Final Report : IT solutions for parcel deliveries - Central London trial

Technology-based solution to facilitate efficient allocation and cross-carrier routing

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Abstract

This document is the final report of the IT solutions for parcel deliveries with electric vehicles in Central London trial funded by the Mayor of London ("Agile 2"). The trial was delivered by Gnewt Cargo in partnership with the University of Westminster.

The trial was designed to test a range of IT solutions for electric fleet management, improving efficient client communication management and routing and planning systems. This report sets out in detail the results and performance of the IT trial implementations. Gnewt Cargo tested IT solutions from Fleetcarma for improved electric fleet management, Emakers for efficient client communication management, PTV Smartour, Optrak and Podfather for routing and planning systems.

Of the solutions tested overall PTV Smartour delivered very promising results and subject to further development has the potential to support and improve freight efficiency. However market does not currently provide a solution for urban freight delivery routing that is sufficiently developed or flexible enough to offer significantly better routing than could be achieved by trained.

All the routing systems tested are predominantly designed for long distance freight traffic. Therefore, it was key in the preparation of the trial to have intensive exchange with the software providers in order to have the current products adapted to the Central London situation, characterised by short distances, small delivery areas, high density of customers, different on-street and off-street loading bays, parking duration allowance and access restrictions.

By using electric vehicles and advanced IT solutions (despite its limitations) in Central London, **Gnewt Cargo achieved 58% distance reduction per parcel, or 240,000 miles less driven on London roads during the one year project from 1st July 2015 to 30 June 2016. The CO_2 emissions were reduced by 88% (167 tonnes of CO_2 saved), the NO_x emissions went down by 72%, and the PM emissions by 93%. The empty distance was reduced by 84%.**

The trial contributed to one of the most important urban policy target of lowering air pollution in London, improving the air quality, lowering the noise level, and improving the health of residents, working population and visitors, while improving the environment for efficiency and profitability of urban freight businesses.

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List of Abbreviations

Agile 2	Agile 2 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
$KgCO_2e$	kilogramme of CO2 equivalent
Kgoe	kilogramme of oil equivalent
kWh	kilowatt-hour
LGV	light goods vehicle
LSP	logistics service provider
m^3	cubic metre
m	million
mi	mile
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)
SOC	State of Charge (of battery)
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' 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 technology-based solution to facilitate efficient allocation and cross-carrier routing ("Agile 2"). Following a competitive grant-funding round, Gnewt Cargo was awarded circa £400K 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 a range of IT solutions for electric fleet management, improving efficient client communication management and routing and planning systems. Prior to this project, there was no publicly available market study, that we are aware of, on the existing IT solutions for the urban freight delivery business.

The objective of the demonstrator project was to assess the potential for using IT solutions for improving the environmental aspects of running consolidated deliveries using electric vehicles in Central London.

The project also assessed the potential for:

1. re-timing of e-commerce B2C activity, away from peak hours
2. re-routing of journeys away from the most congested roads and pollution hot spots
3. consolidation and a reduction in the number of pick-ups/drop-offs
4. utilisation of low emission vehicles
5. reduction in emissions ($CO2$, diesel particulates, NOX)

1.2 IT Solutions Tested

The main IT solutions tested are all market leaders in their field. IT solutions tested include:

- Fleetcarma software for electric vans fleet management
- Emakers software for freight delivery management
- PTV Smartour software for tour planning and scheduling
- PTV Map and guide software for on board routing
- Optrak, a software for load consolidation, tour planning and routing
- Podfather, software for freight delivery management

1.3 Project Targets

The GLA set the following targets to measure the impact of the smart intervention.

- 57% reduction in the number of vehicle trips
- 69% less kilometres travelled
- Reduction in NO_x (71%), reduction in PM (87%)
- Reduction in CO_2 (67%) emissions.
- 30% reduction in running empty vehicles.

A summary of performance against these targets is summarised later in the summary.

1.4 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.

With the participation of key Gnewt client i.e. Client A, TNT UK, Client C, eMakers and Client B, Gnewt was able to test a range of IT software and hardware on designated delivery rounds in London. The technology partners involved in the trials were Fleetcarma, eMakers, Optrak, PTV Group and Podfather.

University of Westminster performed data processing and analysis for the trials.

1.5 Project Costs

The costs breakdown for this project included costs for software and hardware purchase and development (about 20%), internal staff (about 72%), and subcontractors (about 8%). The total budget was approximately £568,000. The GLA funding amounts were circa £400K.

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 IT solutions most applicable for improving its overall transport efficiency. The project also helped securing its long-term business development strategy.

1.7 Preparation Phase

In setting up the project, Gnewt:

1) obtained the devices,

2) fitted hardware to electric fleet (circa 70 vehicles),
3) obtained software licensing
4) set up project specifications
5) was measuring baseline performance before introducing each IT solution
6) was agreeing timescales with IT providers
7) worked with participating clients (Client C, Client A etc.) to collate data in required format to host on a single consolidated platform.

1.8 Delivery Phase

The project consisted of 3 case studies designed to answer specific questions for project delivery. Each case study is used to demonstrate how the project achieved its targets and summarises its contribution to improving the environment for business efficiency and profitability.

1.8.1 Case Study 1

Can we better understand the most effective utilisation and performance of an all-electric fleet by monitoring and telemetry systems?

Fleet Carma is an electric van management system. The FleetCarma system enables the automatic real time data collection (e.g. GPS location, miles travelled, speed etc. By installing FleetCarma hardware on each vehicle (circa 70 vehicles) and monitoring via cloud based software, Gnewt showed how fleet management and driver behaviour can be further improved. For example, vehicle charging scheduling and vehicle utilisation i.e. re-timing of deliveries away from peak hours and re-routing of journeys away from the most congested roads and pollution hot spots.

The FleetCarma solution has demonstrated the usefulness of having vehicle specific data analytics. The findings are documented in this report.

1.8.2 Case Study 2

Can we initiate an IT platform that allows us to better manage multiple retail clients to maximize efficiency and reduce miles travelled on London's roads?

Emakers, is an IT solution for freight delivery management. The Emakers route building and optimisation software enables the joint delivery of multiple retail clients on a single platform. The data arrives directly from the Emakers server, connected via the cloud and is downloaded in database format to Gnewt Cargo servers. This mixing of multiple retailers is beneficial for the overall traffic efficiency by ensuring the majority of vehicles are appropriately laden thus reducing congestion and miles travelled from previously unconsolidated deliveries.

Using the Emakers routing software, Gnewt was able to test the ability to consolidate deliveries with multiple client which included Client C, Client A, Client B and TNT. The results of this trial are detailed in this report.

1.8.3 Case Study 3

What are the beneficial effects of using PTV Smartour, and Optrak routing systems for electric fleet operations in Central London?

Optrak, Podfather and PTV Smartour routing systems were tested in trial phases for duration of approximately 4-8 weeks each. All these systems allow Gnewt Cargo to use algorithmic based solutions to propose routes for the driver to adopt when conducting his daily deliveries with an expectation that this can drive efficiency and productivity. Each routing software package was compared to determine the most viable option for improving delivery performance.

Gnewt experienced mixed results from the routing software and companies trialled. Quality of outputs varied significantly. Currently none of the routing systems tested could handle the intricacies of Central London to formulate a viable automated approach. Of the routing software tested, PTV demonstrated the most potential to adapt its existing technology to address the challenges associated with delivering in dense central London locations.

Gnewt has therefore been working with PTV to develop a new algorithm that will tell the system where drivers commonly stop and then set defined cluster delivery locations that replicate drivers traditional movements. Whilst beyond the scope of this project, Gnewt believes that with further development there is potential to reduce vehicle mileage by up to 50 per cent when compared to electric vehicles run without route optimisation.

1.9 Project Phasing

Financial year		2015/2016		2016/2017
Tasks / Quarters	Q2	Q3	Q4	Q1
Case Study 1 Fleetcarma				
Case Study 2 Emakers				
Case Study 3 Routing				
Design of trials				
Data collection system				
Communicate with client				

Table A: Duration of preparation (green), trial (yellow) and data processing (in blue) for the different studies.

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 months project, between 1st July 2015 and 30 June 2016. 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 keys periods. With this volume of robust data, Gnewt has demonstrated the potential to scale and replicate the positive impacts across the wider London area.

1.11 Limitation of Technology

Consolidation of data sources: All participating Gnewt clients operate bespoke IT delivery platforms. A key challenge was to integrate multiple client delivery data unto a common platform. Due to the complexity of this multi-carrier consolidation approach, a reduction in vehicle trips was not possible during the duration of the trial.

Routing technology constraints: All the routing systems trailed were predominantly designed for long distance freight traffic and was therefore less suited to dense urban route planning. To address this Gnewt had on-going dialogue with IT providers to have the current products adapted to the Central London situation. Adaptations were required to accommodate short delivery distances small delivery areas (e.g. up to a 100m radius), high density of customers, different on street and off-street loading bays, parking duration allowances and access restrictions.

Despite the limitation of the routing software tested, Gnewt and PTV have identified a future route to market which would create cluster delivery areas that accommodate for van and foot deliveries from static parking locations instead of sequential routes. If achieved this would reduce:

- the number of stopping points in dense areas
- traffic congestion as a result of reduced delivery miles
- vehicle emissions (CO_2, PM_{10}, NO_x) for internal combustion engines

1.12 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 reduction in vehicle trips, the project achieved six out of seven of the performance targets set by the GLA.

Whilst the IT systems trialled requires further development and real time testing beyond the scope of this project, the use of multi-carrier consolidation via electric vehicle enabled the project to achieve key targets. Gnewt believes that as IT routing solutions mature, performance targets are likely to significantly exceed current performance levels. Figure A summarises the results below.

Figure A: Key indicators, targets, and achievement of targets, expressed as overall % reduction compared to the situation BEFORE implementing the Gnewt Cargo solution, for the client Client A

Source: Agile 2 demonstration 2016

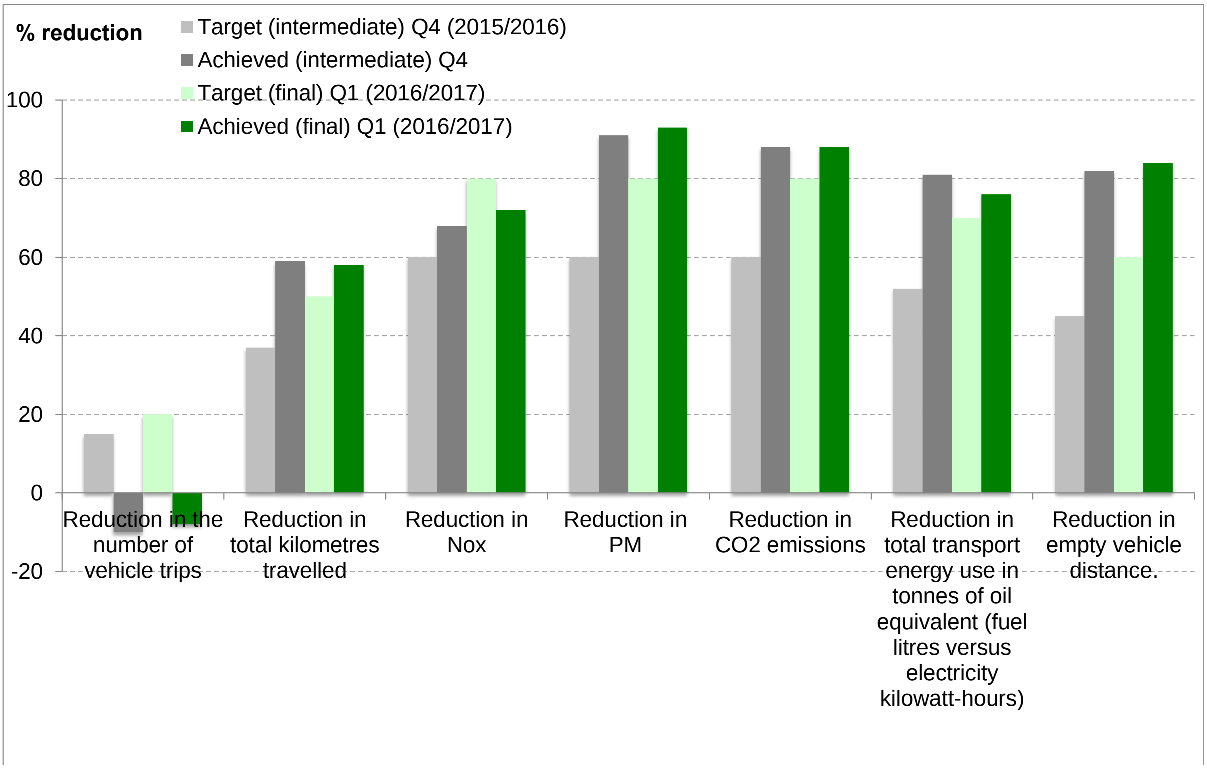


Table B: Target achievements of Gnewt Cargo Agile 2 in the period 1st Jan 2016-30 June 2016, in %

	Target (intermediate) Q4 (2015/2016)	Achieved (intermediate) Q4	Target (final) Q1 (2016/2017)	Achieved (final) Q1 (2016/2017)
Reduction in the number of vehicle trips	15	-10	20	-8
Reduction in total kilometres travelled	37	59	50	58
Reduction in NOx	60	68	80	72
Reduction in PM	60	91	80	93
Reduction in CO_2 emissions	60	88	80	88
Reduction in total transport energy use in tonnes of oil equivalent (fuel litres versus electricity kWhs)	52	81	70	76
Reduction in empty vehicle distance.	45	82	60	84

Source: Agile 2 demonstration 2016

1.13 Legacy

The data collected and analysed during this trial provides evidence that with further development, the IT routing solutions could increase optimise freight delivery and reduce associated traffic congestion in London. Scalability is relatively straight forward as whether you choose to optimize 50 routes or 5000, the logic remains the same. As a legacy, the effects of introducing alternative solutions on the market are a necessity in order to keep London moving with freight deliveries working effectively both for wider society and the environment as well as for the business efficiency and profitability. Gnewt has demonstrated that for a relatively low capital investment for the IT, there is scope for freight companies to improve efficiency and reduce operating costs whilst improving its environmental credentials. Gnewt is not on its own in working through these IT challenges, but would hope that the learning created here will assist like-minded SME's and larger organisation to better understand how they may apply IT solutions to their own businesses and thus limit the number of unnecessary trips travelled.

As a direct result of this trial, Gnewt has launched its own IT solution to improve business efficiency and productivity. To achieve this, further work is required improve routing IT solution in urban areas. Gnewt has committed to continue working with their clients to address these challenges, a key legacy of this project.

2. Introduction and description of the Case studies

2.1 Introduction

The London Smart Cities Programme is targeting the Central London area and the main problems 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 the businesses and the public sector decision makers, what benefits can result from using ultra low emission vans and Central consolidation centres.

Why were these solutions selected?

Urban freight operators and their clients usually don't know where their vehicles are, how full they are, what is the exact status of the delivery, and what would be the best routes or combination of routes for the everyday business of their fleet. IT can provide a big help here, reduce considerably the uncertainty of the delivery business, and reduce traffic as well, but how to create the potential efficiency improvement is not clear. Fleetcarma provides location and electric fleet management features, eMakers provides client communications, and IT routing systems provide optimized itineraries for an entire fleet, so these were first hints of existing solutions selected before the project started.

The development and understanding required in a project such as this is a challenge in itself. There are now a myriad of alternative IT solutions on the open market that propose solutions that may assist with meeting the targets outlined within this programme. We have investigated a number of companies prior to launch and already we have learnt that some actually replicate the analytics of others in the background by sharing fundamental algorithmic logic and some provide a core solution but do not offer a complete package. Therefore it was necessary to narrow down a selection of key products and IT solutions aiming at directly improving the current business of electric van deliveries in London.

The project consisted of three case studies each targeting only one single element and answering one question that the business considered especially important – details of which are explained below. Each case demonstrates how this project achieved its targets, and gives answer on what are the beneficial impacts for the wider society, and how it helps improving the environment for business efficiency and profitability. The Agile 2 demonstrator aims at answering questions that include:

Agile 2 Case Study 1: Fleet Carma electric van management. Can we better understand the most effective utilisation of an all-electric fleet by intelligent electric vehicle specific fleet monitoring and telemetry systems?

Agile 2 Case Study 2: Emakers, an IT solution for home delivery management. Can we initiate an IT platform that allows us to better manage multiple retail clients to maximize efficiency and reduce miles travelled on London's roads?

Agile 2 Case Study 3: Tour planning software testing. PTV Smartour and Map & guide software, and Optrak. What are the beneficial effects on Central London of using routing systems for electric fleet operations?

Before the trials are presented in detail, general information about the business are given below. This is relevant because of the expected expansion and legacy for London: in order to replicate successfully this type business, a decision maker has to understand what are its key characteristics and its commercial framework.

2.2 Parcels delivery business developments, context for all case studies

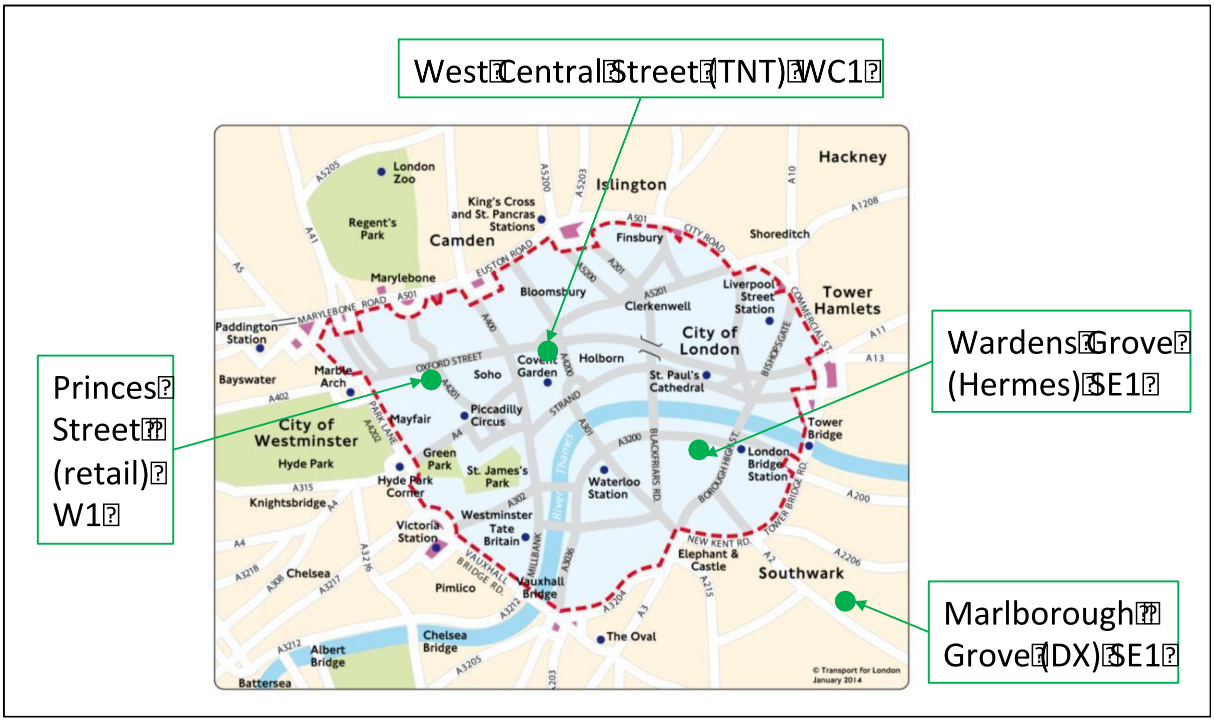


Figure 1: Location of the Gnewt Cargo depots and the main parcel distribution area

Source: Gnewt Cargo Agile 2 project

The Gnewt Cargo business is focused on parcels deliveries to final customers in Central London, starting from four depots located all in the inner part of the urban area. The Congestion Charge zone is the limit of the area of delivery for the clients Client A, TNT, and Client C. Gnewt Cargo is running up to 100 rounds per day for all these clients. Gnewt Cargo's business practice is to use a fully electric vehicle fleet to deliver parcels for its clients.

For two clients, Client B and Emakers, the area of delivery was recently expanded up to the North/South circular ring roads, which effectively doubles the geographic coverage of the Congestion zone displayed above. As of May 2016, this extension was relevant for 4 electric van rounds per day.

What are the baseline business data? The baseline information includes the distance, time and number of parcels collected for Client A, TNT, Client C, Client B and Emakers rounds.

In the period 1 July 2015 to 30 June 2016, there were **13,358** rounds driven on London roads by Gnewt Cargo for Client A. This is more than 1000 delivery trips per month. Each van delivered on average 151 parcels per day. The vans covered a total distance of 148,500 miles in Central London, delivering about 2 million parcels for Client A during the 12 month project. If compared to the first year 2014, for which Client A contracted Gnewt, this represents an increase of about 20-25% in total parcel numbers. In that period however, no new contract was signed and no noticeable qualitative business change took place. The number of vehicles remained stable; the number of routes remained stable. Only the number of parcels increased, which represents an increase in business volume and revenue, and an increase in load factor and effectiveness.

The data for the period 1st July 2015 to 30 June 2016 are shown in Table 1 below. For this KPI statistics, all relevant data are processed.

Table 1: Gnewt Cargo KPIs on Client A rounds and electric deliveries in Central London, 1 July 2015 – 30 June 2016

	Client A delivery rounds	Parcels number	Parcels per round	Miles	Miles per day	Km per day	Km per parcel	Time per parcel
Total	13,358	2,005,728		148,545				
Average			151		11	18	0.119	00:06
Max			668		40	64	8.851	00:53
Min			3		1	2	0.010	00:01

Source: Gnewt Cargo Agile 2 data

The average distance of approximately 11 miles per day for Client A is similar to the previous years.

Table 1 data correspond to Gnewt Cargo rounds for Client A, all driven on Central London roads. The average of 0.119 km per parcel delivered is a good benchmark for measuring the future effects and gains obtained with the IT software implementation, and to compare with the diesel van distribution alternative. It is also a sign of very high efficiency of the delivery business and of a high drop density within Central London. As a comparison, other deliveries in London were estimated for the Client A client, starting deliveries from its depot in Enfield. This shows values around 405 metres per parcel for diesel van delivery in London. Compared to this other benchmark value, **the distance reduction of about 286 metres per parcel is an enormous achievement. It means that for the 2 million parcels per year distributed by Gnewt Cargo on behalf of Client A, there is an estimated saving of 390,000 km (>240,000 miles)** per year, calculated as reduction of the total distance driven on London streets, for an identical service.

For the time spent per parcel, the 6 minutes/parcel appears to be an average. The total time considered is the total working time of a driver between the start of duty and the end of duty. This includes the time a driver spends at the depot loading, driving between depot and first stop; the time spent undertaking all deliveries from the first to the last of the day, including coming back to depot for reloading; the time spent after the last stop returning to depot, and the final checking out at the depot. The total working time is divided by number of parcels to obtain the average time spent per parcel.

Big differences in day-to-day business are a common characteristic for all logistics activities and parcels deliveries. To illustrate this at Gnewt Cargo, maximum and minimum performances show that there is a huge variation in transport demand.

Electric goods vehicles

The fleet consists of purely plug-in electric vans. These vans are all below 3.5 tonnes Gross Vehicle Weight (Table 2). The size of the vehicles is adapted for the parcel delivery business. In many cases, due to the rather small size of the vans, the drivers needs to perform two or more rounds per day to accommodate all the deliveries. This is not a problem because the depots are located very centrally and their accessibility is very good.

There is another reason for the small size of the vans: Bigger trucks cannot access the premises of Gnewt Cargo. When using a 12-tonne lorry, for example for the arrival of the parcels before sorting at the depot, the vehicle has to be unloaded in front of the main door.

The difference in the impact on traffic is rather big, University of Westminster estimates from previous studies concluded a road space occupancy reduction of about 40% for the same delivery performance, when using the vans of Gnewt Cargo compared to a bigger 3.5t diesel van. There is also a debate about the subjective perception of bigger trucks, and the visual difference between a large truck and a small van is very substantial (Figure 2).

However, for fresh food, construction logistics and pallet transport, there is currently no viable, practical alternative to large diesel trucks on the market, even for distribution in city centre. For parcel deliveries, the solution of a smaller, zero emission van is available and competitive.

Figure 2: Visual distinction for goods deliveries vehicles in London. A Renault Kangoo ZE van from Gnewt Cargo in front of a bigger lorry.

Source: Gnewt Cargo Agile 2

Table 2: Fleet specification, Gnewt Cargo depots, Central London, September 2015

Vehicle type	**Renault Kangoo ZE**	**Nissan eNV200**	**MB Vito e-Cell**
Gross Vehicle Weight	2.26t	2.22t	3.05t
Length in metre	4.66	4.56	4.74
Width in metre	1.83	2.01	1.90
Height in metre	1.83	1.86	1.87
Payload (load capacity by weight) in kg	650	703	900

Source: Gnewt Cargo Agile 2 data

By using electric vehicles in Central London, Gnewt Cargo contributes to some of the most important urban policy targets: lowering air pollution in London, improving the air quality, lowering the noise level, and improving the health or residents, working population and visitors.

2.3 Case Study 1: Fleetcarma electric van management

Fleetcarma provides vehicle data and information on the real time location of an electric fleet. It is an IT system based on hardware and software, designed and manufactured by a Canadian company called Fleetcarma. The case study presents the system and the trials. This section starts from the different features and explains how each feature was used during the tests, and what were the main results of the demonstration:

1. *What is Fleetcarma*? Who is the manufacturer? Fleetcarma is a company providing software and hardware aiming at improving the fleet management and the efficiency of the electric vehicle usage. The software and hardware devices are manufactured by Fleetcarma, a Canadian company based in Waterloo, Ontario. The device enables communication between vehicle and head office, transferring data that are important for electric fleet management. The hardware/software combination is called a telematics device. The Fleetcarma data such as GPS location and distance driven are key for the public sector as it enables access to information on the real time localisation and current live performance of the fleet running on London roads.

2. *What are the set up requirements*? The hardware can be mounted on most electric vehicles, including the Renault Kangoo ZE, Nissan eNV200 and MB eVito in use at Gnewt Cargo. The data arrive directly through the Fleetcarma server connected via internet. All data are stored online and can be downloaded by Gnewt Cargo in database format.

3. *How much does it cost*? The licence price for the entire fleet of Gnewt Cargo was set at £60,000.

4. *What does it map*? The system maps the current location of the fleet in real time, and historical data on past positions for all vehicles.

5. *Did it make a difference in terms of reducing number of trips, CO_2 etc.?* It is not the system itself that can make a difference, but the management decisions based on the information provided by Fleetcarma. This information was used to improve the efficiency, by controlling regularly the position of each van and allowing the fleet manager to intervene more rapidly in case of disruptions or problems. As of June 2016, the fleet shows an improvement overall in terms of efficiency and distance reduction, compared to June 2015. It is, however, difficult to derive this benefit directly and quantitatively from the use of Fleetcarma, as other factors, such as manager decisions, influenced this result as well. The key is that Fleetcarma was used to take better informed decisions, which in turn led to an efficiency increase.

6. *What is the range of electric vehicles based on charging*? 60 to 90 km per charge, depending on weight, weather, traffic and other factors. The range did not change after installation of Fleetcarma, but the system allowed a live control of the battery charge status.

7. *How many deliveries per charge*? Each Client A van delivered on average 151 parcels during the demonstration. The vans are used in Central London, with most covering around 11 miles daily distance. It would be practicable for a driver to leave a van up to 2-3 nights without charging and still have enough power to deliver its area in full, but in practice, at Gnewt Cargo, most vans are fully recharged every night.

8. *Is this better than manual routing*? The routing capabilities of Fleetcarma were not leading to shorter trips, because it is not a trip planning and optimisation tool.

Figure 3 shows where the vehicles were located on 15 February 2016. The geographical distribution shows that the vehicles were evenly distributed across Central London for Client A and TNT vans, and only short outside Central London for Client B and Client C vans.

In following picture, the locations of 62 (out of 66) vehicles fitted with the Fleetcarma solution are mapped. Four vehicles, at that time, were located slightly outside Central London Congestion Charge zone. The month of February was selected for this illustration because it is a typical period of logistics business with a normal amount of vehicles on the road performing deliveries. This period is outside the peak demand time for parcel business around Christmas and outside the lower demand time of the July and August summer vacation period.

Figure 3: Location of 62 Gnewt Cargo vans on 15 February 2016 11:00

Source: Gnewt Cargo Agile 2 data, Fleetcarma visualisation webbased software

Following Box shows features that are included into the system.

Box: Features and characteristics of the Fleetcarma fleet information system

Vehicle Report Dashboard: Total & daily average distance driven. Driving energy broken down into battery kWh and charging loss. Time spent driving, idling, charging, & resting. Charging energy. Average starting and ending state-of-charge. Greenhouse gas emissions equivalent & intensity.

Daily Summary: A plot of driving, bulk charging, opportunity charging, and resting events. Distance driven, available range from bulk charging, and potential range from opportunity charging. Temperature, auxiliary load usage, and driver score.

Trip Details: All trips in one table – including the date, duration, distance, starting and ending state-of-charge (%), and electrical energy consumed.

Driver Feedback: Driving score, number of idle events, average speed, % of hard acceleration, and % of hard braking. All these metrics broken down by trip, and graphed to show their trend over time.

Charge Details: A graph of time of day charging energy profile, including the ability to set a target time period.

Alerts : A summary of DTC alerts (vehicle fault alert) for the vans, including the date the alert was opened, the day it was closed, the number of days it was opened, and the specific diagnostics code.

Gnewt Cargo mounted the Fleetcarma system progressivley onto more and more vehicles of the fleet. It started with one van in July and August 2015, then 41 in September 15, 43 in October, 55 in November, 56 in December 2015, and 66 in January to June 2016.

GPS and geo-localisation data: description and analysis

A GPS file is recorded for each vehicle and each day, for the whole year of the project, or since the beginning of the data record on the date when the Fleetcarma system was installed. Each vehicle has one file covering all trips and it contains reference of up to 230,000 different lines with geocodes and time data. Nearly every GPS signal is logged.

All GPS data reports from Fleetcarma are available in excel format. Data were obtained via Fleetcarma telematics, for one van based in West Central Street and delivering parcels mostly in East Central London. All GPS signals from all trips from February 2016 are included in Figure 4. The visualisation of Figure 4 was generated via another software solution.

Figure 4: Visualisation of GPS data log obtained via Fleetcarma, one van in Feb 2016

Source: Gnewt Cargo Agile 2 data; "Tableau" software data visualisation

Performance, energy and emission data: description and introduction

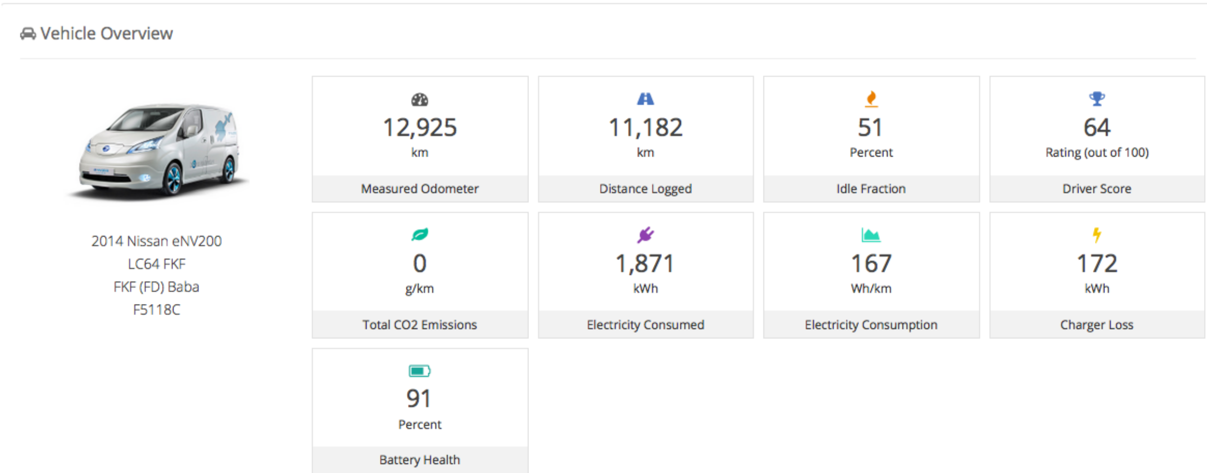
Fleetcarma generates an individual performance report for each vehicle and presents its real time location in London. I It can also generate a historical data record for a selected period.

Figure 5 shows an example of a report for an individual van. Like for GPS data, fleet statistics for all vehicles are available from the beginning of the installation of the software, and up to 30

June 2016. A file was stored for the daily performance of each vehicle. All files are in a dataset that is available as annex to the Monitoring Report M7.

The energy used is electricity purchased from an energy provider with a 100% green electricity generation. There are no greenhouse gas emissions associated with the energy source, and zero tailpipe emission of air pollutants. The only residual air pollutants are from the tyre contact with the street and these emissions cannot be quantified or monitored with Fleetcarma.

Figure 5: Fleetcarma data of a van driven mostly for Client B, 1 July 2015-30 June 2016

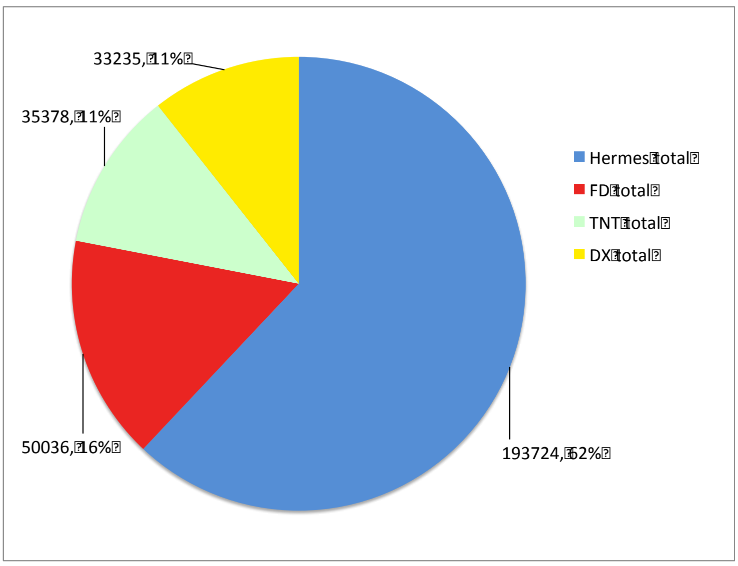


Source: Gnewt Cargo Agile 2 data

Distance data and analysis

Fleetcarma provided a very accurate distance record, with a data breakdown for the clients Client A, TNT, Client C, and Client B. Client B data includes Client B and Emakers distance. The total distance recorded in Central London was about 312 thousand km. Less than 2/3rd of that distance, 193,000 km, was driven for Client A. Fleetcarma gives a good overview of the intensity of traffic generated for the different clients (Figure 6).

Figure 6: Total (km) and relative (% of overall) distance driven for different clients, 1 July 2015 – 30 June 2016



Source: Gnewt Cargo Agile 2 data

To be sure that Fleetcarma provides good data, we looked at another source. Manual records are available for Client A. They show a total distance of 239,087 km for the same period. So Fleetcarma captured 81% of the total distance driven for Client A. Therefore, it can be assumed that the Fleetcarma data covers about 80% of the total fleet performance, which is about 390 to 400,000 km/year.

The big advantage of Fleetcarma over management information provided with manual records is that manual entries include errors that require intensive "data cleaning" to get a workable dataset. Therefore, even after implementing Fleetcarma, there is a bit of uncertainty within the demonstration, and this has the consequence to lower the quality of the estimate for the total duration of the project. The margin of error for performance is estimated at, or below, 5%.

Electric energy records and analysis with Fleetcarma: The electricity usage data were collected via Fleetcarma. Table 3 shows the overall average for the entire period and the entire fleet, and here again the result show big differences between clients. For Client A, Gnewt Cargo drives on average a shorter distance and uses slightly more energy per km than for the other clients. This is due to the higher drop density of deliveries and higher number of parcels carried per day.

Table 3: Fleetcarma data on average fleet performance and energy use, 1 July 2015 – 30 June 2016

	Annual Distance (km)	Average Daily Distance (km)	Idle (%)	Electricity Usage (kWh)	Standard Charge (kWh)	Eco Driving Score	Hard Acceleration (%)	Hard Braking (%)	kWh/ km
Annual total all vans	312,942								
All clients yearly average /van	5,047	25.1	70	1,323	1,607	74	6	6	0.335
TNT average/van	5,991	30.3	62	1,442	1,748	66	7	7	0.292
Client A average/van	4,305	19.4	74	1,233	1,511	76	5	6	0.356
Client B average/van	10,007	58.6	52	1,762	2,010	66	6	7	0.201
Client C average/van	5,539	34.4	64	1,508	1,851	69	6	6	0.337

Source: Gnewt Cargo Agile 2 data

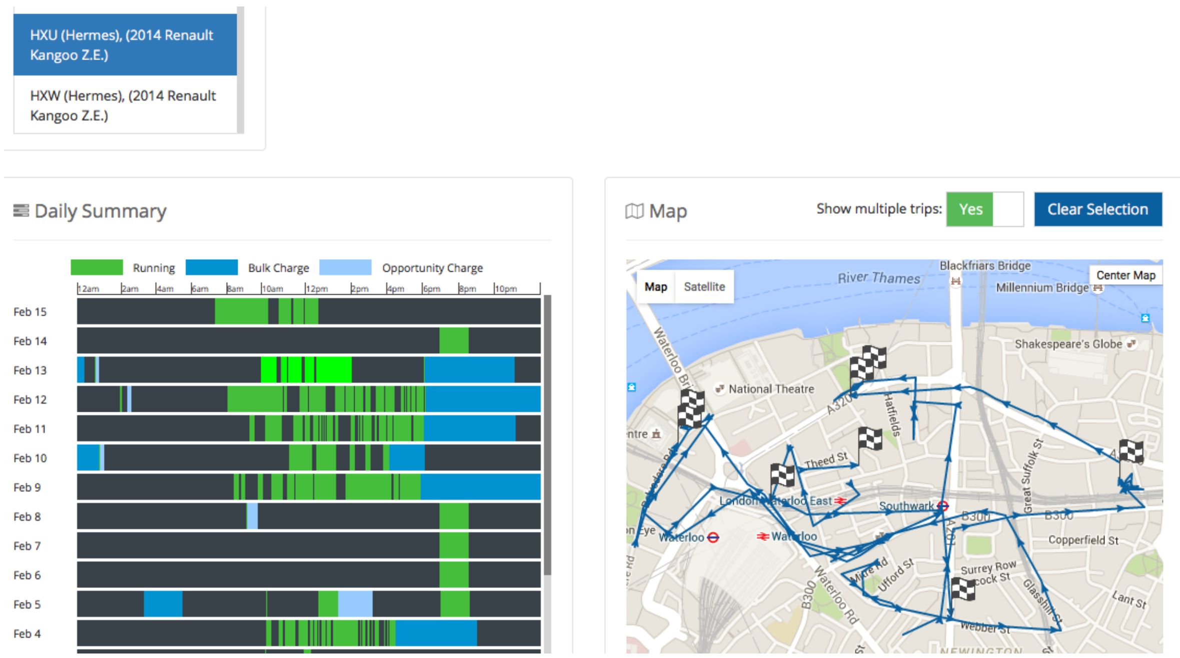
Driving range analysis: The Fleetcarma data shows that the maximum achievable driving range that can be achieved when starting from the depot with a fully charged battery is varying a lot: The range extends between about 60 and 90 km per full charge. This corresponds to nearly a 50% variation, depending on the day business, load, speed, outside air temperature and destination.

Despite this strong variation in range and battery use, all vans were operated within the daily range tolerances of the electric vehicles of this type. This suggests that a larger uptake should not be limited necessarily due to the perceived 'range anxiety' that is prevalent amongst would-be EV users. However for the Client B delivery business, the distances travelled beyond Central London has meant on occasions the range has become a cause for concern.

Time of use analysis: Before using the exact information provided by Fleetcarma, it was not clear how much of the day a driver spent running on the road, and how much time is spent parked while completing the delivery, including walking and waiting time. This information is crucial in order to better understand how to increase the future efficiency of the delivery business.

The utilisation ratio varies between 10 and 22% of the total working time, counting from the first start of the vehicle in the morning to the last switch off in the evening. Utilisation ratio is measured as percentage of total time spent running on the street. The time when the van is idle and switched off during loading or unloading operation is excluded.

Figure 7: Fleetcarma GPS traces of a delivery round performed on 13 Feb 2016



Source: Gnewt Cargo Agile 2 data

A feature of Fleetcarma software is the possibility of mapping past delivery trips (Fig. 7). However we have discovered the strength of the GPS signal is a problem in Central London (due to canyoning) whereby the signal cannot always be established due to the high-rise nature of the buildings and therefore the routes are not completely represented on the traces showed in the map. Figure 7 gives an example of this shortcoming. Other systems need to be used to obtain a better match of real routes driven and mapping visualisation.

Control of the driver behaviour and performance

The fleet manager and depot managers use Fleetcarma on a daily basis, looking where the vehicles are located, and, by doing so, controlling the driver behaviour.

Limitations and shortcomings of using Fleetcarma

The solution has a dedicated use, which is to facilitate the management of a large fleet and control the driver performance. As such, the product is fully operational, fit for purpose and useful. It does not replace tour planning or navigation software and did not lead to a direct reduction in mileage, or a reduction of emission as such. However, the better informed decisions lead to an efficiency improvement.

Legacy and potential future benefits

As legacy, London would benefit from having a high number of vehicles connected with this type of software, generating a part of the so-called transport “big data”. This information is not only relevant for the day-to-day business, but it can also serve as powerful tool to better understand and manage clean transportation in London.

2.4 Case Study 2: Emakers, an IT solution for home delivery management

- *What is Emakers*? Who is the manufacturer? Emakers is a Spanish company providing software aimed at improving client communication and the efficiency of the electric vehicle delivery. At the same time the company also provide a logistics delivery service for retail clients, with Gnewt Cargo is performing the final delivery on their behalf.

  The software features are dedicated to, and linked with, the deliveries of Emakers clients. But it also allows the addition of new clients on top of the existing ones. Included in the software package are features for order management and geolocalisation of the final destinations of delivery. It also provides a basic routing capability.

- *What are the set up requirements*? The technology is internet-based software provided by a Spanish company. The data arrives directly from the Emakers server, connected via internet. All data are accessible online, and are downloaded in database format to Gnewt Cargo servers.

- *How much does it cost*? The licence price for the software used at Gnewt Cargo was set at £10,000.

- *What does it map*? It tracks the route at the end of the day, and the order of the different addresses of deliveries before the start of the day.

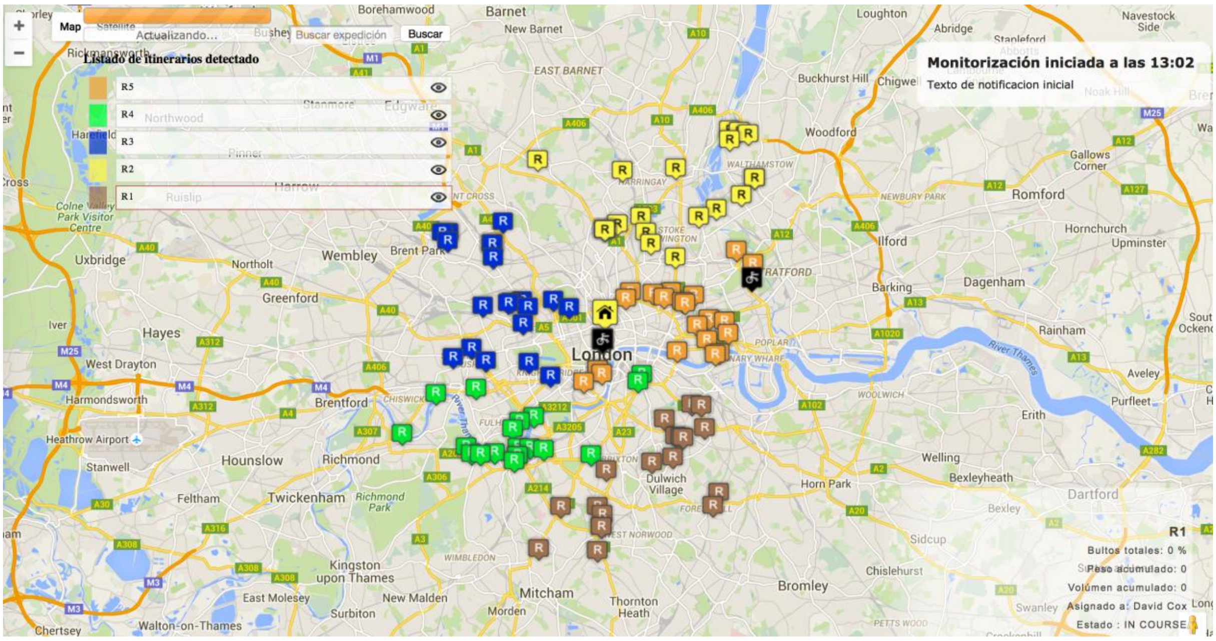
- *Did it make a difference in terms of reducing number of trips, CO_2 etc.*? It is not the system itself that can make a difference, only the management and driver decisions based on the information enables improved efficiency. As of July 2016, the fleet running the Emakers routes showed an improvement overall in terms of efficiency and distance reduction per parcel. Gnewt Cargo could improve efficiency because it was possible to combine the freight of multiple clients into a unique van round. See details on the efficiency improvement below.

- What is the range of electric vehicles based on charging? 60 to 90 km per charge, depending on weight, weather, traffic and other factors. This is not influenced by the Emakers capabilities.

- How many deliveries per charge? Is this better than manual routing? Yes, the routing capabilities of Emakers lead to efficiency increases, mainly because of combined trips for different clients. The Emakers system allows different retail businesses to deliver to their customers in a consolidated way.

Testing of Emakers

Figure 8: Map of the 5 routes run for Client B delivery rounds on 26 October 2015



Source: Gnewt Cargo Agile 2 data

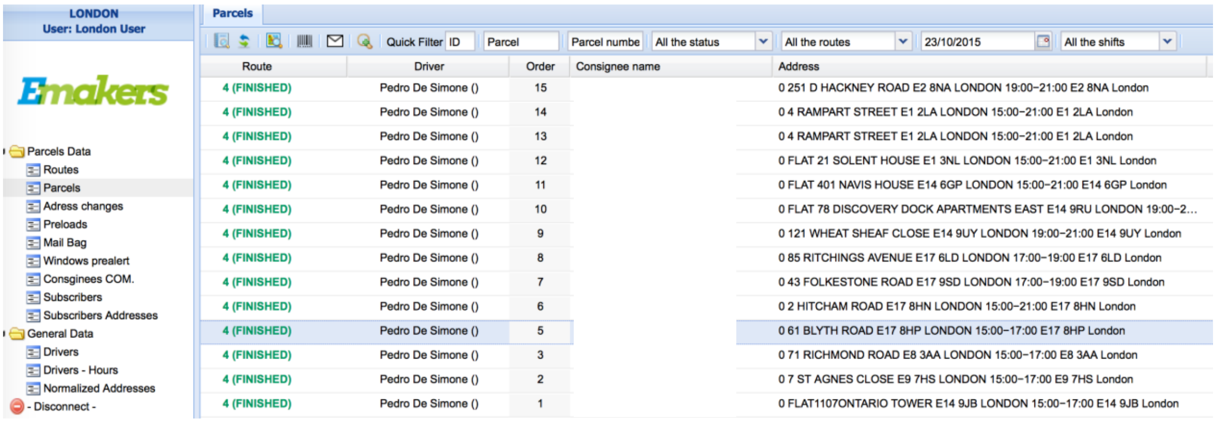
The software features of Emakers, such as round trips generation, are presented in following Figures. Emakers was implemented at Gnewt Cargo and provided a communication platform for retail clients connected via internet. A feature that was improved during the trial was combining trips for multiple clients into a single operative platform.

Figure 8 shows all the delivery points supplied during the 5 rounds driven for Client B, and run on 26 October 2015. On that day, the routes were driven in an extended area of London, largely outside the Central London Congestion Charge zone, but within the outer ring road.

Due to the longer distance and the tight schedule, problems such as battery range and missed time window appear. These challenges are due to the lack of experience with the extended zone of distribution.

Figure 9 shows the basic functions of the order management features used on a daily basis.

Figure 9: Overview of Functionalities of Emakers Software



Source: Gnewt Cargo Agile 2 data

The average Emakers distance per round is relatively high at 30km (Table 7). The distances observed during the trial were far above the average of 18-19 km performed for the Client A client, and above the 26km average for the entire fleet of Fleetcarma vehicles. This relatively longer trip distance is due to the area extension for Client B. But, to compare with a standard diesel operation in London, a Gnewt driver covering 30 km is still doing less than half the average distance of 61 km per round driven by a TNT driver coming to London from the Barking depot.

During the period 1-23 October 2015 the Gnewt drivers performed Emakers deliveries for Client B at an average of 12 parcels per day (Table 4). Which is much lower than the average of 72 drops/day for TNT, the 151 drops for Client A. This large spread of logistics performance is due to the different markets and the type of fresh food for the delivery business targeted by Client B and Emakers.

Table 4: Baseline on the Emakers jobs for the period 1-23 October 2015

Total distance in km for the whole period 1-23 Oct 2015	2,642
Total number of deliveries for the whole period	1,018
Average total distance of all Emakers recorded trips per day, in km	132
Average number of deliveries per day	51
Average distance per round in km	30.4
Average number of deliveries per round	12
Number of days at which parcels were delivered	20
Number of rounds observed in the period 1-23 Oct	87

Source: Gnewt Cargo Agile 2 data

Compared to the Client B delivery situation before there was an efficiency improvement during the trial, with an overall combination of trips with the Emakers routing and scheduling software, enabling an optimisation of Client B, Emakers and TNT delivery jobs.

Due to contractual changes with Client B, it was not possible to proceed with the routing optimisation of Emakers. Instead, Emakers software was used for client communication and order processing. The use of the Emakers software had a beneficial impact on overall efficiency, mainly because of the combination of incoming delivery jobs (orders) from different retail companies into one single system, but the scale of this impact could not be evaluated with hard data.

The reason why no hard data for trips could be obtained is the absence of 'before' data; it is not known where the parcels were coming from prior to the Gnewt Cargo contract.

Shortcomings of using Emakers

The solution has not been improved in a way that was intended, and the day to day use remains slightly under expectations. The system is not very user friendly and requires quite intense manual data processing, especially when combining routes for different clients, or allocating parcels from one route to another. The system does not offer algorithm based tour optimisation. The only optimisation lies in the commercial possibility for Gnewt Cargo to become active as Logistics Service Provider and combine the Emakers orders with the orders from other clients. This type of trip planning optimisation worked very well and the trial met this target.

But overall, the routing performance remained suboptimal for Gnewt Cargo. Therefore, other IT products such as dedicated routing systems and tour planning systems were considered for use. As the shortcomings of Emakers became clear, these other optimisation systems received a lot more attention during the trial, but, as opposed to Emakers, these other systems were not in use in the everyday business of Gnewt Cargo.

Legacy, benefits and future potential

The key functionality of Emakers is beneficial for productivity and overall logistics efficiency: it allows combining multiple clients into a single round. At this stage, Emakers can be considered as sub-optimal, but nevertheless practical and functionally adapted IT solution that can be continuously used on a daily basis.

The two main challenges to be overcome In order to realise the future potential are improved usability of the software solution and a better link to the Gnewt Cargo routing and order management system.

2.5 Case Study 3 Tour planning software testing. Optrak, Podfather, and PTV Smartour

2.5.1 Introduction

The idea behind testing tour planning in urban area is to find the ideal sequence of customer sites to be served by each vehicle. Currently no urban logistics businesses are using this kind of software as driver knowledge is considered unbeatable. In Central London, the number of different addresses is around 300,000, the density is very high, and the challenge for route planning is high.

The goals of IT support for route planning are not new; they depend on the purpose of the plan and optimisation being carried out. Lowering costs to a minimum is always top priority, but to achieve this, other key goals are reducing the distances covered as much as possible, and lowering the time required to complete a tour as much as possible. Another goal is to minimize the number of vehicles being used. In addition, non-monetary issues and factors that are difficult to quantify, such as optimal delivery service, delivery time windows, or best possible capacity utilization and load factor of the vehicles, are targeted as well.

Currently only depot management and driver knowledge are used at Gnewt Cargo to pursue these targets. Every morning, the list of items arrives together with the parcels to be distributed, and there is no time for the drivers to undertake any software run or route calculations. Usually it takes at least 30 minutes to 1 hour to order the parcels for the day and to load the parcels into the van in the right order.

Gnewt Cargo uses business data to plan the delivery rounds. In the daily business, rounds are planned manually, and the deliveries are not ordered according to the software data transmitted from the clients, but the ordering of parcels is done through a mix of client's listings suggestions and driver knowledge.

While most large logistics companies have the resource to develop internal tour planning software as an in-house solution, small and medium-size businesses cannot afford the costs of such a system. The market for available software products was therefore analysed in 2015, and a shortlist of few potential tour planning applications was generated. The shortlist comprised PTV Smartour, Optrak, and Podfather, all capable of planning a tour and optimising multiple drivers' rounds and area served.

IT support, to be effective, would need to improve considerably, because all commercial systems are designed to streamline long distance logistics. All these capabilities can be considered invalid for short distance trips in urban area from the driver point of view. Testing initially led to tour suggestions with much longer trip distances than would be needed. It was immediately clear for the software partners and for Gnewt Cargo that the challenges are high and that adaptations to current system design would have to be performed during the lifetime of the project.

In the first half year of the project, in 2015, the Tour Planning software testing was prepared. The time October to December 2015 could not be used for real trial, as the strain for drivers was high. The trials started in early 2016 with the phases of implementation and data processing. A dedicated computer was purchased, and software was installed.

Optrak and PTV support teams trained the Gnewt Cargo staff responsible for scheduling and IT. The training took place over 3 days for the PTV Smartour software and one day for the Optrak software. The Podfather software was tested without specific training.

Data were collected more extensively for the Optrak and PTV Smartour tests.

What is the tour data when it arrives at Gnewt Cargo? Every early morning, parcels arrive from the depots of the clients. Simultaneously, the data with the address lists arrives however because of the multiple clients; the data arrives in multiple formats.

Gnewt Cargo uses the IT system provided by Client A, the products of the software company Blackbay. This software is used for the orders list, parcel scan with hand held device, proof of delivery and driver communication. It is not possible for Gnewt Cargo to use the Blackbay system for routing optimisation. However, the lists of client's delivery addresses can be exported in Excel format, and then used for the routing optimisation.

For Client B and Emakers parcel business, the data arrives at Gnewt Cargo via the internet in standard csv format, which is usable in Microsoft Excel.

Due to the complications with the heterogeneous data format of Client B and Emakers, the routing and tour planning trials were performed using the Client A routes. However, all data can be normalised by using the streamlined data and management information that has been designed during the project.

2.5.2 Optrak trial

Optrak is a pure trip planning and routing system for freight transport. The software provider is based in UK and the system offers the possibility to calculate the shortest itinerary and combination of stops including timing and distance driven.

Typically, a scheduling manager would obtain a delivery list in the morning and would upload this list into the Optrak system, which is available online. This order list would then be processed and the function 'optimise' would is used to obtain the shortest distance for each trip. It is also possible to combine different destinations and routes and to optimise multiple routes all together.

The objective of the trial was to adapt the current Optrak software to the specific business of Gnewt Cargo, aiming at obtaining optimised routes and plans that would be better and shorter in distance and in time compared to what a driver would do manually.

During the Optrak trial;

1. Optrak developed a conversion program to take the courier report data arriving at Gnewt Cargo from Client A (via their IT provider Blackbay) after deliveries have been made. This then creates to see the actual routes taken, and the sequence that they were taken in. This is the baseline data for routing, without optimisation.

2. Gnewt Cargo experimented with timings for parcels, in order to calibrate the Optrak routing software system and match the system with the recorded route times in Central London as closely as possible. All systems had to be educated to work on predefined rules for example:

How long does it take to complete a delivery on average? This type of information needs to be calibrated in order to create viable outputs.

3. Gnewt Cargo optimised the individual driver's work and generated a comparison between Optrak-optimised routes and effectively driven routes.

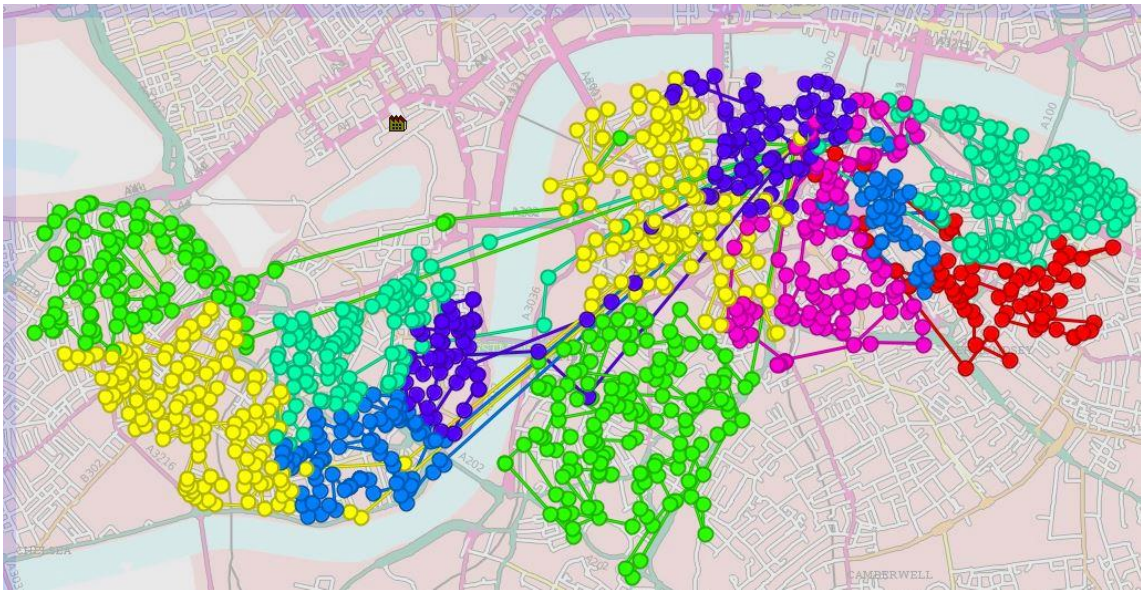
4. Optrak provided a conversion to take data from Blackbay report (i.e. the orders listed in original Client A sequence, before deliveries are made) and create input to Optrak that produce optimised routes. In theory these optimised routes allow Gnewt Cargo to run trips that should be better than the manual planning of Client A rounds. This was done in April and May 2016 and findings are available.

5. Gnewt Cargo was not experimenting with a small number of rounds based on the Optrak routing, because the routing results were never reaching the point where the Optrak route would be better, shorter and quicker than the drivers' knowledge.

The result was available in June 2016. Figure 10, below, shows the optimised routes tested in early 2016. The period was suitable for a trial because it corresponds to an average business situation without peaks or lows in goods volume. The total distance of the routes effectively driven on 22nd January 2016 by the Gnewt Cargo drivers for Client A is available as baseline. Gnewt Cargo uploaded the Client A round data obtained after the deliveries on 22 January 2016. The data are based on the manual tour planning data for 15 delivery rounds performed by Gnewt Cargo for Client A on that day. These routes were uploaded into the system. Figure 12 shows the results of the optimisation of the routes with Optrak. Instead of 15 routes, the system proposes 12 routes, during the same total time.

These preliminary results indicate a reduction in total distance of 25% after optimisation compared with the distance as given by the original list. Moreover, 3 vehicles can be saved, reducing the number of trips and the number of vehicles on the road by 20%, compared to the original list of routes driven on 22nd January. However, this set of routes was calculated afterwards and it was not possible to effectively test-drive all these routes again, and verify the exact distance and practicalities of these results.

Figure 10: Optrak optimisation routes for Client A on 22 January 2016



Source: Gnewt Cargo Agile 2 data

This result had to be validated with further refined runs, performed in the next trial steps of Optrak. As of June 2016, however, all further trials to obtain routes that would be effectively shorter than manual routing after Optrak optimisation, were negative. None of the optimised routes were shorter than what a driver would have done anyway.

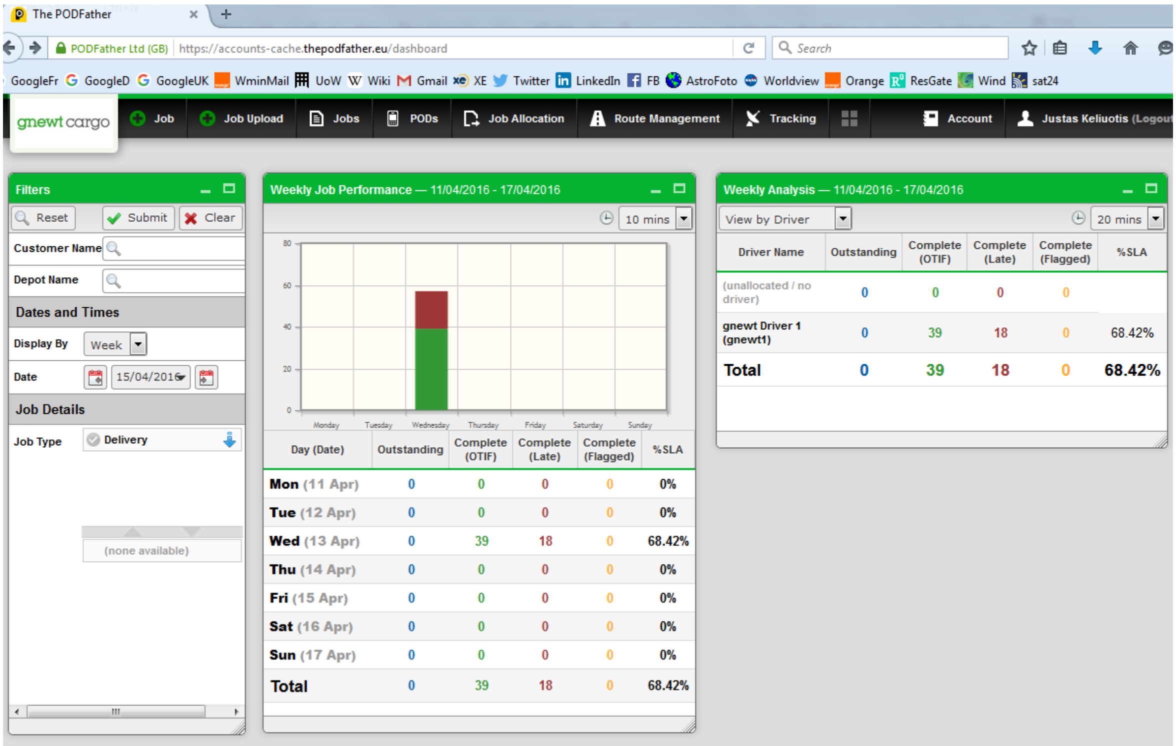
The improved Optrak software was not suitable for future business implementation at this stage.

2.5.3 Podfather trial

Podfather is a web based software application linked with a handheld device. Main functionalities include job allocation, route management, and tracking. Figure 11 shows the standard dashboard of the Podfather webpage with the data of the deliveries for an average day, in this case 13th April 2016.

Gnewt Cargo recorded the job performance, which is related to the number of parcels delivered. April was again a good test period, with an average volume of goods delivered.

Figure 11: Podfather web-based dashboard with job performance of the trial, 13 April 2016



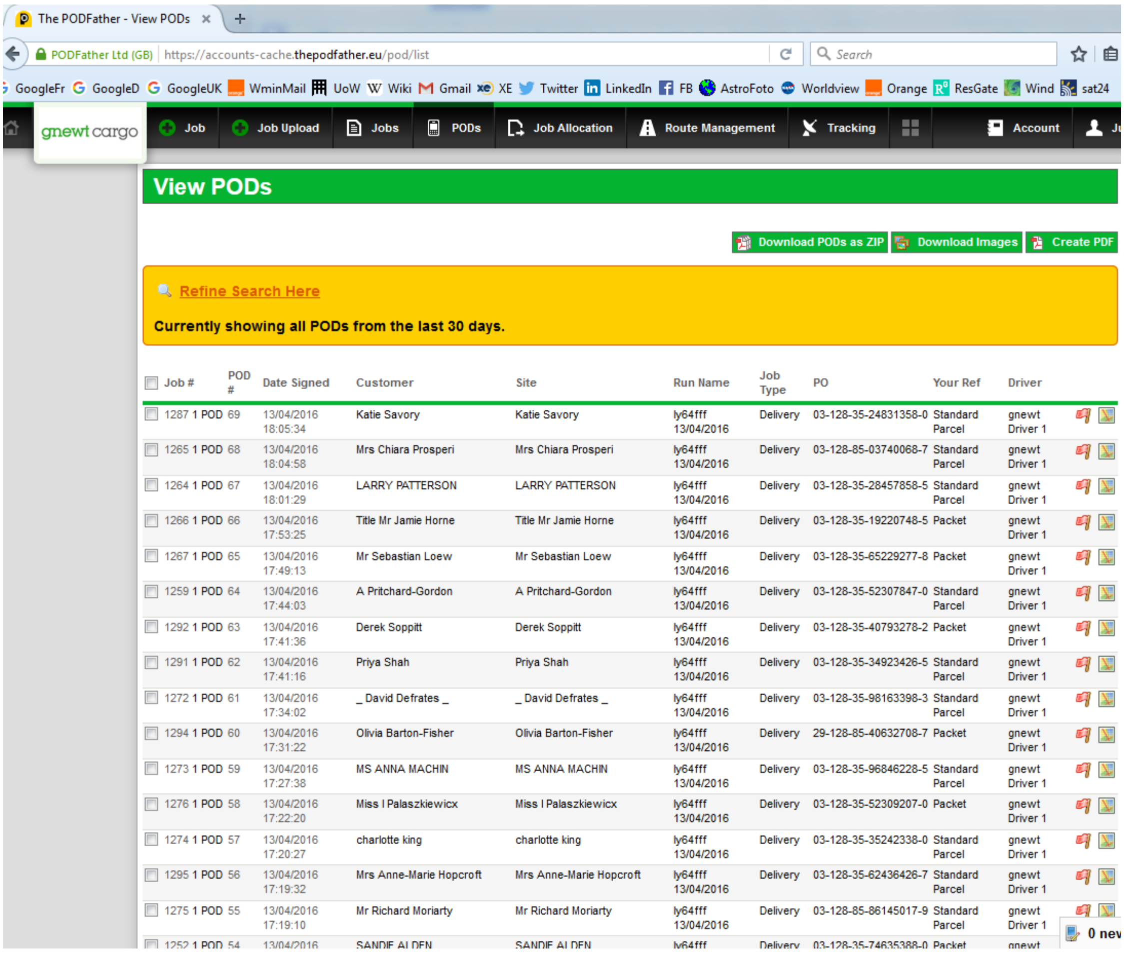
Source: Gnewt Cargo Agile 2 data

Source: Gnewt Cargo Agile 2

Figure 12 shows the Podfather web-based routing management functionality with an example of a set of delivery locations for a day in March 2016.

Figure 12: Podfather routing data example, March 2016

Figure 13: Podfather customers' data with delivery confirmation and routing example

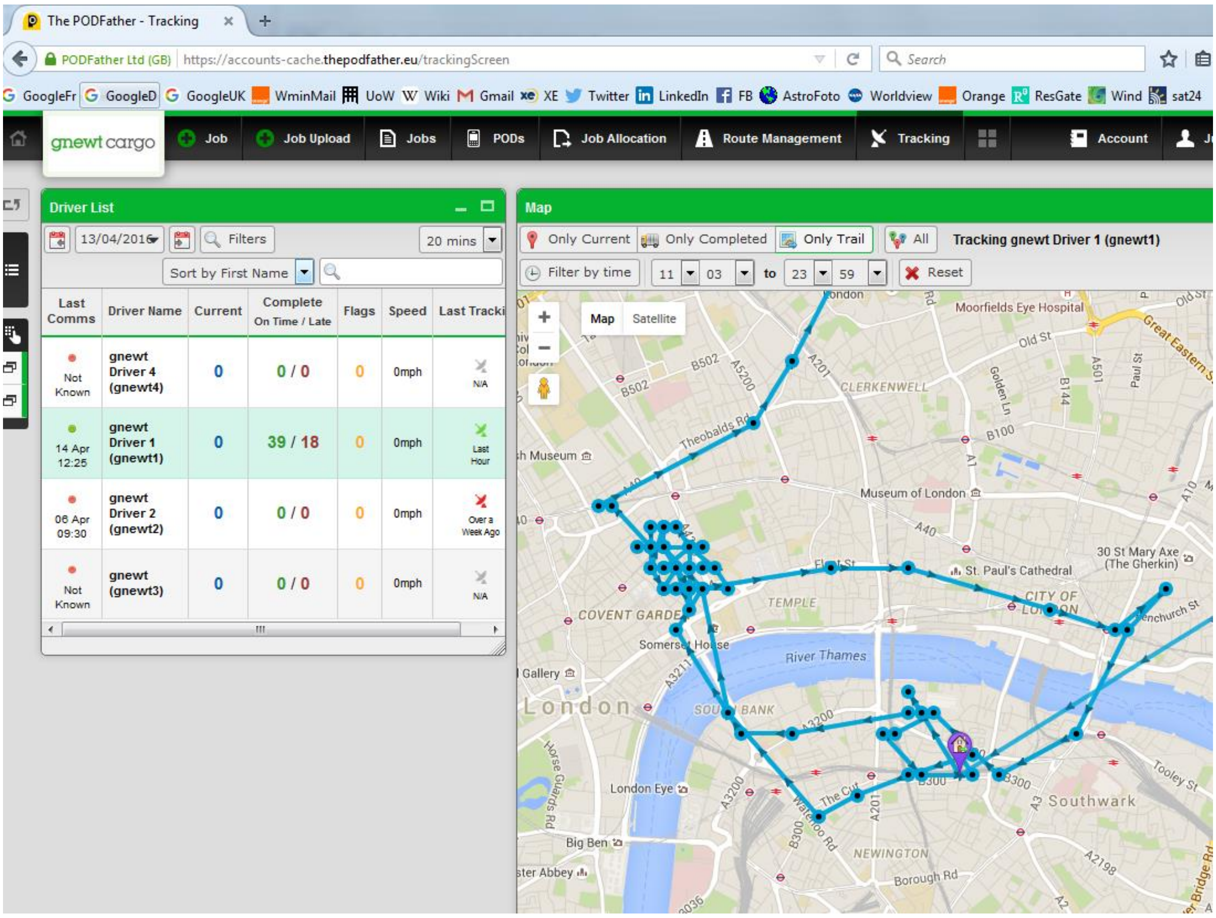


Source: Gnewt Cargo Agile 2 data

On Figure 13, original Podfather and Gnewt data were anonymised. Each delivery point of this delivery list is recorded with coordinates; this information is not available as general map overview. The available overview is called 'Tracking' and shows a map of the delivery trip. The single points (dots in blue and black), as can be seen in Figure 14, are different from the points of delivery. The links correspond to a hypothetical straight line between two dots. It is unclear if the dots on this 'Tracking' map representing either a stopping point, a delivery point, or another location.

At a rather early stage, it became obvious that the trip planning capabilities were not leading to the expected improvement. These shortcomings lead to a rather early conclusion of the trial, as the routing capabilities for the day to day business remained under expectations. It was not possible to generate a route with Podfather, that would be shorter and quicker than a driver would have done manually. The Podfather IT solution is not considered suitable for business implementation at Gnewt Cargo at this stage.

Figure 14: Tracking of the delivery trips performed with Podfather on 13 April 2016



Source: Gnewt Cargo Agile 2 data

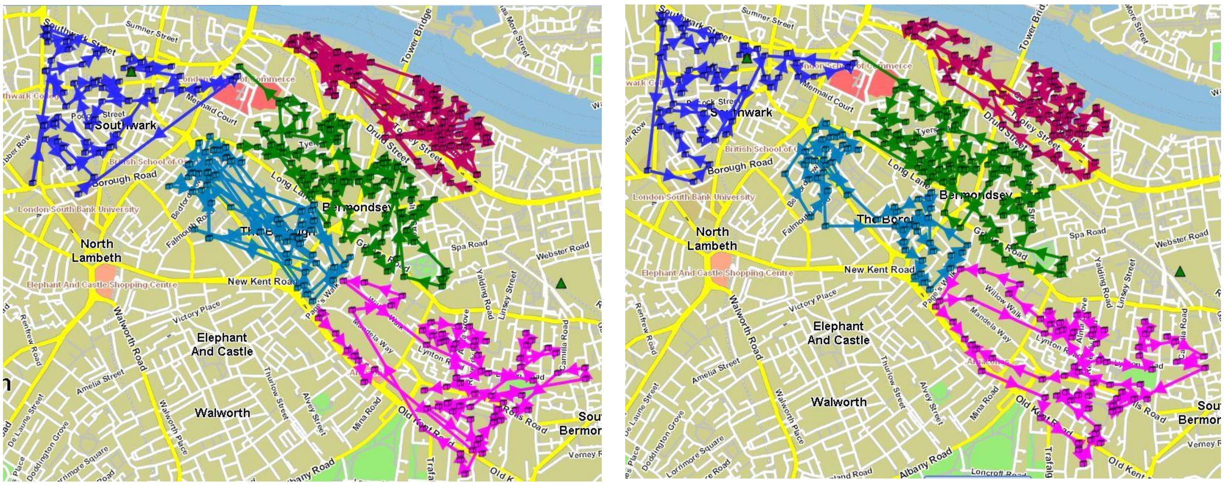
2.5.4 PTV Smartour trial

The PTV trial started in January 2016, and the PTV Smartour software solution was running at Gnewt Cargo. PTV Smartour is again a dedicated route, tour planning and scheduling solution aiming at reducing the overall distance and time of deliveries. This system was developed in Germany for long distance transport. PTV Group is an IT company based in Karlsruhe, Germany, and is active in 60 countries.

The solution works in a similar way to the others: the order list is uploaded into the system via an online web access. Then the optimisation function allows producing a new list with an optimal route for each driver. A combination of routes is also possible. A first analysis was performed on the Client A rounds for the 4th of February 2016, then different tests continued in March until June 2016.

For the PTV software test, the objective is to similarly analyse the difference between normal day-to-day tours with manual planning and the software optimisation. The first results were available early for 5 rounds for Client A on a February day in the Southwark area (Figure 15).

Figure 15: Client A rounds on 4th Feb 2016 in Southwark, before (left) and after (right) optimisation



Source: Gnewt Cargo Agile 2 data, PTV Smartour

This result immediately shows a problem with the Client A data obtained via the current information system. The routes in the left image were not driven exactly how they are shown on the map. In this map, each dot corresponds to the location where the Gnewt Cargo driver scans the parcel barcode information. Sometimes the scan occurs exactly at the place of delivery, but sometimes the driver is in a rush and scans the barcode a few minutes later at another place. Thus the original Client A data on the parcel scans are potentially not in the right sequence of delivery, not at the right place, and not at the right time. Therefore, there is a very big difference between the two routing datasets (Table 5).

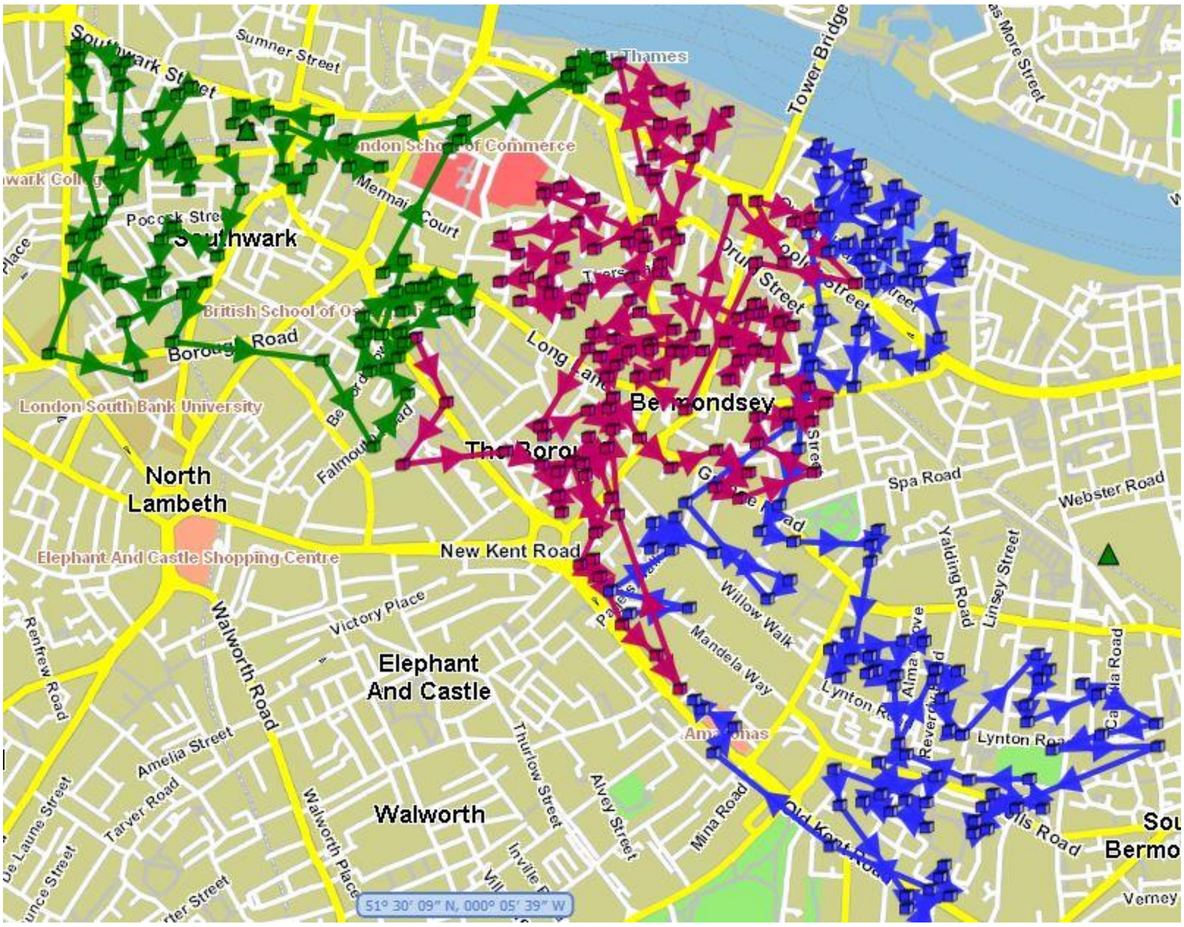
Rounds	Original Client A data Distance in km without optimisation	Optimised Client A data Distance in km with PTV Smartour optimisation	Reduction in %
1	27.50	20.89	24
2	40.98	13.22	68
3	37.40	17.98	52
4	44.62	17.14	62
5	20.09	11.88	41
Total	**170.59**	**81.11**	**52**

Table 5: Distance driven for 5 rounds on 4th Feb, with and without PTV optimised routing

Source: Gnewt Cargo Agile 2 data

The PTV Smartour allows for changes to the area of delivery to optimise the overall delivery situation. Figure 16 presents the solution after optimisation including area reconfiguration.

Figure 16: PTV Smartour optimisation with area reconfiguration



Source: Gnewt Cargo Agile 2 data

The reconfiguration of the entire delivery area can be seen in figure 16. The results of the PTV optimisation, including the merging of the delivery area, shows that out of 5 rounds, only 3 would be needed This indicates a **potential reduction of 56% in the number of trips and number of vehicles on the road**. But this important effect might also be strongly overstated, due to a distortion with the round data obtained with the current logging system.

For almost all trips, the real data shows a shorter distance than the data obtained after running the optimisation software. In one case during the second week of April 2016, and after many months of improvement in the software application and useability, it was possible to run an optimisation that was shorter than the trip that would have taken place without optimisation. This one time beneficial result would need confirmation before an improvement could be claimed with certainty.

A further set of verification steps was conducted, with real test drives. The objective was to confirm with real drives if the optimised routes would be shorter than a driver would have done without optimisation.

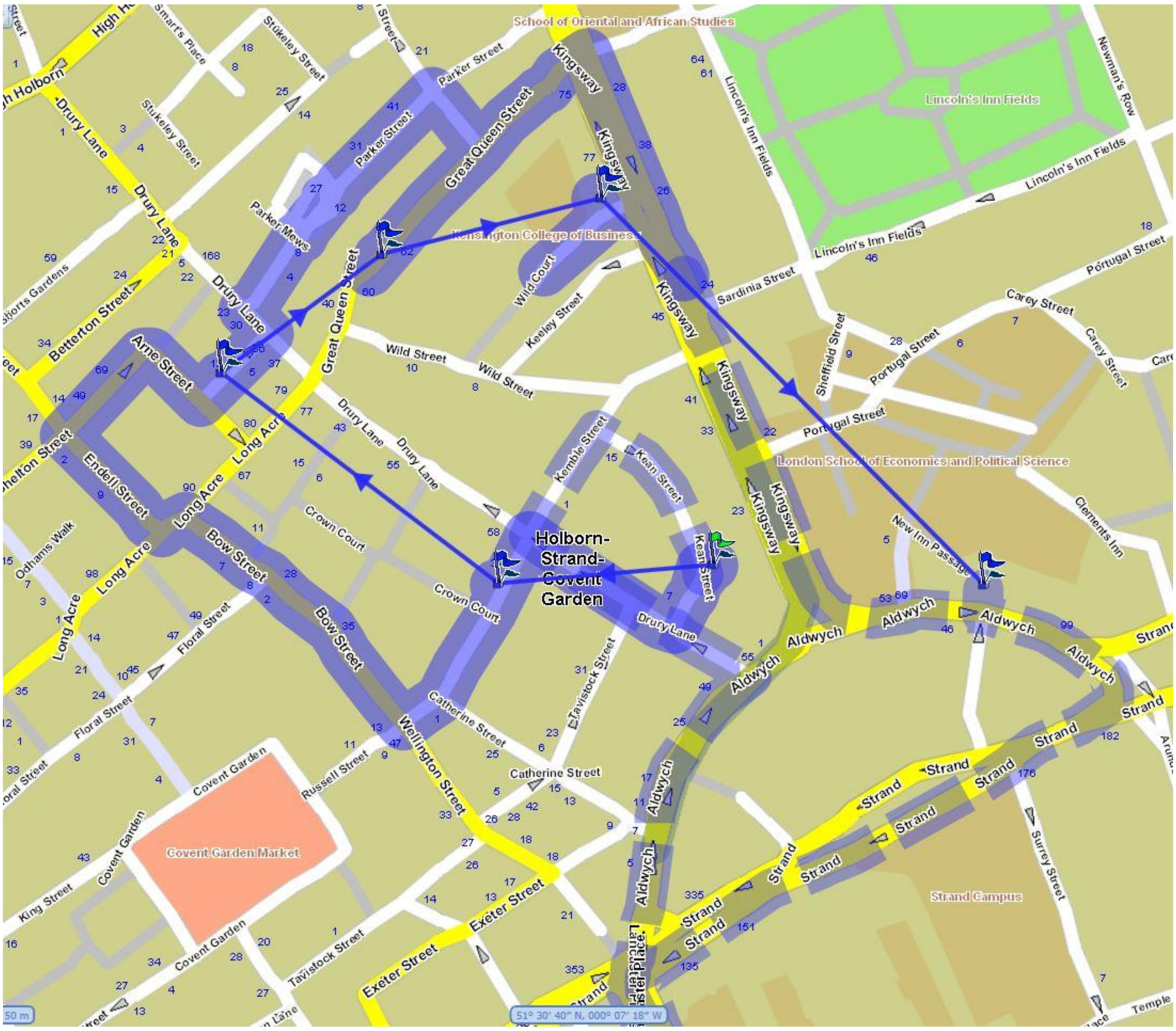
Combination of pedestrian and street routing optimisation

An innovation was made at this stage during the trial; combining pedestrian and street routing optimisation, PTV and Gnewt Cargo worked together to reduce the number of stops by allocating addresses to stopping areas in Central London.

In one example, the number of stops was reduced to 5 for 57 parcels delivered on 14 April 2016 (Figure 17). This solution was tested with real drives, after manual optimisation.

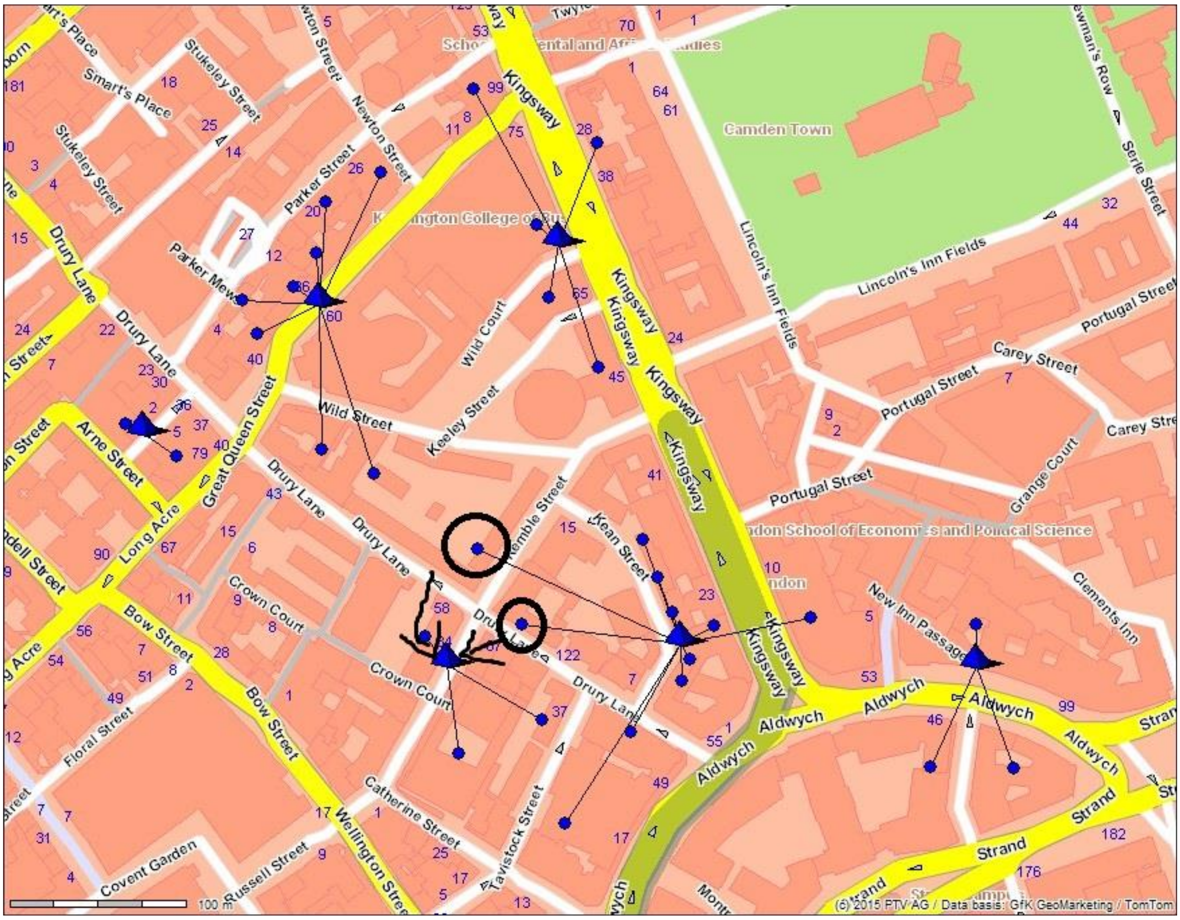
The manual work consisted of looking at the different delivery addresses and grouping them around central loading bays or stopping points that would be less than 100 metres or less than 50 metres away from the entrance doors. Manually, the tour-planning manager assigned each entry in the list of orders to a central stopping point (Figure 18).

Figure 17: Tour planning combining pedestrian and road distance to reduce total number of stops, PTV Smartour solution, effectively driven on 14 April 2016



Source: Gnewt Cargo Agile 2 data

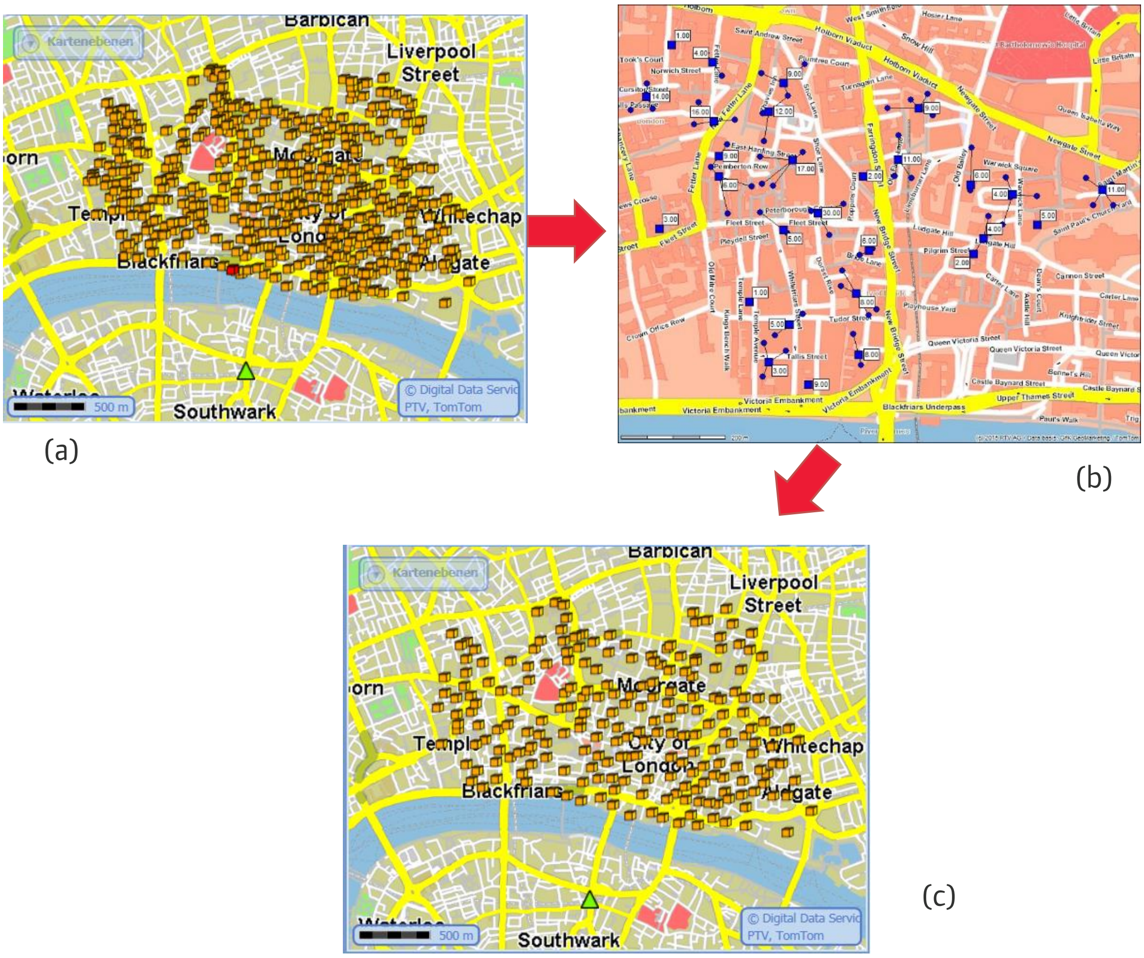
Figure 18: Manual work linking delivery addresses with central stopping points to reduce total distance and number of stops, driven on 14 April 2016



Source: Gnewt Cargo Agile 2 data

Groupage of orders

Figure 19: Initial delivery points (a), groupings (b), stopping points reduced by 50% (c)



Source: Gnewt Cargo Agile 2 data

Figure 19 presents one of the trial results obtained by testing in May and June 2016. Initially Gnewt Cargo and PTV considered a list of 480 stops for Client A deliveries .Grouping of orders within a radius of 100 metres was done with the help of excellent geodata and an external groupage function in PTV Map& Market. As a result, the number of stops was cut down to 218, a reduction of more than 50%.This finding was positive and lead to effective test-drives on multiple days.

On these trips with fewer stopping points, the average distance of 11 miles per day was reduced by about half, down to 5.5 miles per day, of which 1 mile was the one way distance to the area. So the traffic in the target area was really reduced down to a very low level.

Optimisation of the area of delivery

Currently each driver serves a dedicated area. His knowledge is key for successful service and high completion rate. The trial considered the optimisation of the area of delivery, along with a reorganisation of the trips and a slight change of area for the drivers (Figure 20).

Figure 20: Area and trip reconfiguration after PTV "territory planning" optimisation

PTrip	Duration	Deviation relativ	Length in mi	Deviation relativ
1	06:53	-6%	8,56	-6%
2	07:33	3%	8,76	-4%
3	10:21	41%	11,98	31%
4	07:16	-1%	10,40	14%
5	05:49	-21%	6,94	-24%
6	06:13	-15%	8,11	-11%
SUM	44:06		54,75	
AVG	07:21		9,13	

territory	Duration	Deviation relativ	Length in mi	Deviation relativ
1	07:00	-3%	7,45	-8%
2	06:43	-7%	7,10	-12%
3	06:56	-4%	7,34	-9%
4	08:28	17%	9,37	16%
5	05:30	-24%	7,36	-9%
6	08:45	21%	10,02	24%
SUM	43:24		48,63	
AVG	7:14		8	

Source: Gnewt Cargo Agile 2 data

In theory, this 'territory planning' worked well, with a slight reduction in time and about 10-15% reduction in distance driven, as can be seen in the Tables in the lower parts of Figure 20. But in practice, this solution would imply that the driver knowledge would have to be extended to a much wider area than currently, so this solution was not tested in real delivery rounds.

Due to the constraints of the trial, it was not possible to modify the PTV Smartour software to include the capability of joining pedestrian and driving distance as a regular feature. So the important saving has only been shown with manual entries and manual combination of delivery addresses. Manual entries into the system are time consuming, not very user friendly, and cannot be made on a daily basis.

Therefore the tested PTV Smartour solution remained below expectation. We discovered that the most beneficial effect, the reduction of the total number of stops by using centralised loading bays, could only be implemented after a long manual procedure. In the day-to-day business, this would take too much time, but this is where the main idea for a future project was born.

At the end of the trials, therefore, it is too ambitious to claim a 50% reduction because these positive results might not withstand further testing of multiple trips in different business situations. Further testing will need to take place after the software has been further developed to include the beneficial features.

As of June 2016, at the end of the trial, the functionality of the route optimisation in PTV Smartour offers the possibility in future developments to link pedestrian and van driving routes and combine different areas to optimise the overall delivery situation, saving time, distance and cost. However further software adaptation and demonstration projects are needed to achieve this.

2.6 Evaluation of IT solutions for routing, planning and optimisation

2.6.1 Selection of indicators and valuation criteria

To evaluate the IT solutions for routing optimisation tested at Gnewt Cargo, a set of criteria has been developed. At the end of the trials, it was possible to give marks for each indicator and provide an overall assessment. The indicators and points for valuation are set out for the assessment in table 6.

The most important benefits indicators are those about the improvement of the delivery performance in terms of distance and time. Other indicators are about the usage experience and the costs of the product itself.

In general, the criteria received zero points when the condition of use seems to lead to the conclusion that the system would have no tangible impact, could not be practically used at all, or where it could only be used with difficulty.

Table 6: Form with indicators and valuation for IT trial assessment

How fast is it to perform a round trip plan starting from raw customers' orders spreadsheet?

Minutes	<30	<60	<90	<120	>120
Points	4	3	2	1	0

Possibility to connect multiple customers' orders into one single round trip plan?

Answer	Yes	No
Points	5	0

Possibility to connect to/use a powerful routing system with time forecasting

Answer	Yes	No
Points	5	0

Accuracy of time forecast vs real time of run during trial

Answer	<5%	<10%	<15%	<20%	>20%
Points	4	3	2	1	0

Reduction of time spent per day compared to manual routing (productivity factor 2)

Answer	>20%	<20%	<15%	<10%	<5%
Points	4	3	2	1	0

Reduction of distance driven per day compared to manual routing (essential for traffic and CO_2-pollutant reduction - factor 2)

Answer	>30%	<30%	<20%	<10%	<5%
Points	4	3	2	1	0

Increase in number of parcels per driver per day compared to manual routing (productivity - factor 2)

Answer	>20%	<20%	<15%	<10%	<5%
Points	4	3	2	1	0

Initial purchasing costs of IT solution for the entire fleet of Gnewt Cargo

Answer	<£2k	<£4k	<£6k	<£8k	>£8k
Points	4	3	2	1	0

Running costs of IT solution per year for the entire fleet of Gnewt

Answer	<£1,000	<£2k	<£3k	<£4k	>£4k
Points	4	3	2	1	0

Difficulty/easiness to use the software in the daily business routine

Answer	Easy	Medium	Difficult
Points	4	2	0

Difficulty of the initial training, to understand how to manipulate the routing, scheduling and data merging features

Answer	Easy	Medium	Difficult
Points	4	2	0

Software updates

Answer	Frequent	Seldom	Rarely/None
Points	4	2	0

Final evaluation on 2 August 2016

Gnewt Cargo tested the efficiency of routing software in the context of urban parcels delivery business. These IT solution tests were sufficiently advanced to give an evaluation in form of valuation of criteria relevant for the day-to-day business (practicality), profitability (costs and benefits balance) and for the usability (ease of use). Evaluation results are presented in Table 7 below.

Overall, the general impression is that none of the systems achieved a better performance than a trained driver in terms of either distance or time reduction. Failing these two main efficiency criteria is crucial, because this leads to a negative result of the routing trials when the question is asked: are any of the systems tested good enough to be implemented and used on a daily basis?

However, promising round trips were run with a software adaptation that is not on the market right now. In another, future project, the combination of pedestrian and driving parts of the delivery trips might allow Gnewt Cargo to use the software in the day-to-day business. Once this new solution is implemented, it is reasonable to expect that this would lead to a substantial improvement in the numbers of trips and the time taken for deliveries.

Table 7: Final valuation of IT routing solutions tested in Case Study 3

	Smartour	*Optrak*	*Podfather*
1) Time spent from manifests to optimised routes?	1	0	1
Minutes: <30 | <60 | <90 | <120 | >120 Points: 4 | 3 | 2 | 1 | 0			
2) Possibility to connect files of multiple customers' orders into one single round trip plan?	5	5	5
Answer: Yes | No Points: 5 | 0			
3) Possibility to connect to/use a powerful routing system with time forecasting	5	5	5
Answer: Yes | No Points: 5 | 0			
4) Accuracy of time forecast vs real time of run	0	0	0
Answer: <5% | <10% | <15% | <20% | >20% Points: 4 | 3 | 2 | 1 | 0			
5) Reduction of time spent per day compared to manual routing (productivity factor 2)	0	0	0
Answer: >20% | <20% | <15% | <10% | <5% Points: 4 | 3 | 2 | 1 | 0			
6) Reduction of distance driven per day compared to manual routing (essential for CO2-pollutant reduction)	0	0	0
Answer: >30% | <30% | <20% | <10% | <5% Points: 4 | 3 | 2 | 1 | 0			
7) Increase in number of parcels per driver per day compared to manual routing (productivity factor 2)	0	0	0
Answer: >20% | <20% | <15% | <10% | <5% Points: 4 | 3 | 2 | 1 | 0			
8) Initial purchasing costs of IT solution for the entire fleet of Gnewt Cargo	0	0	0
Answer: <£2k | <£4k | <£6k | <£8k | >£8k Points: 4 | 3 | 2 | 1 | 0			
9) Running costs of IT solution per year for the entire fleet of Gnewt	4	4	4
Answer: <£1k | <£2k | <£3k | <£4k | >£4k Points: 4 | 3 | 2 | 1 | 0			
10) Difficulty/easiness to use the software in the daily business routine	2	0	2
Answer: Easy | Medium | Difficult Points: 4 | 2 | 0			
11) Difficulty of the initial training, to understand how to manipulate the routing and data merging features	0	0	0
Answer: Easy | Medium | Difficult Points: 4 | 2 | 0			
12) Software updates	2	0	2
Answer: Frequent | Seldom | Rarely/None Points: 4 | 2 | 0			
Total	19	14	19

Source: Gnewt Cargo Agile 2 data

3. Targets achievements

The targets for the project "IT solutions for parcel deliveries with electric vehicles in Central London" are based on the comparison of real-time operations of traditional diesel based delivery systems and the electric vehicle based delivery at Gnewt Cargo. The IT solutions enabled Gnewt Cargo to consolidate deliveries from different clients with the deliveries of Client A and other carriers or retailers into one single vehicle. The effect of the IT system is to facilitate the consolidation using technology so that in order to realise the beneficial effects on transport efficiency.

The target results demonstrate increased overall efficiency using the trialled systems compared to the existing system of provided by Client A. It is assumed that one electric van from Gnewt Cargo replaces one diesel van from Client A.

The comparison of Client A deliveries for Central London for the situation without Gnewt Cargo (BEFORE) and with Gnewt Cargo as Logistics Service Provider and subcontractor (AFTER) is presented in the following tables). The entire distribution system is compared, not only the last mile from the depot. We need this procedure to calculate the right impact, because in the case of Client A it is necessary to compare the exact same logistics performance.

For example for distance performance the measurement unit is the distance driven between the original Client A depot in Enfield and the final customer served in Central London. The best KPI metric here is the **distance per parcel**, expressed in metres. For information, the total distance reduction and the annual distance were calculated in Table 8.

3.1 Target distance reduction and urban traffic mitigation impact

A target distance reduction of 50% was set at the beginning of the project, to be achieved by the end of the Agile 2 demonstration. Accurate data are available for the 12-month period, having used the distance data collected with Fleetcarma telematics, and compared with the management system in use at Gnewt Cargo.

The error margin is below 5%. At the end, the overall distance reduction for the Client A business was 58% (relative) and 390 thousand km (absolute). This is about 240,000 miles less driven on Central London roads. The average distance per parcel went down from 337 metres to 143 metres, annual average, for the last mile of the Client A parcels delivery business.

Table 8: Target reached for distance reduction

		Number of vans/ trucks	Parcels delivered during year	Distance in m/ parcel	Total annual distance in km
BEFORE Client A	Diesel trucks & large vans	49	2,005,728	337	676,599
AFTER	Diesel truck	4	2,005,728	23	46,864
Gnewt	Electric van	49	2,005,728	119	239,087
	Total	53	2,005,728	143	285,951
	Total distance reduction in km				390,648
	Before-After reduction in %			**58**	**58**

Source: Gnewt Cargo Agile 2 data, Client A data

3.2 Target for CO_2 reduction and climate impact mitigation

A target carbon dioxide (CO_2) reduction of 80% was set at the beginning of the project. Gnewt Cargo obtained good data on fuel use at Client A, and can consider the entire reduction of one full year of business. A saving of **88% CO_2 reduction per parcel** was observed. The total reduction for the Client A business is 170 tonnes CO_2 per year (Table 9).

Table 9: Target reached for CO2 reduction

		Vans/ Trucks	mpg	l/100km	Litres/ year	Litres/ parcel	$kgCO_2e$/ parcel	Total annual CO_2 in kg
BEFORE Client A	Diesel trucks & large vans	49	31	9	73,885	0.04	0.096	192,839
AFTER	Diesel truck	4	15	18.8	8810	0.004	0.011	22,995
Gnewt	Electric van	49	-	0	0	0	0	
	Total	53			8810	0.004	0.011	22,995
	Before-After reduction in %				88	88	88	88
	Total CO_2 reduction in kg							**169,844**

Source: Gnewt Cargo Agile 2 data, Client A data, CO2 conversion factor from DEFRA

3.3 Target air pollutant reduction and air quality and health impact

A target for reduction of air pollutants Nitrogen Oxides NO_x and Particulate Matters PM10 was set at 80% at the beginning of the project.

The air pollution data was calculated from annual km distance travelled and the National Atmospheric Emission Inventory emission factors (Table 11). This is assuming that the diesel vehicle would produce most of its air pollution through diesel engine combustion, and the electric vehicle would not produce any air pollutant from the electric motor. Differences in pollution from tyre and break wear cannot be assessed because of lack of data for the electric vehicles. It is assumed that lighter vehicles would have less tyre wear and thus lower emission than larger ones, but this would require a dedicated investigation to demonstrate, so tyre and break wear emissions for PM were entirely left out.

As result, the emission reduction for NO_x was 72% and for PM10 93% over the duration of the project (Table 10). The target of 80% was exceeded for PM10 but slightly missed for NO_x. This is due to the high emissions from 7.5t diesel trucks used to deliver the parcels to the premises of Gnewt Cargo at night.

Table 10: Target for air pollutants reduction

		Vans/ Trucks	NO_x g/parcel	PM_{10} g/parcel
BEFORE Client A	Diesel trucks & large vans	49	0.3031	0.0186
AFTER	Diesel truck	4	0.0842	0.0014
Gnewt	Electric van	49	0	0
	Total	53	0.0842	0.0014
	Before-After reduction in %		72	93

Source: Gnewt Cargo Agile 2 data, Road Transport Emission Factors: 2011 NAEI

Table 11: Emission factors, based on distance observed

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

Source: Road Transport Emission Factors: 2011 NAEI

3.4 Target for reduction of energy use

The target for energy was set at a 70% reduction. Gnewt Cargo collected excellent energy data from Fleetcarma (in kWh used) and used the Client A data for diesel fuel. An annual average of 0.356 kWh per km was calculated for all Client A trips starting with electric vans from the Gnewt Cargo depot.

Overall the total energy used was reduced by 76%, expressed in gram of oil equivalent (goe) per parcel delivered (Table 12). Other indicators were collated, to give more detailed information on the energy savings obtained when using Gnewt Cargo. The total amount is about 48 tonnes of oil equivalent saved during one year of operation with 49 electric vans in use.

Table 12: Target reached for energy use

		Before = 49 diesel vans	After: 4 diesel trucks	After: 49 electric vans	After: Total all vehicles	Before-After reduction in %
Distance/year	km	676,599	46,864	239,087	285,951	58
Electric energy used	kWh/year			85,037		
	kWh/km			0.356		
Conversion factor	kgoe/kWh			0.0859845		
Total litres	litres/year	73,885	8,810		8,810	88
Conversion factor	goe/litre	845	845			
Total energy use	kgoe/year	62,432	7,445	7,312	14,757	76
Results energy per km	goe/km	92	159	31		
Results energy per parcel	goe/parcel	31	4	4	7	76

Source: Gnewt Cargo Agile 2 data, Client A data, IEA conversion factor

3.5 Target for reduction of empty distance

The average empty distance for a Client A truck is 12 miles per day, for all vehicles this corresponds to about 250,000 km per year. Empty distance for electric vans is 1 mile, and the empty distance travelled by diesel trucks returning to the depot after delivering to Gnewt Cargo at night needs to be added into the calculations.

Table 13: Target achieved for empty distance reduction

		Vans/ Trucks	Empty vehicle distance/ year in km
BEFORE Client A	Diesel trucks & large vans	49	246,036
AFTER	Diesel truck	4	20,085
Gnewt	Electric van	49	20,503
	Total		40,588
	Before-After reduction in %		**84**

Source: Gnewt Cargo Agile 2 data, Client A data

As result of using Gnewt Cargo, the empty distance over one year is reduced by more than 200,000 km, which is more than 80% reduction. The accuracy of this data is much lower than the other data. Many assumptions had to be made due to the lack of hard data. Most of the time, Gnewt Cargo vans are not coming back completely empty, but with a small load of parcels that were not delivered, or that were collected during the round.

In this conservative estimate however, it is assumed that on average every Gnewt van is driving one mile per day back to depot empty. The same assumption applies to the Client A vans and trucks used in the situation before. On those trips, it is assumed that the trucks started full and came back empty. Therefore, the number of 84 % reduction is an estimated value.

3.6 Target for number of vehicle trips

The number of vehicles used increased by 8% (Figure 21). This is partly due to the lack of data on the driver productivity and the assumption that the same number of drivers is needed to perform the same number of deliveries.

As a result there are four trucks that need to be added to the previous distribution system, the reasons are explained below.

3.7 Assumptions for the targets achieved

How was the calculation, analysis and data processing for the target achievements performed?

Gnewt Cargo deliveries are compared with what Client A would have done with the same amount of parcels and vehicles, but starting from its depot in Enfield and running with a diesel fleet. Of course, this is a hypothetical comparison, because the real observations are only of the trips and performance of Gnewt Cargo.

What Client A would have done, with the identical business demand, is based on calculations, assumptions, and estimations from data that we collected in real observations. Even though they are hypothetical, the calculations and assumptions are made with data that are as robust as possible. The target calculations were done this way to show what would happen if more businesses in London would apply the Gnewt Cargo solution.

There is a set of **real observation data collected for Client A** in this Agile 2 trial:

- Client A Enfield depot distance for trucks and vans is about 12 miles until the border of the delivery area and about 14 miles to the depot at Wardens Grove

- Average mpg for diesel trucks and diesel vans are 15 and 31 respectively.

Assumptions for Client A are:

- Total number of vehicles for all deliveries remains identical at 49 (as no robust IT optimisation is effectively proven at this stage)

- Total number of parcels is about 2 million for the 12-month period (identical business assumed, no change in service for clients).

Calculation background for Client A and Gnewt Cargo energy, CO_2 and air pollutant analysis

There is a series of calculations, data processing and analysis: Using CO2 emission factors from DEFRA (1 litre diesel = 2.61 kg CO2), air pollutant emission factors from the National Atmospheric Emissions Inventory (Table 11), and energy conversion factors (kWh to kgoe, Table 12) from the International Energy Agency (IEA). The standard unit of energy, the grams of oil equivalent. This goe unit shows the energy content of electricity and diesel fuel used during the trials, and it enables a comparison of different energy sources. The truck trips use diesel energy, and this diesel energy is included in the AFTER case.

Further assumptions are made:

- Four 7.5t trucks are used to transport parcels from the Client A depot in Enfield to Gnewt Cargo depot in Wardens Grove. Three of these trucks are used to make delivery trips at night. One is used during the day to bring back the empty rollcages to the Enfield depot.

  There is a potential to drive at night with much larger trucks, and replacing the 4 small trucks running 4 return trips with 2 big trucks running 2 return trips resulting in more efficiency and reduction in number of vehicle. However, this solution would require another depot location with accessibility for large trucks.

- There is no driver productivity increase assumed; it is possible that there was a real increase, but it is uncertain. The 49 rounds undertaken for Client A by Gnewt Cargo could correspond to more rounds if these rounds started from the depot in Enfield, due to the additional 12 miles distance and at least one hour drive during peak hours, although no evidence could be obtained for this assumption. The driver productivity in parcels per day is assumed to remain the same.

- There is a possibility to consolidate goods of two different clients into one single van. This scenario was left out in this study.

- These assumptions lead to an overall efficiency that could still be increased in future, leading to even more savings. This untapped efficiency potential is identified in the remaining relatively high total number of trips. This could be lowered in future.

- The calculation and analysis is done with the BEFORE-AFTER approach, one of the key methods for impact assessments in logistics.

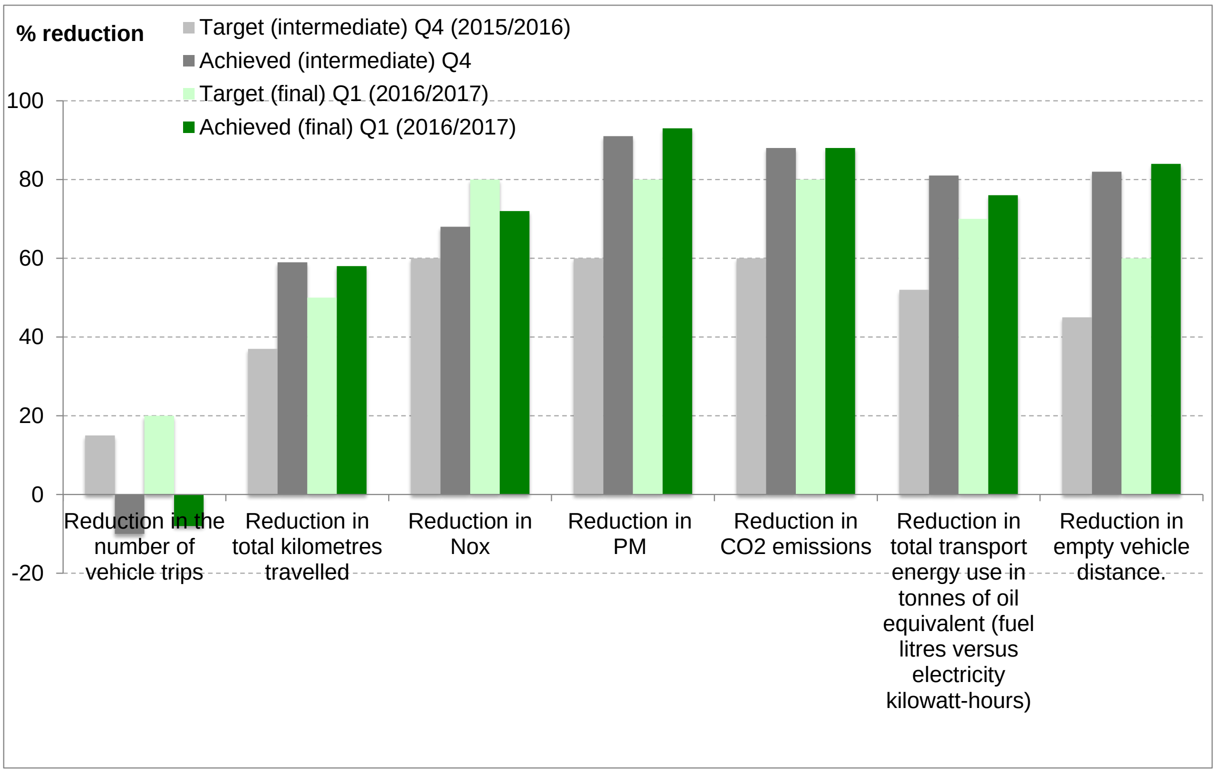
3.8 Overview on targets achievements after 6 and 12 months (in Q4 (2015/2016) and Q1 (2016/2017))

Figure 21 shows the final results against all the achievement targets in the final quarter of the project. These achievements were reached during the Quarter 4 (Q4) of the fiscal year 2015/2016 and Quarter 1 (Q1) of the fiscal year 2016/2017.

The intermediate target for the Quarter four (Q4) of the financial year 2015/2016, are the left column (lighter gray), and the achievements for Q4 are presented in the second column from the left (darker grey). Final target (Q1) is in light green and final achievement in darker green columns. While most values are above target, the number of trips and the NO_x emissions remains somewhat below target.

The positive evolution towards better achievements is due to the progressive improvement in data collection, elimination data errors, and the different business periods observed.

Figure 21: Target achievements of Gnewt Cargo Agile 2 project, 1st Jan-30 June 2016



Sources: Gnewt Cargo Agile 2 trials; TNT UK; DEFRA conversion factors 2012, NAEI, IEA

4. Concluding remarks.

Multiple tests were performed for the IT trials of Gnewt Cargo Agile 2 project. The datasets were collected and are available. The data shows that Gnewt Cargo has reached most of its objectives. The very short distance driven per day in Central London, for the same logistics performance, business turnover and number of deliveries, is a major benefit of the solution.

The data shows different average trip distances and numbers of parcels for the different clients. For Client A, final results of Optrak, Podfather and PTV systems tests indicates a high potential for future routing and scheduling optimisation. It is too early to claim that the 50% improvement with PTV Smartour would be replicable on a daily basis.

However, the demonstration was successful and expectations are that targets could be reached in the long term, when the software solution will be further developed. As of June 2016, the routing and scheduling trials have all been completed according to plan, and the multiple data collection exercises and processing led to a huge amount of outstanding data. This data are now available for public use in London.

The most data have been collected for the months July 2015 to June 2016. The results of the analysis are finalised for all case studies and all elements of the project. The total amount of information is very high, so that only a part of the information about >15,000 round trips, currently available, can be shown in this report.

The targets were achieved for distance and traffic reduction (58%), CO_2 reduction (88%), PM10 reduction (93%) and energy reduction (76%); the targets were somewhat missed for number of vehicles (+8% instead of -20%) and NO_x reduction (72% instead of 80%).

Limitation of Technology: Technical barriers, constraints and challenges experienced during the project

We were constrained by the duration of the project and the number of IT solutions we could test, but feel comfortable that the findings so far demonstrate some very valuable analytics and learning, some of which is summarised in more detail below.

The project was set up in July 2015, with each case having a variable duration of preparation and monitoring, peak and or challenging periods. The most challenging item was to find a routing system that would be capable of reducing the distance of the round trip, if compared with what a knowledgeable driver would do without routing assistance. Unfortunately, the market does not currently provide a solution for urban freight delivery routing that would be better than a trained driver. All the routing systems are predominantly designed for long distance freight traffic. Therefore, it was key in the preparation of the trial to have intensive exchange with the software providers in order to have the current products adapted to the Central London situation, characterised by short distances, small delivery areas, high density of customers, different on-street and off-street loading bays, parking duration allowance and access restrictions.

It therefore took longer than expected, until January 2016, to have the first routing systems up and running. By the end of May 2016, all systems had been successfully implemented. Some systems were dropped entirely, due to the fact that they did not provide any substantial results. Only those systems that were effectively tested in real life operations are presented above: These are: Fleetcarma, Emakers, Optrak, PTV Smartour, and Podfather. The data obtained in real trials was stored in a file and was compared with the situation before. The data can be considered robust, was collected on a real life delivery round performed on the basis of the IT optimisation of the solution tested.

Legacy

The data collected and analysed provides evidence that the IT solutions trialled can function, be scaled up with ease and provide quantifiable results in the ability to increase fundamental efficiencies by applying 'smart' technology to the tracking of vehicles, route optimisation and the scheduling of routes on a daily basis. Scalability is relatively straightforward because whether you choose to optimize 50 routes or 5000, the logic remains the same, meaning if these systems work on a micro level they can, and should, be expanded to the betterment of the whole industry and for London. However, whilst scalable they must concurrently be effective, otherwise there is a risk of scaling a problem rather than a solution. It is therefore vital that emphasis is placed on the route data produced by these systems to ensure that they improve the operations overall.

Gnewt's business model and infrastructure was tailored towards this type of operating model from the company's inception. This has enabled Gnewt to achieve the environmental savings and operational efficiency that has proved difficult for other logistics companies. The concept of smaller, central consolidation centres, 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.

As a legacy introducing alternative solutions to the market are a necessity in order to keep London moving with freight deliveries working effectively for wider society and the environment as well as for the business efficiency and profitability. Gnewt is not on its own in working through these IT challenges, but would hope that the learning created here will assist like-minded SME's to better understand how they may apply IT solutions to their own businesses and thus limit the number of unnecessary trips travelled.

As main legacy on future IT technology use in London logistics, the PTV Smartour software solution was found to be potentially very powerful in its beneficial impacts on business. To achieve this, another project to improve the software is needed. Such a project could see the software implemented on a daily basis and deliver a public database on London's most convenient stopping points, linked to final postcode addresses, and providing relations between pedestrian and driving parts of the delivery trips.