Data 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 data 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.

This document presents the data of the "Agile 2" demonstrator project, which took place in London between 1 July 2015 to 30 June 2016. It first defines indicators and units, then gives details on the information collected, and showcases the trial performance. It gives a solid background on the monitoring and methodology used to run the tests, the assumptions made and it provides references.

This report is designed as a complement to the Final Report of the "Agile 2" demonstrator. There, the focus is on analytical explanations, further calculations and in-depth results obtained after analysis. Here, in this data report, Gnewt Cargo focuses on showing and explaining the different series of data collected. Each section explains what Gnewt Cargo is demonstrating with the data.
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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 CO_2 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

This document is the final data report for 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.

This report presents the data providing evidence for the benefits we obtained with these solutions tested in the Agile 2 demonstration. This Data Report contains two parts, the data available before the trial started, and the data collected during the IT trials. The full and final set of data collected and monitored was recorded between the 1st July 2015 and the 30th June 2016. For some indicators and some information, the duration of observation was different (longer or shorter periods). As of June 2016, the data was extended to:

- General business data providing evidence on the framework and trial background
- The baseline data on the situation before the start of the demonstration
- The preparation data collected for the calibration of IT solutions
- The data evidencing the IT test results.

All data was collected in a real commercial business environment. The origin of the data was demonstrations and tests made in London with electric freight delivery vehicles fitted with innovative technologies. The objective of the data collection was to obtain evidence on the different solutions. The real business data, collected with independent experts, is useful for other market actors in London.

2. Data monitoring: Introduction

2.1 Type of data and definitions

This report is a complement of information and should be considered together with 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").

Gnewt Cargo conducted data collection, monitoring and processing following the methodology of the University of Westminster. The fundamental principles and the method for data collection were tested and developed in multiple previous projects. The before-after approach was adapted and implemented so as to fit well with the IT solution testing.

The key idea is to compare the business changes and the external effects of logistics activities before and after implementing a new solution, without changing any other business parameter, so that each benefit is clearly attributed to one single solution.

The main method is to prepare the data collection for the trial of the new solution together with the IT partner businesses. In parallel, Gnewt Cargo organised its internal data collection with its current software solution. Past data collection was used to obtain the background information and the baseline data. In parallel with the data collection, the efforts consisted of applying the solutions such that they run effectively and produce desired benefits.

The data collection started on 1st July 2015 and ended on 30 June 2016. The following key performance data relevant for the assessment of the objectives was collected for one year:

- Number of vehicles in use
- Vehicle monitoring data (distance, location, load factor)
- Driver monitoring data (behaviour)
- Clients served (Client A, TNT, Client B, CLENT C, Emakers)
- Distance (km per van per day, total distance of all vehicles, etc.)
- Number of parcels (parcels per client)
- Energy use (kWh)

In the Final report document of the "Agile 2" project, all the data were combined together with the analytical and numerical assessment, to obtain clear recommendations. This final report presents additional data obtained after extensive calculation and data processing. For example, some of this additional data is the % achievement in traffic reduction, CO2 and air pollutant mitigation. Here, in this monitoring and data report, the data of the final report are presented, defined and explained.

Beyond the key performance data listed above, the data presented in Table 1 is considered relevant and was also collected. The different IT solutions tested during the project each provided part of the data set presented in Table 1. This monitoring and technology data is complemented by other impact data.

Table 1: Overview on parameters collected for the monitoring of benefits of IT solutions at Gnewt Cargo Agile 2

General logistics and business data	Driving behaviour	Trip difficulties	Additional information
Date, time Position (GPS) Vehicle, driver Status (driving/rest/charging)) Mileage on tachograph Trip distance driven Parcels delivered Battery use (running and stationary) Completion rate	Braking behaviour Gear changing behaviour Driving pedal movements Speed and constancy of speed	Gross vehicle weight rating Number of stops Average gradient	kWh counter readings Litre of diesel fuel

Source: Gnewt Cargo Agile 2 data

Out of all collected data, few information stands out (Table 2).

Table 2: Key data definition

Key Data	Unit, abbreviation	Definition, means of collection, and impacts
Mileage	Mile, mi Kilometre, km	Distance of delivery trip, measured in miles, converted into km. Distance allows a first estimate for the traffic impacts and the business efficiency
Number of parcels Deliveries	Number	Often defined in parcels delivered per trip, per day, per vehicle, or per client. This is a key business volume indicator, also giving hints for logistics performance, costs and for economic growth and employment
Energy: Electricity and fuel use	Kilowatt-hour, kWh Miles per gallon, mpg Litres per 100 km, l/100km	Indicating the energy used either in form of electricity or fuel, also informing on the environmental and health impacts
Reduction of impacts	Percentage, %	Defined as percentage reduction of the external impacts of transport activities: congestion, accident, ghg emissions, noise, air pollutants. The reduction is expressed as difference between the situation before and after the solution is implemented, or with and without the solution.
Time	Minutes, min	Time spent to accomplish defined tasks
Completion	Percentage, %	Number of parcels effectively delivered on first attempt, compared to the number of parcels loaded onto the vehicle at departure from depot

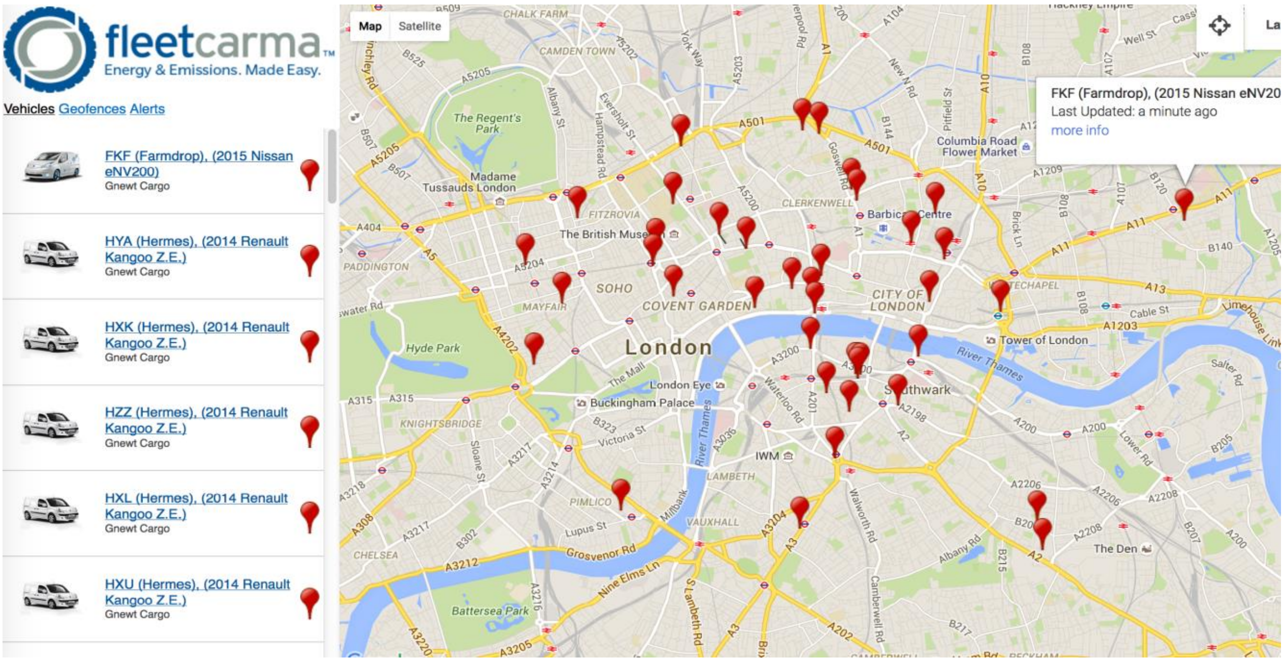
Urban logistics is a young discipline and many indicators require precise definitions. For this reason, additional definitions of indicators and units will be presented for each Table in this report. The limits of the system of observations will be clarified, as much as possible. These limits are variable, for example if we speak about the operations of Gnewt Cargo for one client, or if we mention the entire supply chain of a client.

The mileage data enables the calculation of congestion reduction, since it is assumed that a distance reduction per parcel, if widely implemented, will lead to substantial traffic reduction. For the fuel use, diesel data provides the basis for the calculation of the CO2. We calculate the emission by multiplying the litre diesel with the emission factor 1l=2.61kg CO_2 equivalent. To calculate the air pollutant emissions, the distance is multiplied by the emission factors of the National Atmospheric Emission Inventory NAEI, given for several air pollutants.

The information and data on the performance of the IT solution itself are more qualitative and descriptive. For example, when speaking about a routing solution, the solution is best described by its functionality, understanding how it works and for which business situation it is suitable and usable. The information on its impacts and benefits will be more quantitative, for example with the mileage reduction obtained with the routing solution, expressed as % of the previous mileage.

Some additional and specific data such as the geographical distribution of the fleet in Central London at a certain time was collected for one snapshot during a day, for a particular time of a day that is considered more or less average and representative for the entire business situation as a whole (Figure 1). This standard situation mostly occurs in the afternoon, when all drivers are out for deliveries, and the fleet is evenly distributed across all Central London neighbourhoods.

Figure 1: Geographical distribution of the fleet of Gnewtcargo on 16 October 2015



Source: Gnewt Cargo Agile 2 data

Figure 1 shows the location of the fleet of Gnewt Cargo vehicles equipped with the Fleetcarma software on 16 October 2016 at 15:30hrs. This map demonstrates that Gnewt Cargo distribution operations were centralised mostly within the area within the Congestion Charge Zone in Central London (a few vehicles were recorded performing deliveries outside the zone).

2.2 Additional data relevant for London urban freight policy

During the Case Study trial period, the project Gnewt Cargo Agile 2 collected information on a number of other more qualitative variables relevant for public sector policies. This data will benefit London in the short term because it demonstrates the beneficial impacts of the Gnewt Cargo solutions, encouraging replications of the business model of electric vehicles and consolidation centres. Thus this data contributes to helping reduce congestion and emissions as well as increase the market share of clean vehicles in Central London.

These additional data indicators include:

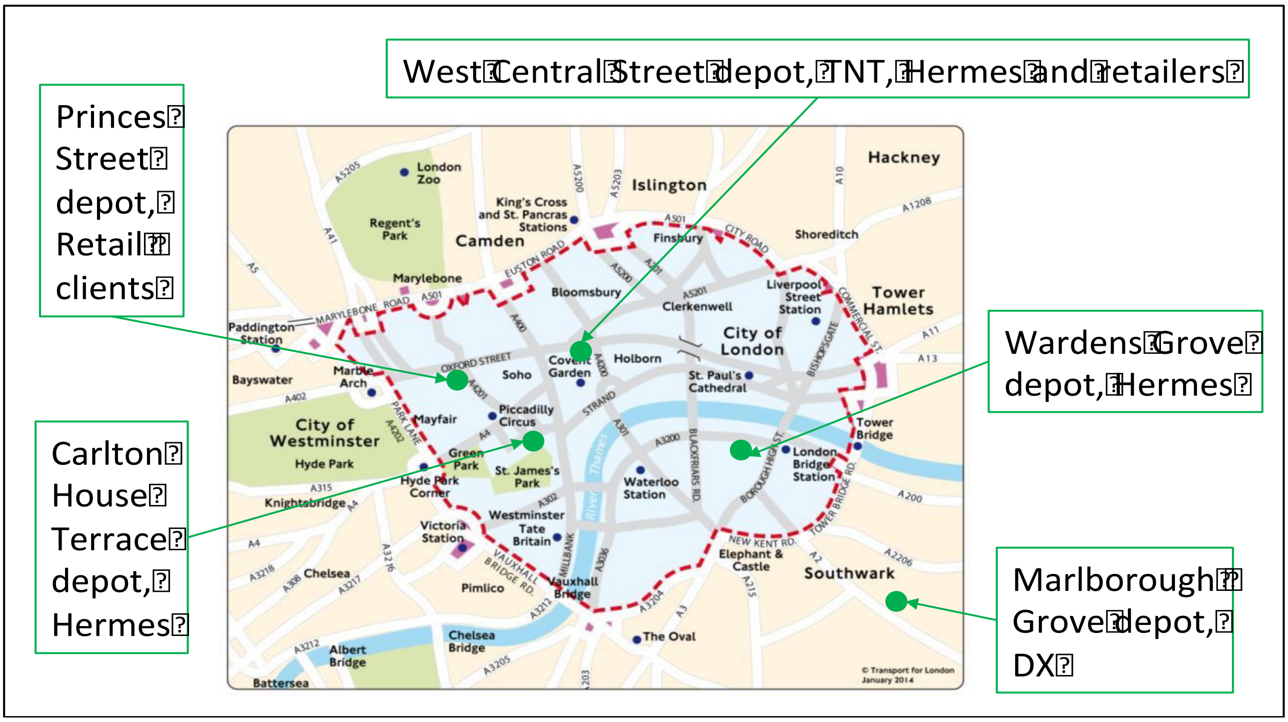
- Vehicle movements reduction, expressed in %
- Reduction in miles travelled per parcel delivered, expressed in km/parcel
- Time vehicles spent on the road, expressed in minutes
- CO_2, PM and NOx reductions achieved by a van delivering the same freight in the same area versus the diesel alternative and versus the alternative without IT optimisation
- Efficiencies of varying types of electric vehicles
- Business case data such as:
- costs of IT solutions purchase and/or leasing
- Disruption and risk management for electric vehicle fleet operations

3. Data monitoring of case studies

3.1 General data relevant for all case studies, and baseline data

Gnewt Cargo operates delivery operations from five depots situated in the inner part of London, however mostly vehicles based at West Central and Wardens Grove sites have participated in the IT trial. Figure 2 illustrates the locations of the depots together with the Congestion Charge Zone area marked as a broken red line.

Figure 2: Location of the Gnewt Cargo depots & Central London delivery area



Source: Gnewt Cargo Agile 2 project

Detailed information on locality and operating times of the participating depots are presented in Table 3. Both sites are open 7 days a week between 2am and 11pm.

Table 3: Depot locations and operation time data

Depot name	Postcode	Town	Street/House number	Open from	Open till	Mon	Tue	Wed	Thu	Fri	Sat	Sun
West Central	WC1A1AB	London	13 West Central Str.	02:00	23:00	yes	yes	yes	yes	yes	yes	yes
Wardens Grove	SE1 0HT	London	Wardens Grove	02:00	23:00	yes	yes	yes	yes	yes	yes	yes

Source: Gnewt Cargo Agile 2 data

General data on distance and number of parcels was collected at Client A and TNT for the baseline data. The Client A baseline data was collected in spring and summer 2015 and the TNT baseline data was collected in September 2015. Table 4 presents the baseline data for the 'before' situation at TNT

Barking depot for September 2015, while vehicle specification data for the diesel fleet used at the site is presented in Table 5.

Table 4: Baseline (before) data: TNT week distance and deliveries at Barking depot with diesel fleet, 1-5 Sept 2015

Route ID	Vehicle Type	Details	MPG	Week distance in km	Parcels delivered during week	Distance in km/ parcel
143	Van	3.5t 3m sprinter	31	363	425	0.852
144	Van	3.5t 3m sprinter	31	420	417	1.007
145	Van	3.5t 3m sprinter	31	399	427	0.934
146	Van	3.5t 3m sprinter	31	443	532	0.832
147	Box Van	Luton	28	190	422	0.450
148	Van	3.5t 3m sprinter	31	417	562	0.741
149	Van	3.5t 3m sprinter	31	20	2	11.236
150	Van	3.5t 3m sprinter	31	777	562	1.381
151	Van	3.5t 3m sprinter	31	308	509	0.605
152	Van	3.5t 3m sprinter	31	342	507	0.674
153	Bike			518	589	0.879
154	Van	3.5t 3m sprinter	31	360	126	2.849
155	Van	3.5t 3m sprinter	31	391	94	4.145
156	Van	3.5t 3m sprinter	31	344	100	3.456
203	Truck	7.5t	15	205	288	0.711
204	Truck	7.5t	15	145	142	1.017
777	Truck	7.5t	15	521	858	0.608
778	Truck	7.5t	15	279	853	0.327
779	Truck	7.5t	15	105	1091	0.096
789	Van	3.5t 3m sprinter	31	469	73	6.426
921	Van	3.5t 3m sprinter	31	93	93	1.008
922	Van	3.5t 3m sprinter	31	98	27	3.677
923	Van	3.5t 3m sprinter	31	93	11	8.740
924	Truck	7.5t	15	48	20	2.451
Total				7,348	8,730	
Average						**0.841**

Source: Gnewt Cargo Agile 2 data

During 4 weeks in September 2015 the drivers from TNT covered an average distance of 0.798 metre/parcels, for all vehicles and all rounds to Central London starting from the TNT depot in Barking.

Table 5: Fleet specifications, TNT Barking depot, baseline data, September 2015

Vehicle type	Truck	MB Sprinter	Box van Luton
Gross Vehicle Weight	7.5t	3.5t	3.5t
Length in metre	5.18	3.4	4
Width in metre	2.31	1.7	2
Height in metre	2.16	1.7	2.2
Payload (load capacity by weight) in kg	2500	1200-1500	1100 -1200

Source: Gnewt Cargo Agile 2 data

Similar Gnewt Cargo data (data on the trial situation "after" introducing change in the delivery scenario) was collected from July-October 2015 and continued to be collected until the 30th June 2016. For example, during one month in July 2015, there were about 1,170 delivery rounds performed on London roads by Gnewt Cargo vehicles.

Table 6: Extract of business performance indicators 1 July 2015-30 June 2016

Metadata	Business, data ownership	Gnewt Cargo Ltd
	Project	Agile Category 2
	Period of observation	1 July 2015-30 June 2016
	Clients	Client A (CLENT C, TNT, Emakers, Client B)
	Vehicles in use	Renault Kangoo ZE, Nissan 2-NV200
	Area of delivery	Congestion Charge Zone and Central London
Performance Indicators	Total parcels delivered	2,005,728
	Average parcels delivered per week	38,572
	Average parcels per van per day	151
	Maximum parcels/van/day	668
	Minimum parcels/van/day	1
	Total miles driven	148,545
	Average miles per van per day	11
	Average metres per parcel	119
	Average completion	87%
	Total driver working time in minutes per parcel	6

Source: Gnewt Cargo Agile 2 demonstrator, 2016

Table 6 shows an extract of the collected information and key general statistics, which remained constant over the period July 2015 to June 2016. This stability is confirmed in the Fleetcarma data further below. The data demonstrates the high variability of the day to day business.
Data is available for more than 14,000 rounds driven on Central London roads.

Most raw data is stored in reference files to monitor the activity in the form of monthly tables of more than 1000 lines each, one line per round. It is clearly not suitable for a report to present the full dataset of over 14,000 lines with details of each round.

Instead, this raw data is used to calculate statistics such as the baseline presented in Table 6 above. The data in Table 6 shows a large extract of Gnewt's operations. It is extended to the data for which a continuous set of information was gathered on distance and number of parcels and other indicators for the whole duration of the project.

3.2 Case Study 1: Data of Fleetcarma electric van management

3.2.1 Key information and data on the Fleetcarma system

Fleetcarma provides vehicle data on logistics & transport performance and 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 with a description of key characteristics, shows data on each feature used during the tests, and gives evidence on the main results of the demonstration.

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 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 is important for electric fleet management. The hardware/software combination is called a telematics device. The Fleetcarma data, such as GPS location and distance driven, is key for the public sector as it enables access to information on the real time location and current live performance of the fleet running on London roads.

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 arrives directly through the Fleetcarma server connected via the internet. All data is stored online and can be downloaded by Gnewt Cargo in database format.

How much does it cost?

The licence price for the entire fleet of Gnewt Cargo was set at £60,000.

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.

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 regularly identifying 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 showed 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.

What is the range of electric vehicles based on charging?

About 160 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 control of the battery charge status.

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.

Is this better than manual routing?

The routing capabilities of Fleetcarma did not lead to shorter trips, because it is not a trip planning and optimisation tool.
The following features are included in 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.

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.

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

Alerts: A summary of 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.

The data and information presented in the following Figures and Tables was collected by Fleetcarma software trialled by Gnewt Cargo. Fleetcarma serves mainly as a fleet management solution and allows for a wide range of parameters/data to be collected from electric vehicles. The examples are extracted from the large amount of data recorded on Fleetcarma servers for Gnewt Cargo.

The purpose of the following pages is to show and understand the various quality of data available, and to demonstrate what we can derive from it.

3.2.2 Fleetcarma logistics Performance data

Fleetcarma software provides essential business data on the transport performance of the fleet.
The total distance recorded by all Fleetcarma vehicles in the period 1 July 2015 to 30 June 2016 is 318,174 km. The average distance per van per day was 22 km.

The fleet was progressively fitted with Fleetcarma recording devices. The real total distance driven by all Gnewt Cargo vans, including those that were not equipped with Fleetcarma in the early months, is certainly much higher. For those vehicles that produce a Fleetcarma report, the reliability and the quality of the data is very high. Therefore, it is very likely that the average distance of 22 km per day for all vehicles is representative for the entire business for the entire period of the project. Thus,

Fleetcarma allows us to estimate the total annual fleet distance. A rough estimate of 70 vans each driving 22 km for 230 working days gives a result slightly above 350,000 km annual fleet distance.

Table 7 presents data collected for the whole one-year period for each of the 62 vans. Values for the total annual amount underestimate the total distance and the total energy use of all vans. This is due to the missing months when Fleetcarma was progressively implemented. The results produced by Fleetcarma were available progressively starting from one van in July and August 2015, 41 vans in September, and 65 vans in June 2016. Three of these vans were not used for deliveries on some months so the data is presented for 62 vans.

For these reasons, in Table 7, the average figures (shown in italic at the bottom of the Table) are robust. The fleet data is available for each vehicle and each day of driving, allowing a more detailed analysis of the trips. In Fleetcarma, each driving sequence is recorded as one line on a spread sheet (Table 8), with one sequence = one line in Table 8. A line of data is a record between two stops where the driver switches off the motor.

Table 7: Performance data of each van, Fleetcarma 1 June 2015 – 30 June 2016

Vehicle ID	Odometer (km)	Total Distance (km)	Average Daily Distance (km)	Idle (%)	Electricity Usage (kWh)	Standard Charge (kWh)	Eco Driving Score	Hard Acceleration (%)	Hard Braking (%)	kWh/ km
1	19,499	1,660.1	13	73	415	792	73	4	5	0.477
2	15,559	7,800.6	64.5	55	1,387	1,509	63	8	9	0.193
3	12,925	1,1182	49.7	51	1,871	2,138	64	6	8	0.191
4	9,477	4,674	23.8	73	1,009	1,097	70	6	6	0.234
5	19,941	11,011.7	60.8	53	1,961	2,113	72	3	5	0.191
6	21,985	10,667.3	67.9	48	1,993	2,124	66	5	7	0.199
7	17,725	9,373.9	50.1	53	1,596	2,167	65	6	7	0.231
8	8,928	4,454.1	15.9	77	1,127	1,460	75	4	6	0.327
9	11,405	6,675.9	23.1	76	1,944	2,306	74	6	7	0.345
10	9,865	5,279.1	18.4	70	1,457	1,886	78	3	5	0.357
11	6,223	2,735.1	13	83	914	1,150	88	4	5	0.420
12	11,949	4,768.9	21	71	1,273	1,581	78	5	5	0.331
13	9,916	4,299.5	21.5	75	1,315	1,738	73	14	13	0.404
14	10,818	5,343.5	23.5	73	1,299	1,656	73	4	4	0.309
15	9,022	4,383.7	19.8	75	1,473	1,710	75	8	7	0.390
16	13,009	4,710.4	20	76	1,441	1,623	74	6	7	0.344
17	9,971	3,376.2	19.6	71	820	956	70	7	7	0.283
18	9,743	4,070.2	17.7	76	993	1,164	82	2	2	0.286
19	9,659	4,185.3	18.9	74	1,225	1,588	76	5	4	0.379
20	9,887	5,456.9	20.5	76	1,454	1,910	74	6	7	0.350
21	13,958	5,939.1	29.4	56	1,399	1,624	63	7	6	0.273
22	7,788	3,122.9	16.2	82	942	1,216	83	4	4	0.389
23	15,366	7,237.1	37.1	60	1,796	2,245	64	9	7	0.310
24	13,374	5,459.8	27.4	66	1,292	1,577	68	7	6	0.288
25	7,985	3,030.8	14.2	79	1,210	1,520	78	5	4	0.501
26	15,307	4,862.5	33.1	67	1,413	1,628	71	5	6	0.334
27	9,794	5,328.9	20.9	79	1,765	2,075	80	6	5	0.389
28	10,034	4,694.8	17.6	75	1,379	1,618	80	2	4	0.344
29	9,520	4,058.0	18.9	76	1,170	1,361	78	3	3	0.335
30	9,537	4,276.2	17	68	1,266	1,432	74	7	5	0.334
31	9,500	4,074.1	18.9	71	1,081	1,320	79	5	5	0.323
32	8,805	1,695.0	20.4	82	599	6,64	75	12	12	0.391
33	11,622	6,202.1	22.3	69	1,691	2,096	72	6	7	0.337
34	9,795	5,553.5	20.3	69	1,790	2,211	88	7	7	0.398

Vehicle ID	Odometer (km)	Total Distance (km)	Average Daily Distance (km)	Idle (%)	Electricity Usage (kWh)	Standard Charge (kWh)	Eco Driving Score	Hard Acceleration (%)	Hard Braking (%)	kWh/ km
35	8,922	4,285.4	16.7	77	1,136	1,449	77	5	6	0.338
36	11,517	5,736.1	20.4	77	1,899	2,235	75	10	11	0.389
37	12,438	6,490.9	24.2	68	1,603	1,835	73	5	6	0.282
38	9,866	4,204.2	19	73	1,145	1,389	75	4	5	0.330
39	10,771	4,100.8	18.8	71	1,042	1,186	79	4	5	0.289
40	9,941	4,140.9	19.1	79	1,274	1,511	79	5	6	0.364
41	11,174	4,004.5	16.6	82	1,329	1,670	81	13	12	0.417
42	11,363	5,356.5	26.9	59	1,257	1,643	74	5	5	0.306

Source: Gnewt Cargo Agile 2 data

Table 7 cont'd: Electric van performance data (continues)

Vehicle ID	Odometer (km)	Total Distance (km/year)	Average Daily Distance (km)	Idle (%)	Electricity Usage (kWh)	Standard Charge (kWh)	Eco Driving Score	Hard Acceleration (%)	Hard Braking (%)	kWh/ km
43	9,388	3,987.6	19.1	77	1,197	1,602	75	3	5	0.401
44	9,501	4,126.5	18.2	75	1,369	1,601	76	6	6	0.388
45	9,887	4,566.7	22.3	71	1,239	1,707	72	5	6	0.373
46	18,412	7,149.7	36.1	71	1,333	1,800	73	6	3	0.251
47	12,241	5,140.9	26.2	65	1,383	1,688	67	8	8	0.328
48	8,623	4,303.3	20.7	71	1,286	1,468	72	6	6	0.341
49	19,032	7,296.6	36.9	61	1,716	1,977	67	6	7	0.270
50	15,921	5,430.6	31.4	64	1,593	1,976	75	2	2	0.363
51	15,497	6,578.3	36.5	62	1,943	2,309	68	6	7	0.351
52	12,309	3,846.1	21.2	75	1,220	1,340	74	6	6	0.348
53	18,824	3,801.2	37.6	55	1,059	1,228	64	6	7	0.323
54	9,464	3,776.8	17.6	80	1,273	1,617	75	4	3	0.428
55	15,698	5,412.5	31.5	67	1,710	2,165	65	9	11	0.399
56	9,983	4,119.5	18.7	73	1,437	1,649	75	3	4	0.400
57	11,537	5,629.7	23.3	63	1,540	1,944	76	3	3	0.345
58	9,993	3,609.0	16.5	78	996	1,308	78	5	5	0.362
59	9,853	3,997.1	17.4	63	1,177	1,404	69	2	4	0.351
60	30,832	4,875.0	25	61	1,069	1,378	67	5	6	0.282
61	17,798	667.5	12.8	77	164	214	75	5	5	0.320
62	25,697	4,665.3	27.3	69	854	1,107	66	5	6	0.237
All vehicles		312,942								
All clients	Average/ van/ year	5,047	25	70	1,323	1,607	74	6	6	0.335
TNT	average	5,991	30	62	1,442	1,748	66	7	7	0.292
Client A	average	4,305	19	74	1,233	1,511	76	5	6	0.356
FD	average	10,007	59	52	1,762	2,010	66	6	7	0.201
CLENT C	average	5,539	34	64	1,508	1,851	69	6	6	0.337

Source: Gnewt Cargo Agile 2 data

The energy indicator kWh/km shows that clients with high drop density and a vast majority of trips located within the Central London Congestion Charge Zone require more energy per km driven.

Table 8: One-day report for deliveries with one electric van on 29 June 2016

Time	Duration	Trip Distance (km)	Electricity Consumed (kWh)	Start State of Charge	End State of Charge	Eco Driving Score	% Hard Acceleration	% Hard Braking	% Time Idle	Average speed in km/h
4:10:16 PM	00:35:13	5.84	1.27	65.6	60.9	66	5	5	45%	9.9
3:49:24 PM	00:11:33	2.16	0.42	67	65.6	66	4	8	44%	11.2
2:50:13 PM	00:37:58	1.96	0.76	71	67	88	2	2	74%	3.1
2:35:44 PM	00:10:25	0.89	0.26	72.3	71	82	0	0	69%	5.1
2:21:27 PM	00:10:57	1.39	0.39	74.4	72.3	65	10	0	43%	7.6
2:03:35 PM	00:02:13	0.1	0.04	74.5	74.4	89	0	0	74%	2.7
1:51:40 PM	00:08:57	0.23	0.2	76.1	74.6	91	0	0	85%	1.5
1:29:57 PM	00:02:19	0.32	0.07	76.5	76.1	72	0	0	58%	8.3
1:15:32 PM	00:05:37	0.54	0.15	77.7	76.5	80	20	0	68%	5.8
12:55:41 PM	00:08:17	0.51	0.16	79.1	77.7	77	0	0	71%	3.7
12:47:06 PM	00:07:50	1.7	0.29	82	79.1	64	0	12	38%	13.0
12:16:20 PM	00:22:52	3.12	0.63	86.8	82	63	5	6	45%	8.2
12:08:25 PM	00:06:29	0.86	0.16	88	86.8	60	8	0	51%	8.0
11:40:12 AM	00:23:47	2.66	0.48	92.1	88	75	0	3	59%	6.7
11:32:34 AM	00:05:46	0.14	0.05	92.3	92.1	99	0	0	83%	1.5
11:13:07 AM	00:07:15	0.64	0.11	93.5	92.4	76	0	0	46%	5.3
10:25:31 AM	00:02:58	0.04	0.03	93.9	93.5	100	0	0	70%	0.8
10:17:54 AM	00:02:46	0.05	0.02	94.1	93.9	98	0	0	71%	1.1
9:46:02 AM	00:02:25	0.06	0.02	94.4	94.1	100	0	0	74%	1.5
4:00:09 AM	00:01:42	0	0	94.4	94.4	100			96%	0.0
3:53:51 AM	00:05:50	0.12	0.03	94.4	94.4	100	0	0	66%	1.2
Total	03:35:37	23.3								
Average										**6.5**

Source: Gnewt Cargo Agile 2 data

The average daily distance is particularly important for understanding the operational productivity of each vehicle. With values ranging from 7km to 77km in September, and 10km to 85km in October, the variability is high. Assuming that, to run a van, the driver incurs similar costs and has a similar working time each day, then it is clear that some vans are much more effectively utilised than others. Table 9 displays the original data from the Fleetcarma fleet-wide reports for activities, for the whole duration of the project. A wide range of analysed and reported parameters includes: distance, speed, driving energy, utilisation time, charger energy.

In Table 9, the utilisation ratio varies between 10% and 22%. It is measured as percentage of total time spent on the road. The time when the van is idle and switched off during loading or unloading operations is excluded. This exact Fleetcarma data available for the whole year is a confirmation that other data collected with other methods is valid and robust. According to one-off observations and interview statements made during the project, the time a driver spends driving on the road is about 1/5 or ¼ of the total working time.

Table 9: Fleetcarma fleet-wide report 1 July 2015-30 June 2016

Month	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Total	Avg.
Number of Vehicles	15	15	55	60	63	66	67	66	65	66	66	66		
Total km	7,819	6,274	18,543	34,083	33,010	32,747	30,253	31,734	31,953	31,584	30,423	29,751	318,174	26,515
Total km/Veh	521	418	337	568	524	496	452	481	492	479	461	451		473
Daily km	22	22	24	24	23	21	20	21	21	21	21	19		22
Average Speed km/h	13	14	15	15	15	15	15	15	15	15	15	15		15
Battery kWh	1,532	1,161	4,126	8,221	9,341	8,914	10,054	9,804	9,083	7,861	6,588	6,595		6,940
Charging Loss kWh	161	126	423	805	898	871	967	935	884	767	649	660		679
Driving Hours/month	590	457	1,273	2,217	2,219	2,186	1,996	2,100	2,147	2,069	2,003	2,012		1,772
Driving hours per Veh/ month	39	30	23	37	35	33	30	32	33	31	30	30		32
Idle Hours/month	984	769	2,627	5,116	5,621	6,089	5,642	5,368	5,387	5,461	5,315	5,541		4,493
On Hours/month	1,574	1,226	3,901	7,333	7,840	8,274	7,638	7,468	7,534	7,530	7,319	7,554		6,266
On Hours/day	4	4	5	5	5	5	5	5	5	5	5	5		5
Charging Hours	934	740	2,468	4,703	5,204	5,002	5,693	5,482	5,169	4,540	3,809	3,884		3,969
Resting Hours	5,965	5,018	12,567	21,756	21,972	24,524	23,340	23,266	24,353	24,145	24,104	25,570		19,715
Off Hours	6,898	5,758	15,035	26,459	27,176	29,526	29,034	28,748	29,522	28,686	27,913	29,454		23,684
Idle %	63	63	67	70	72	74	74	72	71	73	73	73		70
Utilization %	19	18	21	22	22	22	21	21	20	21	21	20		21
Availability %	70	72	66	64	63	65	64	64	66	67	68	69		67
Level 1 kWh	51	45	22	21	33	93	81	35	66	51	25	13		45
Level 2 kWh	196	1,528	5,252	10,023	11,168	10,772	11,930	11,579	10,906	9,498	8,069	8,215		7,367
Average Start SOC (State of charge) %	94	97	96	97	93	90	92	89	91	92	92	92		93
Average End SOC %	**66**	**72**	**66**	**66**	**61**	**62**	**57**	**55**	**61**	**65**	**68**	**69**		**64**

Source: Gnewt Cargo Agile 2 data

The average speed of Gnewt Cargo was 15 km/h, corresponding to 9.3 mph. This result is slightly higher than the Transport for London figures for Central London with 8.1 mph for 2016.

The average time a van spent driving on the streets was 32 hours per month. The data enables detailed analysis for distance and energy. For example: in September 2015, the energy use varies between 0.16 and 0.39 kWh/km, in October 2015, it varies between 0.18 and 0.44 kWh/km. The average distance per day is 25km and 26 km respectively. These relatively even numbers in energy use and transport distance are a sign of relative stability in the day to day tasks of performing deliveries in Central London, despite the high variations in number of parcels. This is a good sign for business stability and long term sustainability of the business model.

l/100km values are calculated on the basis of the kWh usage of the electric vans according to Fleetcarma conversion factors. This conversion factor does apply for a conventionally sourced electricity purchase. But this conversion factor cannot be used for further calculations at Gnewt Cargo, because the electricity used is based on 100% renewable energy sources. It can only be used as a benchmarking reference.

Table 10 presents changes in the data, for a 3-month period. It focuses on fleet performance improvements, better understanding the changes occurring within the three months.

Table 10: Gnewt Cargo performance and energy use changes 1 March 2016 - 31 May 2016

	March 2016	April 2016	May 2016	March-May Change in %
Number Of Vehicles	64	65	65	2
Charger Energy				
Average Start Battery Charge (%)	94.1	94.7	95.3	11
Average End Battery Charge (%)	57.2	63.1	67.3	18
Quick Charge (kWh)	35.3	6.5	0	-100
Standard Charge (kWh)	10,903	9,404.9	7,927.7	-27
Distance				
Daily Average Distance per Vehicle (km)	25	24.6	24.1	-4
Total Monthly Distance all Vehicles (km)	31,808.3	31,195.4	29,980.4	-6
Total Monthly Distance per Vehicle (km)	497	479.9	461.2	-7
Speed				
Average Speed (km/h)	14.9	15.3	15.2	
Driving Energy				
Battery Energy Consumption (kWh)	9042	7759.8	6480.9	-28
Charger Loss (kWh)	878	755.3	635.8	-28
Utilization Time				
Availability (%)	66.8	67.4	68.5	3
Charging Hours	5138.2	4477.3	3737.6	-27
Daily On Hours	5.9	5.8	5.8	-2
Driving Hours	2137.4	2037.9	1970.5	-8
Idle Hours	5356.1	5385.5	5201.1	-3
Idle Time (%)	71.5	72.5	72.5	1
Off Hours	30,570.5	29,128.6	27,508.4	-10

	March 2016	April 2016	May 2016	March-May Change in %
On Hours	7493.5	7423.4	7171.6	-4
Resting Hours	25,432.3	24,651.3	23,770.7	-7
Utilization Time (%)	19.7	20.3	20.7	5

Source: Gnewt Cargo Agile 2 data

Average speed and distance are stable from one month to the next (Table 10). There is a slight reduction in energy use and utilisation time over the period. The battery energy consumption was lowered by about 25% during the months March to May 2016. This effect is probably influenced by the better battery management introduced with Fleetcarma.

3.2.3 Fleetcarma GPS and positioning data

A GPS file was 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 big GPS 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.
Table 11 is an example of the first lines of a vehicle dataset, which has 222,798 lines of GPS information recorded.

Table 11: GPS log for the start of an electric van trip in London, 16 September 2015

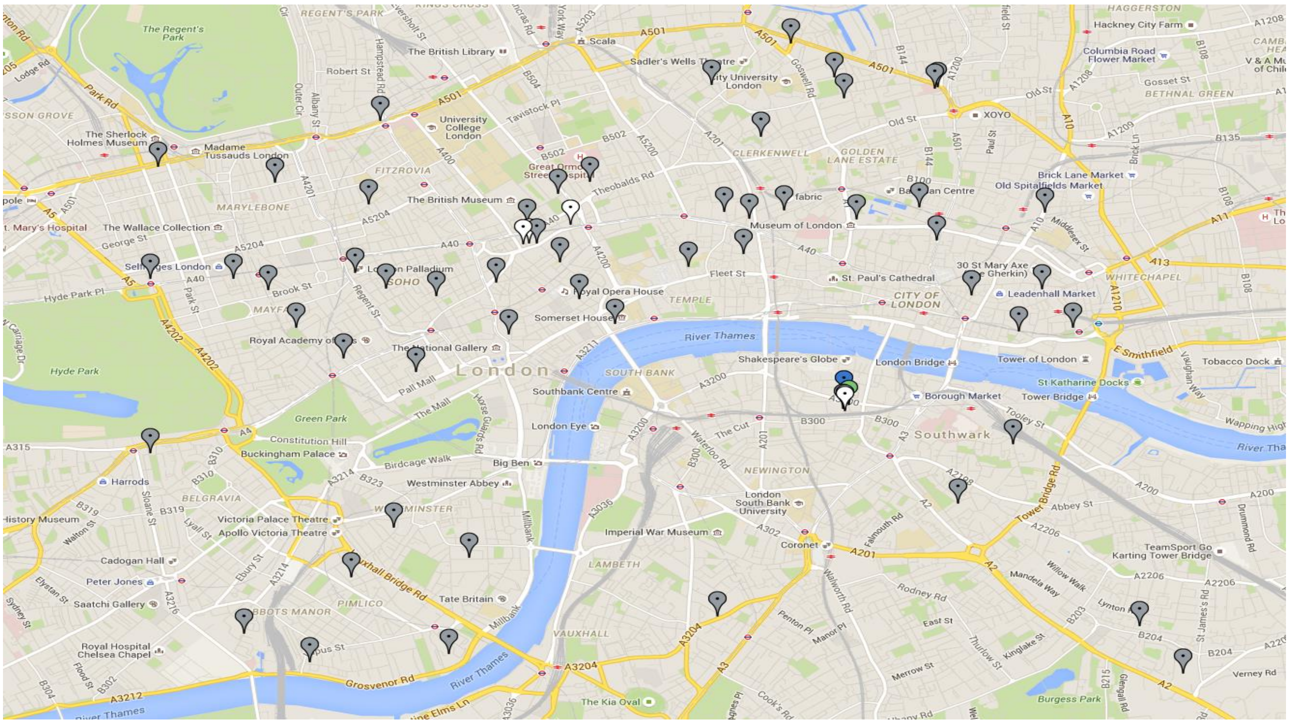
Vehicle_ID	Trip_ID	Timestamp	Latitude [deg]	Longitude [deg]	Altitude [mi]	GPS Speed [MPH]
3110	2.311	9/16/2015 8:45:16 AM	51.50352	-0.095958333	0.068	9.09
3110	2.311	9/16/2015 8:45:26 AM	51.5032933	-0.095765	0.075	11.60
3110	2.311	9/16/2015 8:45:36 AM	51.5025117	-0.095078333	0.068	23.71
3110	2.311	9/16/2015 8:45:46 AM	51.5020817	-0.094756667	0.055	0.04
3110	2.311	9/16/2015 8:45:56 AM	51.5020817	-0.094756667	0.055	0.04
3110	2.311	9/16/2015 8:46:06 AM	51.5020383	-0.094756667	0.053	1.71
3110	2.311	9/16/2015 8:46:16 AM	51.5017067	-0.094241667	0.046	12.60
3110	2.311	9/16/2015 8:46:26 AM	51.5015017	-0.093983333	0.042	0.01
3110	2.311	9/16/2015 8:46:36 AM	51.5015017	-0.093983333	0.042	0.04
3110	2.311	9/16/2015 8:46:46 AM	51.5015017	-0.093983333	0.042	0.04

Source: Gnewt Cargo Agile 2 data

Figure 1 and Figure 3 show where the Gnewt Cargo vehicles were located after the beginning and towards the end of the project, on 16 October 2015 and 7 June 2016, respectively. The geographical distribution shows Central London locations for Client A and TNT vans, while Client B vans were located only a short distance outside Central London.

The main change in business in summer/autumn 2015 was the area extension beyond the boundaries of the Congestion Charge Zone, as can be seen in Figure 1 and 2 (Central London focus) and Figure 3 (extension towards 2^{nd} ring road). This extension was presented and explained in the final report.

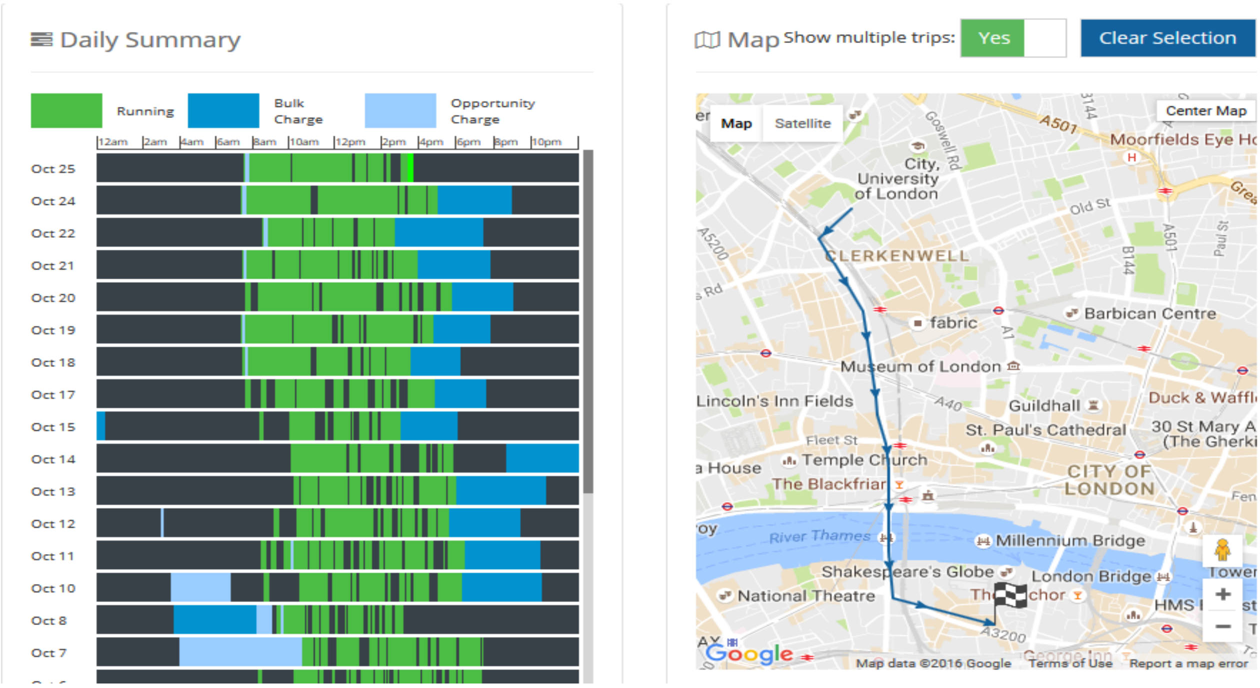
Figure 3: Location of the Gnewt Cargo fleet on 7 June 2016



Source: Gnewt Cargo Agile 2 data

The difficulty with the GPS record is the data visualisation with Fleetcarma, which is linking the dots and simplifying the large amount of data, not showing all GPS points (Figure 4).

Figure 4: GPS log visualisation with Fleetcarma, 25 October 2016



Source: Gnewt Cargo Agile 2 data

This visualisation in Figure 4 (right side) refers to the last part of the delivery trip performed on 25 October 2016 and is shown in the map with a series of blue lines and arrows. This part of the trip is shown in light green on the left hand part of the graph.
With this Fleetcarma map software, a sole visualisation of the entire trip of 25 October does not produce a clear picture, as all dots are joined with lines regardless of the existence of a street network underneath.

Overall, this geo-localisation and trip mapping information was considered sub-optimal, and other software was used in the project.
Data was visualised 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 5.
The visualisation of Figure 5 was generated via a commercial software solution called Tableau software. This software does not generate lines between the dots so the information is better matched with actual streets.

Figure 5: Visualisation of GPS data log obtained via Fleetcarma, one van in Feb 2016

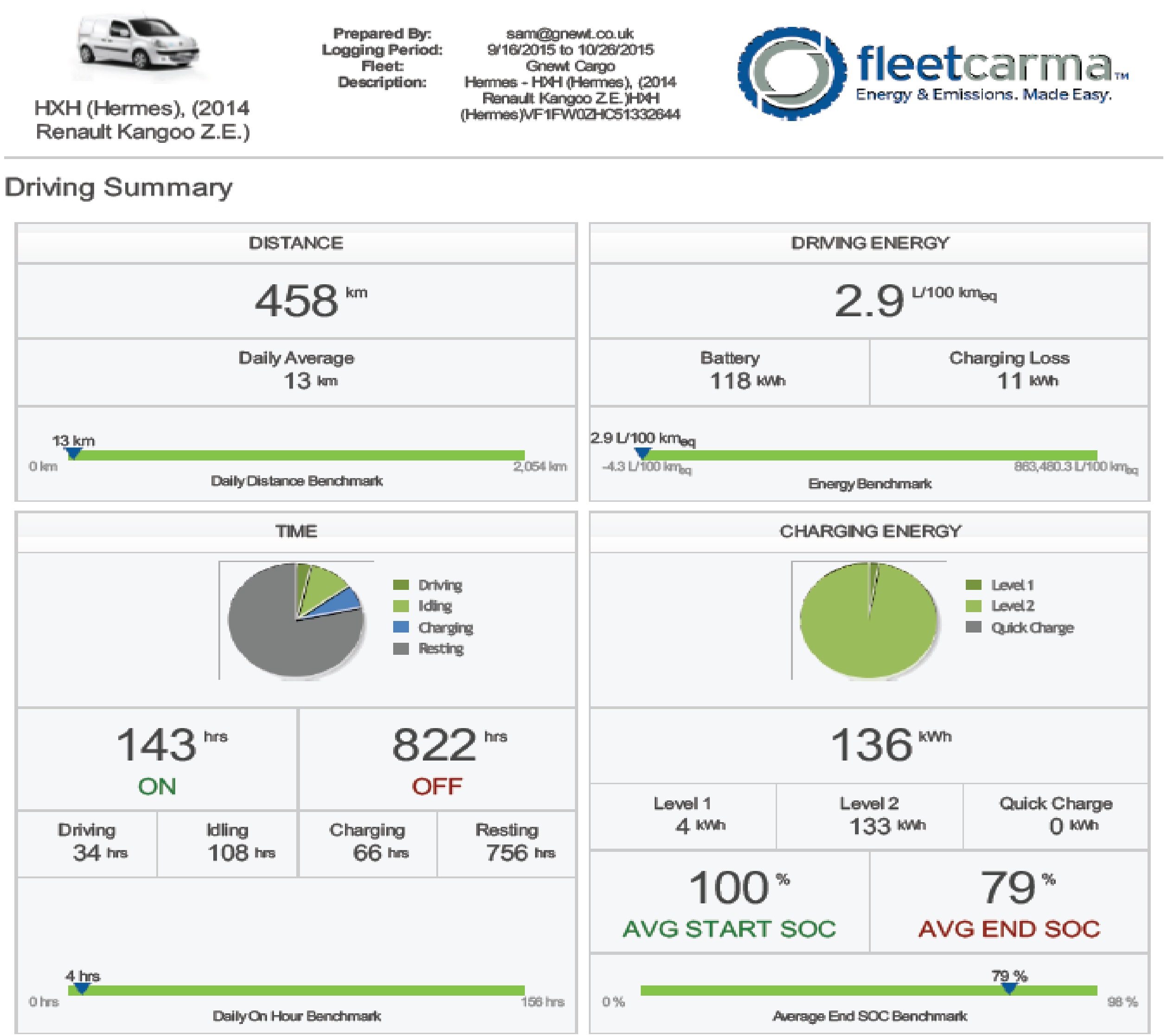
Source: Gnewt Cargo Agile 2 data; "Tableau" software data visualisation

The delivery business can be analysed in detail, for a very specific area of London, with the help of the visualisation techniques and the GPS data obtained.

3.2.4 Fleetcarma energy data

In the Fleetcarma software, the so-called Vehicle Report Dashboard provides a summary table with information on a range of parameters, including: the total and daily average distance driven, driving energy broken down into fuel mpg equivalent, battery kWh and charging loss, time spent driving, idling, charging and resting, charging energy from Level 1, Level 2, and Quick Charge Electric Vehicle Supply Equipment, average starting and ending state-of-charge, GHG emissions and intensity. An example overview of this function for a single vehicle within Gnewt Cargo fleet is presented in Figure 6.

Figure 6: Individual vehicle data of the Gnewt Cargo Fleetcarma fleet, 16 Sept - 26 October 2015

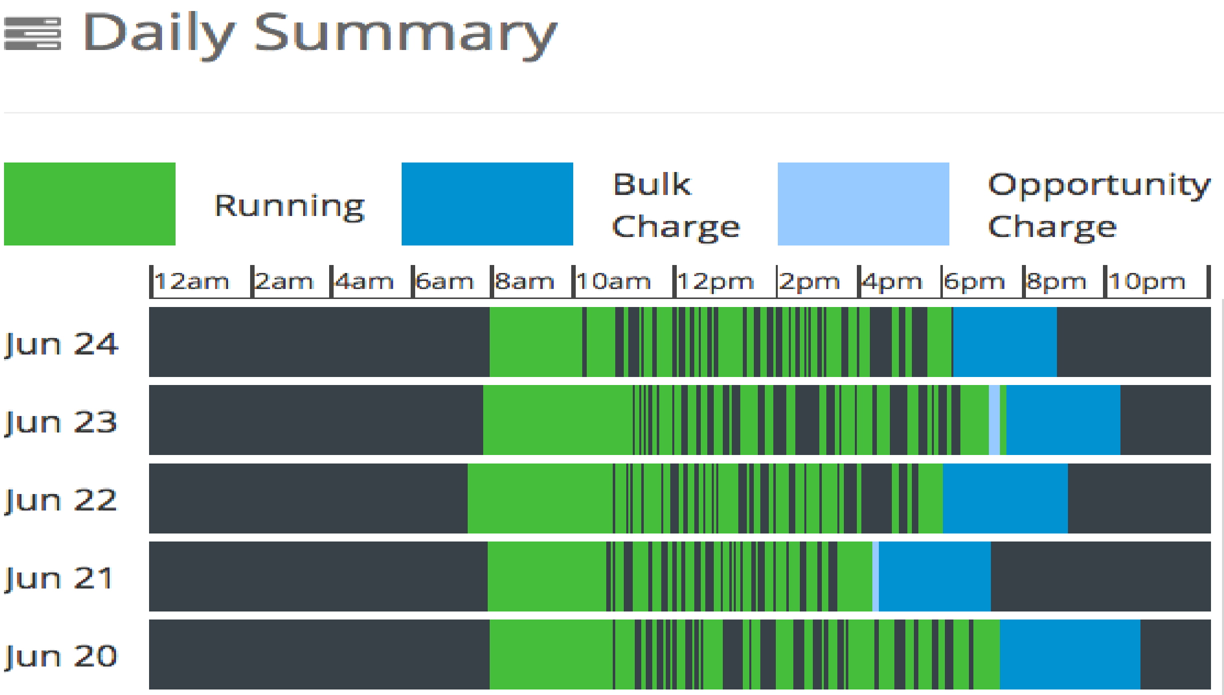


Source: Gnewt Cargo Agile 2 data

Fleetcarma also produced a daily summary for each vehicle including information on the following parameters: bulk charging, opportunity charging, and resting events, distance driven, available range from bulk charging, and potential range from opportunity charging, starting State of Charge (SOC), ambient temperature, auxiliary load usage, and driver eco-score.

An example overview of this function for a single vehicle within Gnewt Cargo fleet is presented in Figure 7 for one week.

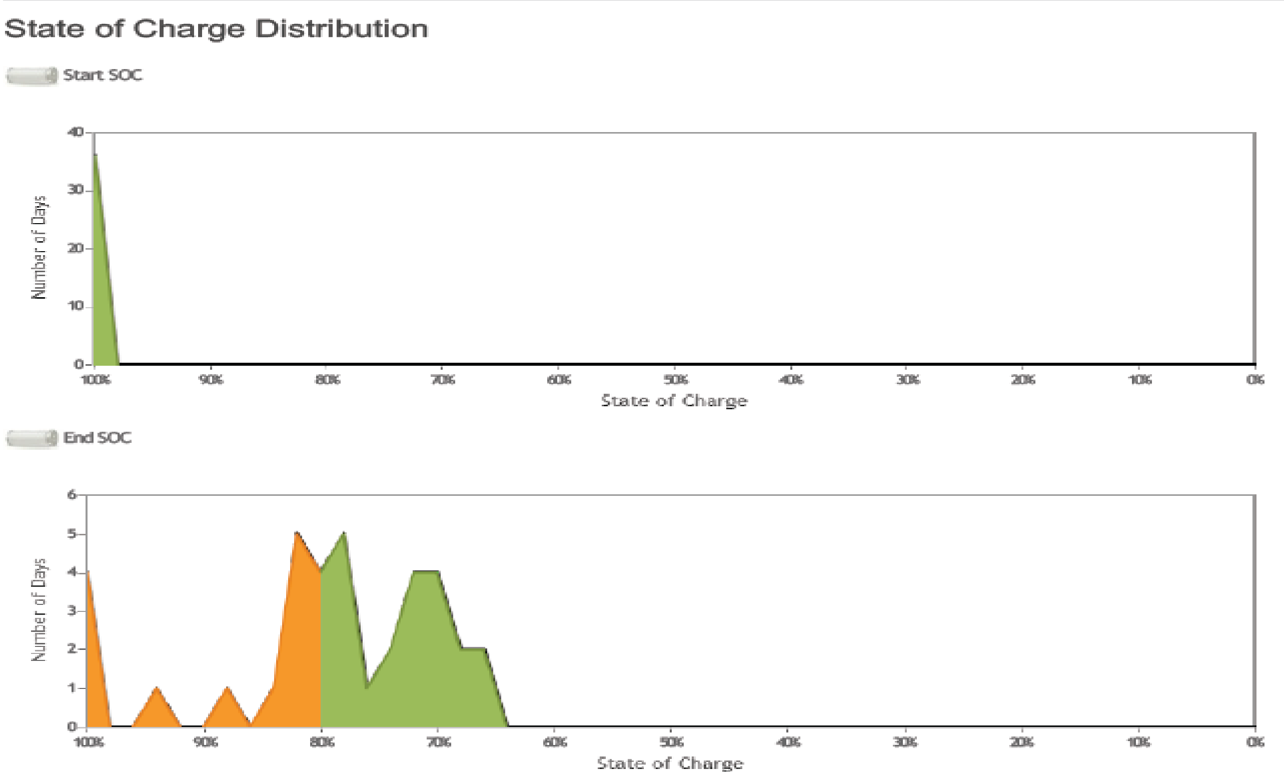
Figure 7: Fleetcarma Daily summary, extract for one vehicle, 20 to 24 June 2016



Source: Gnewt Cargo Agile 2 data

Vehicle charge details are also analysed and presented by Fleetcarma and Figure 8 presents an example of this functionality in a form of charge distribution graph.

Figure 8: Charge distribution graph, fleetcarma vehicle report, 16 Sept-25 Oct 2015



Source: Gnewt Cargo Agile 2 data

3.3 Data of Case Study 2: Emakers, an IT solution for home delivery management

3.3.1 General data and information on Emakers solution

- *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 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 an internet-based software solution provided by a Spanish company. The data arrives directly from the Emakers server, connected via the internet. All data is accessible online, and is 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.

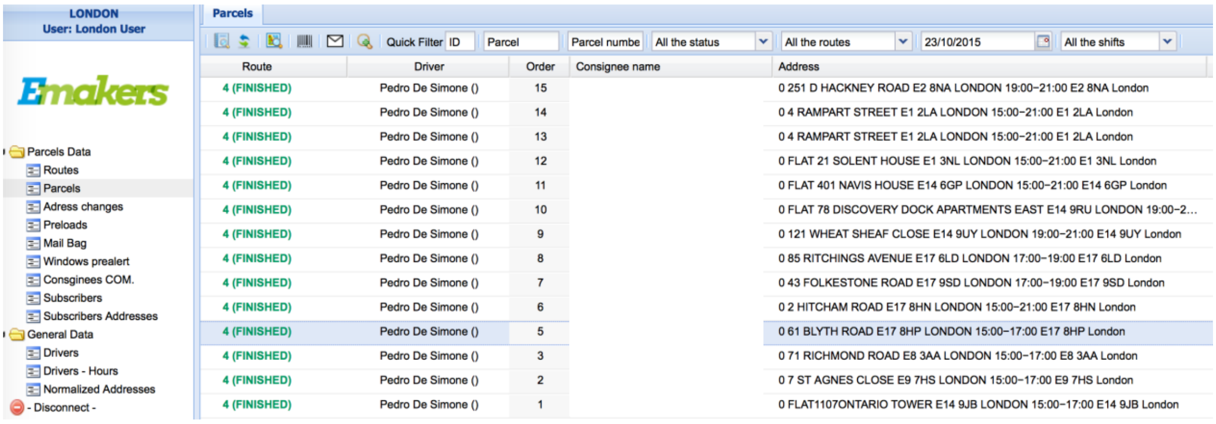
- *What is the range of electric vehicles based on charging?* Up to 160 km per charge, depending on weight, weather, traffic and other factors. This is not influenced by the Emakers capabilities.
- *How many deliveries per charge? Is this better than manual routing?* Yes, the routing capabilities of 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.

3.3.2 Emakers trial data

The data collected by the Emakers software is presented in following graphs and tables while the analyses and explanations are provided in Agile 2 Final Report. Emakers is a B2C solution for urban freight deliveries, enabling online retailers to distribute their goods to their clients with a fleet of electric and cycle freight vehicles.

The IT solution is part of the commercial package, including delivery management and information exchange with customers during parcel delivery operations. Figure 9 presents an overview of functionalities offered by the software.

Figure 9: Overview of Functionalities of Emakers Software



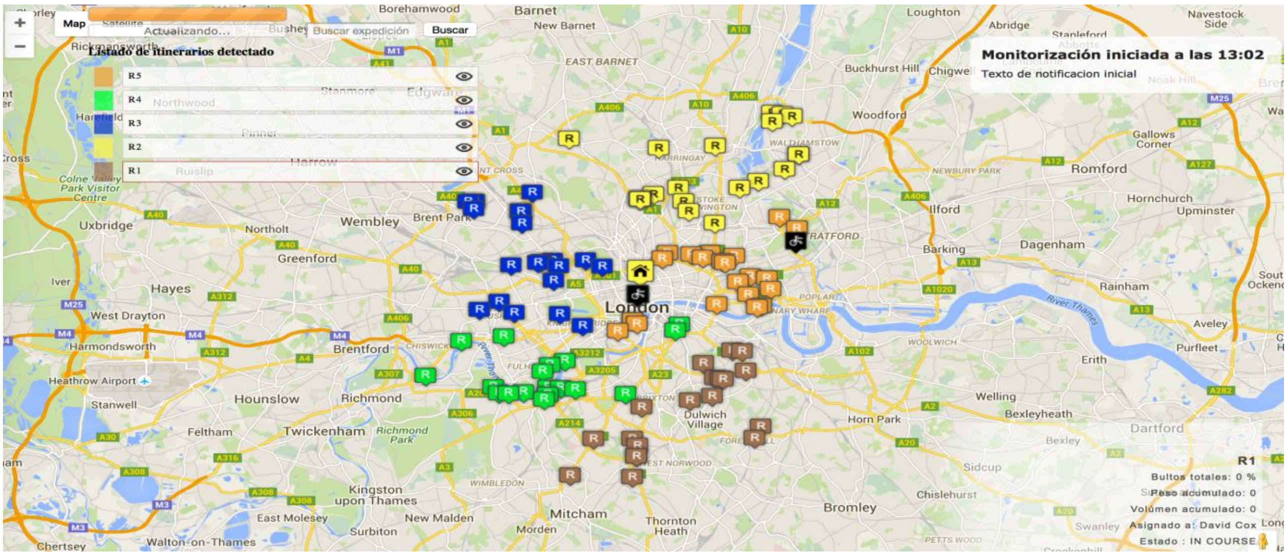
Route	Driver	Order	Consignee name	Address
4 (FINISHED)	Pedro De Simone ()	15		0 251 D HACKNEY ROAD E2 8NA LONDON 19:00–21:00 E2 8NA London
4 (FINISHED)	Pedro De Simone ()	14		0 4 RAMPART STREET E1 2LA LONDON 15:00–21:00 E1 2LA London
4 (FINISHED)	Pedro De Simone ()	13		0 4 RAMPART STREET E1 2LA LONDON 15:00–21:00 E1 2LA London
4 (FINISHED)	Pedro De Simone ()	12		0 FLAT 21 SOLENT HOUSE E1 3NL LONDON 15:00–21:00 E1 3NL London
4 (FINISHED)	Pedro De Simone ()	11		0 FLAT 401 NAVIS HOUSE E14 6GP LONDON 15:00–21:00 E14 6GP London
4 (FINISHED)	Pedro De Simone ()	10		0 FLAT 78 DISCOVERY DOCK APARTMENTS EAST E14 9RU LONDON 19:00–2…
4 (FINISHED)	Pedro De Simone ()	9		0 121 WHEAT SHEAF CLOSE E14 9UY LONDON 19:00–21:00 E14 9UY London
4 (FINISHED)	Pedro De Simone ()	8		0 85 RITCHINGS AVENUE E17 6LD LONDON 17:00–19:00 E17 6LD London
4 (FINISHED)	Pedro De Simone ()	7		0 43 FOLKESTONE ROAD E17 9SD LONDON 17:00–19:00 E17 9SD London
4 (FINISHED)	Pedro De Simone ()	6		0 2 HITCHAM ROAD E17 8HN LONDON 15:00–21:00 E17 8HN London
4 (FINISHED)	Pedro De Simone ()	5		0 61 BLYTH ROAD E17 8HP LONDON 15:00–17:00 E17 8HP London
4 (FINISHED)	Pedro De Simone ()	3		0 71 RICHMOND ROAD E8 3AA LONDON 15:00–17:00 E8 3AA London
4 (FINISHED)	Pedro De Simone ()	2		0 7 ST AGNES CLOSE E9 7HS LONDON 15:00–17:00 E9 7HS London
4 (FINISHED)	Pedro De Simone ()	1		0 FLAT1107ONTARIO TOWER E14 9JB LONDON 15:00–17:00 E14 9JB London

Source: Gnewt Cargo Agile 2 data

Emakers offers a mapping functionality enabling the visualisation of customer addresses. Emakers' visualisation and mapping of addresses occur at the planning stage, when preparing the delivery rounds.

This mapping is illustrated for delivery addresses for one of Gnewt Cargo's client, Client B, on 26 October 2015 (Figure 10). On that day, 5 routes were driven in London, to a large extend outside the Central London Congestion Charge Zone, mostly within the 2nd ring. Due to the newly extended distribution zone involving longer distances and tighter schedules, problems such as battery range and missed delivery time windows became apparent.

Figure 10: Map of the Emakers addresses for Client B trips on 26 October 2015



Source: Gnewt Cargo Agile 2 data

Table 12: Emakers trip overview 1-23 October 2015

Trip ID	Distance in km	Number of deliveries	Distance per delivery, in km	Date
1	14.7	13	1.13	01-Oct
2	14.6	9	1.62	01-Oct
3	40.8	8	5.10	01-Oct
4	22.9	8	2.86	01-Oct
5	10.1	1	10.09	02-Oct
6	59.1	14	4.22	02-Oct
7	14.7	18	0.81	02-Oct
8	43.4	7	6.19	02-Oct
9	40.2	13	3.09	02-Oct
10	86.7	18	4.82	03-Oct
11	14.7	20	0.73	03-Oct
12	69.3	15	4.62	04-Oct
13	11.6	4	2.90	05-Oct
14	21.1	12	1.76	05-Oct
15	6.5	1	6.52	06-Oct
16	9.5	0	0	06-Oct
17	6.6	4	1.65	07-Oct
18	18.3	9	2.03	07-Oct
19	41.2	14	2.94	07-Oct
20	66.4	15	4.43	07-Oct
21	14.7	21	0.70	07-Oct
22	29.2	20	1.46	07-Oct
23	14.7	15	0.98	08-Oct
24	5.8	7	0.83	08-Oct
25	7.4	2	3.70	08-Oct
26	50.5	13	3.88	08-Oct
27	14.6	10	1.46	08-Oct
28	45.0	9	5.00	08-Oct
29	14.6	13	1.13	08-Oct
30	15.7	3	5.24	08-Oct
31	15.4	3	5.12	09-Oct
32	2.7	1	2.65	09-Oct
33	54.0	15	3.60	09-Oct

Table 12: Emakers trip overview (continues)

Trip ID	Distance in km	Number of deliveries	Distance per delivery, in km	Date
34	14.7	15	0.98	09-Oct
35	14.6	14	1.05	09-Oct
36	43.8	18	2.43	09-Oct
37	74.8	20	3.74	10-Oct
38	72.0	19	3.79	10-Oct
39	14.7	17	0.86	10-Oct
40	25.9	10	2.59	12-Oct
41	21.1	14	1.51	14-Oct
42	51.7	17	3.04	14-Oct
43	53.4	21	2.54	14-Oct
44	62.3	8	7.79	14-Oct
45	37.9	18	2.11	14-Oct
46	76.6	21	3.65	15-Oct
47	16.6	14	1.19	15-Oct
48	5.8	3	1.95	15-Oct
49	4.9	2	2.47	15-Oct
50	53.3	14	3.81	15-Oct
51	14.6	9	1.63	15-Oct
52	48.4	10	4.84	15-Oct
53	14.6	12	1.22	16-Oct
54	7.5	2	3.74	16-Oct
55	3.7	1	3.68	16-Oct
56	16.2	0	0	16-Oct
57	52.7	7	7.53	16-Oct
58	46.0	16	2.88	16-Oct
59	14.6	14	1.05	16-Oct
60	44.4	18	2.47	16-Oct
61	43.5	15	2.90	16-Oct
62	56.4	16	3.53	17-Oct
63	59.5	20	2.97	17-Oct
64	66.5	12	5.54	17-Oct
65	14.6	18	0.81	17-Oct
66	23.0	12	1.92	19-Oct
67	4.4	2	2.21	20-Oct
68	6.1	2	3.07	20-Oct
69	6.6	4	1.64	21-Oct
70	9.8	4	2.44	21-Oct
71	19.4	11	1.76	21-Oct
72	29.2	17	1.72	21-Oct
73	54.4	27	2.01	21-Oct
74	14.7	20	0.73	21-Oct
75	14.7	22	0.67	21-Oct
76	57.7	23	2.51	21-Oct
77	14.7	12	1.22	22-Oct
78	14.6	9	1.62	22-Oct
79	34.1	8	4.26	22-Oct
80	14.6	16	0.92	22-Oct
81	21.2	8	2.65	22-Oct
82	5.1	4	1.28	23-Oct
83	56.8	16	3.55	23-Oct
84	56.9	14	4.06	23-Oct
85	60.7	11	5.52	23-Oct
86	50.6	12	4.21	23-Oct
87	29.2	14	2.09	23-Oct
Total	2642.3	1018		
Average	30.4	11.7	2.6	

Source: Gnewt Cargo Agile 2 data

Emakers software was used for Gnewt Cargo delivery operations between 1 and 23 October. Table 10 shows data on distance travelled and number of deliveries performed in that time. It is clear that some days were less busy than others and the number of completed deliveries varied greatly among different vehicles.

Values of distance per delivery are particularly useful as they help understand trip characteristics and whether fewer deliveries per van meant longer distances travelled.
The analysis of Emakers data collected between 1 and 23 October is presented in Table 13.

Table 13: Statistics on the Emakers data 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	11.7
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

3.4 Case Study 3: Data of the tour planning software testing

3.4.1 Qualitative information about the IT systems tested for routing and tour planning optimisation

The idea behind testing tour planning systems in urban areas is to find the ideal sequence of customer sites to be served by each vehicle. Currently no urban logistics business uses 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 supported by IT 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 an 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 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 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 a 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 areas 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 areas from the driver's 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 the 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. October to December 2015 could not be used for a real trial, as the workload for drivers was high due to it being the peak period. The trials started in early 2016 with 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 was collected more extensively for the Optrak and PTV Smartour tests. 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, which has as a main component the products of the software company Blackbay. This software is used for the order 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 the client's delivery addresses can be exported in Excel format, and then this exported data was used for the routing optimisation trial.

For Client B and Emakers parcel businesses, 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. The Optrak, Podfather and PTV Smartour tests started with a phase of calibration.

3.4.2 Optrak trial data

Optrak is a pure trip planning and routing system for freight transport. The software provider is based in the 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' 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 routes 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 the Blackbay report (i.e. the orders listed in the original Client A sequence, before deliveries are made) and created an input to Optrak that produced optimised routes. In theory these optimised routes allowed 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 the findings are available.
5. Gnewt Cargo did not experiment with a small number of rounds based on the Optrak routing, because the routing results never reached the point where the Optrak route would be better, shorter and quicker than the drivers' knowledge.

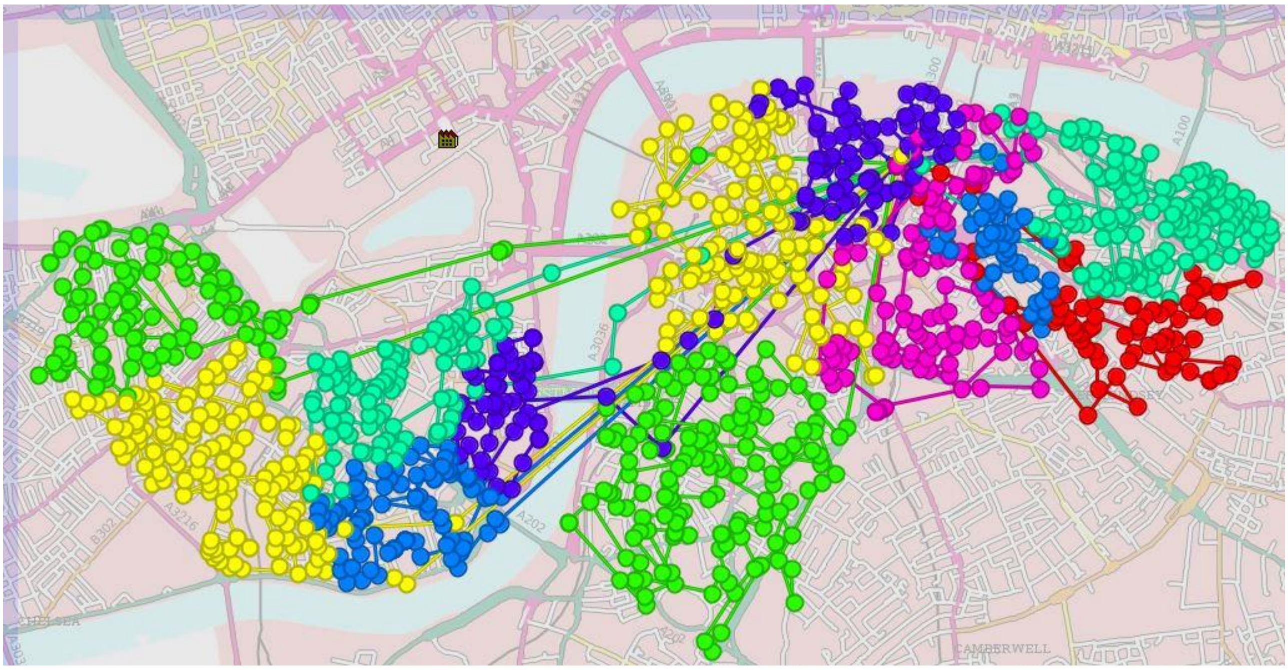
The results were available in June 2016.

Figure 11, below, shows the optimised routes tested in early 2016. This period was suitable for a trial because it corresponds to an average business situation without peaks or troughs in volume. The total distances of the routes driven on 22nd January 2016 by the Gnewt Cargo drivers for Client A is available as a baseline. Gnewt Cargo uploaded the Client A round data obtained after the deliveries on 22 January 2016.

The data was 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 proposed 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 11: 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.

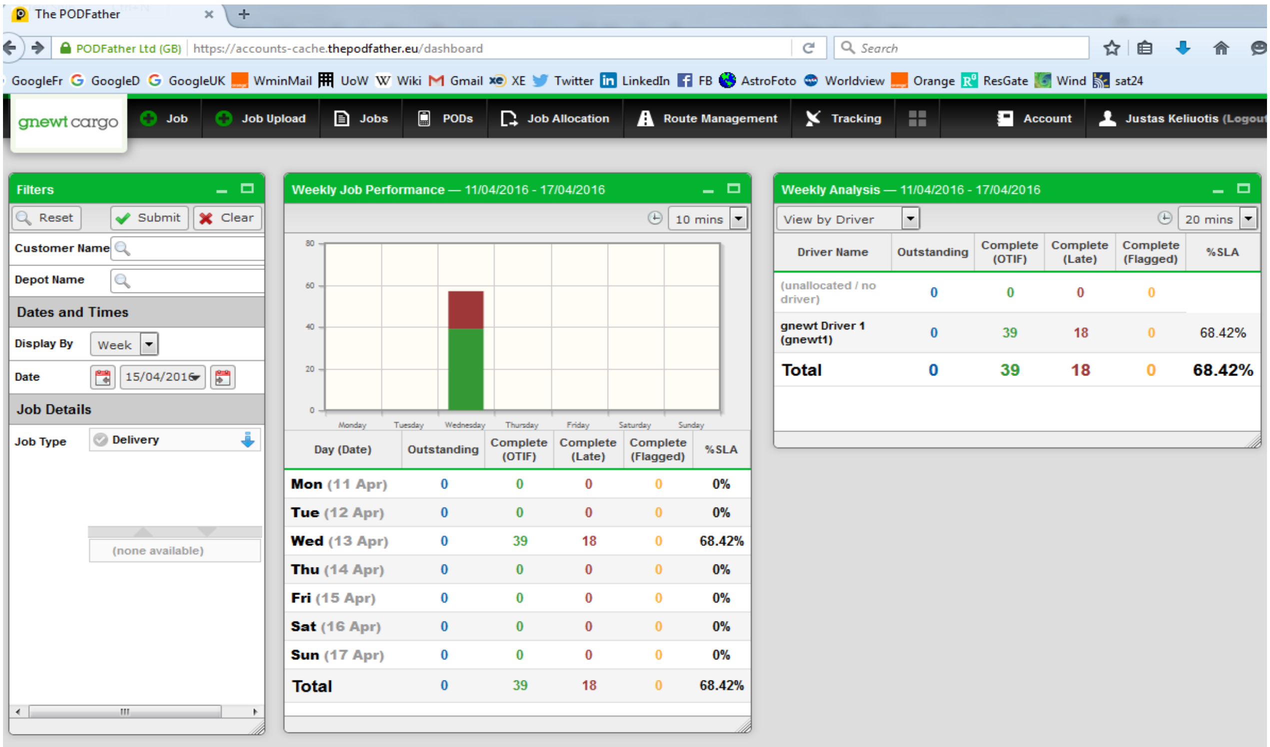
The improved Optrak software was not suitable for future business implementation at this stage.

3.4.3 Podfather trial data

Podfather is a web based software application linked with a handheld device. Main functionalities include job allocation, route management, and tracking. Figure 12 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 12: Podfather web-based dashboard with job performance of the trial, 13 April 2016



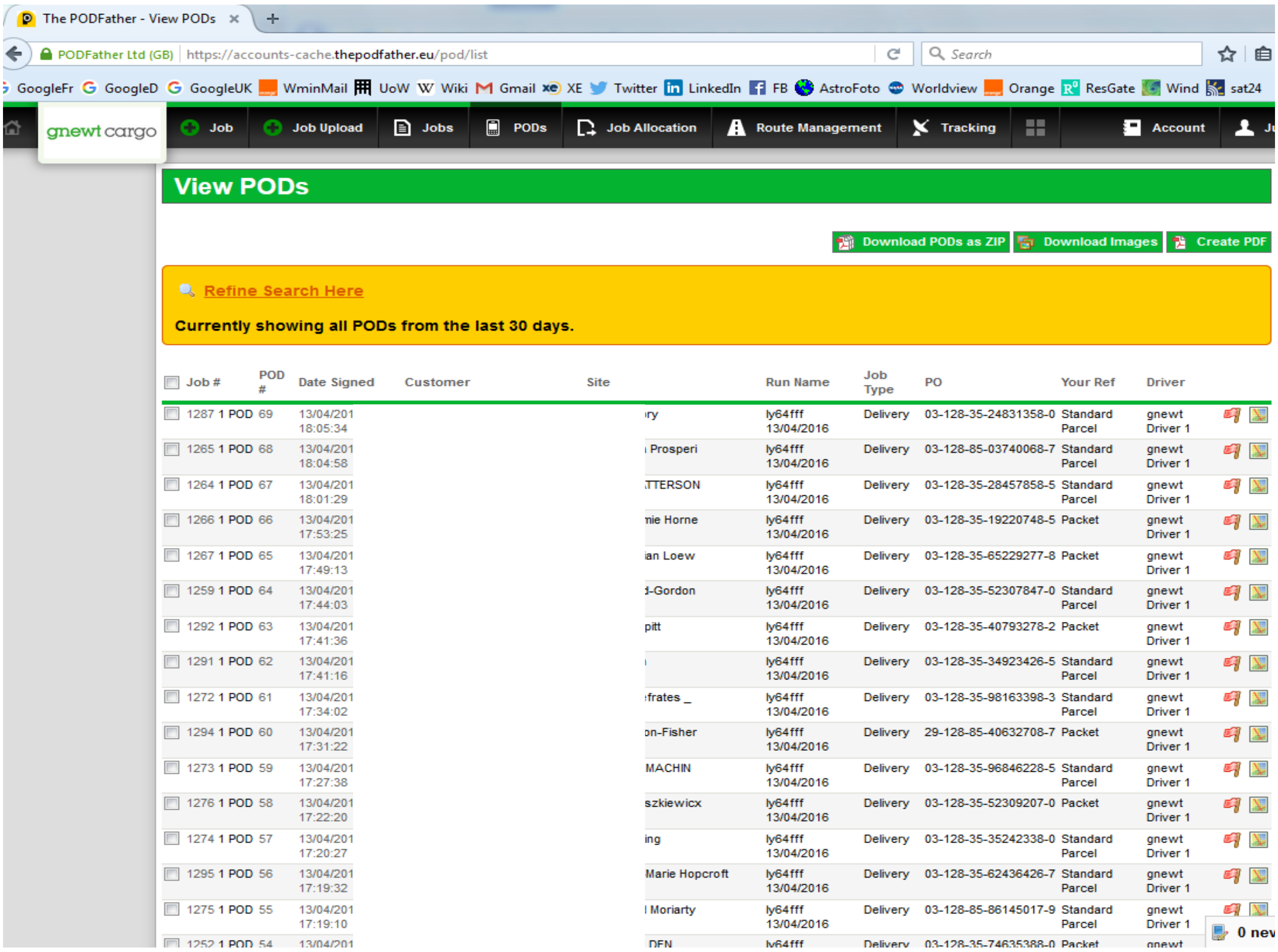
Source: Gnewt Cargo Agile 2 data

Figure 13 shows the Podfather web-based routing management functionality with an example of a set of delivery locations for a day in March 2016.

Figure 13: Podfather routing data example, March 2016

Source: Gnewt Cargo Agile 2

Figure 14: Podfather customers' data with delivery confirmation and routing example



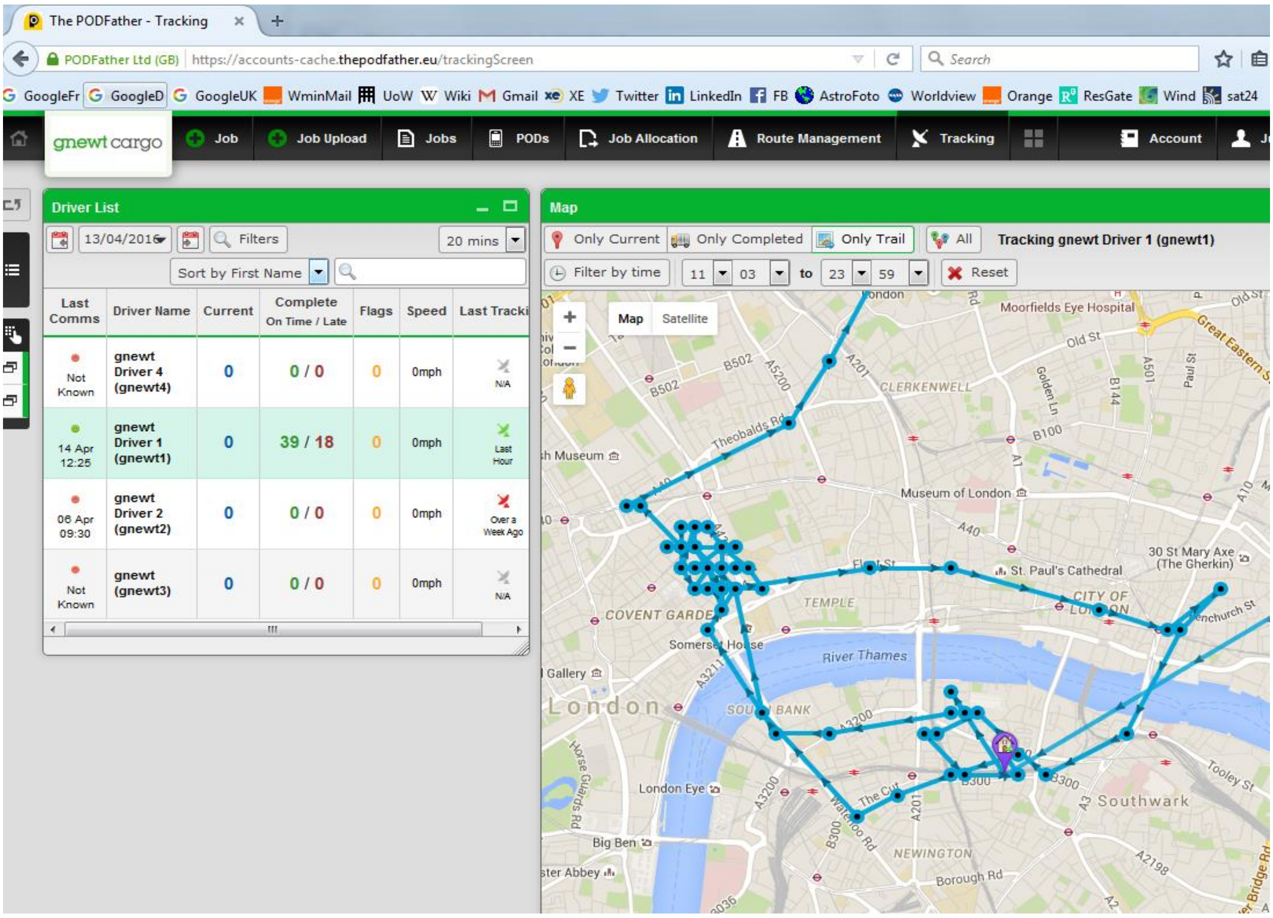
Job #	POD #	Date Signed	Customer	Site	Run Name	Job Type	PO	Your Ref	Driver
1287 1 POD	69	13/04/201 18:05:34		ıry	ly64fff 13/04/2016	Delivery	03-128-35-24831358-0	Standard Parcel	gnewt Driver 1
1265 1 POD	68	13/04/201 18:04:58		ı Prosperi	ly64fff 13/04/2016	Delivery	03-128-85-03740068-7	Standard Parcel	gnewt Driver 1
1264 1 POD	67	13/04/201 18:01:29		‌TTERSON	ly64fff 13/04/2016	Delivery	03-128-35-28457858-5	Standard Parcel	gnewt Driver 1
1266 1 POD	66	13/04/201 17:53:25		nie Horne	ly64fff 13/04/2016	Delivery	03-128-35-19220748-5	Packet	gnewt Driver 1
1267 1 POD	65	13/04/201 17:49:13		ian Loew	ly64fff 13/04/2016	Delivery	03-128-35-65229277-8	Packet	gnewt Driver 1
1259 1 POD	64	13/04/201 17:44:03		d-Gordon	ly64fff 13/04/2016	Delivery	03-128-35-52307847-0	Standard Parcel	gnewt Driver 1
1292 1 POD	63	13/04/201 17:41:36		pitt	ly64fff 13/04/2016	Delivery	03-128-35-40793278-2	Packet	gnewt Driver 1
1291 1 POD	62	13/04/201 17:41:16		ı	ly64fff 13/04/2016	Delivery	03-128-35-34923426-5	Standard Parcel	gnewt Driver 1
1272 1 POD	61	13/04/201 17:34:02		·frates _	ly64fff 13/04/2016	Delivery	03-128-35-98163398-3	Standard Parcel	gnewt Driver 1
1294 1 POD	60	13/04/201 17:31:22		on-Fisher	ly64fff 13/04/2016	Delivery	29-128-85-40632708-7	Packet	gnewt Driver 1
1273 1 POD	59	13/04/201 17:27:38		MACHIN	ly64fff 13/04/2016	Delivery	03-128-35-96846228-5	Standard Parcel	gnewt Driver 1
1276 1 POD	58	13/04/201 17:22:20		szkiewicx	ly64fff 13/04/2016	Delivery	03-128-35-52309207-0	Packet	gnewt Driver 1
1274 1 POD	57	13/04/201 17:20:27		ing	ly64fff 13/04/2016	Delivery	03-128-35-35242338-0	Standard Parcel	gnewt Driver 1
1295 1 POD	56	13/04/201 17:19:32		Marie Hopcroft	ly64fff 13/04/2016	Delivery	03-128-35-62436426-7	Standard Parcel	gnewt Driver 1
1275 1 POD	55	13/04/201 17:19:10		l Moriarty	ly64fff 13/04/2016	Delivery	03-128-85-86145017-9	Standard Parcel	gnewt Driver 1
1252 1 POD	54	13/04/201		DEN	ly64fff	Delivery	03-128-35-74635388-0	Packet	gnewt

Source: Gnewt Cargo Agile 2 data

On Figure 14, original Podfather and Gnewt data was 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 15, 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 represent 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 below 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 15: Tracking of the delivery trips performed with Podfather on 13 April 2016



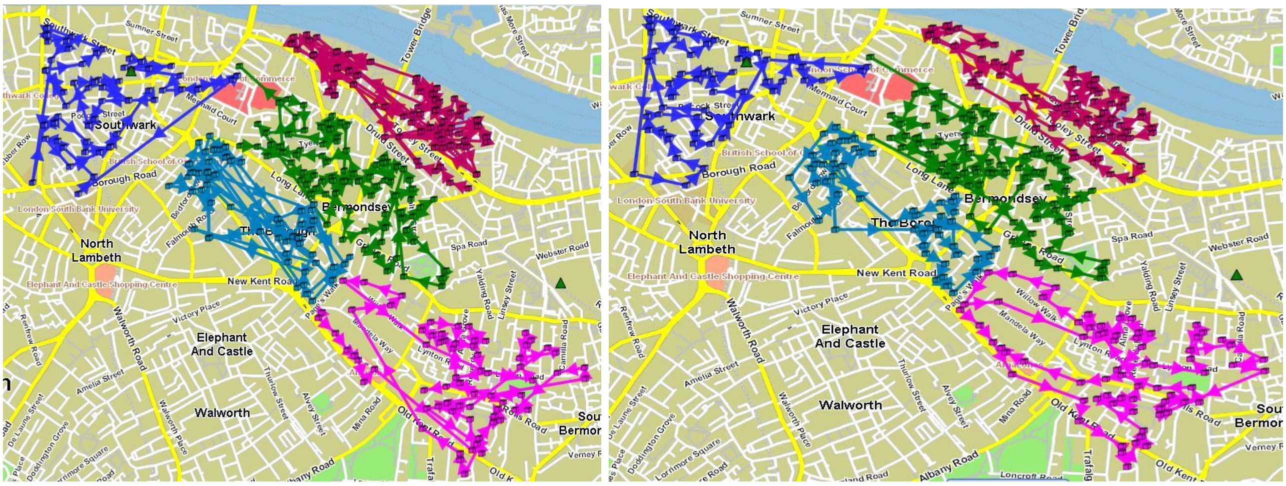
Source: Gnewt Cargo Agile 2 data

3.4.4 PTV Smartour trial

The PTV trial started in January 2016. 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 way similar to the others: the order list is uploaded into the system via an online web access. Then the optimisation function allows the production of 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 analyse the difference between normal day-to-day tours with manual planning and the software optimisation. The first results are shown in Figure 16 for 5 rounds for Client A on a February day in the Southwark area.

Figure 16: 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 14).

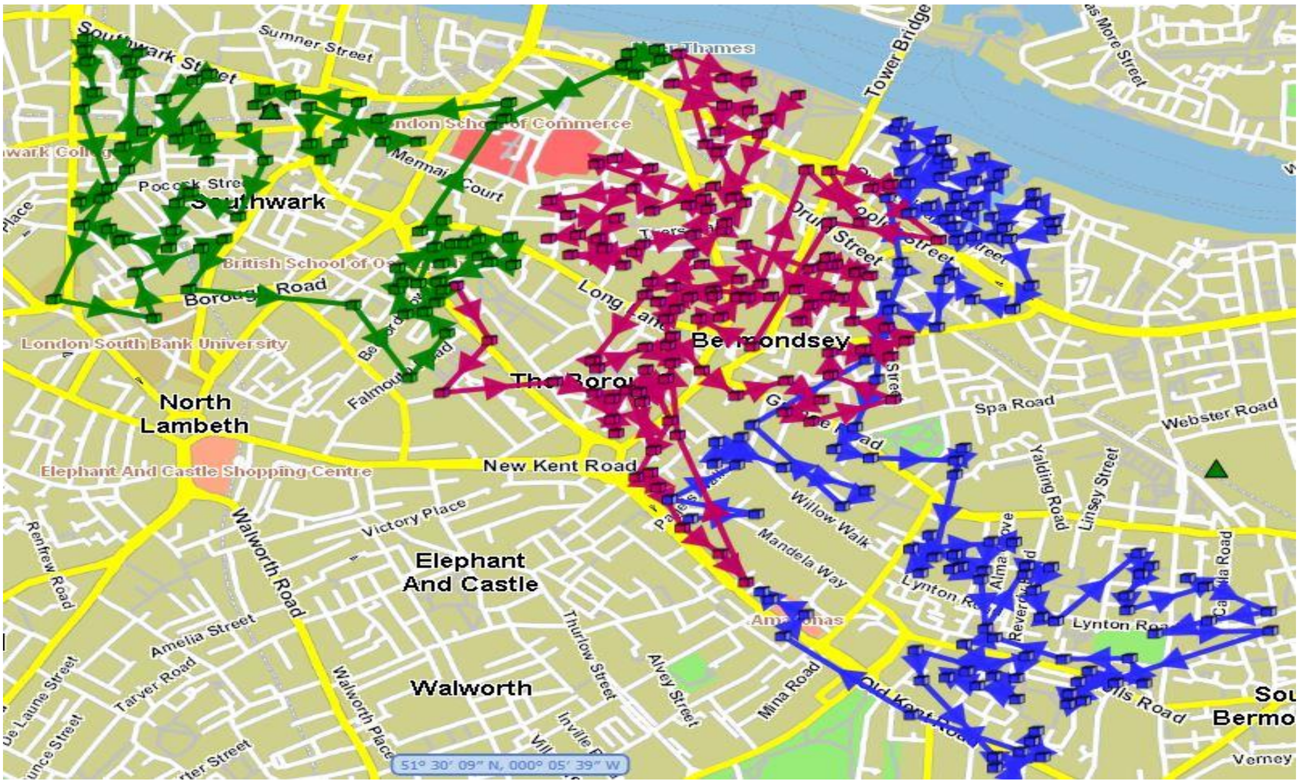
Table 14: Distance driven for 5 rounds on 4th Feb, with and without PTV optimised routing

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

Source: Gnewt Cargo Agile 2 data

The PTV Smartour allows for changes to the area of delivery to optimise the overall delivery situation. Figure 17 presents the solution after optimisation including area reconfiguration.

Figure 17: PTV Smartour optimisation with area reconfiguration



Source: Gnewt Cargo Agile 2 data

The reconfiguration of the entire delivery area can be seen in Figure 17. The results of the PTV optimisation, including the merging of the delivery area, shows that rather than 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 usability, 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.

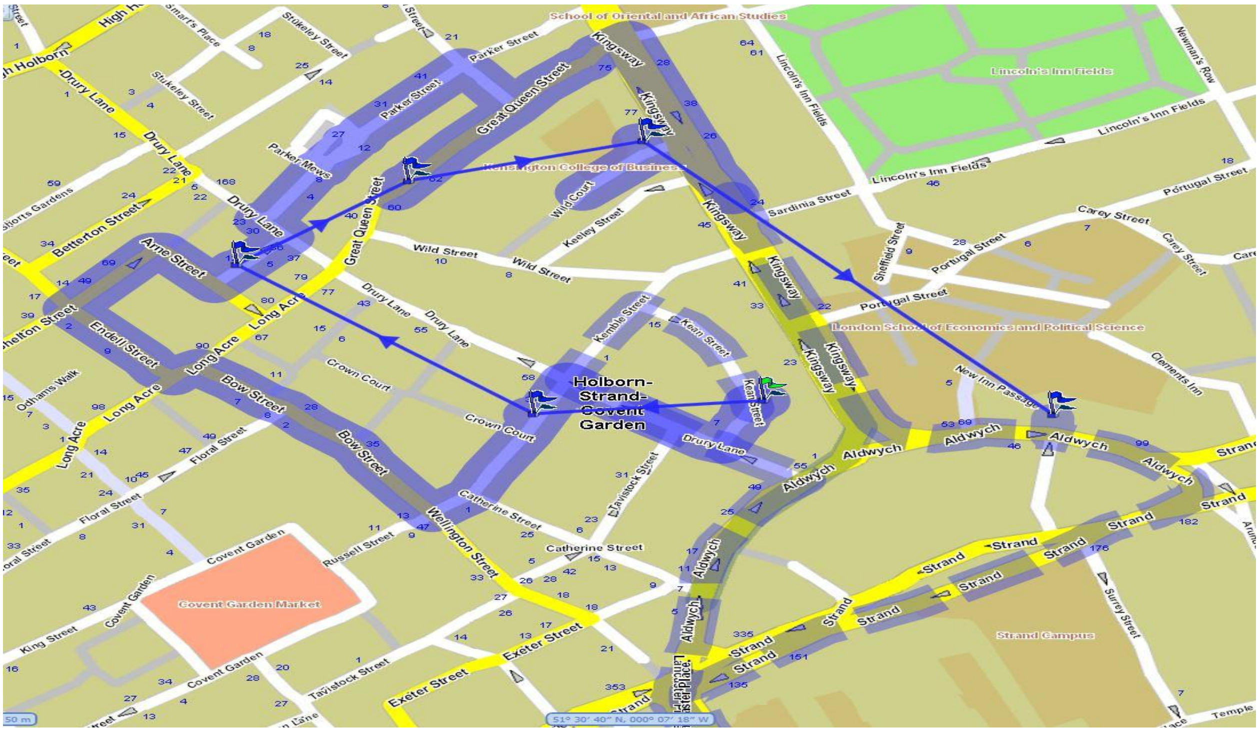
A further set of verification steps was conducted, with real test drives. The objective was to confirm with real test drives if the optimised routes would be shorter than a driver would have done without optimisation.

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.

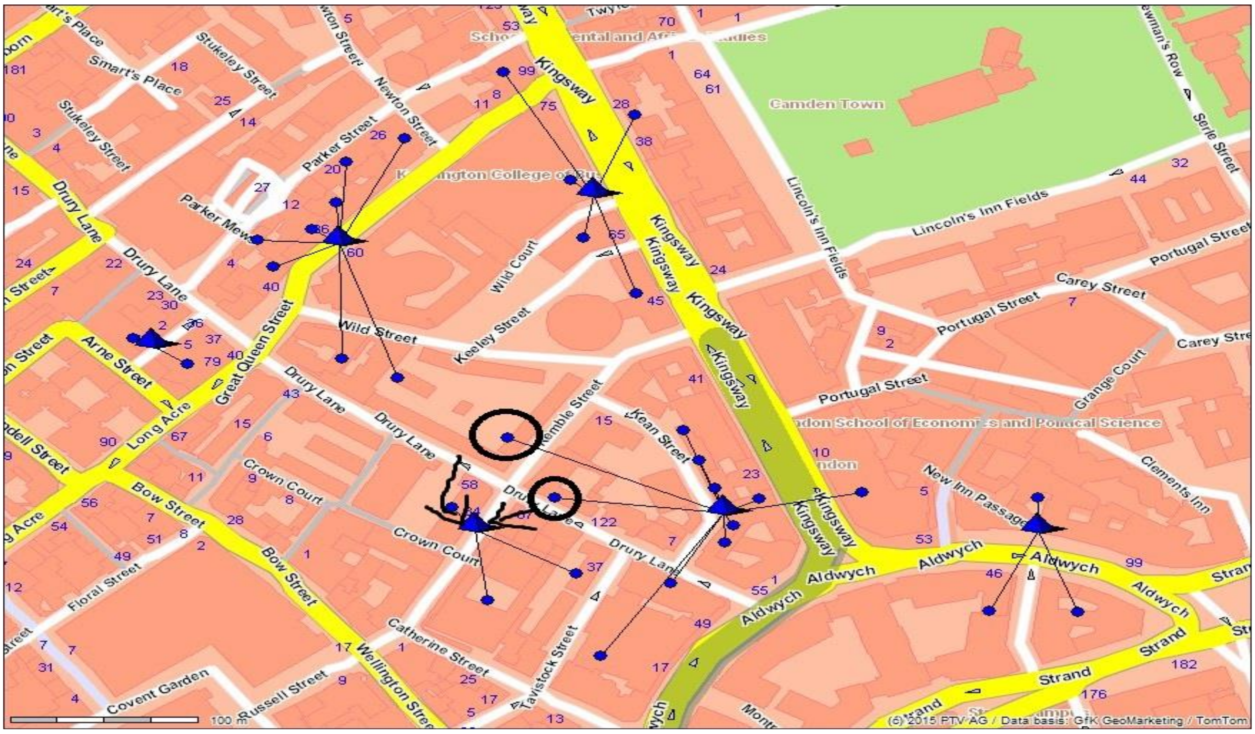
In one example, the number of stops was reduced to 5 for 57 parcels delivered on 14 April 2016 (Figure 18). This solution was tested with real test drives, after manual optimisation. The manual work consisted of looking at the different delivery addresses and grouping them around central loading bays 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 19).

Figure 18: 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

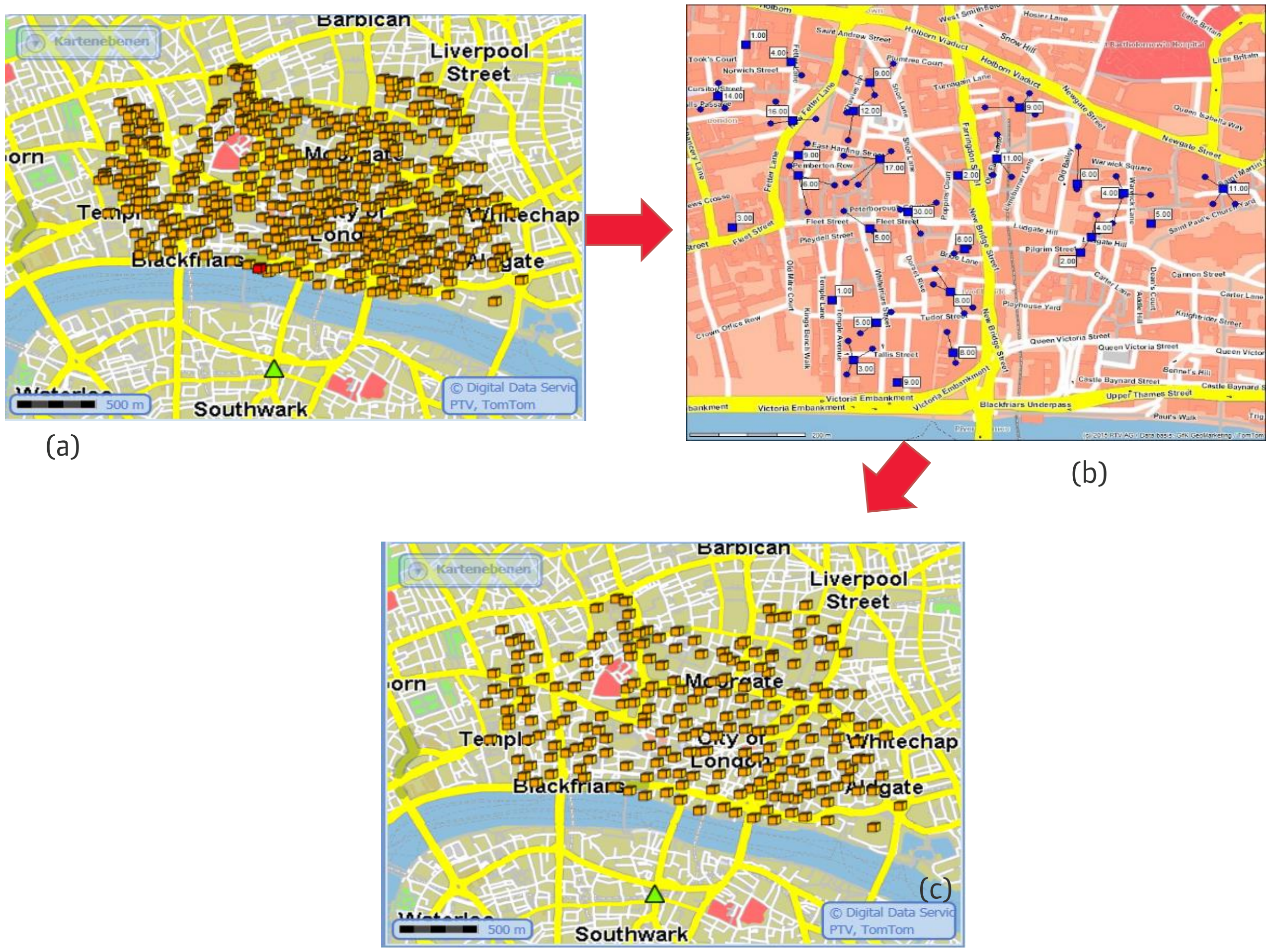
Figure 19: Manual work linking delivery addresses with central stopping points to reduce total distance and number of stops, driven on 14 April 2016



Source: Gnewt Cargo Agile 2 data

Groupage of orders

Figure 20: Initial delivery points (a), groupings (b), stopping points reduced by 50% (c)



Source: Gnewt Cargo Agile 2 data

Figure 20 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 21).

Figure 21: 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 below in Figure 21. 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 expectations. 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 operation, this would take too much time, many hours of manual work. But this is where the main idea for a future project where this procedure could be automated, 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.

3.4.5 Evaluation of IT solutions for routing, planning and optimisation

3.4.5.1 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 15.

The most important benefit indicators are those to do with 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 15: Form with indicators and valuation for IT trial assessment

How fast is it to perform a round trip plan starting from raw customer 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

3.4.5.2 Final evaluation on 2 August 2016

Gnewt Cargo tested the efficiency of routing software in the context of urban parcel delivery. These IT solution tests were sufficiently advanced to give an evaluation in the form of valuation of criteria relevant for the day-to-day operation (practicality), profitability (costs and benefits balance) and the usability (ease of use). Evaluation results are presented in Table 16 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 walking and driving parts of the delivery trips might allow Gnewt Cargo to use the software in the day-to-day operation. Once this new solution is implemented, it is reasonable to expect that this would lead to a substantial improvement in the number of trips and time taken for deliveries..

Table 16: Final valuation of IT routing solutions tested in Case Study 3

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

Source: Gnewt Cargo Agile 2 data

4. Targets achievements data

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 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 17.

4.1 Target distance reduction and urban traffic mitigation impact in Q1 (2016/2017)

A target distance reduction of 50% was set at the beginning of the project. Accurate data is 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 17: Target reached for distance reduction in Q1 (2016/2017)

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

Source: Gnewt Cargo Agile 2 data, Client A data

4.2 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 18).

Table 18: Target reached for CO2 reduction in Q1 (2016/2017)

		Vans/ Trucks	mpg	l/100km	Litres/year	Litres/ parcel	kgCO2e/ parcel	Total annual CO2 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	8,810	0.004	0.011	22,995
Gnewt	Electric van	49	-	0	0	0	0	
	Total	53			8,810	0.004	0.011	22,995
	Before-After reduction in %				88	88	88	88
	Total CO2 reduction in kg							**169,844**

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

4.3 Target air pollutant reduction and air quality and health impact

A target for reduction of air pollutants Nitrogen Oxides NO_x and Particulate Matters PM_{10} 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 19). 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 pollution 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 emissions 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 PM_{10} 93% over the duration of the project (Table 20). The target of 80% was exceeded for PM_{10} 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 19: Target for air pollutants reduction in Q1 (2016/2017)

		Vans/ Trucks	NOx g/parcel	PM10 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: Agile 2 data, Road Transport Emission Factors: 2011 NAEI

Table 20: Emission factors, based on distance observed

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

Source: Road Transport Emission Factors: 2011 NAEI

4.4 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 21). 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.

Table 21: Target reached for energy use in Q1 (2016/2017)

		Before = 49 diesel van	**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	7312	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

4.5 Target for reduction of empty distance

The average empty distance for a Client A truck is 12 miles per day, for all 49 vehicles observed this corresponds to about 250,000 km per year. The 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 22: Target reached for empty distance reduction in Q1 (2016/2017)

		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	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 (Table 22). The accuracy of this data is much lower than for 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 the 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.

4.6 Target for number of vehicle trips

The number of vehicles used increased by 8% (Figure 22). 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.

4.7 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 same business 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 is as robust as possible. The target calculations were done this way to show what would happen if more businesses in London applied the Gnewt Cargo solution.

There is a set of **real observation data collected for Client A** in this Cat 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 effect is 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 CO_2 emission factors from DEFRA (1 litre diesel = 2.61 kg CO_2), air pollutant emission factors from the National Atmospheric Emissions Inventory (Table 20), and energy conversion factors (kWh to kgoe) from the International Energy Agency (IEA).

The standard unit of energy, the grams of oil equivalent, is calculated for different energy sources. This unit shows the energy content of electricity and diesel fuel, and it enables a comparison of different energy sources. The truck trips use diesel energy, and this diesel energy is included in in the AFTER case.

Further assumptions were 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 replace 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 areal 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.
- These two assumptions lead to an increase in the total number of trips.
- The calculation and analysis is done with the BEFORE-AFTER approach, one of the key methods for impact assessments in logistics.

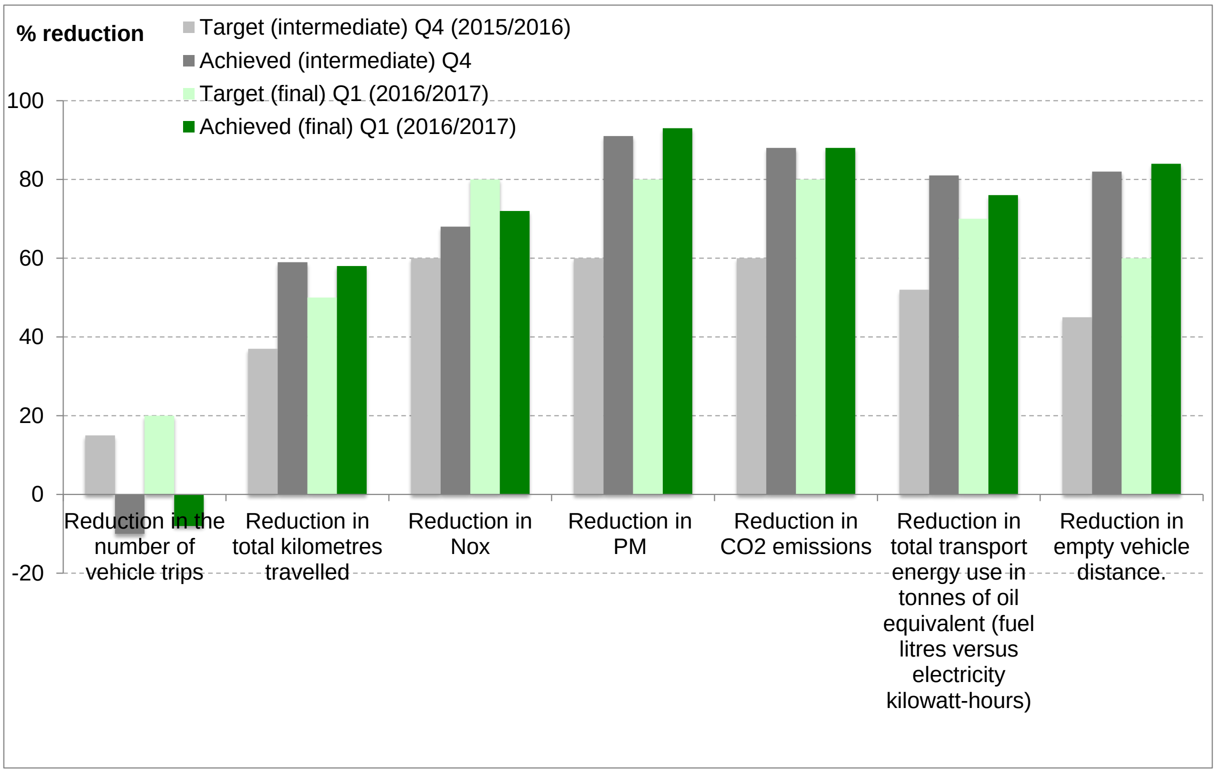
4.8 Overview on targets achievements in Q4 (2015/2016) and Q1 (2016/2017)

Figure 22 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 grey), 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 22: 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

5. Concluding remarks.

Multiple tests were performed for the IT trials of Agile 2 project.

The data shows that Gnewt Cargo reached most of its objectives. The very short distance driven per day in Central London 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, the final results of Optrak, Podfather and PTV system 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 is further developed.

As of June 2016, the routing and scheduling trials were all completed according to plan, and the multiple data collection exercises and processing led to a huge amount of outstanding data.
This data is now available for public use in London. The datasets have been collected for the months July 2015 to June 2016. The results of the data monitoring and data processing are now finalised for all case studies and all elements of the project Agile 2.

The total amount of information is very high, so that only a part of the information about >14,000 round trips, currently available, can be shown in this report. The targets were achieved for distance and traffic reduction (58%), CO_2 reduction (88%), PM_{10} 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%).