Final Report : Single-carrier consolidation - Central London trial

Consolidating deliveries of retail and non- retail clients into single electric van deliveries

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Greater London Authority
28 April 2017

Published by
Greater London Authority
City Hall
The Queen's Walk
More London
London SE1 2AA
www.london.gov.uk
enquiries 020 7983 4100
minicom 020 7983 4458
ISBN

Copies of this report are available
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Abstract

This document is the final report of the Mayor of London's single - carrier consolidation - Central London trial (Agile 3) that ran from 1st July 2015 to 30 June 2016.The trial was delivered by Gnewt Cargo Limited. The trial explored scenarios for consolidating deliveries of multiple retail and non-retail clients using a single carrier (Gnewt Cargo) in a single van. All deliveries were done using electric vans. The aim of the trial was to reduce the number of delivery trips, reduce congestion and improve air quality outputs compared to a diesel equivalent approach by utilizing zero emissions electric freight delivery vehicles.

During this demonstrator, Gnewt carried parcels for final delivery in central London for multiple businesses, e.g. TNT, Marlborough Grove depot in Southwark, SE16 biscuit Factory and Emakers, all of which are active in business-to-consumer (B2C), home deliveries, and business-to-business (B2B) operations in London and the UK. Gnewt also carried parcels for other retail companies including Client B (local produce on-line grocery store), Emakers (e-commerce delivery business), and Spicers (leading uk wholesale office suppliers).

This report presents in detail the results of the trial implementations and performances. Overall the trial results show a strong decrease in distance, CO_2, NO_x & PM_{10} emissions, total energy use, and in empty distance miles, but a slight increase in total number of vehicles. The efficiency increase in operations during the trial leads to lower air pollutants emissions per parcel delivered. The lower distance also diminishes all external costs of transport such as accidents and congestion costs that are distance related.

For example, the TNT case study, Gnewt Cargo achieved 67% distance reduction per parcel driven on London roads. The CO_2 emissions, NO_x and PM tailpipe emission were reduced by 100% compared to diesel equivalent vehicles used by participating clients. The energy use went down by 85% and the empty distance was reduced by 93%. By using electric vehicles in Central London for retail and parcel deliveries, the trial contributed to meeting the Mayor's key target for lowering air pollution in London and improving the health of residents, working population and visitors, while improving the environment for efficiency and profitability of urban freight businesses.

As a legacy, the effects of introducing the solution on the market are clearly beneficial for the environment, business efficiency and profitability. The data collected and analysed provides evidence that the operational solution trialed can be replicated, new Central London depots can be opened and run efficiently, and new clean freight vehicles can be acquired and used successfully in London.

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List of Abbreviations

Agile Cat 3	Agile Category 3 Demonstrator project
BEV	battery electric vehicle
B2B	business to business trade
B2C	business to consumer trade
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
EC	East Central London (UK Postcode area in London)
EFAO	European Alternative Fuel Observatory
EU	European Union
EV	electric vehicle
ft^2	square feet
GHG	greenhouse gas
GLA	Greater London Authority
goe	gram of oil equivalent
GPS	Geo Positioning System
HGV	heavy goods vehicle
Km	kilometre
Kg	kilogramme
Kgoe	kilogramme of oil equivalent
kWh	kilowatt-hour
LGV	light goods vehicle
LSP	logistics service provider
m^3	cubic metre
NAEI	National Atmospheric Emission Inventory
NO_x	nitrogen oxides
OEM	original equipment manufacturer
PM	particulate matters
PM10	particulate matters with a size <10 micron
R&D	research and development
SE	South East London (UK Postcode area in London)
SW	South West London (UK Postcode area in London)
TfL	Transport for London
UK	United Kingdom
veh	Vehicle
W	West London (UK Postcode area in London)
WC	West Central London (UK Postcode area in London)

1. Executive Summary

1.1 Background and Objectives

The Mayor's Smart London Demonstrator programme aims to bring together emerging concepts and opportunities in Smart and Sustainable Cities to demonstrate the economic, social and environmental value that can be created through the application of digital (data-driven) solutions. It also explores systemic approaches to city infrastructure and services.

The Agile Urban Logistics project was delivered under the Mayor's Smart London Demonstrator programme. The aim was to trial innovative solutions for the light freight sector that allows it to adapt to changing regulatory and market conditions, mitigating congestion and emissions impacts.

In April 2015, the GLA invited grant-funding proposals to deliver a "single-carrier consolidation trial targeting poor air quality zones". Following a competitive grant-funding round, Gnewt Cargo was awarded circa £350K funding from the GLA to run a 12-month (1st July 2015 to 30th June 2016) central London demonstrator.

The demonstrator was designed to test and measure how a defined set of changes affects transport logistics for retail and non-retail businesses. The trial explored scenarios for consolidating deliveries of multiple retail and non- retail clients using a single carrier (Gnewt Cargo) in a single van. All deliveries were done using electric vans. The aim of the trial was to reduce the number of delivery trips, reduce congestion and improve air quality outputs compared to a diesel equivalent approach by utilizing zero emissions electric freight delivery vehicles.

The project also assessed the potential for:

- re-timing of e-commerce B2C activity, away from peak hours
- re-routing of journeys away from the most congested roads and pollution hot spots
- consolidation and a reduction in the number of trips
- utilisation of low emission vehicles
- reduction in emissions (CO_2, diesel particulates, NO_X)

1.2 Smart interventions tested

The main smart interventions tested include:

- Reducing the total freight distance of last mile logistics of parcel deliveries for retail and e-commerce clients, by changing from outer London depots to centrally located logistics distribution centres in London
- Using electric vehicles instead of diesel vans to reduce air pollutants
- Consolidating deliveries of retail and non- retail clients into one single van delivery trip to reduce the number of vehicle movements, associated congestion and air pollution.

Achieving improvements in the areas noted above are key for future efficiency improvements in London urban logistics, to lower congestion and improve air quality.

1.3 Project Partners

The project was delivered by Gnewt Cargo, a London SME, who is currently the single biggest operator of a 100% electric van fleet for urban freight in the world. Gnewt is a growing Logistics Service Provider running delivery operations with 100% full-electric vans and cycles in Central London and has been trading since 2009.

During this demonstrator, Gnewt carried parcels for final delivery in central London for several major parcel delivery businesses, namely Client A, TNT and CLIENT C, all of which are active in business-to-consumer (B2C), home deliveries, and business-to-business (B2B) operations in London and the UK. Gnewt also carried parcels for other retail companies including Client B (local produce on-line grocery store), Emakers (e-commerce delivery business), and Spicers (leading uk wholesale office suppliers). The e-commerce demand for transport remained unchanged, only the last mile logistics and how the parcels were transported to their final destination was the subject of smart interventions.

In this report, Gnewt Cargo presents two case studies for Client B and TNT, selected among the two main types of customers; carriers and retailers. Each type of customer has very similar parcel logistics processes. Within each group, carrier or retailer, one typical partner was selected that is representative for all others, and this partner was selected in order to present to the public a much more in-depth assessment. Because the basics of all customers of Gnewt Cargo are similar, initially the business activities were looked at from a more general perspective. For this, Gnewt considered the data of a major customer Client A representative. Client A data showed how the whole parcel logistics business in London could be improved with Gnewt Cargo, if the activities of this demonstrator became the norm.

Why does the demonstrator approach differ from the standard?

Each case study below is used to demonstrate the benefits of the trial approach used by Gnewt Cargo. The three main benefits of the innovations showcased in this demonstration are:

- Gnewt Cargo carries parcels for multiple carriers/customers in Central London using a single van to make deliveries; this makes a big difference in terms of efficiency, high load factor, much shorter distances and better performance.
- the use of the Central London depot as base for a fleet of electric vehicles, for clean last mile deliveries; this makes a big difference to emissions because it replaces polluting diesel trucks and vans with zero emission vehicles for all trips to the final recipients of the parcels.
- the use of diesel trucks at night to bring the parcels to Central London during a low traffic, low emission time; this triggers a huge benefit for London because it completely avoids the usual peak traffic time in the mornings on the congested arterial roads towards Central London.

For the project partners and its customers, Gnewt Cargo offers a quick service of high quality because of the close proximity to the final destination, a good image and an efficient use of resources overall.

Challenges experienced in the trial Challenges included:

- difficulty finding a better logistics depot located in Central London,
- changes in the delivery area of Client B,
- and the changes in the depot location used for the client TNT UK.

A summary of how Gnewt addressed these challenges and how it how it dealt with the clients' needs, are summarized in this report.

University of Westminster was also a partner of the demonstration, performing data processing and analysis for the trials.

1.4 Project Targets

The GLA set the following targets to measure the impact of the smart interventions listed in Section 1.2 above during the project.

- 20% reduction in the number of vehicle trips
- 50% less kilometres travelled
- Reduction in NOx (80%), reduction in PM (80%)
- Reduction in CO2 (80%) emissions.
- 70% reduction in total energy use
- 60% reduction in empty vehicles distance.

1.5 Project Costs

The costs breakdown for this project included costs for internal staff (about 90%), and subcontractor (about 10%). The total budget was approximately £515,000. The GLA funding amounts were circa £350K. Gnewt Cargo performed the Cat 3 project as a demonstrator similar to an applied R&D consultancy project. The funding enabled Gnewt Cargo to develop this type of consultancy and applied R&D activity that was not at all the focus of Gnewt's business to date. The project Cat 3 was designed to test innovative solutions and to collect data about them, that would have remained unknown, and to make it clearer to customers and to the public how beneficial and efficient the different types of urban logistics activities really are.

Through the trial, Gnewt Cargo tested different solutions to improve the efficiency of logistics, and experimented in joining different types of operations for a single carrier. Since the logistics business is a low margin business, there is usually no opportunity to trial different management solutions or different types of activities. The funding of this GLA demonstration provided a good framework for this testing and demonstrated the usefulness of innovative solutions.

It also ensured the production of reports and evidence supported by the University of Westminster. The funding allowed a big data collection as well as an assessment on the public sector benefits, in terms of lower pollution and lower traffic. The trials included preparation, management, ensuring the correct methodology, to result in the creation of data and critical assessment thereof; all of which would have been impossible under normal business conditions.

1.6 Benefit to GLA/TFL, Gnewt and the London Business Community

In addition to providing valuable data to inform the GLA and TFL freight policies, the project helped Gnewt Cargo obtain robust evidence about the solutions most applicable for improving its overall transport efficiency. The trial also helped Gnewt secure its long-term business development strategy.

The findings from this project will be published on the GLA website so that other logistics companies can benefit from lessons learnt during this project.

1.7 Preparation Phase

In setting up the project, Gnewt:

1. measured the baseline performance (i.e. operation of diesel equivalent vehicle) before introducing each smart intervention
2. developed trials and testing for retail and non-retail clients
3. worked with participating clients (Client B, TNT, Client A etc.) to collate data in the required format to host on a single consolidated platform
4. Analysed the data to demonstrate the results

1.8 Delivery phase

The project consisted of 3 case studies designed to answer specific questions for the project delivery. Each case study is used to describe the trial methodology and to demonstrate how the trial achieved its targets. Case studies are also used to summarise the tria's contribution to improving the environment for business efficiency and profitability. The main questions were:

Case Study 1: Consolidation into one depot in Central London and use of 2.2t electric vans (4.5m^3 capacity, about 100-150 parcels of average size) for the retail clients Client B and Emakers.

What is the business case for clean urban freight consolidation and single carrier deliveries for retail clients

Case Study 2: Consolidation and electric vehicle use for non-retail clients such as TNT.

What is the business case for clean urban freight consolidation and single carrier deliveries for non-retail clients in Central London?

What are the differences with retail clients?

Case Study 3: Testing the Fitness for Purpose of Different Electric Vehicles for Different Clients.

Generic study 1: Testing Design of Technology Tests.

What is the best solution for designing technology tests and how do we manage them efficiently?

Generic study 2: Improved Data Collection. What is the best method for collecting data consistent with previous information systems in place?

The findings are documented in this report.

1.9 Project Phasing

Table A: Preparation phase (green) and implementation phase (yellow) for the different studies.

Financial year		2015/2016		2016/2017
Tasks Quarters	**Q2**	**Q3**	**Q4**	**Q1**
Case Study 1 Client B				
Case Study 2 TNT				
Case Study 3 Electric vehicles				
Data processing				

1.10 Monitoring and Evaluation, Data Processing and Quality Checks

Gnewt collected data on 13,360 freight deliveries via electric vans, covering 148,500 miles, delivering about 2 million parcels during this 12 month project, between 1st July 2015 and 30th June 2016. The volume for Client A grew by nearly 100% in the last 3 years. Compared with the 300,000 trucks and vans driving every day in London, the Gnewt Cargo market share, with about 100 vans, is very small. The volume of collections for Client A represents only 1% of the delivery volume.

The average performance demonstrates how efficient and clean this logistics solution is: the average successful distribution is 151 parcels per van per day, the average distance is 11 miles per van per day and 119 metres per parcel delivered, the average time taken is 6 minutes per parcel, and the average completion rate is 87%.

There were many unique challenges for each of the individual companies based on e.g. business size, location, technology, type of vehicles, size and weight of parcels etc. For example, none of the city centre depots of Gnewt Cargo are accessible for larger lorries and articulated trucks. To cope with that challenge, the customers send the goods to the Gnewt Cargo depot on smaller trucks, usually 12 tonne lorries. Many modifications were needed to accommodate the different needs of the clients, and these operational changes are reported in detail in the case studies below.

The logistics industry has key peaks during its annual cycle e.g. lower delivery movements during the summer and above average delivery volumes during the Christmas period. By collecting the trial data over a twelve-month period, Gnewt was able to demonstrate the impact of these key periods. To cope with the increased volume over the Christmas period, Gnewt Cargo rented 11 electric vans from October 2015 to January 2016. This was effective but the issue of lack of space centrally remains crucial and the search for a bigger depot in Central London, accessible by large truck, is compulsory.

With this volume of robust data, Gnewt has demonstrated the potential to scale and replicate the positive impacts across the wider London area. Quantitative impacts and benefits are presented below

and explained in detail in this report. Why is this demonstration scalable and replicable in London? The key ingredients are central depots close to the final delivery area, a fully-electric fleet, and know-how.

1.11 Performance Against Project Targets

Mid-term and final targets were set for the duration of the demonstrators (June 2015 - July 2016). With the exception of the reduction in vehicle trips, the project achieved six out of seven of the performance targets set by the GLA.

The same numbers of vehicles were needed because it is very difficult to increase driver productivity. Significantly time spent walking deliveries takes about 60-80% of the total logistics activity; it is essential and nearly impossible to compress.

Table B: Target achievements of Gnewt Cargo Cat 3 in the period 1 July 15-30 June 16, in %

	Target (final) Q1 (2016/2017)	**Achieved (final) Q1 (2016/2017)**
Reduction in the number of vehicle trips	20	0
Reduction in total kilometres travelled	50	67
Reduction in NOx	80	100
Reduction in PM	80	100
Reduction in CO2 emissions	80	100
Reduction in total transport energy use	70	87
Reduction in empty vehicle distance.	60	93

Source: Agile Cat 3 demonstration 2016

For **Case Study 1** the demonstration was run for Emakers and Client B, consolidating the parcels into multi-drop deliveries starting from Central London with electric vehicles instead of from a suburban depot with diesel vans. For Client B the data shows a huge change in emissions, more than 90% reduction for CO_2 and particulates, and less reduction for distance (-11%). This is because the Client B depot wasn't located very far away from Central London, and so Gnewt Cargo obtained a traffic reduction through the use of their own West Central Street depot, limited to 11%. The effect on distance is proportional to the depot location. If a depot is further out, the impact of using Gnewt Cargo becomes stronger.

Case Study 2 demonstrates a high potential impact of joining different business streams within carriers like TNT. What was the main challenge of consolidating multiple business streams? The internal processes in a large organization are complicated and difficult to change. The benefits are not only for business costs, but also for London as a whole, with delivery di[1]stance per parcel reduced by

[1] A starting price for a new Renault Kangoo ZE is about £17,000 in Sept 2016. For a Nissan e-NV200 the starting price is around £14,000. Purchase conditions such as battery leasing, number of orders and vehicle size might change the price considerably.

67%, and CO_2 emissions and air pollutants down to zero. These findings need further confirmation over a longer timescale. The next step of the trial is to increase the amount of deliveries from the new TNT depot in Bermondsey. This could not be done during the timescale of the project because the tests started with 5 vehicles due to the lack of available space, and there was a need to first obtain evidence with a limited number of small changes before it can be scaled up.

For Cat 3 Case Study 3 the main electric vehicles currently in operation are the Renault Kangoo ZE and Nissan e-NV200. Both had very good results in terms of reliability and low energy costs.

For **Generic Study 1**, The impact of smart intervention was analysed using before (baseline) and after (performance post smart intervention) data collection for the design of the tests. This proved effective and will be reused in future demonstrations and trials of new technologies or new business developments.

For **Generic Study 2**, a new data collection system was added to the existing Gnewt Cargo information system, allowing for a clear coverage of all parts of the business activities and enabled seamless linkages with the interests of the GLA Agile Urban Logistics program. The new data collection system is based on the University of Westminster Urban Freight Impact calculation methodology. Data points are continuously collected all year round for multiple indicators. Similar data files were created for each client of Gnewt Cargo. The dates of the interventions, when specific changes were implemented, were noted. So the impacts of the changes can be calculated afterwards when using the information entered in the data files.

Previously the data was not collected in a similar way for different clients. Previous systems were fragmented. No coherent dataset could be generated and therefore no impact clearly calculated.

The data on the IT trial was collected successfully for the routing software from Optrak, Podfather and PTV Smartour, using a similar procedure. This data is presented in the Cat 2 report.

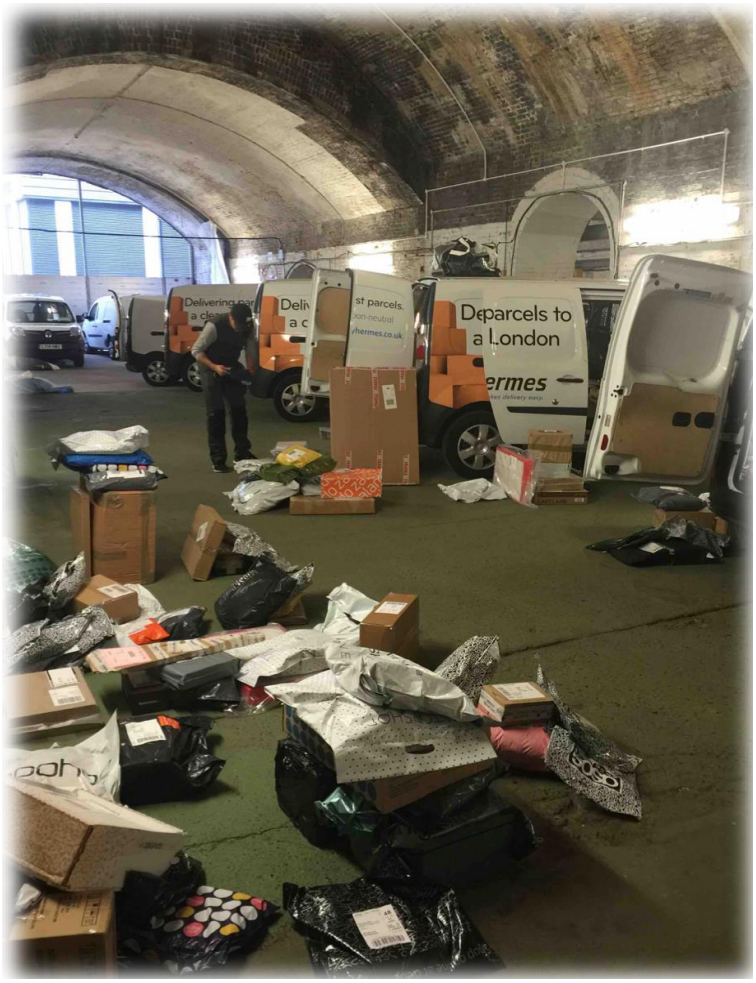
1.12 Constraints and challenges experienced during the project

Lack of a large depot accessible for big trucks – This is the main limitation to further growing this business in Central London and to successfully apply the approach trialed in this project and the ability to deliver the legacy above.

The search for bigger, affordable depots in Central London is a key on-going task. There is a clear need for help from The GLA, TfL and the London Boroughs in helping to identify and safeguard larger depots for clean deliveries in Central London.

We believe that areas of new development should be safeguarded and incorporated in the planning to achieve the scalability and success that this project has demonstrated.

Figure right: Delivery round preparation demonstration



Source: Gnewt Cargo Agile Cat 3

1.13 Legacy

The effects of introducing the solution on the market are clearly beneficial for wider society both for the environment and also for business efficiency and profitability. The data collected and analysed provides evidence that the operational solution trialed can be replicated, new Central London depots can be opened, and new clean freight vehicles can be purchased and used successfully in London.

In order to scale this project, several possibilities are feasible: economic growth of the current business through acquisition and contracting of new large-scale clients in London, the opening of new larger depots with access for large articulated trucks, and the purchase of additional clean vehicles. The knowledge on how to do this is now available from this trial and is replicable.

The greatest barrier to a lasting legacy may be in the lack of available space within city centers, safe-guarded for environmentally friendly logistics last-mile solutions that will become an absolute necessity to keeping parcel movements moving in the future in a clean and efficient manner (See Section1.12). The new central depot would need to accommodate bigger trucks to avoid multiple smaller trucks coming to London at night to bring the goods in.

The second concept would be to transfer the solution to another area of London, to open a new depot there, to obtain a contract with a new client or expand volume with existing clients, and to purchase a clean vehicle fleet. Again this transfer of good practice would benefit from a trial phase and from a quantitative evaluation. The only general limit to a growth of electric vehicles and Central London depots is the entire logistics and transport fleet circulating each day within Greater London. Long distance transport is not currently in a stage where electric vehicles are a viable option. Also very heavy weight volume such as construction materials and specific tasks such as waste collection cannot be currently performed with electric trucks.

Long distance trucks coming into or going out of London would need to be excluded. Gnewt estimates that currently up to 200,000 vehicles could be targeted. The expansion of the Gnewt Cargo system is at a much smaller scale, because every new contract has to be implemented in high quality and to the satisfaction of the clients. This requires a lot of effort in the day to day business, so a transfer and a scale-up unfortunately takes time.

Gnewt's business model and infrastructure was tailored towards this type of operating model from the company's inception. It is this fact that has enabled Gnewt to achieve the environmental savings and operational efficiency that has proved a barrier to other logistics companies. The concept of smaller, central consolidation centers, a fully 100% electric fleet, a robust data collection system and monitoring of operations is integral to the success of Gnewt and the ability to provide viable research results to GLA.

It remains unclear at this stage if this model could be replicable in outer London Boroughs e.g. Richmond, Enfield, etc. or if it is only suited to inner London. This has not been tested yet. Tests will be conducted in future in outer London Boroughs, because it does not appear impossible. The need for short distance between depots and delivery area will be identical. Problems will arise if a client has a very low drop density. If vans need to drive for more than 1 mile between two stops, the delivery becomes very expensive and profitability is hard to achieve. This is the main problem with an expansion in a lower density area of London.

Technical barriers: The electric freight business is not currently suitable for heavy loads transported by Heavy Goods Vehicle. For pallets or heavy goods deliveries to receivers of more than one tonne per day, trials with other alternative fuels are likely to currently prove more successful. An example of such is the experience of Howard Tenens with biogas as fuel and a gas motor as the main engine. This has not been tested in London yet.

A 100% full-electric freight business is also not suitable for long distance transport and the current range of approximately 60 miles per day is fairly limited, but this is considered sufficient for parcel deliveries. Due to the range limitation, a high density of customers is required. In our experience, a transport business that would require long distances between customers is not suitable for full-electric vans at this time.

Concluding remark: The results so far show a strong decrease in distance, CO_2 emissions, NO_X & PM_{10} emissions, total energy use, and in empty distance, but a slight increase in total number of vehicles. The efficiency increase in operations, measured as a much shorter distance per parcel, leads to lower air pollutant emissions per parcel delivered. The lower distance also diminishes all external costs of transport such as accidents and congestion costs that are distance related. The results are in

line with the Quarter 4 objectives set at the beginning of this project, except for the fleet reduction. A specific strategy is planned to tackle this issue. These results are fairly similar for Case Study 1 and Case Study 2, so the differences between retail and non-retail clients do not appear to be substantial.

2. Introduction, challenges and objectives

The main question of the Agile Gnewt Cargo Cat 3 project is, to find out, "what is the business case for clean urban freight consolidation and single carrier deliveries from the point of view of the operator in Central London".

Before we can answer this question, it is important to look first at the background and the market conditions faced by logistics businesses active in parcel deliveries with clean vehicles in London.

2.1 The Greater London Authority Programme on Agile Urban Logistics

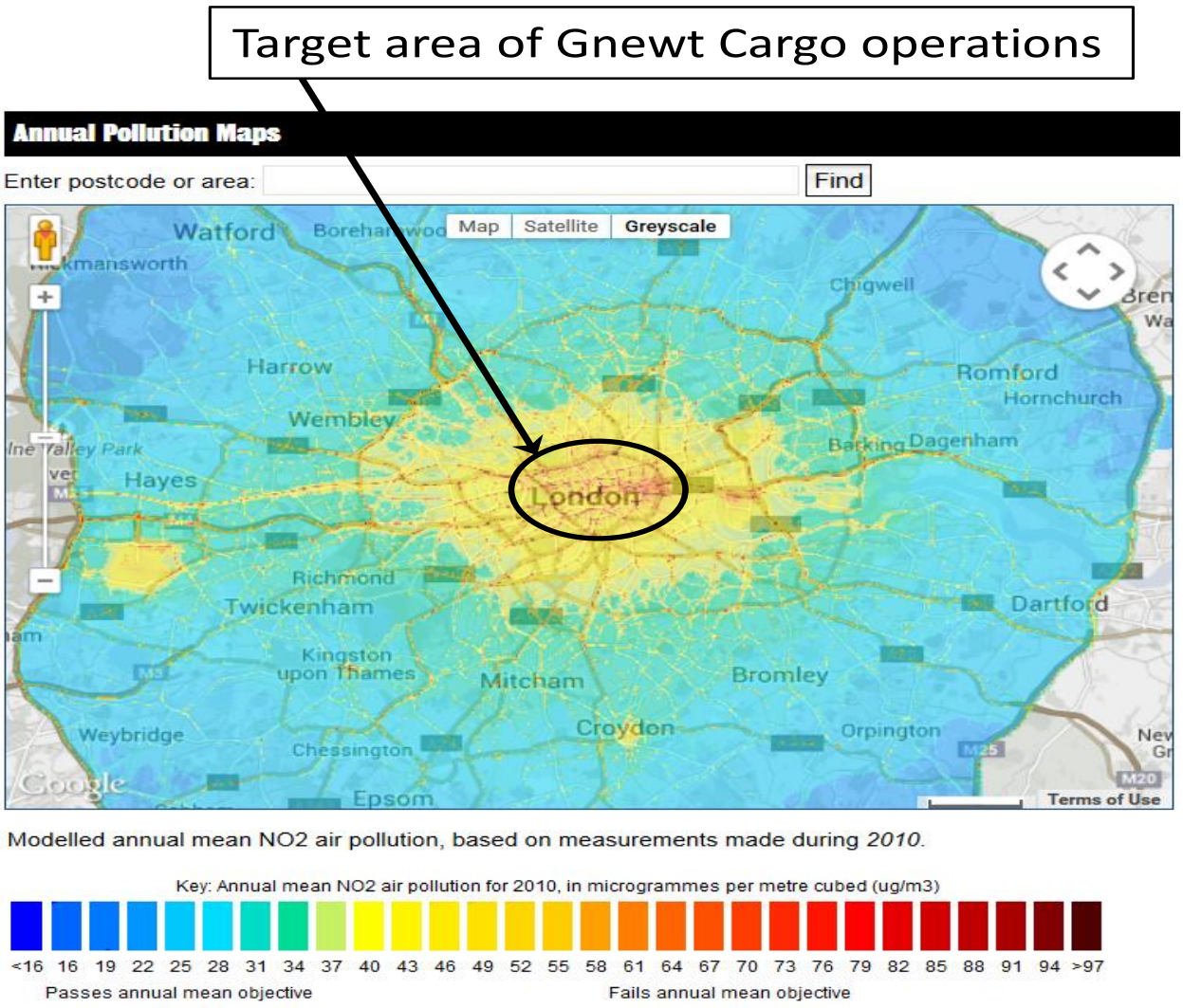
The London Smart Cities Programme is targeting the Central London area and the main problems that are to be tackled are air pollution and traffic congestion. The programme primarily addresses the following Mayoral priorities: job creation, reduced traffic congestion and mitigation of local air pollutant emissions and carbon emissions.

One of the projects proposed by The Greater London Authority (GLA) within the broader framework is the Agile Urban Logistics project, focusing on goods transport. It addresses congestion and emissions caused by the growth in smaller vehicle freight deliveries on London's roads, associated with the growth in e-commerce. In this context, GLA supports and funds demonstration projects that have the objective to show to businesses and the public sector decision makers, what benefits can result from using ultra low emission vans and Central consolidation centres.

This is seen as important as light freight journeys are already responsible for 80% of freight mileage on London's roads; TfL (2014) projects that by 2030 this will grow by 43%. Congestion costs the economy an estimated £2 billion a year. Stationary traffic in London has been found to lead to 8% more CO_2, 6% more PM_{10} and up to 9% more NOx emissions than free-flowing traffic.

The growth in e-commerce and personal deliveries is identified as a major contributor to this rate of increase. As such, light freight vehicles are a growing source of congestion. Congestion extends journey times, reduces business efficiency and contributes to poor air quality and carbon emissions.

Figure 1: NO2 air pollution distribution in London 2010, and targeted area of operation



Source: Londonair : Annual Pollution Maps http://www.londonair.org.uk

In this context, the Greater London Authority (GLA) and Transport for London (TfL) wanted the Agile Urban Logistics project to gain a better understanding of innovative solutions for the light freight sector that allow them to adapt to changing regulatory and market conditions, mitigating congestion and emission impacts, whilst improving business efficiency and customer experience.

Using Innovate UK funding, the GLA and TfL funded a series of Agile Urban Logistics projects to develop, demonstrate and evaluate 'on-the-ground' demonstrator trials in London from 2014-16. The demonstrators were used to assess the potential for wider adoption and their impacts on key economic and environmental indicators.

The target area of the Agile Urban Logistics project corresponds to the sectors of London that are most problematic for air pollution. Clear target areas are identified in the maps (Figure 1 and 2). Figure 1 shows air pollution in London - central and inner London areas are more strongly impacted than the suburban areas.

The centre of London is therefore a target area for policies aimed at better air quality. Figure 2 shows the location of the focus area for the GLA Smart Cities demonstrations during this project.

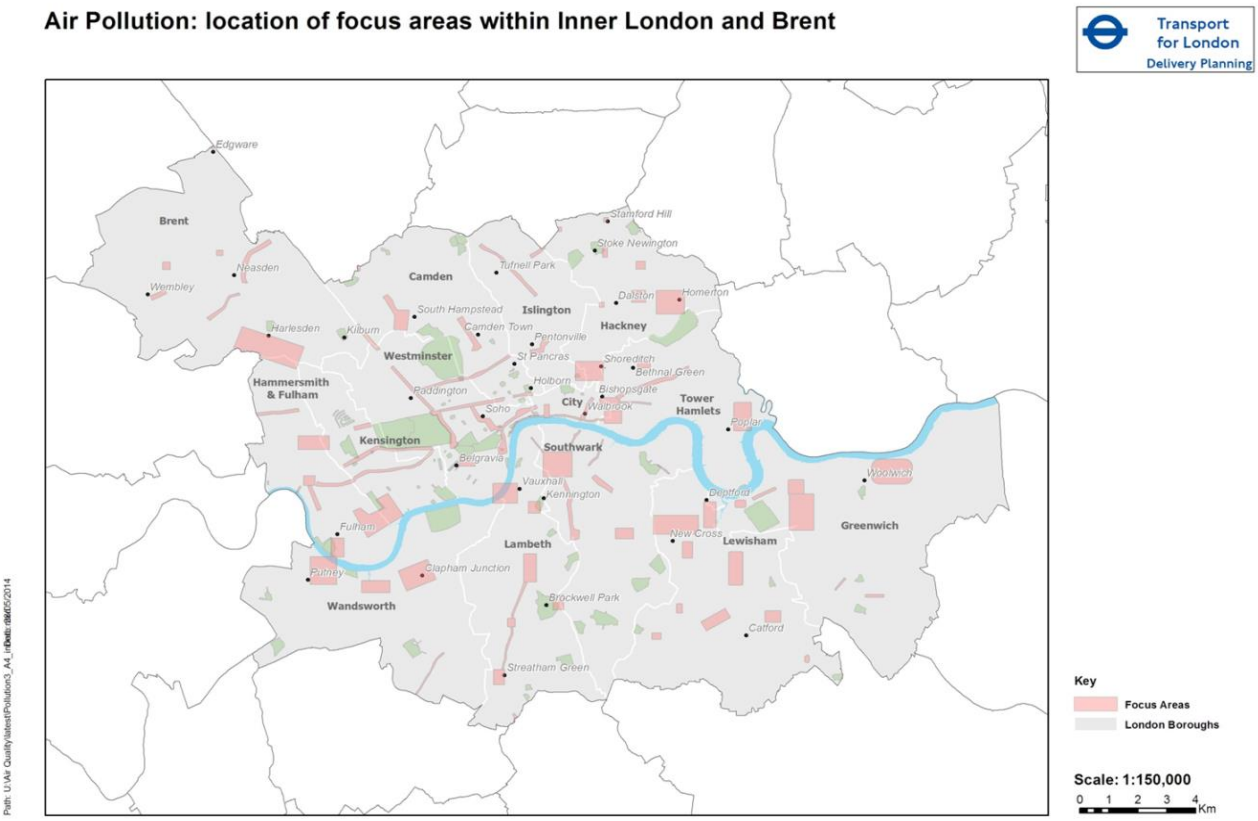


Figure 2: Focus areas in London targeted by the GLA demonstration programme

Source: The Greater London Authority (GLA) 2015

The GLA funded demonstration projects to show to the business community and public sector decision makers the benefits that result from using clean electric freight vehicles and consolidation centres. The so-called Category 3 demonstrators in Agile Urban Logistics were defined as: "Single carrier consolidation centre targeting poor air quality zones"

The Agile Gnewt Cargo demonstration reported in this document is defined as a Category 3 demonstrator in the GLA Agile Urban Logistics programme.

2.2 Gnewt Cargo and urban logistics in the frame of the trial

Gnewt Cargo is a growing Logistics Service Provider running delivery operations exclusively with fully-electric vans. These vans service clients mainly in the Central London Congestion Charge Area. 5 depots and a fleet of about 100 electric freight vehicles are in use. One main depot is based in Southwark on Wardens Grove near Great Guilford Street, another central depot is located in West Central Street near New Oxford Street.

A third, smaller depot, is located on Princes Street near Regent Street. The depot of a client, CLIENT C, located in Marlborough Grove in Southwark, is also used by Gnewt Cargo. The Carlton House Terrace depot is used for the deliveries to the West End area during peak time at Christmas (Figure 3).

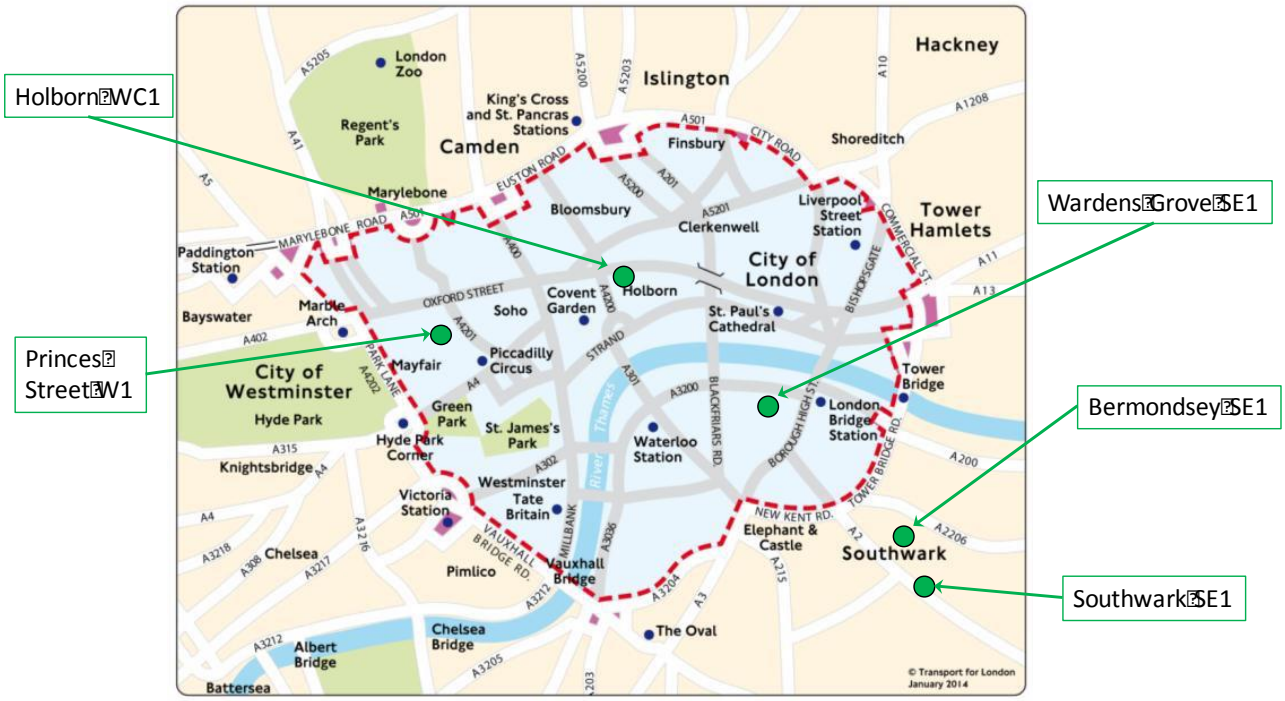
The main clients of Gnewt Cargo are:

- carriers specialised in parcel services, performing mostly courier and home delivery services for online retailers and SMEs, and
- retailers that send ordered goods to their final clients.

The main objective of this project is to thoroughly assess the benefits and impacts of the activities of single carrier consolidation of multiple clients (Figure 4, page 15). These benefits and impacts are firstly 'internal' i.e. business benefits such as cost reductions and supply chain efficiency, and secondly 'social' benefits i.e. reduced traffic congestion, improved air quality and noise reduction.

This Agile Cat 3 project was performed for a full year in order to consolidate knowledge and to obtain a broader, more robust and less risky business case.. To our knowledge, no such trial has been performed or evaluated to assess the overall changes pre and post-trial. The results demonstrated benefits that are also valid for any other freight business operating in London, and that other businesses will be able to transfer this knowledge to their companies and apply it successfully to their operations. **The added value for the business community is therefore high.**

Figure 3: Locations of the Gnewt Cargo depots used for electric deliveries in Central London



Source: Gnewt Cargo Cat 3 demonstrator, 2016

The logistics model monitored in Agile Cat 3 focuses on freight consolidation for multiple clients using a single carrier and vehicle. Figures 4 and 5 show and compare pre and post demonstrator business changes and outcomes.

Figure 4 is a simplified model of the activities of three logistics service providers making their deliveries without Gnewt Cargo. In this model, 3 suppliers of goods are delivering themselves to their clients in the city centre and all trips take place during rush hour in the morning traffic. These suppliers have their depots located in the suburban area of London and this implies a long journey towards the city centre during peak traffic (stem mileage). The fleet used in the parcels business is mainly light goods vehicles fuelled with diesel. Diesel is the main energy source for commercial fleets in UK.

The challenges of this logistics model are:

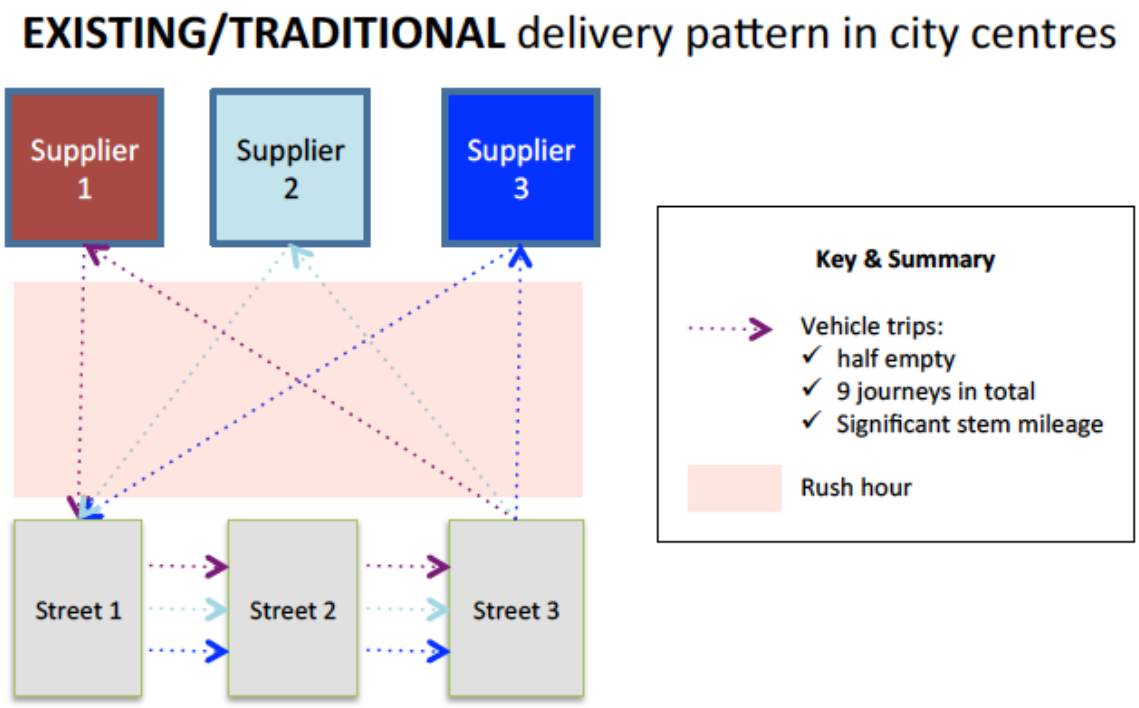
Low load factors: Despite missing data on the average load factor, the tendency observed in European studies seems to suggest that the average load factor is decreasing by weight and by volume. Vans are filled at around 50% from capacity at departure from depots.

High number of journeys: All vans needs to run all the way from the suburbs to the centre of the city and back.

Significant stem mileage: The part of the delivery trip occurring between depot departure and the first customer delivery in Central London is called stem mileage. The distance spent on this part of the trip is very long, more than 2/3^{rds} of the total distance driven during the day.

Contribution to rush hour congestion: Most vehicles need to drive during rush hours on the main axis towards central London. The cause of this is the business requirement to arrive at the first delivery point early in order to be able to distribute effectively and efficiently a high number of parcels during the day. Additionally, some parcel deliveries are required to take place within the time windows specified when the clients place their order. Normally the client can receive the goods all day. But for premium parcel deliveries, most carriers offer the option of a delivery before 09:00, 10:00 or 12:00. These are the reasons why the vans need to start from the suburban depots between 06:00 and 08:00, and arrive into Central London between 07:00 and 08:30. This morning trip corresponds to the peak congestion time.

Figure 4: BEFORE: Traditional logistics model of three freight carriers with standard vehicles



Source: Gnewt Cargo Cat 3 demonstrator, 2016

The participating companies and their logistics will be presented further down in the case studies.

Figure 5 below shows how this logistics model evolves when using the solution in place at Gnewt Cargo. The benefits of the solution are not only relevant for businesses but also for traffic, environment and the public sector interests:

Higher load factor: Instead of sending a high number of vans from the suburban depot towards the city centre, now fewer bigger trucks are used to bring the goods from the three supplier depots to the designated Gnewt Cargo depot. These trucks are not used again to deliver the parcels to the final recipients, only to unload at the depot. When we compare the truck trips now with the previous van trips occurring on the same arterial road, the trucks have a much higher load factor than the vans. Trucks are usually 100% full and it was estimated that the vans were only 50% full. These trucks are better loaded on the way into the city centre, but return empty; for some clients such as TNT, vans are not completely empty and they are filled on their way back with a few parcels that have been collected from customers.

For Gnewt Cargo, electric vans start full at departure from the depot in Central London. The number of empty return trips has almost disappeared. The distance driven empty is the distance between the last delivery point and the Central London depot, and fro Gnewt Cargo this distance is less than one mile.

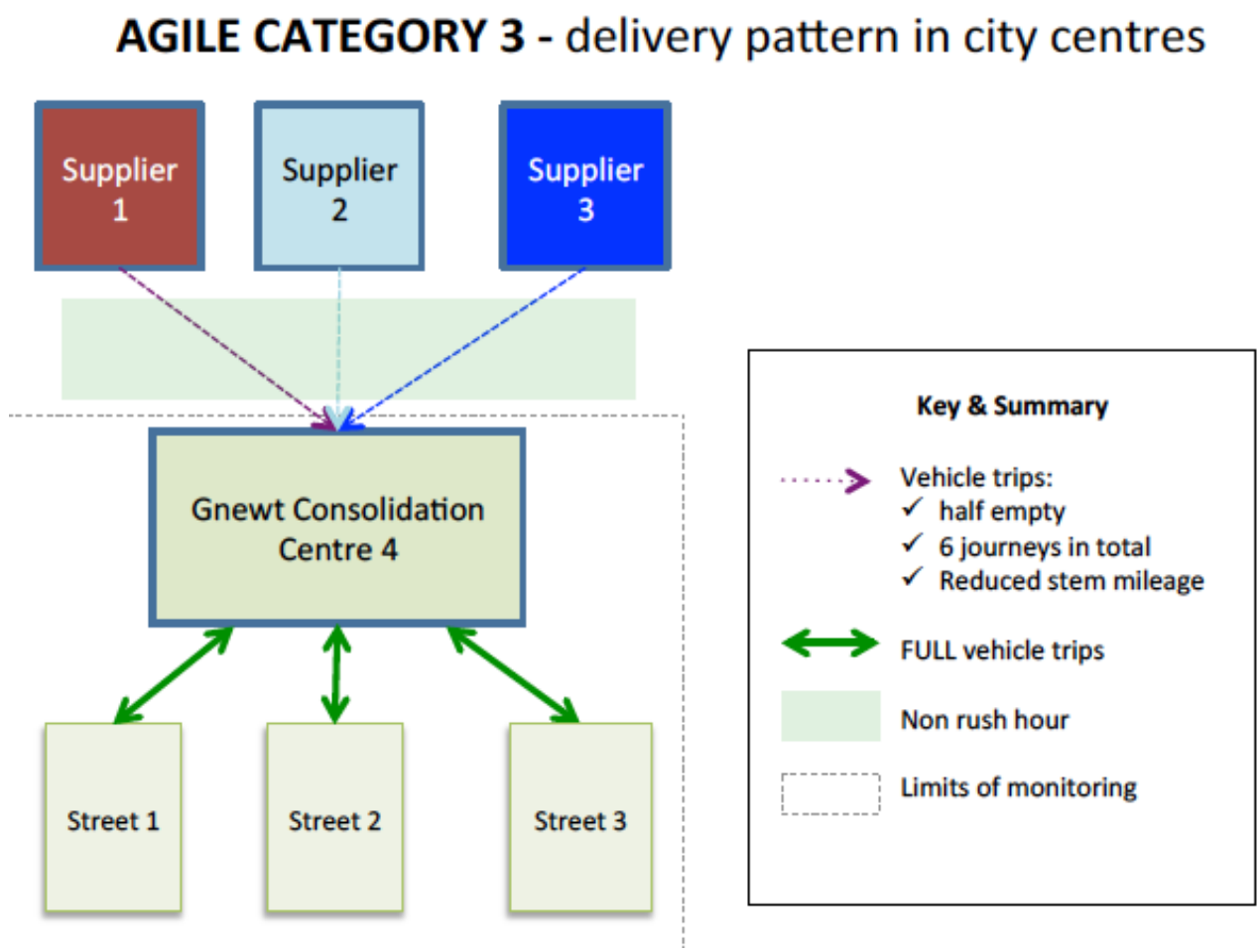
Reduced number of journeys: the goods that previously were brought in using multiple vans can now be brought into the city centre using a single larger truck from the supplier depot. It is possible

to replace up to 7 vans with a single truck. In the case of Client A, three to seven vans are replaced by one truck. In the case of TNT, the number of vans replaced by one truck is approximately 4.

Reduced mileage: the trip reduction leads to a corresponding reduction in total distance. This reduced mileage is best estimated in km per parcel, or km per delivery unit, because this indicator allows the comparison of different distribution systems and different businesses.

Off-peak trips: The trips between the suppliers' depots and the depot of Gnewt Cargo occur at night and during the early morning hours. These off-peak trips almost entirely replace the journeys occurring during the rush hours on the main roads towards Central London.

Figure 5: AFTER: Logistics model with consolidation, single carrier delivery and e-vans



Source: Gnewt Cargo Cat 3 demonstrator, 2016

2.3 Objectives and tasks of the Agile Cat 3 project

The Cat 3 project looks at ways of improving both the environmental aspects of delivering in Central London as well as reducing the number of miles travelled per parcel, the reduction in kerbside space, the reduction in CO_2 emissions, air pollutants and noise by comparing the electric fleet of Gnewt with the diesel alternatives used previously by the clients.

It also aims to demonstrate the validity and longer-term viability of a micro-consolidation activity in the framework of a single carrier business.

The Cat 3 demonstration ran between the 1st July 2015 and the 30th June 2016. The trial took place in London using a fleet of vans mainly located at Gnewt's West Central Street depot. Freight delivery data was collected from the following participating companies who are clients of Gnewt Cargo:

- Client B
- Emakers
- TNT
- and others.

At the beginning of the trial in July 2015 there were about 6-10 vans involved in multi-carrier deliveries for these suppliers, but this number of vans was variable, and the depots used to receive the goods and to start the delivery rounds also changed.

Due to the variations in the operation, there was fluctuation in fleet use. At the end of the demonstrations, all potential depots and all potential vehicles of Gnewt Cargo were included in the data collection of the Cat 3 demonstration, and most of the vans were used to collect data for the project. For example, Gnewt included all the business contracted for a major carrier such as CLIENT A or TNT into the multi-carrier delivery operation in spring 2016. Therefore, all the logistics performance data related to CLIENT A or TNT, from July 2015 to June 2016, is part of the demonstration. All data is very relevant in showcasing the benefits. In the case study, many suppliers were included in the multi-carrier operation.

The project KPI targets are:

- 20% reduction in the number of vehicle trips
- 50% less kilometres travelled
- 80% reduction in NOx,
- 80% reduction in PM
- 80% reduction in CO2 emissions
- 70% reduction in total transport energy use in tonnes of oil equivalent (fuel litres versus electricity kilowatt-hours)
- 60% reduction in empty vehicle distance.

The quarterly KPI targets were set in July 2015 (Table 1).

Table 1: Quarterly targets for impacts

Financial year	**2015/16**			**2016/17**
Quarters	Q2	Q3	Q4	Q1
Reduction in the number of vehicle trips (%)	5	20	20	20
Less kilometres travelled (%)	12	25	37	50
Reduction in NOx (%)	20	40	60	80
Reduction in PM (%)	20	40	60	80
Reduction in CO2 emissions (%)	20	40	60	80
Reduction in total transport energy use in tonnes of oil equivalent (fuel litres versus electricity kilowatt-hours) (%)	17	35	52	70
Reduction in empty vehicle distance (%)	15	30	45	60

Source: Gnewt Cargo Agile Cat 3 demonstrator, 2015

3. Case Study 1: Consolidation into one depot and use of one electric vehicle for retail clients

3.1 Tasks, indicators and methods used for Case Study 1

The main objective of this case study was to identify and demonstrate the business case for multi-carrier consolidation and electric vehicle delivery operations for retail businesses. The main question to be answered in Case Study 1 can be summarised as:

"What is the most promising business case for clean urban freight consolidation and single carrier deliveries for retail clients from the point of view of the operator in Central London?"

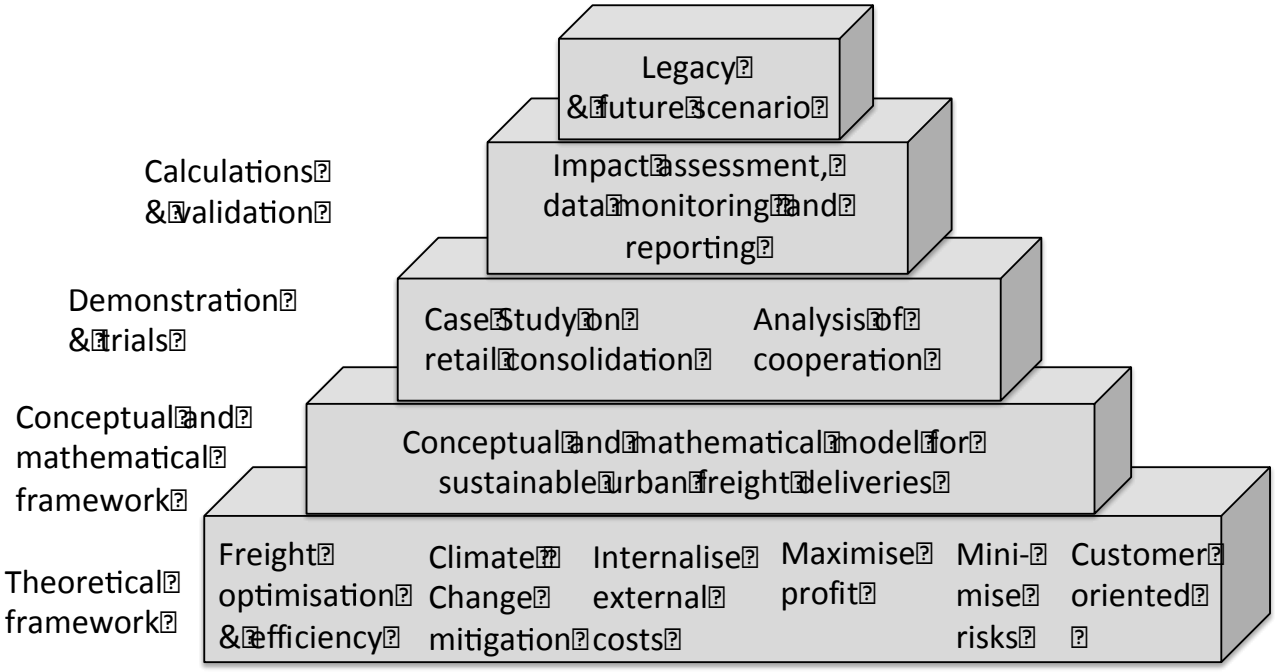
The study was constructed with different building blocks, summarised in Figure 6.

The basic block is the **theoretical framework,** within which the whole question to be answered had to be placed. Freight optimisation and efficiency increases are the aim of the type of single carrier demonstration envisaged. How to achieve this optimisation has already been tested in multiple projects. This project went beyond the current state of knowledge by capturing data on optimisation when one client starts to share its van deliveries with another client. With this framework, Gnewt addresses the London policies of making transport in London more sustainable and contributing to better air quality, while at the same time increasing the internal business optimisation. The main challenges tackled are climate change reduction and internalisation of external costs of transport such as congestion, accidents and health impacts of noise and air pollutant emissions. The maximisation of profit is also a big challenge in the profession, because margins are traditionally very low, thus leaving limited opportunities for innovation, and giving almost no room for the testing of new business concepts. The minimisation of risk is perhaps the number one concept when it comes to the hierarchy of strategies and tactics in place, since no business can take the risk of failure or bankruptcy. This risk is very relevant, as one major parcel carrier active in London went bankrupt at the end of 2014, generating turmoil in the market.

To deal with this framework, a second block, the **data and numerical models**, had to be developed. The conceptual and mathematical model for sustainable urban freight deliveries was developed in previous studies at the University of Westminster. It is simple enough to be handled in the frame of a one-year investigation, and complete enough to cover all dimensions mentioned above in the theoretical framework. The basis of this mathematical model is the linking of performance metrics, such as number of parcels delivered and distance driven on London roads, with impact metrics such as CO_2 per parcel, air pollutants or costs per parcel. Another basic element of this calculation model is the before-after (or with/without) comparison, a method of measurements prior and after any changes, which provided robust evidence on the reductions achieved and the targets attained during the demonstration.

Data before the demo started was collected first, and the data during the trial was collected later, after all practical procedures had been successfully put in place, and the freight transport operations had started to adapt. This practical step is called the demonstration. But in effect this demonstration cannot be successful if the data collection effort had not started much earlier than when the effective transport process had started to change, and the first parcel had been delivered with the new model. So in most **demonstrations and trials**, the real start of the operation occurs after a preparation period that is an integral part of it. One major task in this block is the case study on retail consolidation. Another task is the case study on non-retail consolidation.

Figure 6: Diagram on the approach used in Case Study 1



Source: Gnewt Cargo Agile Cat 3 demonstrator, 2016

The next block is the **calculation and validation** of the demonstration results. The key tasks consisted of grouping all raw data collected and monitored during the trial, such as vehicles, fuel use, number of parcels, distance, etc. and to calculate the secondary impact indicators such as distance per parcel, CO_2 per parcel, etc. Here, the different elements of the numerical model are readily available and applied.

The final building block is the **legacy and scenario analysis**, in which the lessons learnt from the trial and the strategies and tactics are presented. The conclusion is a set of solutions that would be most suitable and conditions that would be most favourable for an up-scaling of the solution at Gnewt Cargo, or for their broad scale implementation in London including other market actors and operators.

Data collection

From 1 July 2015 until 30 June 2016, data was collected at the West Central Street and the Wardens Grove depots, and at all other depots if relevant business occurred there, for the duration of the project. Several vans, and their running operations were observed for retail clients such as Client B and Emakers, for a period of twelve months.

The data allows us to quantify the effects on the internal business operations and on the business case. This data was collected in a before and after approach, with the objective being to demonstrate the profitability, barriers and success factors of this type of multi-carrier consolidation.

The effects on traffic, distance, emissions, road space occupancy and empty runs were measured with the before-after approach, providing evidence on impacts relevant from the public sector perspective. The data on these impact variables was also collected during the full duration of the project, from 1st July 2015 to 30 June 2016.

Additionally, data verification and validation took place. Some very specific and business relevant data such as time spent per parcel per client was collected with a sample approach on a time scale of one day or one week in live observation, and this sample was repeated and compared with the on-board electronic data and management data available for one year. This validation step helped to make sure that the short term, detailed data, and the long-term data corresponded well with each other, thus both datasets collected were valid and robust.

What type of data was collected?

During the Case Study trial period, a number of variables were collected:

- Vehicle movement reductions
- Reduction in miles travelled per parcel
- Time vehicles spent on the road
- CO2, PM and NOx reductions obtained from an electric vehicle relative to a diesel van delivering the same freight in the same area
- Efficiencies of varying types of electric vehicle
- Business case and KPI data such as:
    - costs of vehicle purchase and/or leasing
    - variable running costs per parcel or per stop for different clients, different area and different depots
    - fixed and variable depot management costs, depot rental and
    - other fixed and variable costs
- Disruptions and risk management for electric vehicle fleet operations

Raw data, pre-demonstrator baseline data, details on the design of the data collection and the results of it are presented in the data and monitoring report M7.2.

This report includes analysis and results for the entire period starting in July 2015 up to June 2016.

The ‘before’ situation corresponds to the ‘baseline’ against which the impacts are calculated. The ‘before’ situation is defined as the delivery situation of a retail client before starting a delivery contract with Gnewt Cargo. The results of Case Study 1 are benchmarked against many of the previous results of other case studies performed at Gnewt Cargo. Directly comparable data on emissions and traffic reduction are available.

The data collection of Case Study 1 started in July 2015, simultaneously with the start of the trial, and ended in June 2016. This covered the peak in demand for parcel deliveries around Christmas, and it also covers the lower demand period in other months.

3.2 Case study 1 results

3.2.1 The main job: to deliver a high amount of parcels

The first job of Gnewt Cargo is to deliver parcels for its clients. The total number of parcels delivered varies every day, for each driver, for each area of London and for each client. To give an idea of daily fluctuation see Figure 7 which shows the "number of parcels delivered per round per day" (Figure 7).

Gnewt Cargo presents here only the parcels distributed for Client A, for data quality reasons. Client A is the only client for whom we managed to collect and process a very high amount of data resulting in high quality statistics. The data for other clients show great similarities with Client A so this data can be considered representative for the whole of London parcel delivery business.

One dot represents one van, and the number of parcels it delivered (vertical axis) during one day (Figure 7). The horizontal axis shows the trip ID, with the 13,358 dots showing the number of parcels for all Client A round trips recorded at Gnewt Cargo in the period between 1st of July 2015 and 30th June 2016. In Figure 7, each blue dot represents the number of parcels successfully delivered to the final client during one day (one day = one round = one dot). If a driver had to drive back to the depot to reload on that day, it is considered part of the same round and does not represent a separate dot.

The average number of parcels effectively delivered is about 150 per round for Client A, but during peak the number is above 600 (during the Christmas period) and the lowest number is 1 parcel (mainly on Saturday and Sundays) for 1 round trip. Some drivers manage to deliver consistently very high number of parcels per day, due to the very dense area and the higher number of parcels that can be delivered at one single place.

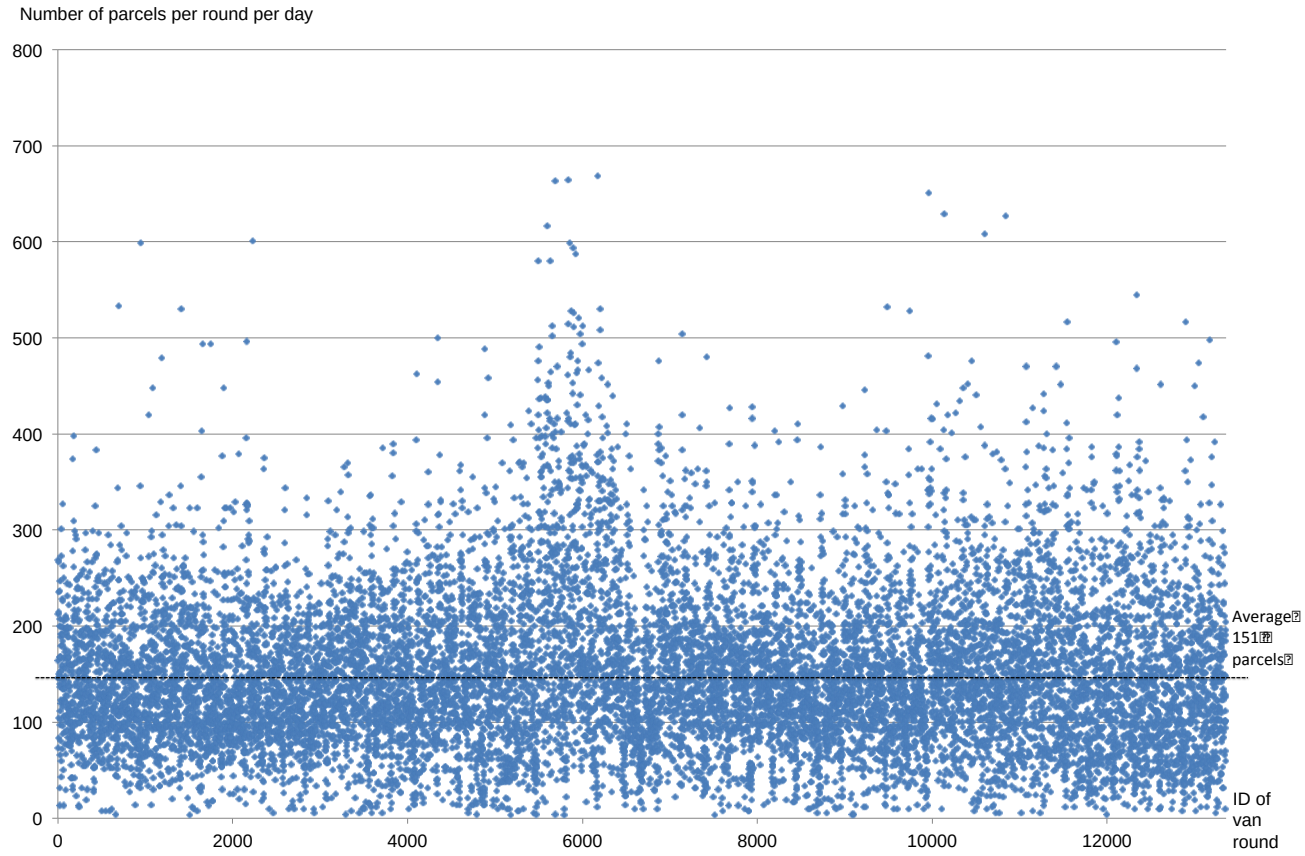
This graph in Figure 7 describes the core of the business of Gnewt Cargo. Other key Gnewt Cargo performance indicators are presented in Table 2 below.

Table 2: Key performance indicators of Gnewt Cargo Client A business 1 July 2015-30 June 2016

Total parcels delivered	2,005,728
Parcels per week	38,572
Average number of parcels per van per day	151
Max parcels/day	668
Min parcels/day	1
Total miles driven in one year during deliveries	148,545
Average miles per van per day	11
Average metres per parcel	119
Average completion	87%

Source: Gnewt Cargo Agile Cat 3 demonstrator, 2016

Figure 7: Number of parcels delivered per round per day, 1 July 2015 – 30 June 2016



Source: Gnewt Cargo Agile Cat 3 demonstrator, 2015-2016

3.2.2 Overview, business characteristics, specifications and operation details

The following observations were made on current developments at Gnewt Cargo. These qualitative business specifications and survey results are valid and similarly important for retail and non-retail clients (Case Study 1, Case Study 2) and relevant for the fleet analysis (Case Study 3).

Table 3: Overview, business characteristics, specifications & details, July 2015-June 2016

Load, type of goods	On arrival at Gnewt Cargo, parcels are delivered by clients in roll-cages, sacks and/or pallets. Parcels: average weight of one parcel is between 0.5kg and 10 kg; on average 100-300 boxes fits within vans of 4 m^3. The average volume is about 0.03 m^3 per parcel, equivalent to the size of a shoebox. The dimensions of Client B parcels is about triple the size of other clients. Client B delivers food and the food boxes are much bigger than normal parcels (because usually food supplies are ordered for more than one person). So there about 4 parcels on average per delivery. On arrival, parcels are usually pre-sorted by delivery round and postcode area.
Depots for Client A / TNT/ CLIENT C / retail distribution operations	The warehouses of the 5 main clients Client A (Enfield depot), TNT (Barking. Standsted, and Bermondsey depots), CLIENT C (Marlborough Grove depot in Southwark), Client B (SE16 biscuit Factory) and Emakers (Airmail via Heathrow or Stansted, then DHL van delivery) are Regional Distribution Centres for London and its surroundings. From these regional warehouses, the diesel vans would be loaded and would start their delivery rounds. In classical urban logistics, each round starts during morning peak traffic from the suburbs, at least 10-15 miles away from Central London. This is what happened "before", the so-called "baseline" situation. Instead, now (after), the clients send larger urban trucks to the depots of Gnewt Cargo. These trucks travel mostly at night, reducing the daytime congestion in London. Each truck transports parcels between depots thus replacing several smaller van deliveries which reduces the number of trips on the main roads towards Central London at peak traffic time in the mornings and afternoons. Gnewt Cargo then runs its own delivery operations from its depots: • West Central Street depot: 10,000 ft^2 • Wardens Grove depot: 25,000 ft^2 • CLIENT C depot by Old Street in London, 1000 ft^2 • Princes Street near Regent Street: <500 ft^2 The main functions of the depots are 'cross-docking' operations (receiving goods during the night, unloading, sorting, loading the electric vans and distributing these goods on the same day). Another main task is recharging the batteries of the vans parked overnight. No overnight stay occurs in Princes street depot, and therefore no charging, due to lack of space.
Business	Starting from July 2015, about 5-7000 parcels/day were delivered during 'normal' times. During Christmas peak time, a period starting in September 2015 and ending in early January 2016, the day to day business consisted of up to 20,000 parcel deliveries per day. The area served was the Central London Congestion Charge area. The type of business is B2C and B2B; there are both business and residential customers in this area of London. Each driver has a specific area, different from other drivers, to serve in Central London. Each driver knows their area very well.

Area of delivery and traffic	Delivery areas are almost exclusively the EC, SW, WC, W, SE postcodes (Congestion Charge zone) in the central Boroughs of London. The area is characterised by a mix of very busy narrow roads or, if a wide road, no stopping (double red) lines and heavy traffic in the morning peak hours, and quiet residential streets. The Client B delivery area is much extended beyond this Central London zone, and reaches within and slightly beyond the North and South circular roads. Visual observation of the morning traffic: between a third and a half of the traffic consists of vans of various sizes and small trucks, the other half being cars.
Vehicle fleet	Christmas peak period saw an increase in the Gnewt cargo fleet: Up to 100 electric vans were in daily use. 13 hired electric vans were added to the fleet during peak, starting at the end of November 2015 up until the end of February 2016. Hire costs were £490+ VAT/month. The van type was Renault Kangoo ZE. Fleet status as of March 2016: slightly decreased compared to Christmas peak: 79 electric vans in own fleet, +9 electric vans owned by subcontractors = 88 vans total fleet in use. Spring data about the fleet: 61 electric vans and one cycle in daily use at the Wardens Grove depot. Other vans are used at the other depots on rotation depending on the needs of the operation. Last purchase of an electric van occurred in August 2014. Fleet composition: • Renault Kangoo ZE (55) • Nissan eNV200 (6) • Mercedes Vito (4) • Goupil G5 (4) • Peugeot Boxer (2) • Cargocycles (2 runs for Zipjet, 2 runs for Dropit, 1 runs for Betterbankside)
Drivers	Between 60 and 100 drivers and subcontractors were employed in the period July 2015-June 2016, covering the London delivery area. Maximum peak drivers allocation to clients was: • 74 to Client A including 9 management and 9 subcontractors • 5 for Client B • 11 for TNT + Emakers + Spicers • 10 for CLIENT C • 1 for Dropit
Goods arrival by diesel trucks at the Gnewt depots	Depending on the total volume of the day, in normal times 4 Client A trucks (DAF FT45), deliver at night to the Wardens Grove depot. During peak times, the number of Client A truck trips increased up to 9 per night. 2 TNT trucks deliver at night to the West Central Street depot. During peak, 4 Client A trucks arrive at the West Central Street depot. The CLIENT C depot is a warehouse where the goods are sorted and rounds prepared. The electric vans from Gnewt Cargo start their Central London delivery round from the CLIENT C depot. No diesel trucks are used by CLIENT C, and for this last mile delivery operation, the CO_2 reduction is 100%, and air pollutant reduction is near 100% for exhaust emissions. For the CLIENT C business, there is no increase in total number of vehicles.

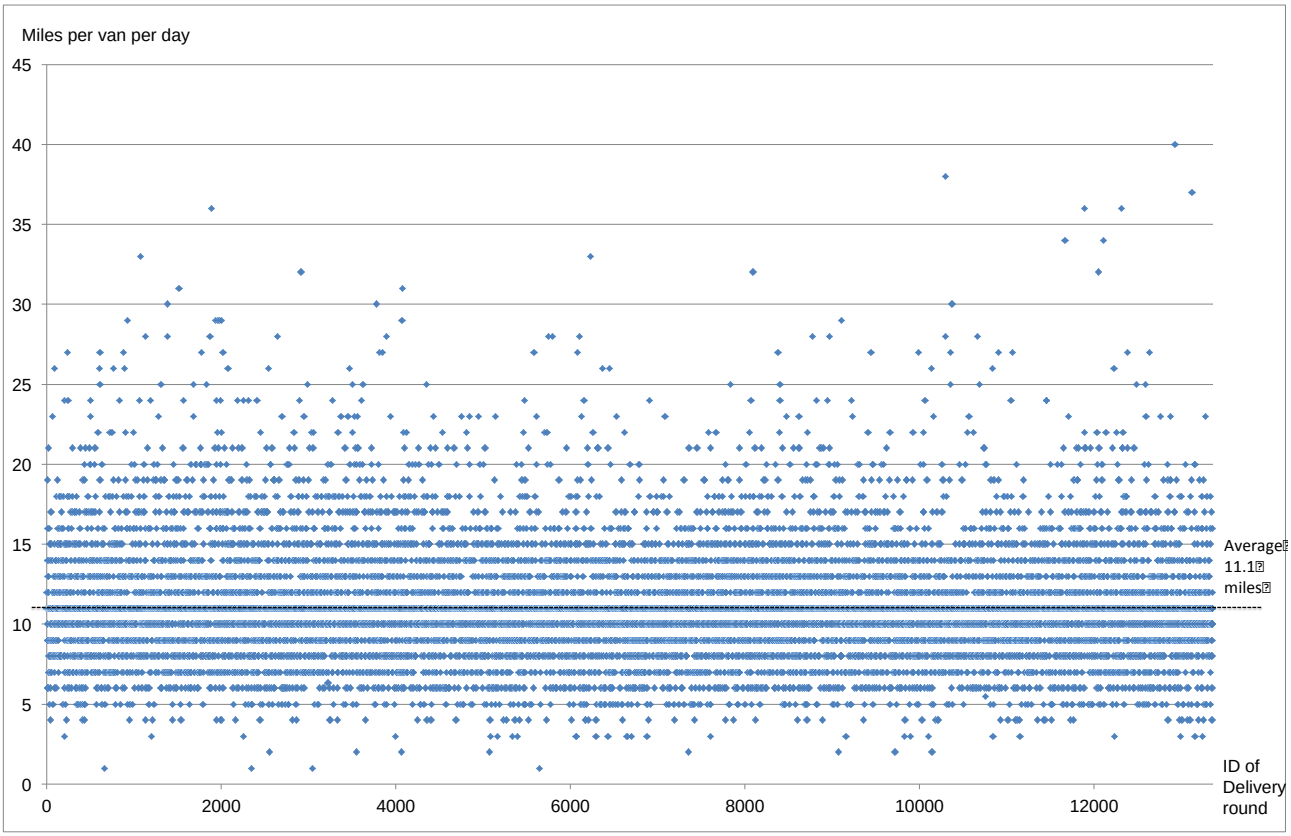
Loading	This activity takes place during the morning. The drivers arrive at the depots between 07:00-08:00. All vans are loaded by Gnewt Cargo drivers. Vehicle loading time is, on average, 45-60 minutes per van. Most clients prepare orders to be delivered on the day's rounds. Within the area, the driver sorts the parcels according to their understanding of their own round. They do this sortation out of a pool of parcels allocated to a certain area in Central London. The drivers sort parcels in the right order and manually load vehicles themselves, during the morning hours.
Parcels collection	The collection consists of return loads (broken, not needed, etc). Between 0 and max 5 items are collected per driver per day. There were a maximum of 74 parcels collected for all 11 drivers of TNT observed on one day on 23rd March. TNT is the business with the most volume on collection.
Working times and time windows for delivery	08:00-18:00 is the main time window for deliveries in Central London.The driver carries out the deliveries in the most logical geographical order. In a few cases, it is necessary for the driver to come back to the same street later in the delivery round to deliver to another client. This is due to delivery time windows that are not coherent for all clients in the same area. Typical day of operations at Gnewt Cargo is as follow: 08:00 First drivers leave depot 10:00 Almost all drivers are out on delivery trips 18:00 Most drivers are back to the depots 19:00-20:00 Last drivers are returning to the Gnewt Cargo depots
Trolley	2 wheel trolleys are in use by some drivers.
Walking	The pedestrian part of the delivery trip is important in terms of time and costs. Long walking times are standard. A driver can spend more than two thirds of the working day walking, or waiting for the client. At a maximum, one third of the working time is spent in the vehicle driving on the road. There is currently limited scope to reduce walking time and increase the driver productivity. One possibility would be to increase the number of parcels from different clients to be delivered to the same customer.
Van mileage and age	About 3,000 miles/year is the average distance travelled by each electric van. Fleet age is less than 4 years old.
GPS use	All vehicles are now equipped with a GPS on-board unit with data recording and telematics transferring geolocation to the head office. However, the accuracy of the localisation data is rather low, due to the poor conditions with the high rise buildings in Central London.
Handheld device, other IT and software, driver knowledge	Each carrier gives Gnewt Cargo its own hand held device for signature and proof of delivery. No round optimisation or tour scheduling support system is in constant daily except during the trials of the Agile Category 2 project. Postcode order is finalised by the driver according to his knowledge. Driver knowledge takes about 2-3 months to build up which affects efficiency.
Mixing goods from clients into one single van	For the Category 3 demonstrators, Client A vans were used to deliver a mix of goods from different clients e.g., Client B and Emakers.

Source: Gnewt Cargo Agile Cat 3 demonstrator, 2015-2016

3.2.3. The Gnewt Cargo approach: Benefits for London

Figure 8 below shows the distance driven in miles per round per day. While some areas are very dense and close to the depots, others are further away from the depots, which impacts on increased driving instances. The density of clients varies in different areas in which also impacts on the number of parcel deliveries per day.

Figure 8: Distance driven in miles per round per day, 1st July 2015 – 30 June 2016



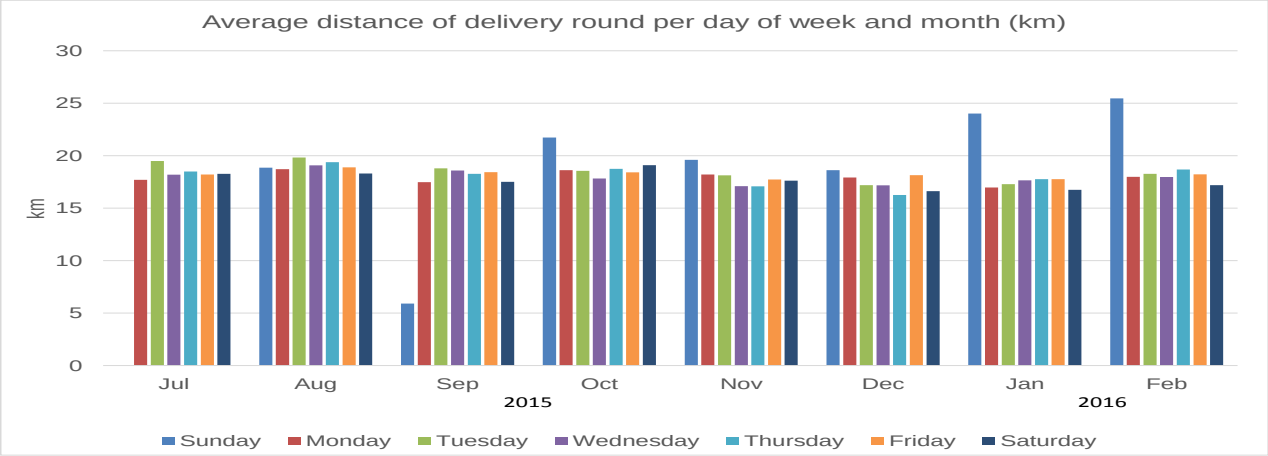
Source: Gnewt Cargo Agile Cat 3 demonstrator, 2015

The average distance per day is 11 miles (about 18 kilometres). For more than 95% of the trips, the daily distance was between 5 and 22 miles per van.

From the public sector perspective, the distance is a very important indicator for negative externalities of transport, such as accidents, congestion, air pollutants and climate change. It is widely accepted that a distance reduction corresponds to an equal proportion (in %) to a reduction in all negative externalities. So, much emphasis is made to better collect and better analyse distance data.

A series of data analyses was performed for the Client A business relevant to the performance/profit analysis. The objective of the following sections is to better understand why in some case the distance is lower than others, and what lessons can be drawn for a future distance reduction in London.

Figure 9: Average distance of Client A fleet per day and month

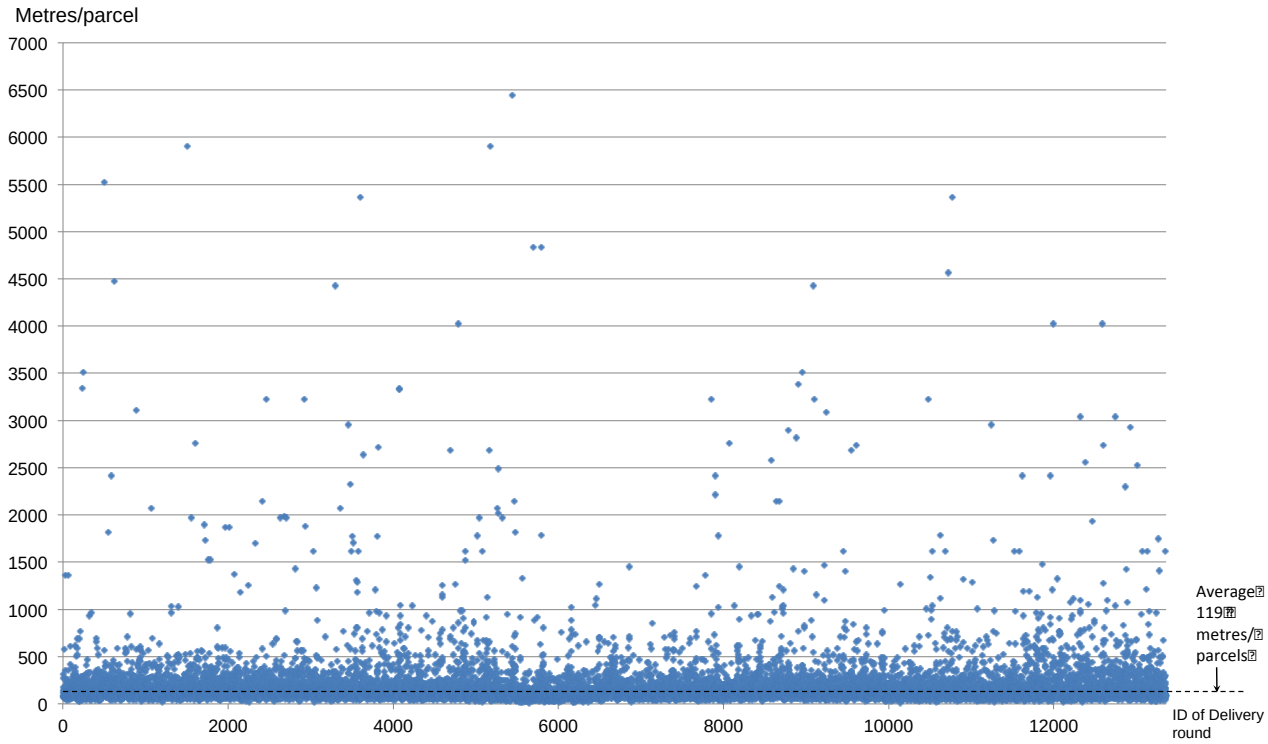


Source: Gnewt Cargo Agile Cat 3 demonstrator, 2015

When looking at the average distance driven per day for an entire month, the variations between the week-days are comparatively very stable, except for Sundays. The variations between months are also marginal, except for Sundays. The reason for the differences in Sunday values is the very low number of parcels delivered on that day.

3.2.4 Analysis: distance per parcel as key metrics for efficient logistics in London

Figure 10: Metres per parcels delivered, 1st July 2015 – 30 June 2016



Source: Gnewt Cargo Agile Cat 3 demonstrator, 2015

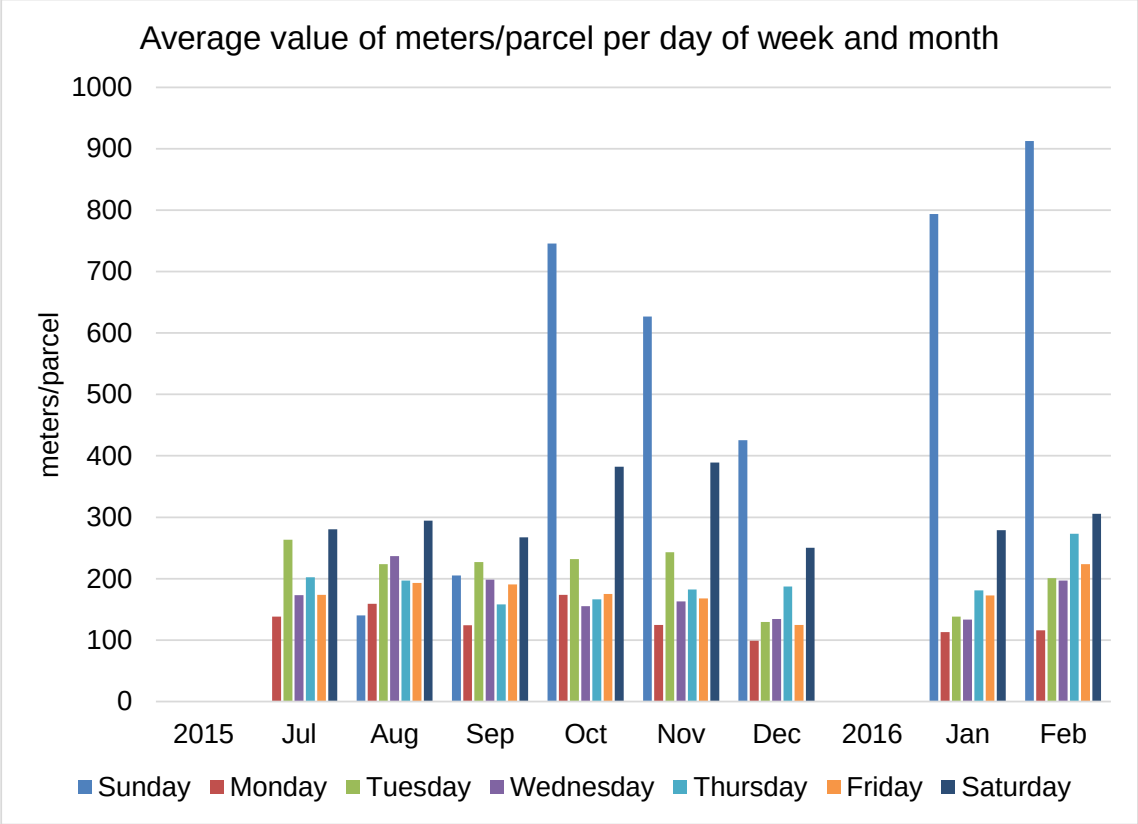
Finally, the most important indicator for future improvements in London was the distance per parcel (Figure 10 and 11). If we look at the distance needed on average, the value obtained for Gnewt Cargo

on its last mile trips for Client A is 193 metres per parcel, when counting the total logistics chain, and 119 metres per parcel, when observing only the distance driven with electric vehicles. This is very low, when compared with the 884 metres per parcel recorded for TNT deliveries from its Barking depot. The TNT business in that case is identical to Gnewt Cargo, except the van starts in the morning from a distance that is much further from the delivery area.

Driving distance varies between 20 metres per parcel in dense areas and on busy days, and almost one kilometre per parcel in less dense areas and on less busy days. Why is that? Why are the variations in driving distance so big? 50 times more distance for one parcel has huge consequences on the operation. We don't know why exactly yet. Very little is understood at this stage about why the variations are that big in the day to day logistics operation. More research could be done leading to a better understanding of these big variations.

Even more interesting is to understand how to reduce those trips generating a big distance per parcel. This challenge is relevant not only for Gnewt Cargo, but for all logistics companies. One explanation that was explored was that the different day of week and different months would show that the main influencing factor is the variation in business. The result of this analysis is shown below in Figure 11 and Figure 12.

Figure 11: Metres per parcel per day of week and month for the Client A fleet



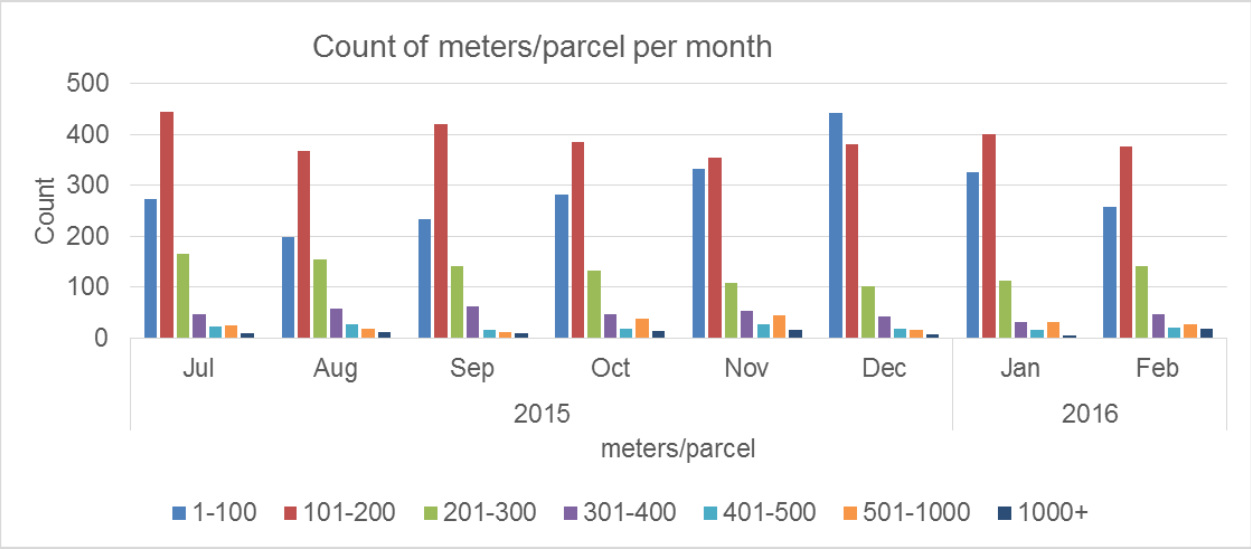
Source: Gnewt Cargo Agile Cat 3 demonstrator, 2015

Figure 11 shows that Sundays and Saturdays are less effective, due to the lower number of parcels per round. Mondays are slightly better than other weekdays, which might be explained with a higher number of parcels to be delivered. To confirm that a better performance is effectively realised when

more parcels are delivered, the next graph (Figure 12) shows clearly that December has the shortest distance of all months. For this graph, all the Client A trips of one month were counted according to their distance. Again evidenced in Figure 12 are many trips showing rather ineffective performances above 500 metres per parcel.

Sometimes a driver needs to drive more than 500 metres per parcel on average for the whole day, why? There is no general reason that would explain this, so far. Further research is needed, both on the causes and on how to improve the performance. The opposite is also true: how is it possible that some drivers can consistently deliver more than 400 parcels a day at an average distance far below 100 m/parcel? Currently we don't know enough about driver productivity.

Figure 12: Metres per parcel per month for Client A deliveries, July 2015 to Feb 2016



Source: Gnewt Cargo Agile Cat 3 demonstrator

3.2.5 High completion rate is another key metric for efficient logistics in London

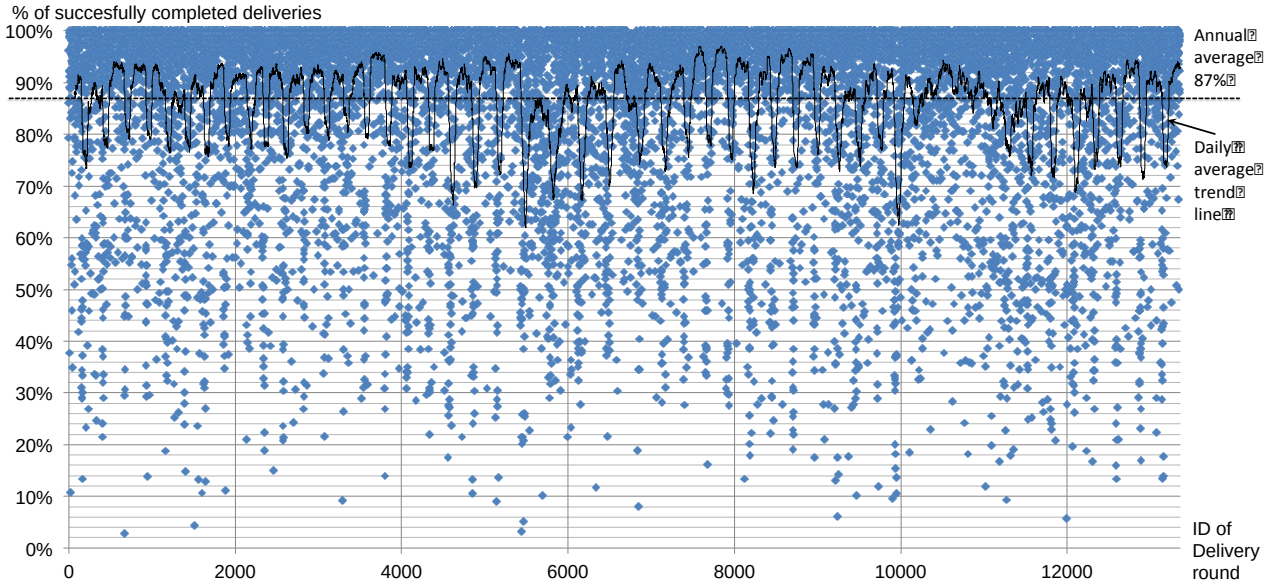
One of the key business indicators of performance is the metric "completion rate", in which we look at a percentage (%) for the number of parcels successfully delivered, compared to the total number of parcels loaded on the vehicle and planned to be delivered on that day. This completion rate factor is a kind of comparison between target and achievement on a daily basis.

Every transport service provider pursues the ideal of having a 100% completion rate, for which all drivers deliver all parcels successfully every day to all clients. In reality, a completion rate of 100% occurs for only 10-20% of all day trips; and a weekday score of 95-97% is very common and is considered a good result. In practice some parcel delivery service providers have been known for being very demanding on this metric, and give penalties to their drivers if more than 5 or even 3% of the parcels were not delivered for whatever reason.

The drivers of Gnewt Cargo performed an annual average of 87% for Client A in the period, due to various reasons, for example lower completion rates on weekends.

When looking at Figure 13 on completion rates, and the trend line showing an average for all vehicles each day, there is a clear dip at the end of each week. The positive aspect is that it shows a rather constant average well above 90% for weekdays (the days with a much higher number of parcels).

Figure 13: Completion rate



Source: Gnewt Cargo Agile Cat 3 demonstrator

3.2.6 Working time per parcel

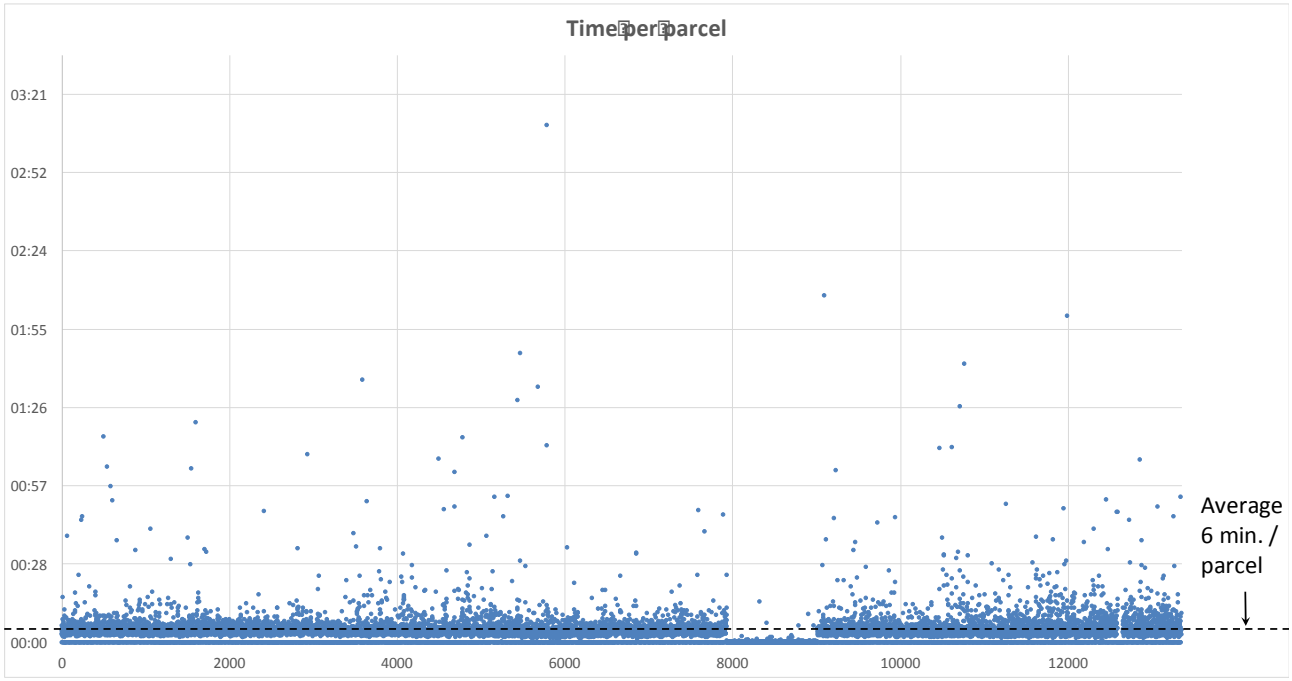
Like distance, reducing the time spent per parcel is a key performance indicator for Gnewt Cargo as this directly impacts on profits. The calculation of the indicator "working time per parcel" accounts for all time spent from starting the work, loading the van, through to the end of duty in the evening divided by the number of parcels.

Transport time data is always difficult to collect and analyse. Difficulties occur in terms of accuracy and validation. To address this, all missing data were excluded. The remaining data cover the period 1 July 2015-30 June 2016, but with many interruptions. Each blue dot is the average time per parcel, for one day, one driver and one van.

Again, the average of 6 minutes per parcel hides the fact that there is a large variation between 1 minute and 50 minutes spent per parcel delivered. All very high values above 10 minutes per parcel occur at week-ends, this is due to the low number of parcels.

Gnewt could follow one strategy to increase the efficiency: completely avoid the trips with a very low number of parcels, say below 10 parcels per day. But currently, the demand of the clients needs to be fulfilled, even if this means making low numbers of deliveries on week-ends.

Figure 14: Working time per parcel, daily average/van, 1 July 2015-30 June 2016



Source: Gnewt Cargo Agile Cat 3 demonstrator

3.3 Results on Emakers and Client B retail business

3.3.1 Key observations

The main retail clients observed in case study 1 for the period up to April 2016 are Emakers and Client B. Emakers is an SME based in Barcelona providing e-commerce parcels deliveries, mainly for clothes. Client B is also an SME, but based in London, providing e-commerce deliveries for food and meals. No refrigeration or temperature control is needed. This case study was run under normal business conditions.

Figure 15: Client B electric van used to deliver food products in London

Source: Gnewt Cargo Agile Cat 3 demonstrator, 2015

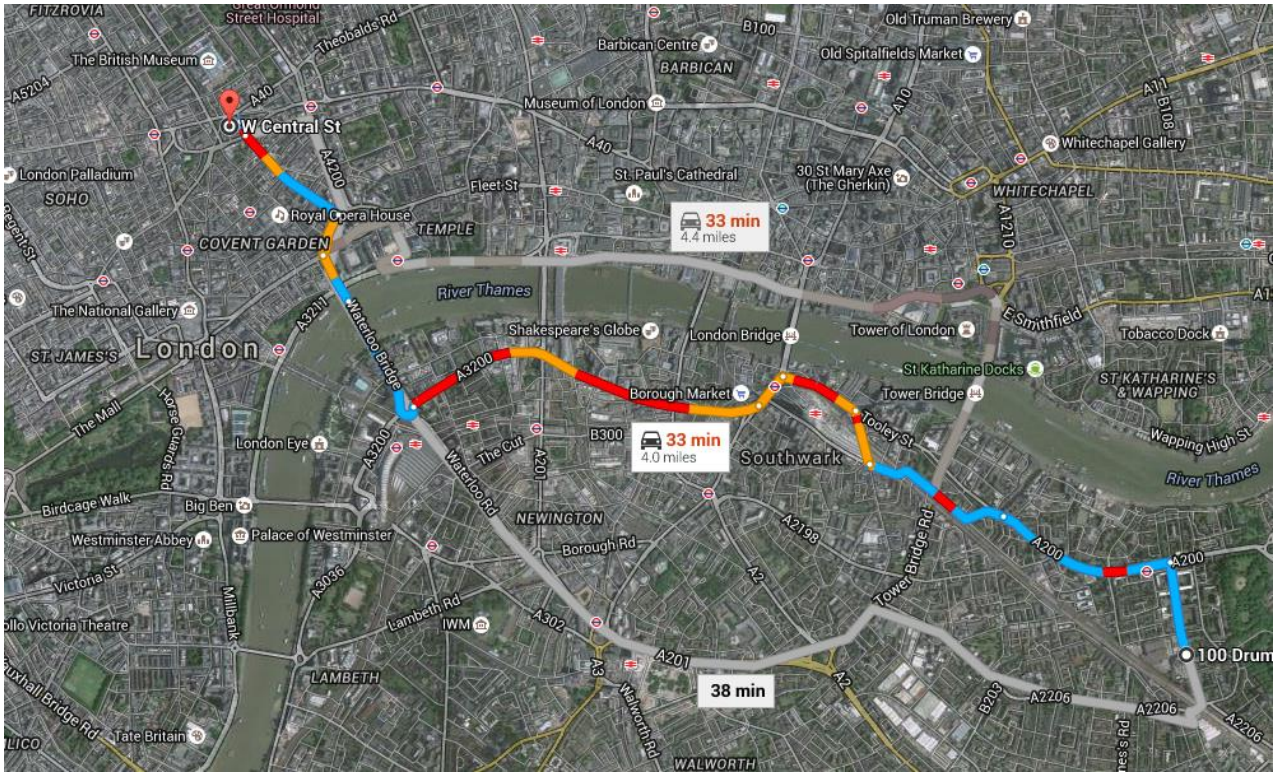
In the period 1st July 2015 to 30 June 2016, the 'before' and 'after' snapshot was of Gnewt operating with Client B. Gnewt observed the business closely, with numerical data collection, presented below. Where data was not available, realistic assumptions were developed.

The assumptions are values obtained from other clients of Gnewt in the year 2015. Some assumptions are a plausible best guess based on the current business configuration and details.

- The delivery area is the Congestion Charge Zone and was identical 'before' and 'after' using Gnewt Cargo as a carrier (assumption).
- In the situation 'before' four diesel vans were housed at a suburban depot (Client B depot) 6 km away from the border of the Congestion Charge zone in Central London (assumption).
- In the situation 'with' Gnewt, one van began from the Client B depot in Drummond Road, SE16 and brought the parcels to the depot of Gnewt Cargo each morning. The distance is 6 km (about 3.7 miles) (observation).
- The depots West Central Street & Princes Street are in use 'after' Gnewt (observation).
- The number of vans in daily use for Client B deliveries 'before' Gnewt is on average 4 (observation)
- The delivery distance of one van round is 54 miles 'before' (assumption) and 47 miles 'after' (observation)
- In a typical round 'without' Gnewt, the driver starts in its diesel van loaded with parcels from the Client B depot located at 100 Drummond Rd, SE16, driving 6 km to the first delivery point, then the deliveries start. After the last delivery point, the diesel van is driven empty back to the depot. The empty distance is 6 km per day (assumption)
- In a typical round 'with' Gnewt, the electric van starts loaded with the parcels from the Gnewt Cargo depot, and then starts its deliveries straight away. After the last delivery point, the electric van is driven back empty to the Gnewt Cargo depot (observation). The empty distance is 1 km per day (observation)
- Parcels for Client B are recorded during 46 days over the period 17 Sept-31 Dec 2015 (observation)
- Number of deliveries per van per day is 18, with an average of 4 parcels per delivery (assumption) The parcel size is much bigger for Client B than for other clients (observation)
- The productivity of the electric van driver is assumed to be identical to the diesel driver (assumption)
- The fuel consumption of a diesel van is on average 31 mpg (observation)
- The fuel consumption of a diesel truck is on average 15 mpg (observation)
- Retail deliveries are to households, offices and shops. The classification is B2C and home deliveries for most of the retail logistics business, with a smaller part of B2B (observation)

The depots of Case Study 1 are located in Central London (Figure 16). Gnewt's depot is at the North West end of the route. The route is shown to illustrate the high traffic conditions in Central London.

Figure 16: Central London locations of the 2 depots used for Case Study 1



Source: Gnewt Cargo Cat 3 demonstrator

The distances of the main types of trips observed are presented in Table 4.

Table 4: Distances between depots of Case Study 1

Distances	Miles	Km
Client B delivery round distance in Central London per day before	47	76
Gnewt Cargo delivery round per day after	47	76
One way Client B depot to first drop	4	6
One way Gnewt depot to Client B depot	4	6

Source: Gnewt Cargo Cat 3 demonstrator, 2015

The 'before-after' logistics system observed for Client B and Emakers is presented in following Figure.

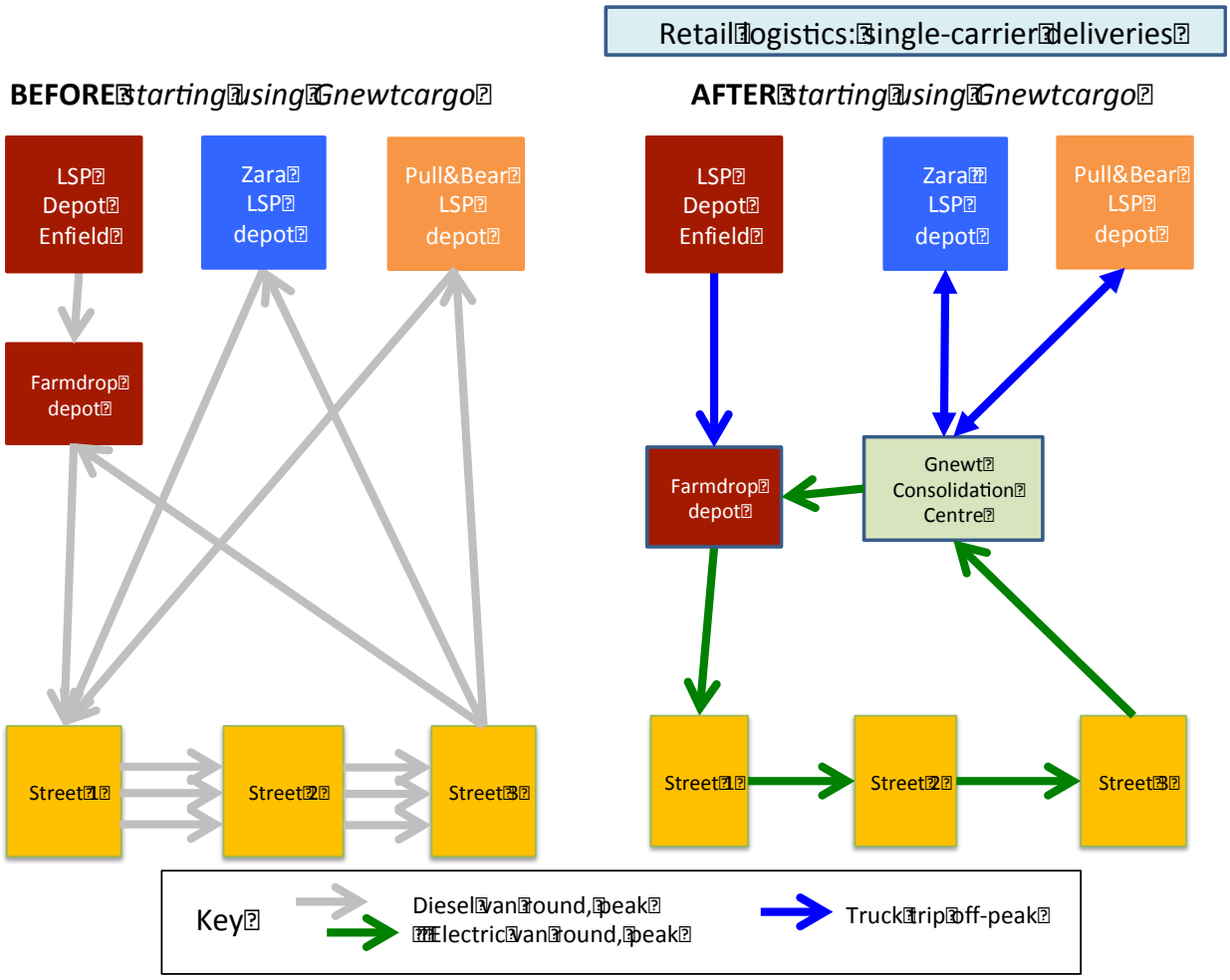


Figure 17: Logistics system observed in Case Study 1 for Client B/Emakers retail business

Source: Gnewt Cargo Cat 3 demonstrator, 2015

The before-after data was collected for case study 1 to demonstrate the impacts on emissions, distance and number of trips. The result is shown in the following Tables for Client B. Data was collected from the 17th September to the 31st December 2015 (Tables 4&5). This period is considered representative for the duration of the project, as the average number of parcels and the distance driven showed small annual variations. The results obtained for the period September to December 2015 are considered valid for an extended period (July 2015-April 2016).

For Client B, the number of retail deliveries performed per driver per day is about 18 on average. For the carrier Client A, the number of parcels per day is 151, about a factor 8 times higher. This is due to the fact that Client B deliveries often count 4 parcels and more per delivery, and the distance driven between two deliveries is much higher, taking more time to perform.

3.3.2 Routes before and after starting using Gnewt Cargo for parcels deliveries

Following data shows the routes driven before and after Client B was starting using Gnewt Cargo.

Table 5: Client B retail demonstration, 17 Sept - 31 Dec 2015, data 'before' Gnewt Cargo

Route ID	Vehicle Type	Delivery days	MPG	Total distance in km	Parcels during period (assumed)	Distance in km/ parcel	l/100km	Total litre	Litres/ parcel
1	3.5t van	46	31	4,109	3,238	1.269	9.1	373.9	0.12
2	3.5t van	46	31	4,109	3,238	1.269	9.1	373.9	0.12
3	3.5t van	46	31	4,109	3,238	1.269	9.1	373.9	0.12
4	3.5t van	46	31	4,109	3,238	1.269	9.1	373.9	0.12

Source: Gnewt Cargo Cat 3 demonstrator 2016

Table 6: Client B retail demonstration, 17 Sept - 31 Dec 2015, data 'after' Gnewt Cargo

Route ID	**Delivery days**	**Total distance in km**	**kWh**	**Distance in km/day**	**Parcels**	**Number of parcels/ day**	**Distance in km/ parcel**	**kWh/ parcel**	**kWh/ day**
1	18	1,316	256	73	1,260	70	1.044	0.20	14
2	52	4,025	716	77	3,640	70	1.106	0.20	14
3	59	4,311	721	73	4,130	70	1.044	0.17	12
4	56	4,402	780	79	3,920	70	1.123	0.20	14
Total		14,054	2473		12,950				
Average	46	3,514	618	75.5	3,238	18	1.079	0.19	14

Source: Gnewt Cargo Cat 3 demonstrator 2016

This route data show one main difference compared to other impacts of the Gnewt business. The best effect is to do with the emissions, and a much smaller effect is seen on the distance driven. This is because the Client B depot is located very close to the city centre, not far out in the suburbs, unlike most other logistics and retail businesses.

The analysis comparing 'before' and 'after' is shown below.

3.4 Targets analysis in Case Study 1

3.4.1 Distance and fleet reduction: target analysis

Table 7: Analysis of distance driven for Client B deliveries, 17 Sept – 31 Dec 2015

	Number of vehicles	Total distance in km	Parcels delivered during period	Distance in km/ parcel
BEFORE: Client B deliveries starting from Client B depot				
Total	4	16,436	12,950	1.269
Average		4,109	3238	1.269
AFTER: Gnewt trunking from Client B depot + deliveries starting from Gnewt Cargo				
Truck	1	595	12,950	0.046
Electric Van	4	14,054	12,950	1.085
Total	4	14,649	12,950	1.131
Average				1.131
% Reduction		**11**		**11**

Source: Gnewt Cargo Cat 3 demonstrator 2016

There is an 11% distance reduction attained for the Client B retail business.

3.4.2 Energy reduction: target analysis

The energy use is expressed in grammes of oil equivalent, as this enables the comparison of the energy from electricity (in Kilowatt hours kWh) and from diesel fuel (in litres).

Table 8: Energy use comparison of the Client B demonstration with and without Gnewt Cargo

		Without Gnewt: Diesel van	With Gnewt: Diesel truck	With Gnewt: Nissan eNV200	With Gnewt: Total	Without-With reduction %
Distance	km	16,436	595	14,054	14649	11
Electric energy used	kWh			2,473		
	kWh/km			0,176		
Conversion factor	goe/kWh			85.984523		
Total period	litres	1,479	112		112	92
Conversion factor	goe/litre	845	845			
Total energy use	kgoe	1,250	95	213	307	75
Results energy per km	goe/km	76	159	31		90
Results energy per parcel	goe/parcel	97	7	16	24	75

Source: Gnewt Cargo Cat 3 demonstrator 2016; DEFRA ghg conversion factors 2016

Gnewt achieved a 75% energy use reduction for the Client B retail business.

3.4.3 CO_2 reduction: target analysis

Gnewt calculates the carbon dioxide (CO_2) emissions with the DEFRA greenhouse gas conversion factor 2016, with 1 litre diesel = 2.61163 kg CO_2 equivalent ($kgCO_2e$).

Table 9: CO2 comparison of the Client B demonstration of Gnewt Cargo

	Mpg	l/ 100 km	Total litres	Litres/ parcel	kgCO2e/ parcel
BEFORE: Client B deliveries starting from Client B depot					
Total 4 large vans		9	1479		
Average	31	9	374	0.11	0.298
AFTER: Gnewt trunking from Client B depot + deliveries starting from Gnewt Cargo					
1 truck	15	18.8	112	0.01	0.023
4 Electric Vans		-	-		0
Total all vehicles			112		
Average all vehicles				0.009	0.023
Reduction in %			**92**	**92**	**92**

Source: Gnewt Cargo Cat 3 demonstrator 2016

Gnewt achieved a 92% energy use reduction for the Client B retail business.

3.4.4 Air pollutant reduction: target analysis

In the absence of average values for emissions of air pollutants of electric vehicles compared with diesel vehicles, it is assumed that the exhaust emissions of electric vans are zero. Gnewt is aware that particulate matters (PM) are emitted when driving on London roads due to tyres and brakes, but this cannot be quantified at the moment. The following target calculation is based on the values of the UK National Atmospheric Emission Inventory from 2011 (NAEI 2011).

Table 10: Emission factors used for air quality impacts calculation

	g/km	g/km
	NO_x	**PM10**
Diesel truck	3.603	0.058
Diesel van	0.898	0.055

Source: NAEI 2011

To calculate this air pollutant impact, we took the kilometre distance per parcel and multiplied it with the emission factor per km. We observed only NO_x and Particulates because these pollutants are widely considered to be the most harmful. However, studies on health impacts of exhaust emissions show that there are many hundreds of harmful different molecules in the exhaust, and these additional impacts can be included as part of this target.

Table 11: Air pollutant emissions of the Client B demonstration with and without Gnewt Cargo

WITHOUT: Client B deliveries starting from Client B depot	NOx in g/parcel	PM10 in g/parcel
Truck	1.1401	0.0701
WITH: Gnewt trunking from Client B depot + deliveries starting from Gnewt Cargo		
Truck	0.1657	0.0027
Electric Van exhaust	0	0
Average	0.1657	0.0027
Reduction in %	**85**	**96**

Source: Gnewt Cargo Cat 3 demonstrator 2016

Gnewt achieved a 85% NO_x reduction and a 96% Particulate Matter reduction for the Client B retail business.

3.4.5 Empty distance reduction: target analysis

There is a problem of inefficiency in urban logistics that is due to empty runs in London. One of the benefits achieved with the Gnewt concept is that the electric vans return empty from their last point of delivery to the Gnewt depot close by. The empty distance is much shorter than usual because the depot is so close to the delivery area.

Table 12: Empty distance reduction achieved for the Client B demonstration

BEFORE: Client B deliveries starting from Client B depot	**Empty distance in km**
Truck	1,191
AFTER: Gnewt trunking from Client B depot + deliveries starting from Gnewt Cargo	
Truck	298
Electric Van	185
Total	483
Reduction in %	**59**

Source: Gnewt Cargo Cat 3 demonstrator 2016

3.4.6 Additional explanations and analysis of the energy and emission results

The energy per parcel transported with an electric vehicle during the last mile logistics operation is about 24 grams of oil equivalent (goe), compared to 97 goe for the diesel alternative, a reduction of 75 %.

Looking at the electric energy use per km, this is a pure indicator for vehicle energy efficiency, regardless which logistics solution or business configuration it refers to.

At Gnewt Cargo, the evidence collected so far for Case Study 1 Client B delivery business show values of:

- 76 goe/km for diesel vans,
- 159 goe/km for diesel trucks,
- only 15 goe/km for electric vans

Compared to the truck, the electric van represents an energy consumption reduction of 90%, when calculated in grams of oil equivalent per km.

3.5 Targets achieved in Case Study 1 Client B demonstration

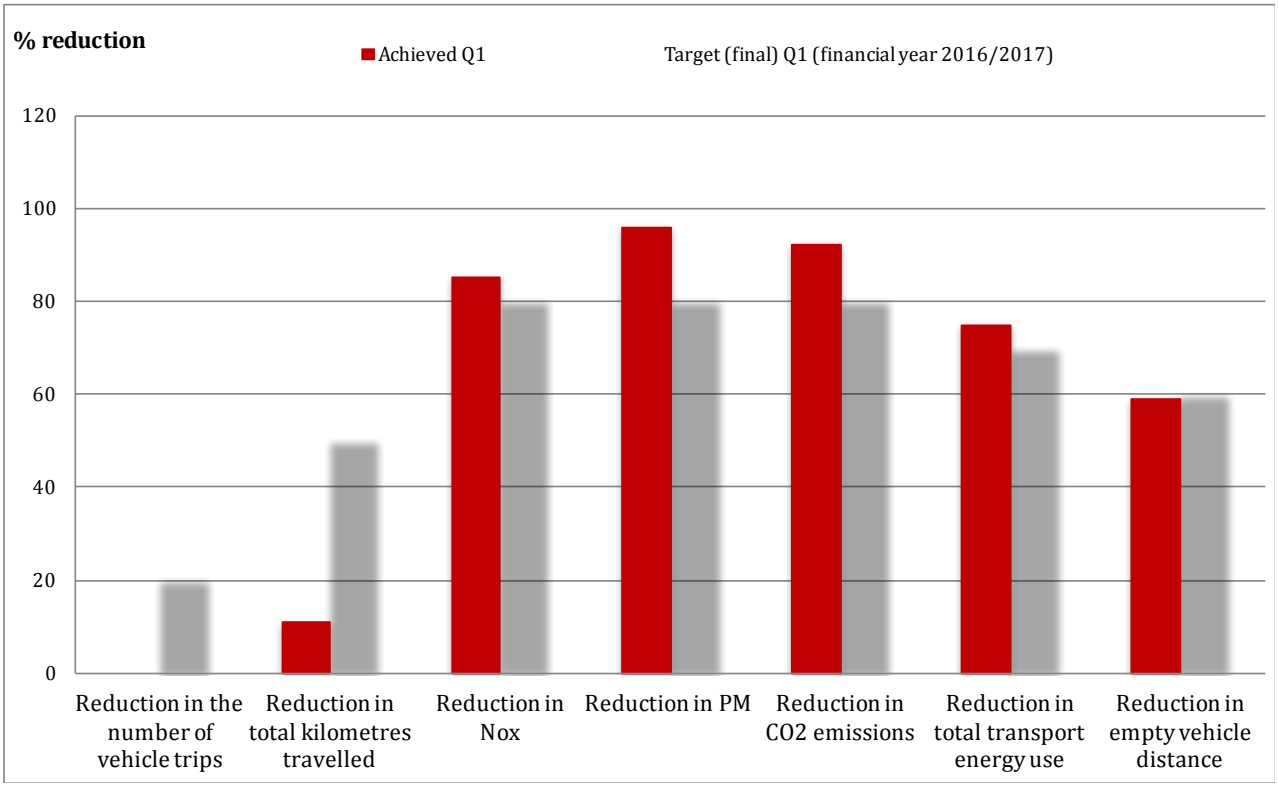
The targets are achieved to a variable extent (Figure 18). The change from diesel to electric, the reduction in distance and the change in transport energy use lead to a strong reduction in carbon emissions of 92% for the Client B business. The value for number of trips is unchanged and the value for distance is only a reduction of 11%.

The unchanged number of trips is due to the assumption of the use of identical number of vehicles, a 1 to 1 replacement of diesel with electric vans. So the target of reducing the number of trips has been clearly missed for the Client B case study 1. The cause is simple: It is assumed that the driver productivity does not change. It is likely that future research will be able to demonstrate that the driver productivity increases when using Gnewt Cargo, compared to other logistics providers. One key fact under the assumption that it does not change for now, is that there is time needed walking up and down the buildings, waiting for the clients to sign for the deliveries, and this working time can hardly be changed. So at this stage, the Gnewt driver is assumed to have the same work performance in terms of parcels delivered per day than another driver in London. Since one driver = one trip, there is no trip reduction.

On the values of 85% reduction for NOx, and 96% for particulates, the target is clearly attained, above other indicators.

Finally, there is a strong reduction in the total distance of empty trips back to the depot after the end of the last delivery. With 59% reduction, empty distance is much reduced, increasing the overall efficiency of the distribution system.

Figure 18: Case study 1 Client B demonstration target achievements, June 2016



Source: Gnewt Cargo Cat 3 demonstrator, 2016

Table 13: Client B demonstration targets and achievements numbers for Case Study 1 in %

Key Target Achievement Indicators	Target (final) Q1 (financial year 2016/2017)	Achieved Q1
Reduction in the number of vehicle trips	20	0
Reduction in total kilometres travelled	50	11
Reduction in NOx	80	85
Reduction in PM	80	96
Reduction in CO2 emissions	80	92
Reduction in total transport energy use	70	75
Reduction in empty vehicle distance	60	59

Source: Gnewt Cargo Cat 3 demonstrator, 2016

Public sector benefits: When considering this business model in place, the main beneficial impacts for the public sector was a better utilisation of existing capacity with more efficient logistics that added to the positive effects of electric vehicles on emissions reduction clean air and less noise. The quantified impacts shown in Figure 18 demonstrate that the final targets for reduced emissions, reduced energy use and for reduced empty distance were met.

4. Case Study 2: Consolidation and electric vehicle use for *non-retail* clients

4.1 Main tasks, indicators and method of Case Study 2

The main questions to be answered in Case Study 2 of this demonstration can be summarised as:

> "What is the business case for clean urban freight consolidation and single carrier deliveries for non-retail clients from the point of view of the operator in Central London ?
>
> and
>
> what are the differences with retail clients?"

Case Study 2 is constructed with the same building blocks presented in Figure 6, and all elements of these blocks are identical with Case Study 1.

Data was collected on 10 TNT vans at the depot in West Central Street for a period of twelve months, starting 1st July 2015 and ending 30 June 2016. The depot in West Central Street and the TNT Kangoo ZE vans are presented in Figure 19.

Figure 19: West Central Street depot with TNT vans

Source: Gnewt Cargo Cat 3 demonstrator, 2016

TNT is currently shifting parts of its business from the multi-carrier consolidation to the single carrier consolidation approach. As part of the demonstrator, TNT agreed to Gnewt Cargo transporting TNT parcels together with the parcels of other clients on the basis of a full vanload for TNT. This type of parcel carrier business offers a very singular consolidation impact that differs from the retail business in so far as it is denser and therefore more effective from the point of view of drop density. The relatively high density of TNT deliveries is one key beneficial factor for the business case.

Like in Case Study 1, the impact data were evaluated by measuring the before and after effect which enables a very clear basis for comparison, and showing the effects of this type of consolidation and electric delivery business for a specific client.

The 'before' data is considered as the baseline against which the impacts were calculated. The 'before' data measured the deliveries for non-retail clients prior to joining Gnewt Cargo.

During this Case Study trial period a number of variables were collected including:

- Vehicle movement reductions
- Reduction in miles travelled per parcel
- Time vehicles spent on the road
- CO2 and NOx reductions obtained from an electric vehicle relative to a diesel van delivering the same freight in the same area
- Business case and KPI data such as:
  - costs of vehicle purchase and/or leasing
  - variable running costs per parcel or per stop for different clients, different area and different depots
  - fixed and variable depot management costs, depot rental and
  - other fixed and variable costs
- Disruptions and risk management for electric vehicle fleet operations

4.2 Case study 2 results

4.2.1 Baseline data analysis and before-after analysis

The key first step of case study 2 was the analysis of different parts of the TNT business, one of the main clients of Gnewt Cargo. This client accepted the principle of sharing the use of the vans with other clients, creating a solution for future efficiency increases through consolidation.

Data was obtained on the TNT international and the TNT domestic businesses pre and post demonstrator.

Gnewt Cargo was used to deliver TNT international parcels destined for central London, being a so-called carrier's carrier for TNT. The demonstrator indicated that Gnewt Cargo has scope to potentially also do TNT domestic parcels delivery in Central London.

To analyse this market increase, it was possible to assess in September 2015 the difference between the current situation of TNT making its deliveries with diesel vans starting from the depot in Barking, and the business of Gnewt Cargo delivering the parcels received from TNT but starting from a central London depot in Bermondsey. This depot is a TNT depot, and Gnewt Cargo started its deliveries directly from there. As a consequence, no additional truck trip was needed, and there was a 100% electric distribution for the entire last mile, with a 100% CO_2 reduction.

The business of TNT is to distribute parcels to the centre of London like in any other place, with its own fleet or using a fleet of subcontractors.

The business previously subcontracted to Gnewt Cargo was exclusively the TNT international parcels deliveries. In addition part of the TNT domestic business was added to it.

Exact baseline information is available for the status of deliveries before any changes in operations were made at TNT Barking depot for September 2015. The period selected was September because the lower demand of the month of August was over, and the months with higher demand of November and December were distant enough. So it was assured that the data collected in that period for a client of Gnewt Cargo using a diesel fleet of 20 vans and trucks gave a good baseline for a typical business situation.

In Table 14, each line represented a route driven over 5 weeks by one vehicle in one area of Central London, where Gnewt Cargo also conducted its operation. TNT performed the exact same business as Gnewt Cargo, but with diesel vehicles, except round 153 which was a cargobike, see Table 14. TNT represents the future market for future improvement in London towards ultra clean vehicle use. TNT has just joined the FedEx Group so the total amount of parcels is expected to increase in London. To know exactly what the improvements that can be expected are, the exact same data was collected for TNT and for Gnewt Cargo in the same period. The difference between the two informs us about the market potential for clean vehicles and the benefits to be expected in London when the implementation of all routes is attained at full scale. Now, in September 2016, only 5 new TNT routes were fully implemented by Gnewt Cargo as a carrier's carrier.

Table 14: Baseline data for TNT Barking depot with diesel fleet, 5 weeks starting 1st Sept 2015

Route ID	5-week distance in miles	5-weeks distance in km	Drops delivered in 5 weeks	Average distance in km/ drop	l/100 km	Total litres/5 week	Litres/ parcel	kgCO2e/ parcel
143	3,510	2,194	2,823	0.777	9.1	200	0.07	0.21
144	4,248	2,655	2,572	1.032	9.1	242	0.09	0.28
145	3,978	2,486	2,727	0.912	9.1	226	0.08	0.25
146	4,103	2,564	3,190	0.804	9.1	233	0.07	0.22
147	1,885	1,178	2,561	0.460	10.1	119	0.05	0.14
148	3,150	1,969	3,501	0.562	9.1	179	0.05	0.15
150	7,455	4,659	3,053	1.526	9.1	424	0.14	0.42
151	2,959	1,849	2,834	0.653	9.1	168	0.06	0.18
152	3,150	1,969	3,044	0.647	9.1	179	0.06	0.18
153	4,998	3,124	3,784	0.825	0	0	0.00	0.00
154	4,987	3,117	719	4.334	9.1	284	0.39	1.18
155	3,684	2,303	559	4.120	9.1	210	0.37	1.12
156	3,647	2,279	570	4.002	9.1	207	0.36	1.09
203	1,641	1,026	1,501	0.684	15	154	0.10	0.31
204	1,243	777	997	0.780	15	117	0.12	0.35
777	4,753	2,971	5,849	0.508	15	446	0.08	0.23
778	2,670	1,669	6,205	0.269	15	250	0.04	0.12
779	1,069	668	6,102	0.110	15	100	0.02	0.05
789	4,141	2,588	468	5.528	9.1	235	0.50	1.51
Total	67,271	42,045	53,058			3,973		
Average / day		**84**	**106**	**0.792**			**0.07**	**0.22**

Source: Agile Gnewt Cargo Cat 3 demonstration

Similar to the findings of Gnewt Cargo, there is a high variability in the day to day business and from one area to another. With 106 parcels per day, the volume count is not exactly the same as for Client A, because TNT counts the number of drops, not the exact number of parcels. In that period the TNT domestic business volume to Central London was 30k parcels. During the same period, the TNT international business volume to Central London, operated by Gnewt Cargo was 21k parcels.

Vehicle specification data for the diesel fleet used at TNT Barking depot is presented in Table 15.

Table 15: Fleet specifications, TNT Barking depot, baseline data, September 2015

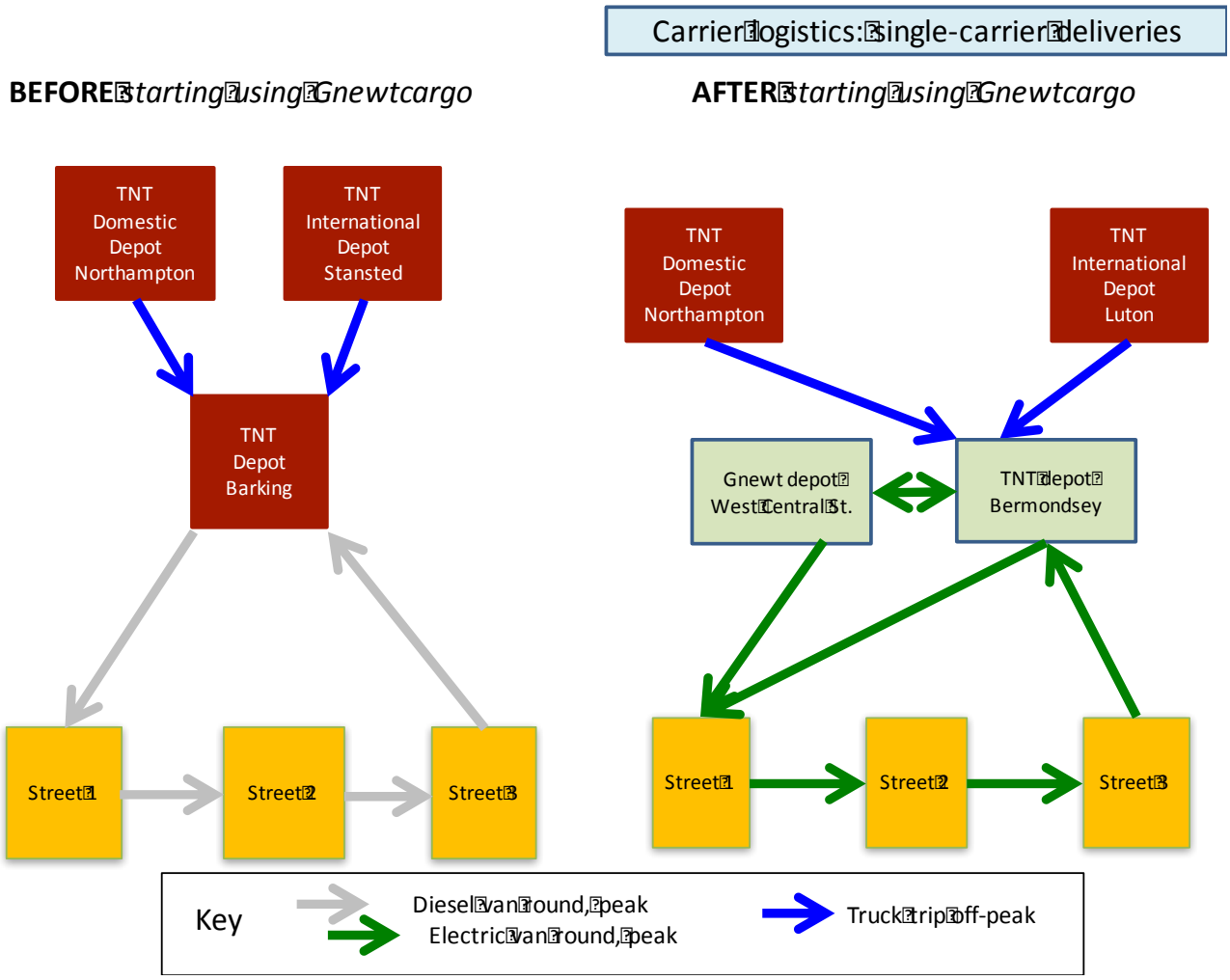
Vehicle type	Truck	MB Sprinter	Box van Luton
Gross Vehicle Weight	7.5t	3.5t	3.5t
Length in metre	5.18	3.4	4
Width in metre	2.31	1.7	2
Height in metre	2.16	1.7	2.2
Payload (load capacity by weight) in kg	2,500	1,200-1,500	1,100 -1,200

Source: Agile Gnewt Cargo Cat 3 demonstration

Essentially the diverse vehicles used by TNT were replaced by electric vans, so there was a classical motor and vehicle size change in the fleet characteristics.

TNT and Gnewt trialled changes in the configuration of the joint last mile delivery system, and the status of the changes in September 2016 can be pictured as follow (Figure 20).

Figure 20: TNT logistics system before and after starting using Gnewt Cargo, Sept 2016



Source: Agile Gnewt Cargo Cat 3 demonstration

To compare the two businesses, domestic (100% TNT diesel fleet) and international TNT parcels services (100% Gnewt Cargo electric fleet), the same data is analysed in following sections.

In the data collection and analysis of this step, the international business is considered 'after' and the domestic business was considered 'before'.

The average distance per parcel was calculated and compared for the two businesses. To obtain an overview on this, one needs to look at the whole logistics system in place observed in Case Study 2 (Figure 18).

To supply Gnewt Cargo with TNT parcels, trucks came from the Stansted and from the Northampton depots every night to the Bermondsey depot. Gnewt Cargo drives to the TNT Bermondsey depot to load the parcels there and start the rounds from the TNT depot directly. At the end of the day the collections are driven back to the Bermondsey depot and the driver returns the electric van to one of the Gnewt Cargo depots in Wardens Grove or in West Central Street.

4.2.2 Distance analysis

In Sept 2016, Gnewt Cargo had an average distance per parcel of 267 metres for the TNT international business. As can be seen in Table 14, TNT had in September 2015 an average last mile distance of 792 metres per parcel, driven between depot and final point of distribution. As of September 2016, the TNT distance was observed only for 10 rounds, and the average was 820 metres per parcel. When looking at the situation in September 2016, with the two distribution systems compared and presented in Figure 18, the distance reduction between the two last mile trips of TNT and Gnewt is shown below (Table 17). As in previous case studies, the baseline data showed longer distances for conventional distribution.

Table 16: Distance of TNT and Gnewt Cargo business analysis, Sept 2016

Distances	**Miles**	**Km**
Average TNT delivery round per day before	73	117
Average Gnewt Cargo delivery round per day after	**16**	**26**

Source: Gnewt Cargo Cat 3 demonstrator, 2016

The number of trips observed was 10 delivery trips per day for 10 diesel vans run by TNT UK for the domestic business and 10 delivery trips per day for 10 electric vans run by Gnewt Cargo for the international business.

Table 17: Comparison of similar Gnewt Cargo and TNT delivery businesses in Central London

April 2016	Parcel units	Miles	Km	Km/ parcel
Gnewt Cargo (TNT international) delivery journeys	21,211	3519	5663	
Average Gnewt (TNT international) delivery distance				0,267
Total TNT domestic deliveries	30,089	15,315	24,647	
Average TNT domestic distance				0,820
Difference in %		**77**	**77**	**67**

Source: Gnewt Cargo Cat 3 demonstrator, 2016

There was a 67 % distance reduction observed between TNT domestic business operated by TNT from the depot in Barking and the TNT international business operated by Gnewt Cargo. This reduction was measured in km/ parcel, and not as overall distance reduction. The observed vehicles drove a much shorter distance to deliver the same job.

There was an overall total distance reduction of 77%. The current business volume (number of parcels) of TNT domestic was higher than TNT international. The detailed results of the before-after distance analysis are presented in Table 18.

4.3 Targets analysis in Case Study 2 TNT demonstration

4.3.1 Distance and fleet reduction of TNT demonstration: target analysis

Table 18: TNT distance reduction, before-after comparison, September 2016

BEFORE deliveries starting from Barking	Number of vehicle trips	MPG	Monthly distance in km	Parcels delivered during month	Distance in km/ parcel
Van TNT domestic	10		24,647	30,089	
Average		31			0.82
AFTER Gnewt Cargo operations					
Electric Van Gnewt	10	-	5,663	21,211	0.267
Total	10		5,663	21,211	0.267
Average					0.267
% reduction	**0**		**77**		**67**

Source: Gnewt Cargo Cat 3 demonstrator, 2016

The beneficial results were strongly influenced by the location of the depots and this will probably not change. So, the final target achievement figures seem rather robust. For example, if the number of vehicles switched from Barking to Bermondsey increases in the future, it is likely that the benefits will be similar.

4.3.2 CO_2 and air pollutant reduction: target analysis

Baseline data in Table 14 shows levels of CO_2 emitted by diesel vehicles that are rather normal for London logistics activities.

The CO_2-emissions for 20 routes and 5 weeks were about 12 tonnes in September 2015. The average value of 220 grams of CO_2 per parcel for TNT is an average baseline value. The 2 million parcels a year represented by Gnewt Cargo, and applying that average, results in a total CO_2 emission of 440 tonnes per year that can be potentially fully avoided. This example shows how the potential future reduction might occur if the Gnewt Cargo logistics solution, or a similar system, would be further developed in London.

The climate impact of the changed routes occurring in the TNT distribution system is a 100% CO_2 reduction, because no diesel truck is used to transport the goods between the TNT depot and the Gnewt Cargo depot. So the last mile operation under observation and for which the data collection occurred was 100% electric.

Fuel use before was 0.07 litres per parcel, equalling 0.195 kilograms of CO_2 equivalent per parcel (kg CO_2/parcel), and this represents a value that is similar to other diesel vans in urban logistics. The lowest CO_2 emissions measured before as an average of one day, was 47 grams of CO_2e per parcel and the maximum was a daily round with an average of 2.38 kgCO_2 per parcel.

Table 19: TNT CO2 reduction, before-after comparison, September 2016

BEFORE deliveries starting from Barking	**Number of vehicle trips**	**l/ 100km**	**Total litre/month**	**Litres/ parcel**	**kgCO2e/ parcel**
Van TNT domestic	10		2243		
Average		9		0.07	0.195
AFTER Gnewt Cargo operations					
Electric Van Gnewt	10	-	-		
Total	10				
Average			0	0	0
% reduction	**0**		**100**	**100**	**100**

Source: Gnewt Cargo Cat 3 demonstrator, 2016

The number of vehicles in use was stable for the Gnewt Cargo business after the changes, due to the use of the electric vans directly starting from the TNT depot in Bermondsey.

The distance travelled was reduced by 77%. This had a strong impact on traffic and on costs, and it is estimated that travel times were also reduced. The cost reduction and the traffic reduction will be monitored further if the implementation is extended in the future.

The total fuel use and CO_2 emissions per parcel were reduced by 100% in the situation 'after', due to the 100% electric vehicle fleet in use from the start of the TNT depot.

The air pollutant emissions of PM10 and NOx decreased also by 100% for the same reason. (As a reminder, only the tailpipe emissions are considered, as no data is available on any other air pollutant emissions from electric vehicles. It is likely that rubber contact with asphalt produces emissions, but the amount is unknown at this stage).

4.3.3 Energy reduction: target analysis

The energy use expressed in goe/parcel takes into account the diesel energy of the diesel vans and compares it with the kWh energy of the electric vans. The value of 87% reduction in energy use per parcel was even higher than the reduction in total distance driven (77%). The conversion factors are the same as for Case Study 1, see above.

Table 20: Energy reduction for the TNT demonstration, September 2016

Indicators **BEFORE deliveries starting from Barking**	**Number of vehicle trips**	**goe/ parcel**
Vans TNT domestic	10	
Average		63
AFTER Gnewt Cargo operations Electric Vans Gnewt	10	8.4
% reduction	**0**	**87**

Source: Gnewt Cargo Cat 3 demonstrator, 2016

4.3.4 Empty distance reduction: target analysis

The empty distance was much reduced as well (93%) due to the fact that electric vans were only empty between the last drop and the return to depot. This empty distance was estimated as 1 km per van per day. The van trip back to the TNT depot in Barking was an empty return, except when the delivery trips were combined with a collection trip, which is estimated to occur on one tenth of all trips. The empty distance for TNT in Barking is estimated to be 16 km, and the empty trip is counted when starting from the last delivery point of the day, for the part of the journey going back to depot.

Table 21: Reduction in empty distance for the TNT demonstration, September 2016

BEFORE deliveries starting from Barking	Number of vehicle trips	Monthly empty distance in km
Van TNT domestic	10	2,984
Average		
AFTER Gnewt Cargo operations		
Electric Van Gnewt	10	210
Total	10	210
Average		
% reduction	**0**	**93**

Source: Gnewt Cargo Cat 3 demonstrator, 2016

Potential strategies that might change or greatly improve the KPI "empty distance" in future are:

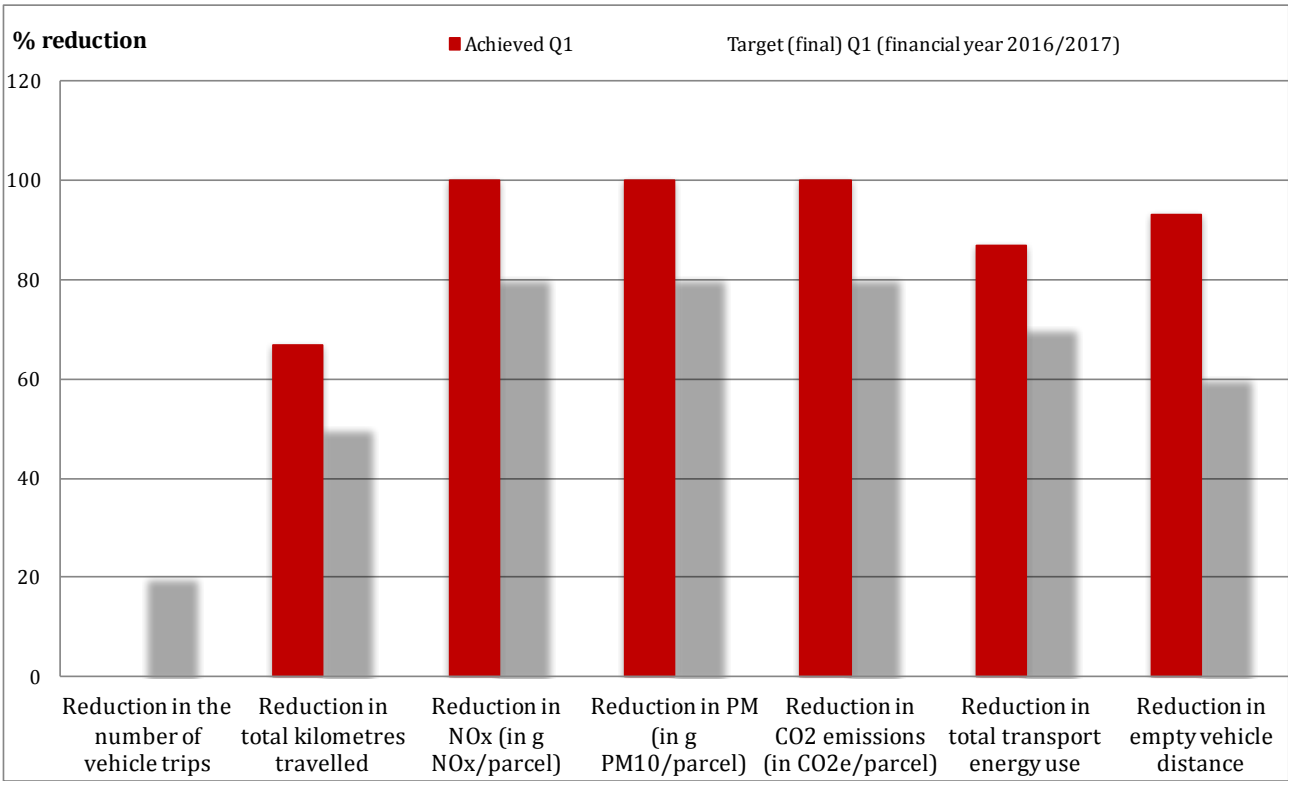
- more parcel collection (after the end or during the same delivery trip)
- parking some Gnewt Cargo vehicles at the TNT depot overnight.

4.4 Target achievements for Case Study 2

Figure 21 presents a graph on the targets achievements for Case Study 2. It shows the values achieved with demonstration of carrier deliveries, and compares it with the targets set at the beginning of the project for Q1 (financial year 2016/2017). The values show that all targets were attained, except fleet reduction.

None of these results can be considered definitive results as the changes to the TNT business occurred during the Case Study 2 demonstration period. These business results are likely to change slightly when the implementation of Case Study 2 is scaled up in future.

Figure 21: Targets achievement at the end of the demonstration in Case Study 2



Source: Gnewt Cargo Cat 3 demonstrator, 2015

Overall, the results from Case Study 2 shows that it is difficult to obtain a reduction in the number of vehicle trips. Very little change in driver productivity was observed, despite every effort being made to collect accurate data before and after the start of the demonstration.

The new Bermondsey TNT depot location in London supports a strong reduction in the total distance travelled, and the main reason is the transfer of logistics activities from the suburban depot of Barking to the TNT and Gnewt Cargo depots in Central London.

The major innovation here is that no additional truck is needed and therefore a total absence of diesel vehicle in the last mile operation of the TNT business enables a 100% CO_2 reduction and a 100% reduction of air pollutants at the tailpipe. The transport energy from electric vehicles is smaller than the transport energy from diesel vehicles, and the difference is 85% in this case.

The distance travelled empty is also strongly reduced, because of the nature of the delivery round trip. At the end of each trip, after the last parcel has been delivered, the vehicle is partly empty for the trip back to the depot. Or it is collecting parcels and is not empty. But when the depot is very far from the area of delivery, like for the Barking depot, the empty distance is much higher. In this case, Gnewt Cargo was able to reduce the empty vehicle distance by 93%.

5. Case Study 3: Testing the Fitness for Purpose of Different Electric Vehicles for Different Clients

Gnewt Cargo has a fleet of different battery electric vehicles comprising mainly Renault Kangoo ZE, Nissan e-NV200. Few other types of older electric vans, cars and cycle are in use or were in use during the period of the Agile project: Mercedes eVito, Peugeot Boxer, Goupil G3, Toyota Yaris. Gnewt Cargo is testing a very small number of these other types of vehicles, so that the trial of an individual vehicle cannot lead to results that are representative for the fleet of the entire area of Greater London. Tests details on Renault and Nissan are available for a great number of vehicles and for more than one year, allowing a more robust validation.

5.1 Market development is still at a very early stage

The market for light goods vehicles with Battery Electric propulsion is very young. Statistics are available from 2011 from the European Alternative Fuel Observatory. In 2016, data was extracted for new registrations of goods transport vans <3.5t in Europe (Table 22, Figure 22).

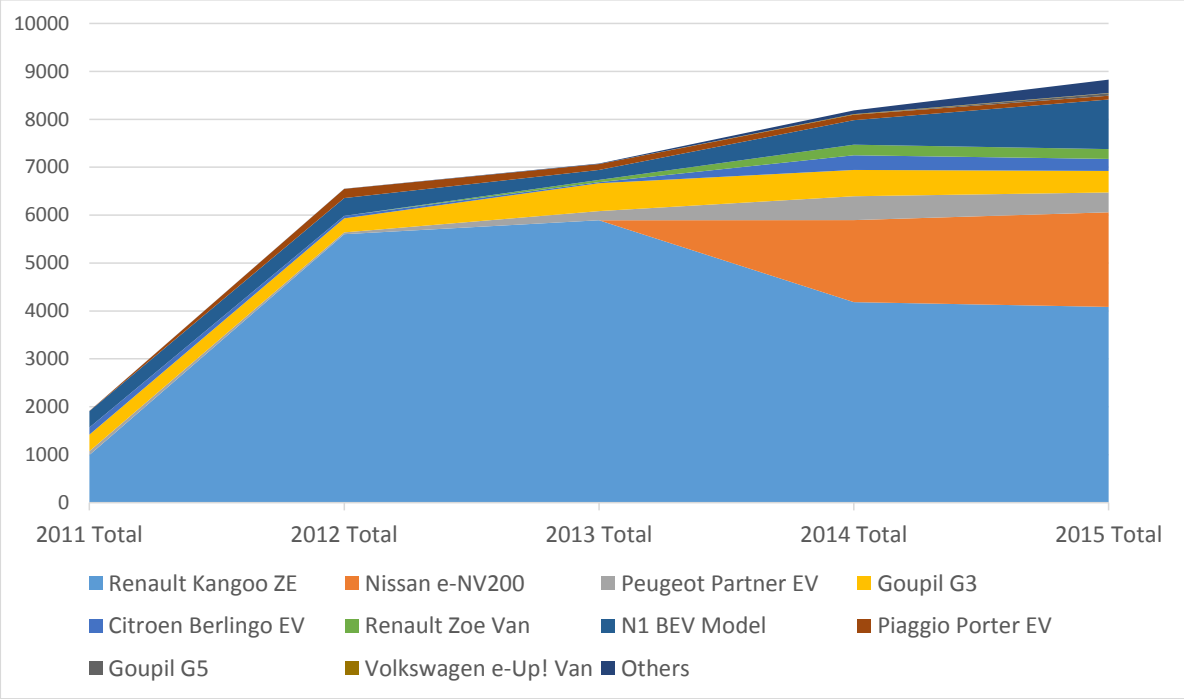
Table 22: Light Commercial Vehicles - Battery Electric Vehicles –new registrations in EU

Ranking	Make	Model	2015 Total	2014 Total	2013 Total	2012 Total	2011 Total
1	Renault	Kangoo ZE	4,084	4,184	5,893	5,602	994
2	Nissan	e-NV200	1,975	1,712	0	0	0
3	Peugeot	Partner EV	414	498	191	37	80
4	Goupil	G3	449	549	582	293	345
5	Citroen	Berlingo EV	251	306	22	52	149
6	Renault	Zoe Van	205	221	47	0	0
7	Unknown	N1 BEV Model	1,035	512	208	372	341
8	Piaggio	Porter EV	79	114	123	192	3
9	Goupil	G5	50	0	0	0	0
10	Volkswagen	e-Up! Van	7	12	0	0	0
Others			279	77	11	3	2
Total			8,828	8,185	7,077	6,551	1,914

Source: European Alternative Fuel Observatory 2016 http://www.eafo.eu/vehicle-statistics/n1

In Europe, the year on year growth rate of new registrations was 8% in 2013, 16% in 2014 and 8% in 2015.

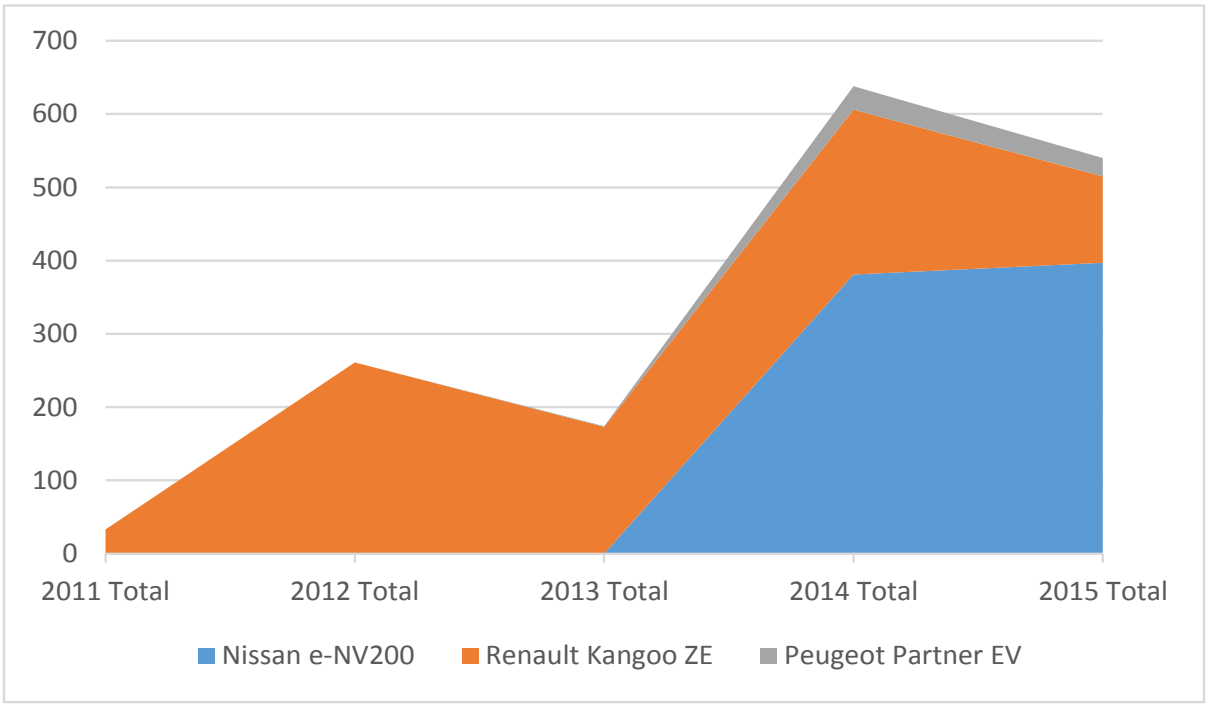
Figure 22: Development of new registrations of Battery Electric Light Commercial Vehicles in Europe, 2011-2015



Source: European Alternative Fuel Observatory 2016

For the UK market, the two main types of vehicles newly registered in recent years are the same ones in use at Gnewt Cargo: Renault Kangoo ZE and Nissan e-NV200 (Figure 23).

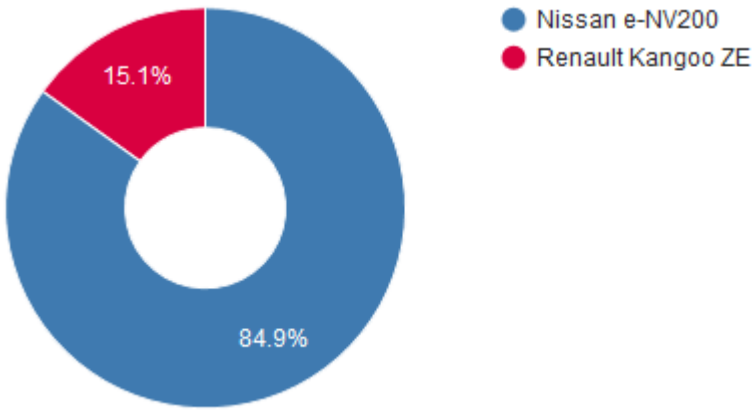
Figure 23: New registrations of Battery Electric Light Commercial Vehicles 2011-2015 in UK



Source: European Alternative Fuel Observatory 2016

In 2015, the new Nissan e-NV200 dominated the sales for new vehicles in the UK (Figure 24).

Figure 24: Market Share in UK, Light Commercial Vehicles, Battery Electric, New Registrations 2016



Source: European Alternative Fuel Observatory 2016

Current new registrations of all UK commercial light goods vehicles was about 400,000 in 2015, and the new registrations of battery electric vehicles was, with 540 new vehicles, about 0.1% of all new registrations (EAFO, 2016).

Turning our attention now to the total market for Light Goods Vehicles (LGVs) in UK (Table 20) including all vehicles running on the roads and streets of UK. The market share of commercial battery electric vans in the UK is currently around 0.1% (Department for Transport, 2016) (Table 23).

Table 23: Licensed light goods vehicles by propulsion or fuel type in UK

United Kingdom						**Thousands/ Percentages**
Year	**Petrol**	**Diesel**	**Gas1**	**Electric**	**Other2**	**Total**
Total number of vehicles						
2014	137.7	3,417.4	9.8	4.1	0.6	3,569.6
2015	134.6	3,587.4	8.7	4.6	0.7	3,736.0
Percentage of vehicles						
2014	3.9	95.7	0.3	0.1	-	100
2015	3.6	96.0	0.2	0.1	-	100

Source: Department for Transport (2016) Statistics. https://www.gov.uk/government/statistical-data-

5.2 Comparison of Renault Kangoo ZE and Nissan e-NV200 in daily use

Quantitative average fleet data was collected for the period 1st July 2015 to 30 June 2016 (Table 24). The objective was to assess if there are important differences in performance. All data was sorted according to the vehicle type.

Table 24: Average performance data of all Nissan and all Renault vans, 1 Jul 2015-30 Jun 2016, Gnewt Cargo, London

Criteria Veh. type	Total Distance (km)	Average Daily Distance (km)	Idle (%)	Electricity Usage (kWh)	Eco Driving Score	Hard Acceleration (%)	Hard Braking (%)
Nissan e-NV200	9118.3	52.8	55.5	1636.3	66.7	5.7	7.0
Renault Kangoo ZE	4622.2	22.1	71.6	1288.8	74.3	5.6	5.9

Source: Gnewt Cargo Agile 3 data collection

The difference in total distance and daily distance is due to the different types of clients. For some clients such as Client B, the delivery area was wide and the distance covered longer. The Nissan was used for such clients with longer trip distance. With 110 miles (about 180 km), it has a similar range than the Renault (107 miles). Gnewt used the Nissan vans for a total distance double the distance of the Renault. But all trips made with the Nissan could have been made with the Renault anyway. So the question of battery range was not an issue throughout daily business.

The Nissan is equipped with a fast charging option. But this feature was not used and all vans were recharged with a standard charging plug.

In conclusion, none of the quantitative parameters observed provided noticeable differences between Renault and Nissan. For all indicators (volume capacity, distance per day, energy use in kWh, maintenance, driving style (hard acceleration or hard breaking)), the two vehicle types showed similar results. The only noticeable difference was in qualitative parameters. The drivers reported a slight inconvenience with the Nissan - when stopping the vehicle, it would have the tendency to keep moving if the brake wasn't continuously depressed.

Both vehicle types are therefore considered suitable for future use at Gnewt Cargo. The analysis however highlights that Gnewt Cargo needs a good performance vehicle capable of transporting larger volume and weight. However, this type of vehicle is currently not available on the market at competitive prices.

6. Generic Elements of the Project

The project also consists of a generic part, based on current and future growth of operations with electric freight vehicles and cargo bikes in Central London.

For the generic part, the project includes following elements.

6.1 Testing innovative technologies and new management

Using the methodology implemented in this demonstrator, Gnewt Cargo found a cost effective business oriented way to test innovative technologies. The process improvements ensure that future, innovations can be easily tested and quickly implemented.

This approach was developed in previous GLA demonstrator trials and adapted to the needs of the Agile Cat 3 demonstrator. Data collected before and after introducing changes was more or less in line with expectations. Gnewt Cargo has now adopted this management approach and will continue to use it for future tests, trials and demonstrations.

6.2 Setting up new data collection, monitoring and processing techniques

Data collated as a direct result of these demonstrators has helped Gnewt Cargo to better understand and assess the scope for future growth conditions for multi-carrier consolidation operations, and makes the planning of future operations with new clients or in new areas of London easier.

All data for all vehicles, all clients' orders and all vans are safely stored on dedicated servers. The data is available for the period 1st July 2015 up to 30th June 2016. Further data will continue to be collected in future tests.

7. Legacy and concluding remarks

For both Case Study 1 (retail) and Case Study 2 (non-retail carrier), the results so far show a similar strong decrease in distance, CO2 emissions, NOX & PM10 emissions, total energy use, and in empty distance, and also a similar stable situation for the total number of vehicles, when compared to a standard diesel delivery, and without consolidation using Central London depot locations. The results are fairly similar for Case Study 1 and Case Study 2, so the differences between retail and non-retail clients do not appear to be very substantial.

The efficiency increase in operations, notably the shorter vehicle distance per parcel delivered for TNT, leads to strongly reducing the distance observed for diesel vehicles, lowering air pollutant emissions per parcel delivered.

By using central London consolidation centres, distance related external impacts such as accidents, noise and congestion are significantly reduced. It also reduces travel time and business costs for the clients, contributing to stabilising the business model of electric van delivery.

As a legacy, the effects of introducing the solution on the market are clearly beneficial for the environment and business efficiency and profitability. The data collected and analysed provides evidence that the operational solution trialed can be replicated, new Central London depots can be opened and run efficiently, and new clean freight vehicles can be acquired and used successfully in London.

In order to scale up the solution demonstrated in this project, several possibilities are feasible. The first would be the economic growth of the current business through acquisition and contracting of new large-scale clients in London, the opening of new larger depots with access for large articulated trucks, and the acquisition of additional clean vehicles. The knowledge on how to do this is now available from this trial and is replicable. The greatest barrier to a lasting legacy may be in the lack of available space within city centers, safe-guarded for environmentally friendly logistics last-mile solutions that will become an absolute necessity to keeping parcels moving in the future in a clean and efficient manner.

The second concept would be to transfer the solution to another area of London, to open a new depot there, to obtain a contract with a new client, and to purchase a clean vehicle fleet. Again this transfer of good practice would benefit from a trial phase and from quantitative evaluation.

Gnewt's business model and infrastructure was tailored towards this type of operating model from the company's inception. It is this fact that has enabled Gnewt to achieve the environmental savings and operational efficiency that has proved a barrier to other logistics companies. The concept of smaller, central consolidation centers, a fully 100% electric fleet, a robust data collection system and monitoring of operations is integral to the success of Gnewt and the ability to provide viable research results to GLA.

Technical barriers: The electric freight business is not currently suitable for heavy loads transported by Heavy Goods Vehicle. For pallets or heavy goods deliveries to receivers of more than one tonne per day, trials with other alternative fuels are likely to currently prove more successful, such as the experience of Howard Tenens with biogas as fuel and a gas motor as the main engine. This has not been tested in London yet.

100% fully-electric freight operations will not suit long distance transportation of goods and the current range of approximately 60 miles per day is fairly limited, but this is considered sufficient for parcel deliveries. Due to the range limitation, a high density of customers is required. A transport business that requires long distances between customers is not suitable for full-electric vans at this time.

Concluding remark: The results show a strong decrease in distance, CO_2 emissions, NO_x & PM_{10} emissions, total energy use, and in empty distance, but a slight increase in total number of vehicles. The efficiency increase in operations leads to lower air pollutants emissions per parcel delivered. The lower distance also diminishes all external costs of transport such as accidents and congestion costs that are distance related. The results are in line with the Quarter 4 objectives set at the beginning of this project, except for the fleet reduction.