshipping platforms e.g. **Postmates**, **Zipments**, **Deliv**, and **Roadie** (McKinnon, 2016). However, such services could see the use of dedicated vehicle trips specifically for parcel delivery which do not necessarily have a beneficial effect on traffic reduction (Allen et al., 2017).

3. The impact of e-commerce on last-mile deliveries

The **impact of e-commerce on urban freight transport varies depending on product type, supply chain and decisions made by the customer**. Some e-commerce last-mile deliveries are made direct from the logistics provider's depot to the customer's business/home. These types of last-mile urban delivery will only require one transport journey (e.g. in the case of large, non-food items, and meals delivered from restaurants). In the case of last-mile deliveries of grocery shopping and non-food small items, the consumer has the choice of having the goods delivered to a location other than their home (as described in the section 'Consignee control mechanisms, above), including a Click & Collect facility, a collection point, a locker bank and, in some cases, a workplace.

Delivery location other than home

If the consumer chooses a delivery location other than their home, then they will have to **personally carry out the final transport journey from this intermediate location to their home**. In carrying out this journey, the consumer will make decision concerning: (i) the mode of transport used, and (ii) the nature of the journey. In terms of the mode of transport, they may choose to carry this out by walking, cycling, using public transport, motorbike or car. In terms of the nature of the journey, the consumer will decide: (i) the time at which the journey takes place, and (ii) whether the journey is carried out solely for this purpose or whether it is combined with another trip purpose (such as a journey to or from work, a school or leisure trip, or as part of a larger shopping trip). Further research into the most sustainable method (in terms of traffic and environmental impacts) of, and location for, last-mile deliveries would be beneficial.

Both the mode of transport and the nature of the journey chosen by the consumer when collecting their e-commerce orders from a location other than their

home will have an important bearing on the traffic, environmental and safety impacts associated with e-commerce last-mile deliveries (see also the section 'Consignee control mechanisms', above). Research has shown that, in general, consumer car journeys to transport online orders between collection points and their home are less efficient from a traffic perspective (and hence also from an environmental and safety perspective) than carrying out these journeys using a home delivery van (which is capable of carrying multiple consumers' goods on a single vehicle which visits each consumer in turn) (Browne et al., 2005; Cairns, 1999; Edwards et al., 2009). However, consumer journeys on foot or by bicycle are likely to have lower traffic, environmental and safety impacts than LGVs used for home delivery.

Effects of time saving

There are two further points worth making about **e-commerce purchases and their potential relationship with their transport activity** (both of which would benefit from greater research).

1. It is important to bear in mind that the **time savings that consumers derive from shopping online** compared with shopping in person in physical stores can be used by these consumers to make additional car journeys for other purposes (such as leisure trips, or to visit friends and relatives). Given that these non-shopping journey purposes tend to have greater journey distances than shopping trips, the substitution of shopping journeys by car with journeys for other purposes by car is therefore likely to result in an increase in the total motorised road transport activity by online consumers who decide to use time saved shopping online to make other car journeys.
2. Some online shoppers **choose to view the actual goods prior to purchase**. This can involve travelling to the shop (either by car or some other mode). If this product-viewing journey is carried out by car there may be no reduction in car-based travel as a result of that particular online order, together with an increase in van-based vehicle traffic associated with the delivery.

Growth in demand for logistics land

As noted in chapter 2, the growth in e-commerce and the consequent deliveries has led to substantial growth in demand for **logistics land in urban areas** to develop E-fulfillment or micro-consolidation centres from which these highly responsive last-mile deliveries can be made. These centres are used for vehicle despatch for last-mile deliveries to consumers in both residential and commercial properties. These centres can also be used in the return flow of goods from consumers to online retailers (Addleshaw Goddard, 2017). It has been argued that there is currently not sufficient logistics land availability in UK cities to meet the demand for these E-fulfillment centres which will result in increasing road freight transport activity levels over time (Addleshaw Goddard, 2017; Turley, 2017; AECOM, 2016; CAG Consultants, 2017). Also, some last-mile delivery companies in more traditional parts of the sector cannot afford the high rental values charged.

Status of workers

Concerns about the **status of workers** carrying out online deliveries and their remuneration and rights have led to legal action and strikes in the UK since 2015, and have been subject to investigation and scrutiny by the Work and Pensions Select Committee and the Taylor Commission (European Parliament, 2016; House of Commons Work and Pensions Committee, 2017; The Taylor Review, 2017).

Many of the current features of last-mile e-commerce deliveries in urban areas are likely to remain broadly as at present in the short to medium term. However, there are some potential changes that may take place in the last-mile delivery of e-commerce orders over this timescale that are worth considering. These are mostly specific to various e-commerce sectors (Table 1). There are no reliable means of providing insights into long-term changes in e-commerce-related last-mile delivery operations in urban areas, as these will be subject to a wide range of economic, social, regulatory, and technological factors. Longer-term technological factors are considered in chapter 6.

Table 1. Possible short- to medium-term developments in last-mile urban delivery operations

| Possible development | Home delivery sector(s) affected | Possible consequence |
|---|---|---|
| Increase in proportion of same-day deliveries | Non-food small items Grocery | Decrease in efficiency of delivery operations; greater total vehicle activity |
| Ever-later order time cut-off for next day deliveries | Non-food small items | Decrease in efficiency of delivery operations; greater total vehicle activity |
| Increase in importance of crowdshipping | Non-food small items Takeaway meals | If applied to non-food small items sector, likely to lead to more, poorly loaded, dedicated journeys |
| Increase in use of Click and Collect services | Non-food small items Grocery | Reduction in van home delivery activity, but increase in consumer transport activity (overall impact on motorised transport activity uncertain) |
| Greater use of agreed delivery time slots | Non-food small items | Reduction in delivery failure rates, but less efficient vehicle routeing (overall impact on motorised transport activity uncertain) |

Source: based on the authors' own judgement.

4. Challenges posed by growth in last-mile logistics

Largely as a result of the growth in online shopping, described in detail above, the logistics industry will come under some specific pressures which will drive the changes outlined in the previous section. These challenges are described below.

Handling peak demand pressure

Carriers' ability to cope with the **ever-growing demand for parcel deliveries** during peak periods will require additional infrastructure investment to maintain service levels. Retailers are adding to these peak demand pressures as they seek to boost sales and their competitive position by importing 'shopping frenzies' with concepts from the USA such as 'Black Friday' and 'Cyber Monday' (Herson, 2015). Retailers are also urging carriers to accept later cut-off times for next-day deliveries to gain customer share (ibid).

Satisfying ever more complex customer demands

Consumers are demanding ever faster, more reliable and convenient delivery services, which has led carriers to offer costly timed, same-day and other traceable services, either direct to door or through attended/unattended collection points (Copenhagen Economics, 2013; Post and Parcel, 2015). Since 2013, there has been an increase in the proportion of parcels sent for next-day delivery and a related decline in parcels sent by economy service (IMRG and Metapack, 2016). Research has shown that 43% of consumers have had a negative experience with the delivery of online orders, and that 66% have chosen one retailer in preference to another because they provided a greater range of delivery options (Metapack, 2015).

Increasing demand for B2C and C2C deliveries

B2C and C2C delivery has seen considerable growth, which will continue, but generates lower average revenues for parcel carriers compared to B2B deliveries. These markets also have attributes that make delivery less efficient, including the sizeable first-time failure rates associated with deliveries to residential customers, and the proportions of single-parcel deliveries compared to multiple items per consignee in B2B operations. B2C and C2C deliveries also involve more suburban and ex-urban delivery locations, with lower drop densities and higher inter-drop distances compared to B2B (Allen et al., 2017).

Scarcity of available logistics infrastructure

Affordable local depots from which to operate last-mile parcel deliveries are becoming increasingly difficult to find due to rising land values in London and other cities in Britain and elsewhere. These increases have forced many freight transport operators to relocate their central urban depots to cheaper peripheral areas (Hesse, 2008), which has led to the suburbanisation of warehousing and distribution facilities (Cidell, 2010; Hesse, 2008; Dablanc and Rakotonarivo, 2010). Often referred to as 'logistics sprawl' (Dablanc et al., 2014), this has the effect of increasing stem mileages (the distance from the depot to the first delivery address, and from the last delivery address back to the depot), resulting in increased vehicle kilometres.

Loss of kerbside space for freight activity

Road space reallocation has taken place in many cities with the expansion of exclusive bus and cycle lanes, pavement widening programmes and dedicated bus lanes in the London Congestion Charging Zone increasing from 24.5 miles in 2003 to 26.5 in 2007 (Barry, 2014). This impedes access and limits dwell times for freight – a situation further exacerbated by increasing road traffic delays, which have risen by between 17% and 31% in central London since 2009 (Transport for London, 2016).

Impacts of 'free' delivery

The decision by many retailers to provide 'free' delivery options in order to attract custom has resulted in low pricing models being demanded from carriers (Consultancy.uk, 2015). A 2016 survey of 350 online retailers found that 16% offered free delivery as standard, with 55% offering it on orders exceeding a specified value threshold. Of interest was that 59% of these retailers charged less than £5 for delivery if the free delivery threshold was not met (Oracle, 2016). Ofcom found that 56% of adults rated free delivery as an important factor when choosing a retailer (Ofcom, 2015).

Managing increasing product returns

Unlike other supply chains, returned products from online shopping represent a sizeable proportion of all goods delivered, with 20% to 30% of all clothing and footwear purchased online (by value) being returned (Barclays, 2014; Verdict, 2016b). Managing this can be a considerable challenge for logistics providers whose operations are geared up to the forward movement of products.

Handling failed first-time deliveries

Failure rates are higher for deliveries to residential compared to commercial addresses, because less than 10% of all parcels and packages ordered online (by value) are compatible with a standard letterbox (Verdict, 2016a). It has been estimated that 13–14% of all online shopping deliveries in the UK arrive either late or when the customer is not at home (IMRG, 2014a), costing retailers and carriers £771 million in 2014 (IMRG, 2014b).

5. What are the implications for decisions that need to be made today?

In relation to the current and foreseen issues impacting on the efficiency of last-mile logistics, the key decisions that need to be made relate to:

- **Enabling local authorities to identify and safeguard key ‘zones’** to site potential freight facilities on-street (e.g. shared drop/ ‘wait-and-walk’ points for LGVs; micro-consolidation points). Careful thought will be needed to identify these, existing post sector locations could be used as a starting point.
- **Promoting and incentivising the use of the ‘carrier’s carrier’ approach** for last-mile distribution where carriers hand over goods to another who may be better placed to make the final deliveries due to their location or their use of more sustainable vehicles.
- **Aiding and incentivising the operation of multi-user freight consolidation centres** to reduce the number of individual freight vehicle trips into urban centres and to drive the take-up of electric last-mile delivery (via ‘carrier’s carrier’ operations).
- **Harmonising loading/unloading regulations** across boroughs and regions.
- **Developing mandatory reporting mechanisms** to gather fleet operating data to better understand the sector (e.g. DfT re-commencing an on-going survey of national LGV operations).

What are the research gaps in understanding how the freight transport system is changing?

- Understanding the totality of LGV and HGV operations in urban areas (e.g. all service-related activities, domestic, industrial and retail).
- Investigating the extent to which e-commerce will continue to grow and proliferate, and the ramifications on logistics of this activity.
- Understanding how the gig economy will impact on last-mile operations with increasing e-commerce activity.
- Determining to what extent high-street logistics will be impacted by e-commerce trends.
- Identifying which services will become remote access, negating the need for freight vehicle activity, and determining the extent to which goods will become digital rather than physical.

6. How is the technology changing the freight transport system?

- **Cargo cycles** (<http://www.cyclinguk.org/article/cycling-guide/guide-cargo-bikes>) are increasingly being used to enhance last-mile operations in dense urban areas, with many logistics providers having undertaken trials and implementations.
- **Lifestyle couriers** are becoming more common as a means of servicing consignees locally, often using sustainable transport modes. These largely part-time casual workers have been enabled through app-based platforms which allow them to interface easily with the main logistics provider to be allocated work which suits their specific working schedules and requirements. This arrangement has been particularly prevalent in the take-away food sector with **Deliveroo** (<https://deliveroo.co.uk/>) and **UberEats** (<https://www.ubereats.com/>) being particular examples.
- **Mobile depots and micro-consolidation hubs** are being used as staging posts in congested urban centres where products are brought in from a distribution centre in a standard trailer and then parked up for smaller sustainable transport modes to then undertake the last-mile delivery. **TNT Express** have experimented with the concept in Brussels (http://www.strightsol.eu/demonstration_B.htm)
- **Traceability of product** by consignees is being enabled by radio-frequency identification (RFID) and GPS where a consignee can visualise the location and status of their goods at any time. This is leading to the development of more dynamic delivery possibilities where carriers might deliver to 'person' rather than traditional 'place'. Using the same tracking technology that allows the Uber taxi driver and client to visualise each other's location over the last 200m, the carrier might be able to identify the intended consignee in an urban area if they choose to make themselves digitally visible. This would enable 'delivery to

person' and could reduce failed first-time deliveries, but would require dynamic optimisation techniques to reconstruct the round each time a consignee was served.

- **Drones and droids** (autonomous delivery vehicles in the air and on the ground respectively) are being tested within the industry. In the case of drones, there are several current examples where small machinery parts and medical samples have been successfully moved by drone between fixed locations (e.g. by **DHL Parcelcopter** (http://www.dpdhl.com/en/media_relations/specials/parcelcopter.html), and the **Matternet Station** (<https://mtrr.net>). Despite the legal and regulatory hurdles, drones do offer potentially large savings in journey times and emissions over conventional transport. A study by the University of Southampton looking into patient sample movements from seven central London clinics to a main hospital using these methods suggested time and emissions savings of up to 61% and 93% respectively over the conventional courier operation (Orda, 2017).

In 2014 **Amazon** obtained a patent for what it called an '**airborne fulfilment centre**', which consisted of airships used as flying warehouses equipped with fleets of drones for final delivery to consumers. Additional airships would be used to replenish stock at the 'fulfilment centre' airship. It was stated that such a concept could be used to serve sporting events or festivals (BBC, 2016). In a trial in December 2016, Amazon made its first, fully autonomous delivery by drone, which consisted of a tablet computer and a packet of popcorn, from one of its fulfilment centres to a customer in a rural part of Cambridgeshire. The delivery was completed 13 minutes after the order was placed (Slide, 2016).

A small-scale trial of a **pavement-based delivery robot** is already taking place in London (<https://www.starship.xyz/starship-launches-in-uk/>) and research is underway into autonomous road freight vehicles (in terms of self-driving goods vehicles operating in convey through to fully autonomous self-driving vehicles), (<https://trl.co.uk/news/news/government-gives-green-light-first-operational-vehicle-platooning-trial>). Due to the many technical and legal challenges associated with operating drones for last-mile delivery in urban areas, it is likely

that any first deployments will involve droid vehicles running between depots and micro-consolidation hubs, from where the last-mile would be undertaken by cycle or foot. Droids have already been successfully deployed in factories and hospitals for moving goods over relatively short, repetitive uncomplicated distances (<http://www.aethon.com/tug/how-it-works/>).

- ***The continued dematerialisation of products*** as they become ever-more digital and shipped online rather than physically (such as books and music) thereby reducing the quantity of material goods that need to be physically delivered.
- ***3D printing*** Instead of the need to order various goods and have them physically delivered from retailer to consumer, 3D printing will increasingly offer the possibility that these 'goods' could be printed either at home or at a local printing facility, thereby reducing the quantity of material goods that need to be transported to consumers.

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