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Night goods transport in Stockholm

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Executive Summary

The purpose of this study is to examine whether goods transport operations at night are more transport network efficient and environmentally friendly than operations at daytime through the use of analysis of GPS data from trucks in Stockholm. These vehicles were conducting trips between various waste collection sites in the city and several waste processing sites in Stockholm.

This report presents an overview of our methodology and the results of our analysis of this GPS data.

The results of the study were affected by issues with compatibility between the datasets used and low observation sample sizes for some time periods. However, despite this we were able to show results that indicated that night-time transport was consistently more efficient than operations at other times of the day in terms of both transport efficiency and emissions.

The study showed that travel times for trucks at night time were around 25-30% shorter.

Travel times were also more reliable at night. For trips carrying garbage to processing sites night operations varied about +/-15% on average around typical travel times, whilst for day operations between 07:00 and 12:00 variation was +/-22%.

The results also indicate that night operations used less fuel and generated less emissions. Night operations used around 2.7-3.6 litres/100km less fuel compared to morning daytime operations. This equated to around 8-11% fewer emissions.

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1. Introduction and background

1.1 Study purpose

This study is conducted as a part of the EU project Civitas Eccentric. It is a part of *Measure 7.4 Night delivery with clean and silent vehicles* in which the city of Stockholm collaborates with KTH (Royal Institute of Technology). The purpose of the measure is to increase knowledge on how a shift to the off-peak hours can be used as a way to increase accessibility and sustainability of freight transport.

The purpose of this study is to examine whether goods transport operations at night are more transport network efficient and environmentally friendly than operations at daytime through the use of analysis of GPS data.

1.2 Study description

In this study we examine GPS data for trucks carrying waste compressors between various waste collection sites in the city and several waste processing sites in Stockholm.

1.3 Other studies

With the project request for proposal (RFP) two previous studies were provided as background to this study. The first was a study by KTH in Stockholm with a focus on noise emissions and transport efficiency by goods transport. The second was a study on transport efficiency by Lots Group on deliveries to McDonald's restaurants around Stockholm at day and at night and with different vehicle types (referred to in this report hereafter as the 'McDonalds Study').

The McDonald's Study aimed to measure the impacts of replacing daytime diesel truck deliveries of goods in urban areas with night-time deliveries using clean and silent electric vehicles. The study also used GPS data and provided a base methodology for us with this study.

2. Method

2.1 Overview

This section briefly outlines our methodology. It firstly describes the GPS data we received and what these contained. Secondly it goes into how we processed, checked, and cleaned the data to prepare it for analysis. Finally, it provides a discussion on the quality/suitability of the data for the purpose of this study.

2.2 Dataset

2.2.1 Description of the data

We received ultimately two truck GPS datasets that were used in the study which were made up of multiple files. These were the following files received on the following dates:

- Scania vehicle data:
  - 2019-11-01:
    - Kopia av SPE621 Spårningsdata JULI.xlsm
    - Kopia av SPE621 Spårningsdata AUGUSTI.xlsm
    - Kopia av SPE621 Spårningsdata SEPTEMBER.xlsm
  - 2019-11-27:
    - Skickad Position Scania 1910.xlsx
- Volvo vehicle data:
  - 2019-11-27:
    - Bilar juli-september.xlsx[1]

These datasets were comprised of timestamped GPS readings (hereafter called 'observations' in this report) with information on:

- Speed
- Fuel tank level and/or accumulated fuel used
- Longitude/latitude location
- Vehicle odometer reading

Figure 1 shows all datapoints received on a map of Stockholm with the central area with more detail.

Unless the source of the data is referred to specifically, for example, "in the Scania dataset", when we refer to "the dataset" in the remainder of this report we refer to a combined dataset of both the Scania and Volvo data files.

[1] File also included data for November despite not being indicated in the file name.

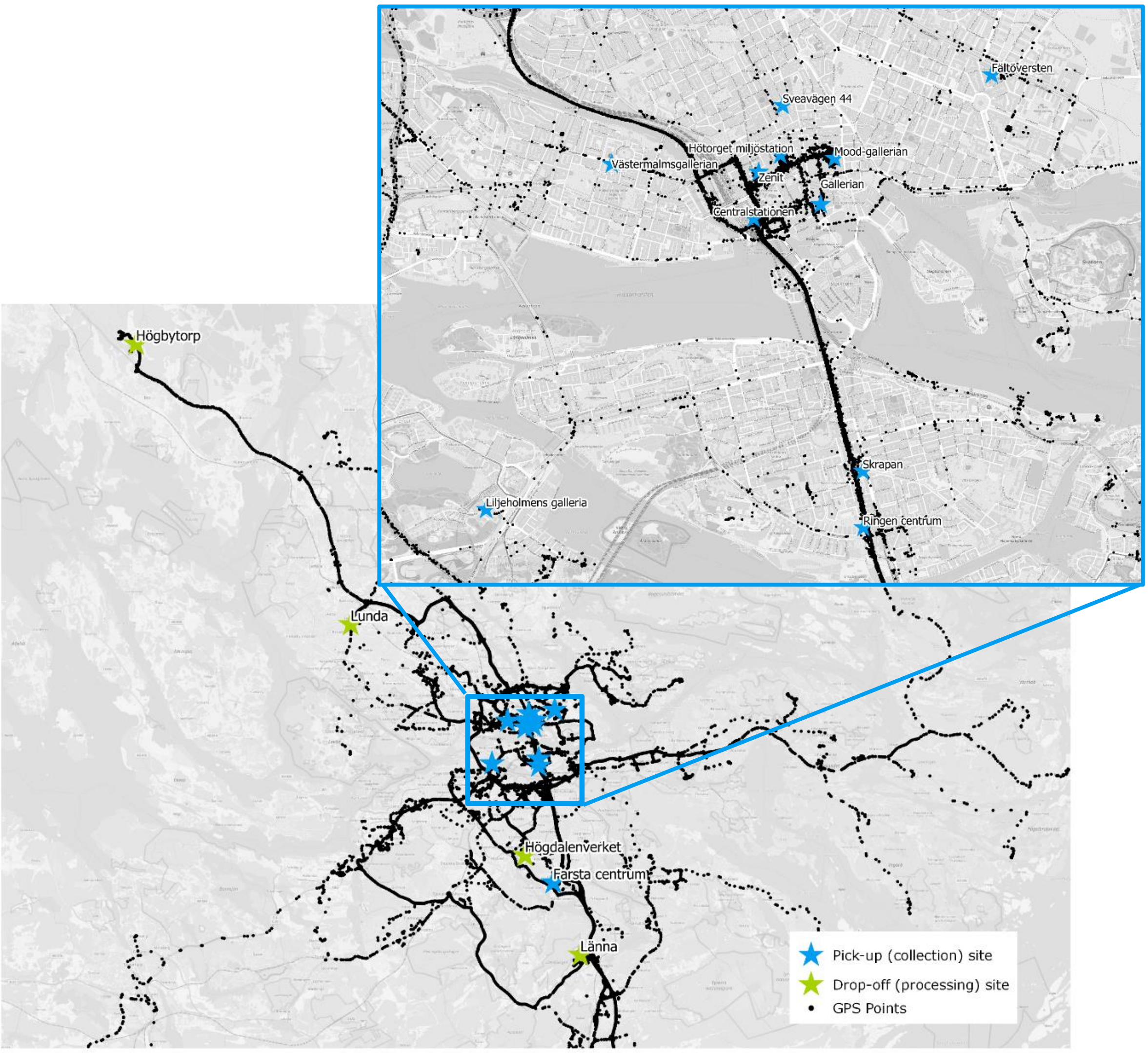


Figure 1 GPS points and pick up / unloading locations around Stockholm

Figure 1 above shows pick up and unloading locations typically visited by the vehicles during their operations.

Not all sites were visited by all trucks during each shift, and some sites were not observed to be visited sufficiently enough in the data to show up as obvious operational locations at all. A list of the sites shown above, and their details are shown in Table 1.

Table 1 Site locations

Type	Location	Address
Pick up site (garbage collection site)	Centralstationen	Centralplan 1, 111 20 Stockholm
	Mood-gallerian	Mellangatan, 111 44 Stockholm
	Hötorget miljöstation	Slöjdgatan 12, 111 57 Stockholm
	Sveavägen 44	Luntmakargatan 27, 111 37 Stockholm
	Ringen centrum	Götgatan 132, 118 62 Stockholm
	Västermalmsgallerian	Fleminggatan 43, 442 40 Stockholm
	Fältöversten	Karlaplan 13, 115 20 Stockholm
	Gallerian	Regeringsgatan 15, 111 53 Stockholm
	Liljeholmens galleria	Nybohovsbacken 38, 117 61 Stockholm
	Farsta centrum	Farstaplan 20, 123 47 Farsta
	Skrapan	Götgatan 78, 118 30 Stockholm
	Zenit	Klara Norra kyrkogata 14, 111 21
Drop off site (garbage processing facility)	Länna	Speditionsvägen 10, 142 50 Skogås
	Lunda	Högforsgränd 1, 163 53 Spånga
	Högdalenverket	Kvicksundsvägen 16, 124 59 Högdalen
	Högbytorp	Högbytorp, 197 93 Bro

The Scania dataset was expected to have the most truck trips during the night time hours, with the Volvo dataset expected to be of mostly daytime operations. Figure 2 shows the number of observations every five minutes for all hours in the day (all records were combined in the dataset from multiple days to show only time in this illustration).

The figure shows that the Scania dataset indeed shows operations during night time hours but in addition it also contains substantial daytime operations as well. The Volvo dataset is overall much smaller and mostly shows daytime operations, with virtually no observations between 00:00 and 06:00.

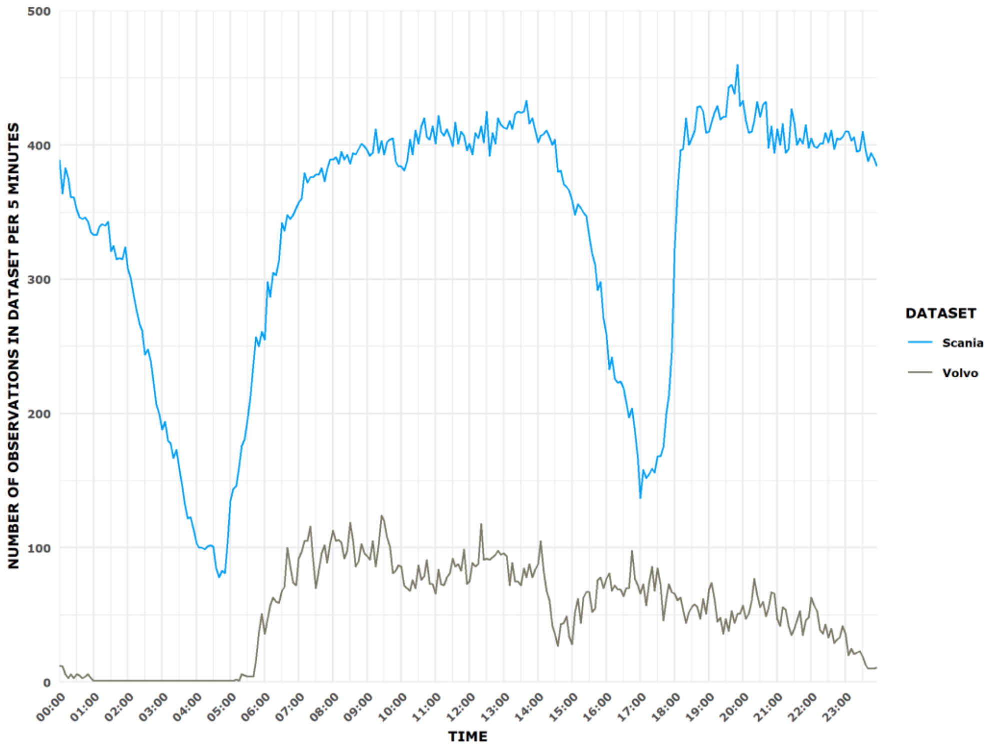


Figure 2: Number of observations in dataset over 24 hours per 5 minutes (Scania and Volvo data shown separately)

2.3 Data preparation

2.3.1 Processing

The data was processed through scripts in order to convert the raw GPS point data into a cohesive and comparable database. This involved:

- Creating a unique identifier for each driver shift to isolate individual shifts from one another (new shifts were said to occur if gaps between consecutive points are sufficiently long, e.g. several hours)
- Calculating Euclidean distance and speed between points for consecutive observations.
- Compensating for if a vehicle refuels mid-trip because start/end fuel levels were important for the emissions calculations as they are used to determine total fuel used for individual trips.

Another key processing task was defining geofenced zones to capture and stamp points that lie within key pick-up (garbage compressor collection site) and drop-off locations (garbage compressor emptying site). This was initially intended to be a similar process to that used in the *McDonald's Study*, however we adapted this implementation to also include disaggregated trips by Origins and Destinations (OD). This is explained below.

Some of the results can be calculated based on the methodology used in the McDonald's Study, and others required the dataset to be OD based.

The Link-based methodology (same as the McDonald's Study) is illustrated in Figure 3. Observations on links that are used by multiple truck trips are analysed together. This method allowed us to look at things like average speed and travel time on key links.

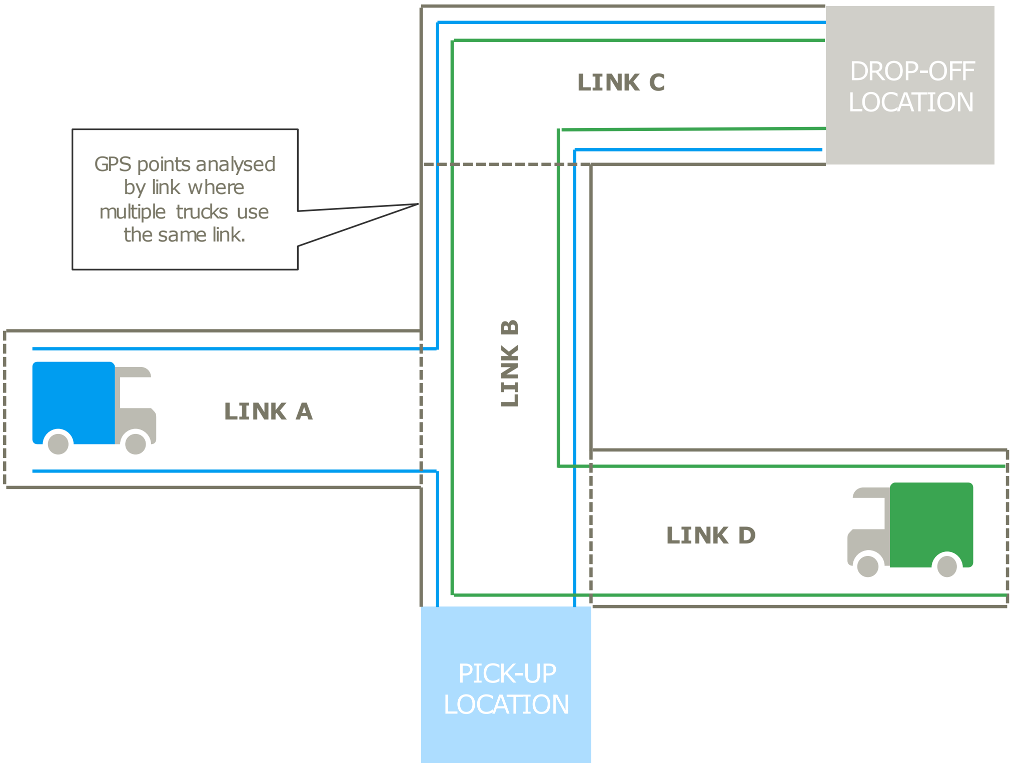


Figure 3: Link-based analysis infographic

The OD-based method is illustrated in Figure 4. Because we are interested in results like rate of fuel consumption per kilometre (for emissions calculations), we needed to extract information from the start of a vehicles trip and compare it at the end of a trip and divide it by total distance travelled. This is not possible using the link-based method. Furthermore, some results might be affected by things like whether the truck is carrying a heavy load of waste for processing (a trip from a compressor pick-up location to a drop-off compressor emptying location). Directionality information to/from processing sites can only be found by converting the GPS data into OD information.

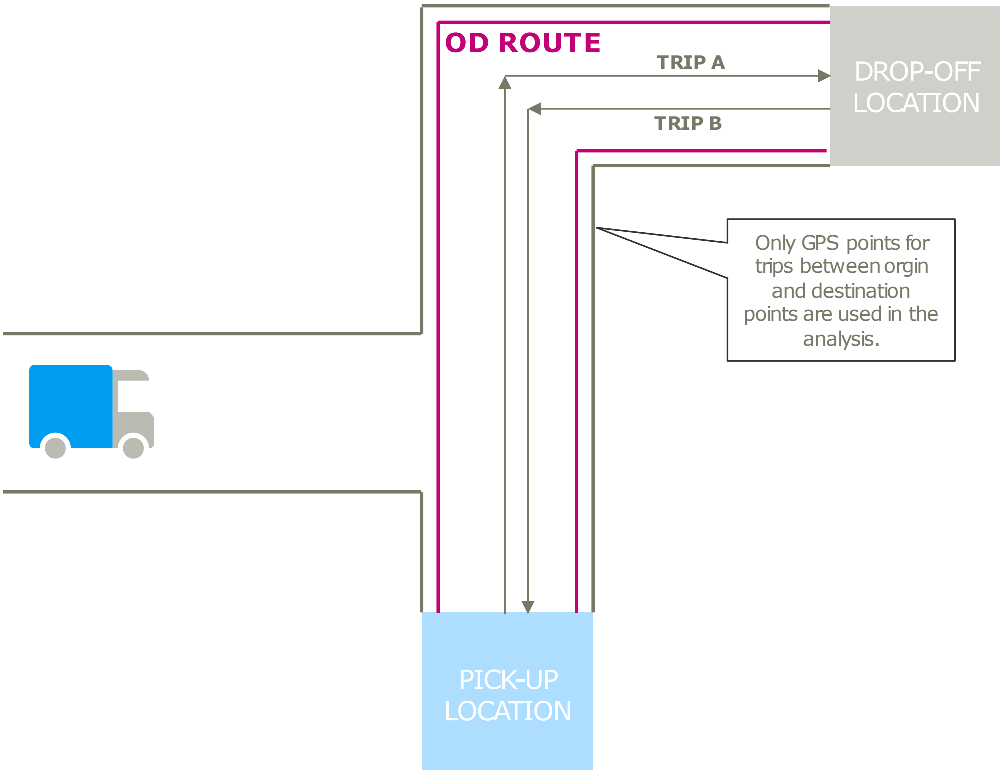


Figure 4: OD-based infographic

Because of the slightly different methodology we had to be more precise with the definition of our geo-fenced zones than the McDonald's Study. Our zones had to be more concisely defined along links and around OD points. Figure 5 shows the zone system applied. Not all links where we had observations were collected in zones as sometimes observations did not lie directly over links due to GPS accuracy issues. This meant that we were not able to determine with certainty that an observation did not lie on nearby by alternative link.

Closer zones around links also allowed us to utilise the *Inrix* dataset for data validation, as this required us to match observations to links in this dataset as well (see Section 2.3.2 for more information).

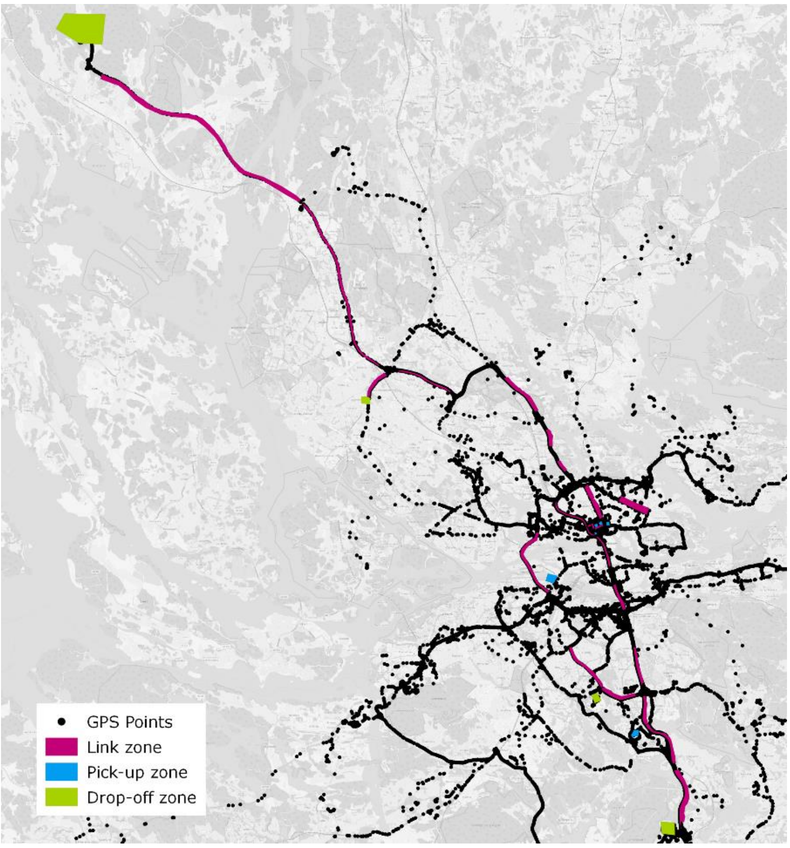


Figure 5: Zone system used

2.3.2 Checking: comparing the data to an independent source (Inrix)

To independently check the GPS data's quality in terms of traffic speed, by location and time of day we compared the data to Inrix traffic data.

Inrix is a 'big-data' supplier that collects and sells GPS data for traffic analysis purposes. Stockholms Stad owns some of these data and provided us with a copy of September/October 2019 traffic speed data for this project for data validation and/or augmentation (adding Inrix data to the dataset to increase either its quality/size, or to fix errors in the data). We were not able to use the Inrix data to augment the dataset due to limited project resources, but we did use it to validate the quality of the GPS data. Figure 6 below shows plots several main roads around Stockholm with Inrix speed data for the month of September 2019 compared to GPS recorded speeds in our dataset (note: only Scania points were used to produce these plots).

Figure 6: Inrix speed data and GPS points compared

These plots show that recorded point speeds for the GPS datasets are not always mirroring the same speeds to the Inrix average speed data, but that in general they show some similar patterns. Differences are expected as each GPS point speed point from our dataset on the graphs above is an average of a much smaller sample of vehicles whilst the Inrix data is compiled at one-minute level intervals for an entire month averaged to 5-minute intervals. Furthermore, the Inrix data is an average speed for an entire link (which can be several kilometres long) and may include several intersections along its length. This means that it may average-out vehicle speeds that are in reality affected by vehicles needing to accelerate and decelerate often. In our GPS dataset we are more likely to capture vehicles travelling at lower speeds during these events.

Is the data validated based on the above comparison to Inrix data? We believe that the data is sufficiently reliable for the analysis conducted in this study because of the differences in the nature of the Inrix data and the study dataset, but caution is advised with the findings from any one study. That said, because we also employ an OD based analysis for several results in this report, we avoid relying on single-point-in-time records in the GPS data for all results instead utilising start and end-of-trip information. This approach reduces the effects on results from any one data point being erroneous.

2.3.3 Data cleaning

The raw GPS data contained around 101 000 GPS observations (Scania: 96 914, Volvo: 4 233). In this we identified 207 driver shifts. When we created an OD dataset from this raw dataset, we identified 1023 unique trips between garbage collection (pick-up) and garbage processing (drop-off) sites.

All consecutive GPS points for unique trips were then joined together by lines and visualised in GIS. This allowed us to remove unusual trips that looked like they contained mid-trip detours or stop-offs elsewhere (perhaps to pick up another driver, refuel, or to conduct other business). Figure 7 shows an example of some trips removed for a particular OD pair. These trips look like detours or alternative routes from the norm.

In the end the final cleaned points dataset contained 28 430 unique observations. This was a much smaller set of points than the 101 000 points in the initial dataset. The reason for this was that almost all of the daytime observations in the dataset were for trips that did not have any connection to the garbage collection or processing sites in our study. This was to be expected because the study sites were specifically chosen for this study because they were known to be accessed at both night and day (to enable the comparisons conducted in this study), unlike many other sites in Stockholm which see operations at daytime only.

This final dataset also contained 737 unique trips between OD combinations. The reduction from the initial 1023 unique trips to this final number was mainly due to removal of unusual/erroneous trips.

Figure 7: Cleaning dataset of unusual trips

2.4 Overall data quality/suitability discussion

After completion of the data cleaning and checking steps the following issues were observed in the overall dataset:

- Whilst the Scania data included significant numbers of observations during daytime hours, these observations were from trucks undertaking other activities not between the garbage collection/processing sites in our study. Therefore, these daytime observations were not useable in the analysis in almost all cases. This meant that we needed to rely on the Volvo dataset instead for daytime operations.

Data from the Volvo vehicles itself had two main usability issues:

- Firstly: the data was at a lower level of detail than the Scania data (time gaps were longer between points). This meant that checking of routes was not possible with the same level of quality assurance, and that an unknown number of trips which may actually have been legitimate trips between pick-up/drop-off points were not picked up due to not having a GPS point in the right zone/location.
- Secondly: the Volvo dataset was smaller to begin with, so due to the inability to use the Scania dataset for daytime analysis the risk of inaccurate results due to small sample size was an issue with using these data.

We attempted to use both datasets where possible and unless otherwise stated data from both are used in the calculation of the results to follow.

We believe that the results presented in this report are relevant findings that indicate some important results that warrant further investigation. In future studies, the same methodology could be used but more data is recommended. In our experience working with GPS data; more is almost always better. This is because significant chunks of data are removed from initial datasets through important cleaning and filtering steps.

2.5 Guide to the results

2.5.1 Time periods

We broke up the 24 hours in a day into four time periods which were based on the ones used in the McDonald's Study. These were:

- Day (morning) 07:00 to 12:00
- Day (afternoon) 12:00 to 17:00
- Evening 17:00 to 22:00
- Night 22:00 to 07:00

Evening was not a time period included in the McDonald's Study but was included in our study to ensure we included data for a whole 24-hour period.

By 'pick-up trip' we refer to trips running with an empty load on their way to pick-up compressors. By 'drop-off trip' we refer to trips that have full compressors on their way to waste processing sites.

2.5.2 How to read the results plots

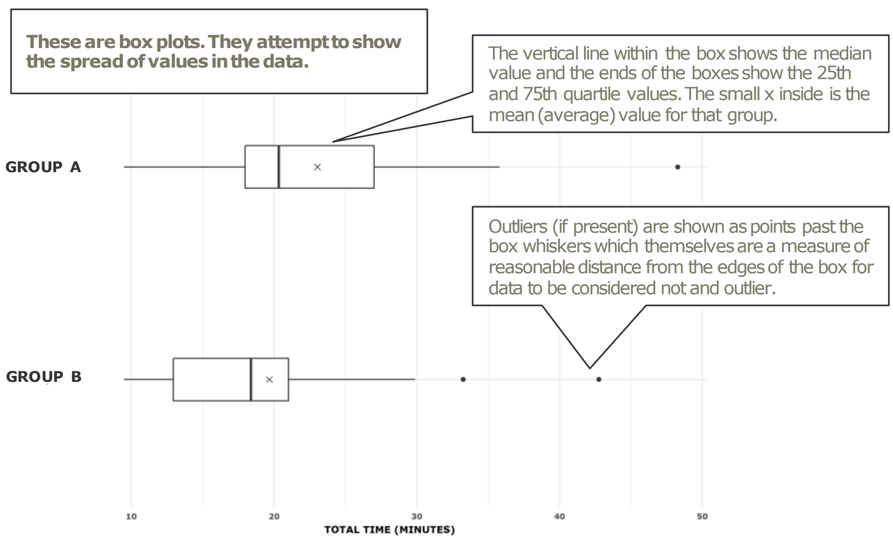


Figure 8: Visual guide to how the results will be presented

2.5.3 **Data significance**

We do not test statistical significance for our results in this study, but instead show values for standard deviation. Standard deviation can be used as an indicator for how spread around the average the data are. If standard deviations are wide, then it is less likely that the results are indicative of a firm result. A smaller standard deviation is indicative to a firmer result.

3. Results

3.1 Transport System

3.1.1 Efficiency: potential time saved by driving at night hours

To compare potential time saved by driving at night hours relative to daytime[2] we did the following:

- We compiled a table of the average time it took to make a trip between each OD, both for night and day separated by whether the trip was to collect garbage (Pick-up) or take a full load of garbage for processing (Drop-off).
- Then we divided the night travel times by the day travel times to get a ratio of night to day.
- This then allowed us to be able to look at all the data at the same time from different OD trips because the differences between OD pairs in terms of distance was cancelled out.

The result of this is shown in Figure 9 and in tabular form in Table 2.

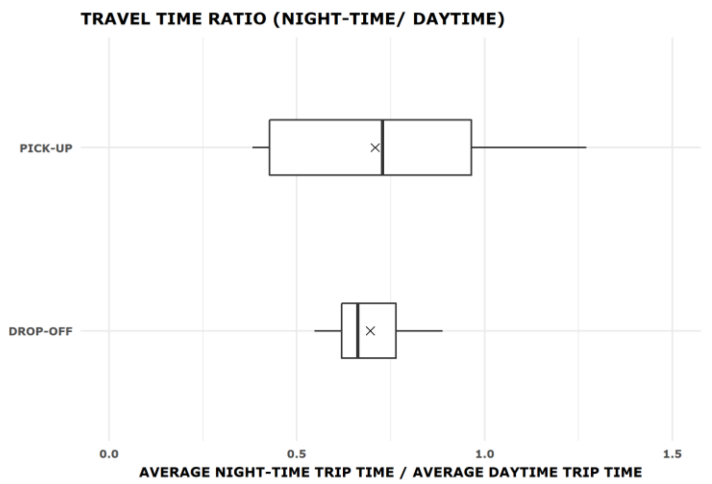


Figure 9: Travel time ratios for night/day by trip type

Table 2: Travel time ratio results (Night/day by trip purpose)

Type	Mean	Median	Q25	Q75	Min	Max	Standard.dev
PICK-UP	0.71	0.73	0.43	0.96	0.38	1.27	0.29
DROP-OFF	0.70	0.66	0.62	0.76	0.55	0.89	0.11

[2] In this analysis we only used the 07:00 to 12:00 day period for the daytime data.

The results show that for both pick-up and drop-off trips night time travel ratios are less than 1.0. In other words, travel times are shorter at night than by day. For pick-up trips there is slightly more variation (wider spread of values), but the mean ratio is 0.7 (i.e. travel times are about 30% shorter). For drop-off trips night time trips are 0.69, again around 30% shorter.

The large standard deviation on the pick-up trips indicates that travel times are much more variable for these trips, making it less certain to draw a conclusion about whether night travel times are indeed shorter for these trips. This may be because pick-up trips involve in-bound travel to the centre of Stockholm, which is the direction of travel with more likelihood of congestion.

To make sure that the differences in travel times were not due to different distances travelled at night compared to day we checked that distance was similar by looking at this in the same way. This showed that night distances were indeed slightly shorter (possibly due to less need at night to use alternative routes to avoid congestion)[3]. This could affect the results by making travel times seem shorter at night, so we recalculated the results accounting for this by adjusting the ratios relative to this relative difference.

These adjusted results are shown in Table 3.

Table 3: Adjusted travel time ratio results (Night/day by trip purpose)

Type	Mean	Median	Q25	Q75	Min	Max	Standard.dev
PICK-UP	0.75	0.77	0.45	1.02	0.40	1.34	0.31
DROP-OFF	0.73	0.70	0.65	0.81	0.58	0.94	0.12

The adjusted results do not change the results very much, and still indicate that travel times are shorter at night time than at day, especially for the drop-off trips. These results are similar to the results found in the McDonald's study, which showed that night time operations were around 30% faster than daytime.

[3] A plot and table of the distance ratio results is included in the appendix to this report.

3.1.2 Punctuality

3.1.2.1 Service reliability by variability in travel times

Reliability of travel times between pick-up and drop-off sites is important for truck operators. In this section we look at how variability in travel times for trips at different times of the day may show how driving at different times can provide a more reliable service. To do this analysis we did the following:

- For each OD we took the calculated mean travel times and standard deviations for travel times and put these in a table.
- Next, we calculated what percentage the standard deviation was of the average travel time. This gave us a measure of how much travel time varied for each OD as a percentage of the average trip time.
- In a new table we dropped out the OD names but kept information on pick-up and drop-off trips and time of day.
- We then were able to compare how the variability measure differed by time period and whether our vehicles were on a pick-up or a drop-off run.
- We dropped out outliers in the data that showed 75% variability in travel times as we judged that these were affecting the results strongly.

The results of this analysis are shown in Figure 10 for pick-up trips and Figure 11 for drop-off trips. Night-time results are highlighted blue in the plot. These results are also shown in tabular form in Table 4 and Table 5 respectively.

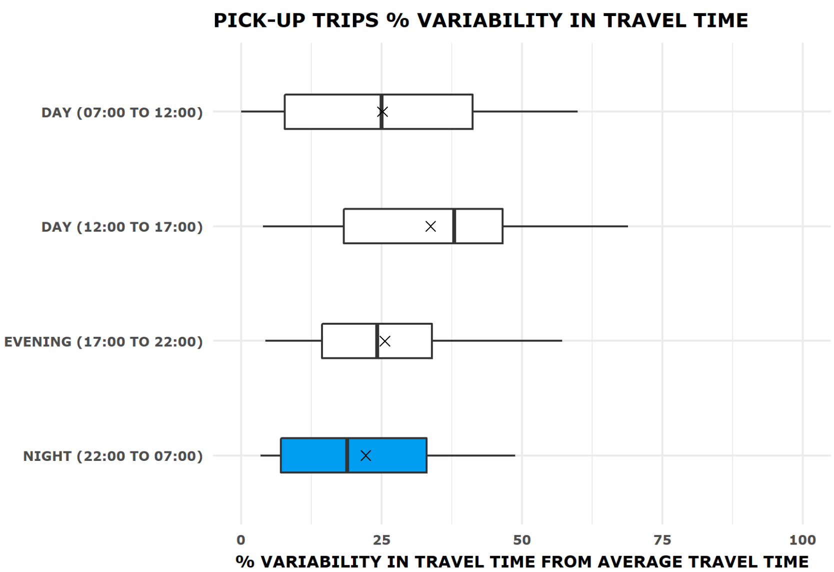


Figure 10: Pick-up trips % variability in travel times by time period

Table 4: Pick-up trips % variability in travel times from average

Time period	Mean	Median	Min	Max	Standard.dev
DAY (07:00 TO 12:00)	25.1	25.0	0.0	59.9	20.1
DAY (12:00 TO 17:00)	33.7	38.0	3.8	68.9	22.4
EVENING (17:00 TO 22:00)	25.6	24.2	4.3	57.1	16.5
NIGHT (22:00 TO 07:00)	**22.2**	**18.9**	**3.4**	**48.8**	**16.7**

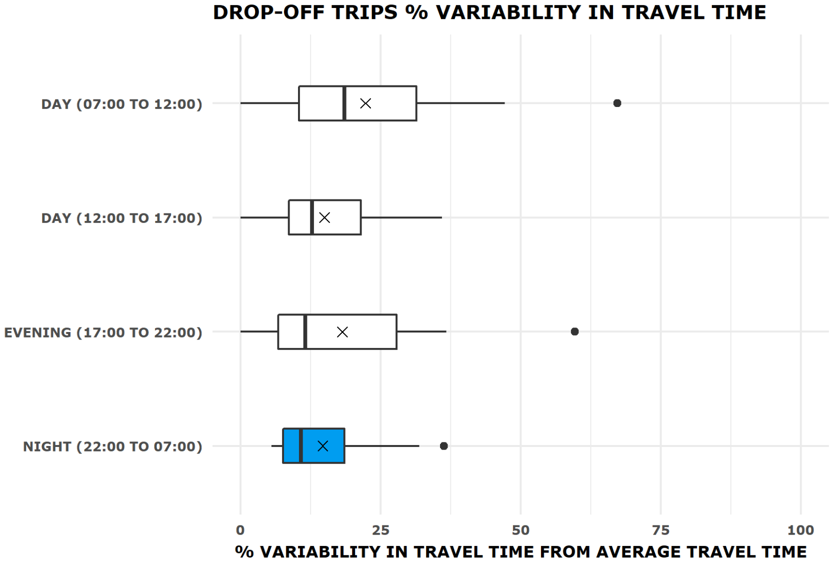


Figure 11: Drop-off trips % variability in travel times by time period

Table 5: Drop-off trips % variability in travel times from average

Time period	Mean	Median	Min	Max	Standard.dev
DAY (07:00 TO 12:00)	22.3	18.5	0.0	67.3	18.6
DAY (12:00 TO 17:00)	14.9	12.7	0.0	36.0	11.4
EVENING (17:00 TO 22:00)	18.1	11.5	0.0	59.7	15.4
NIGHT (22:00 TO 07:00)	**14.6**	**10.8**	**5.5**	**36.3**	**10.0**

These results highlight that night time driving had the lowest variability for both trip types. This indicates that more reliable travel times are expected at night relative to day.

3.1.3 Link speeds

Figure 6 in Section 2.3.2 above showed a comparison of GPS point speed (Scania dataset) on links against Inrix speed data. One of the plots in Figure 6 is re-presented here to show how it indicates that the GPS data points as well as the Inrix data shows slightly higher link speeds at night-time as well as more reliable (less variation) speed at night compared to day. This figure is shown below (Figure 12). During the middle of the day there is more variation in average speeds in the Inrix data (grey shading), and there are generally slower speeds (blue line). The GPS points are more scattered; however, these also show a similar relationship. More scattering is evident through the day hours in the GPS point speeds and more clumping together during the night hours. Points during the night hours show also slightly higher speeds.

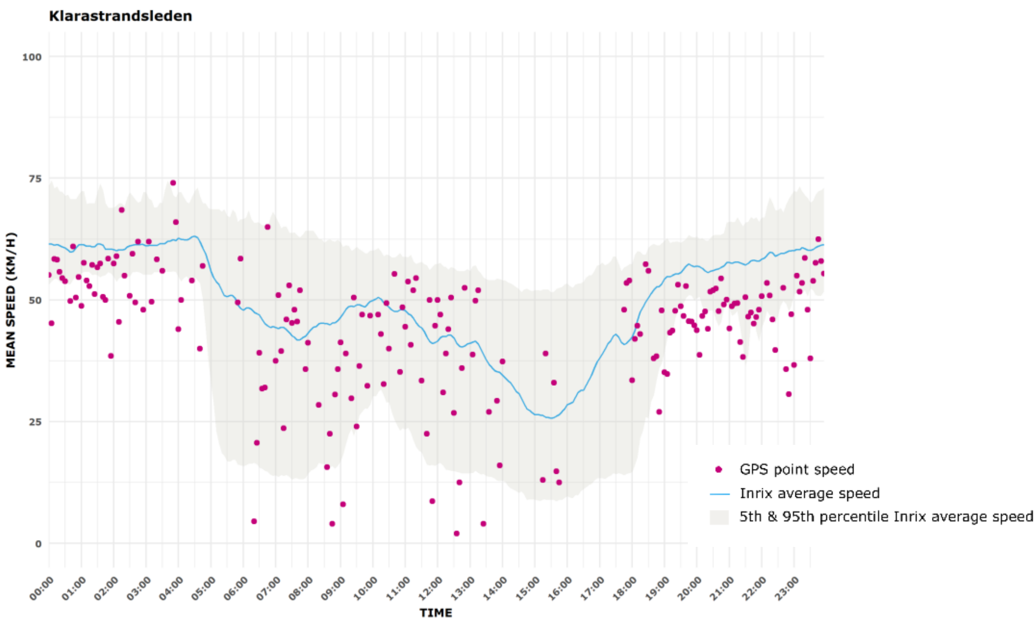


Figure 12: Klarastrandsleden average link speed, GPS and Inrix data

3.2 Environment

3.2.1 A note about the emissions results

Initially we intended to use the full dataset in the environmental analysis, like in the transport efficiency analysis above. However, whilst the Scania dataset contained many observations at daytime, these were in the vast majority for trips conducting other transport operations and not trips to/from the sites in this study. Because of this we were therefore not able to determine whether a vehicle was on a pick-up trip or a drop-off trip (which could have impacted its fuel usage due to weight differences in truck loads). Also, the Scania data for fuel usage was presented only as percentage of full tank. For these reasons, it was not suitible to utilise the Scania day-time data in the fuel use / emissions analysis.

Combining the Scania night-time trips and the Volvo day and night data as an alternative solution was also ultimately not possible. This was because the vehicles in these two datasets use different fuel types (methane gas and diesel, respectively). Because we look at fuel consumption rates, these can differ significantly based on fuel type.

So ultimately because of these issues we had to use the Volvo dataset for both day and night observations in the analysis of environmental results in this section. This much smaller dataset had far fewer observations at night-time so the statistical inference of the results in this section is likely to be low.

3.2.2 Fuel efficiency

Using the Volvo data, we looked at rate of fuel use (litres per 100 kilometre) by type of trip (pick-up and drop-off) by day and night. In the Volvo dataset the three vehicles tracked all used diesel and were Euro-6 emission class vehicles.

Using a rate allowed us to make direct comparison between trip types. Some routes within the data may have had more fuel intensive driving characteristics than other trips (for instance, driving up steep grades), but we judged that due to the small dataset size looking at specific trips individually to separate out these subtleties would not be possible. Any differences related to traffic conditions (congestion) at certain times of the day may be stronger than these other effects and these types of effects are more relevant for this study.

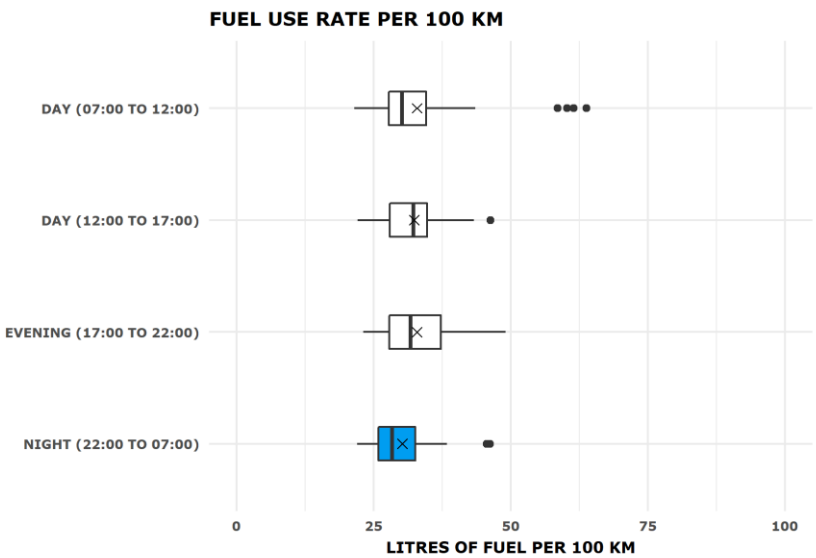


Figure 13: Pick-up trips fuel usage (litres per 100 km)

Table 6: *Pick-up trips fuel usage (litres per 100 km)*

Time period	Mean	Median	Min	Max	Std.dev	Observations
DAY (07:00 TO 12:00)	32.9	30.1	21.5	63.8	9.5	50
DAY (12:00 TO 17:00)	32.4	32.2	22.1	46.3	5.7	29
EVENING (17:00 TO 22:00)	32.9	31.7	23.1	49.0	6.3	43
NIGHT (22:00 TO 07:00)	**30.2**	**28.3**	**21.9**	**46.2**	**7.2**	**18**

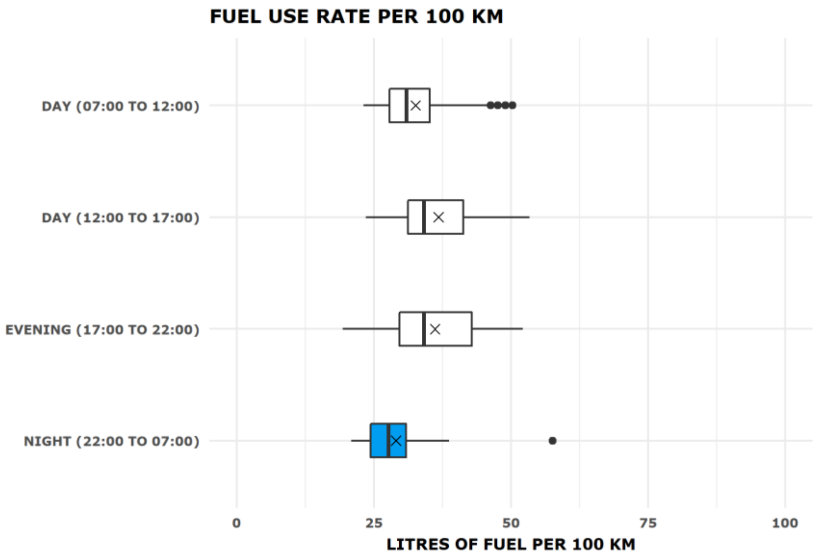


Figure 14: Drop-off trips fuel usage (litres per 100 km)

Table 7: Drop-off trips fuel usage (litres per 100 km)

Time period	Mean	Median	Min	Max	Std.dev	Observations
DAY (07:00 TO 12:00)	32.6	30.9	23.1	50.3	6.7	60
DAY (12:00 TO 17:00)	36.8	34.2	23.5	53.3	8.3	27
EVENING (17:00 TO 22:00)	36.1	34.1	19.3	52.2	9.1	38
NIGHT (22:00 TO 07:00)	**29.0**	**27.7**	**20.8**	**57.6**	**8.1**	**20**

These results show a pattern of lower fuel use at night. Comparing night operations to day time operations in the morning (07:00-12:00) the differences in mean fuel consumption is 2.7 litres/100km and 3.6 litres/100km for pick-up and drop-off trips respectively.

3.2.3 Emissions

We received environmental reports on fuel use and emissions from both Scania and Volvo operators. These are both provided as appendices to this report. The Volvo emissions rates for Euro-6 diesel vehicles per litre combusted are shown in Table 8.

Table 8: Emissions rates for Euro-6 class vehicles (Volvo trucks in the dataset) per litres of diesel combusted

	Co2 (kg/L)	**PM10 (g/L)**	**NOx (g/L)**
Euro-6	2.631	0.012	0.900

Based on the differences in the previous section for mean fuel consumption rates we calculated the difference in emissions per 100 kilometres at different times of the day for pick-up and drop-off trips. These are shown in Table 9 and Table 10 respectively.

Table 9: Pick-up trips emissions per 100 kilometres driven

Time period	**Co2 (kg/L)**	**PM10 (g/L)**	**NOx (g/L)**
DAY (07:00 TO 12:00)	86.56	0.38	29.61
DAY (12:00 TO 17:00)	85.24	0.38	29.16
EVENING (17:00 TO 22:00)	86.56	0.38	29.61
NIGHT (22:00 TO 07:00)	**79.46**	**0.35**	**27.18**

Table 10: Drop-off trips emissions per 100 kilometres driven

Time period	**Co2 (kg/L)**	**PM10 (g/L)**	**NOx (g/L)**
DAY (07:00 TO 12:00)	85.77	0.38	29.34
DAY (12:00 TO 17:00)	96.82	0.43	33.12
EVENING (17:00 TO 22:00)	94.98	0.42	32.49
NIGHT (22:00 TO 07:00)	**76.30**	**0.34**	**26.10**

These results indicate that for both pick-up (empty compressor) and drop-off (full compressor) trip types, night-time operations produce lower emissions for all three emission types. This is approximately 8% fewer emissions for pick-up trips and 11% for drop-off trips when comparing night to day operations (07:00-12:00).

4. Conclusions

In this report we used GPS data to assess whether night-time operations for trucks carrying waste between collection and processing sites were more efficient from both a transport system and an environmental (emissions) perspective.

We outlined how the analysis required us to develop two ways of looking at the data. These were at the link level and at trip OD level. We also described the steps to clean and filter the dataset to prepare it for reliable analysis.

We checked the data against an independent source (Inrix) data for a set of key links around the network. This showed a mixed picture, but on balance we were satisfied with the dataset being sufficiently accurate for this study.

The results of the study were affected by issues with compatibility between the datasets and low observation sample sizes for some time periods. However, despite this we were able to show results that indicated that night-time transport was consistently more efficient than operations at other times of the day in terms of both transport efficiency and emissions. The headline results were:

- The study showed that travel times for trucks at night time were around 25-30% shorter.
- Travel times were also more reliable at night. For trips carrying garbage to processing sites night operations varied about +/-15% on average around typical travel times, whilst for day operations between 07:00 and 12:00 variation was +/-22%.
- The results also indicate that night operations used less fuel and generated less emissions. Night operations used around 2.7-3.6 litres/100km less fuel compared to morning daytime operations. This equated to around 8-11% fewer emissions.

5. References

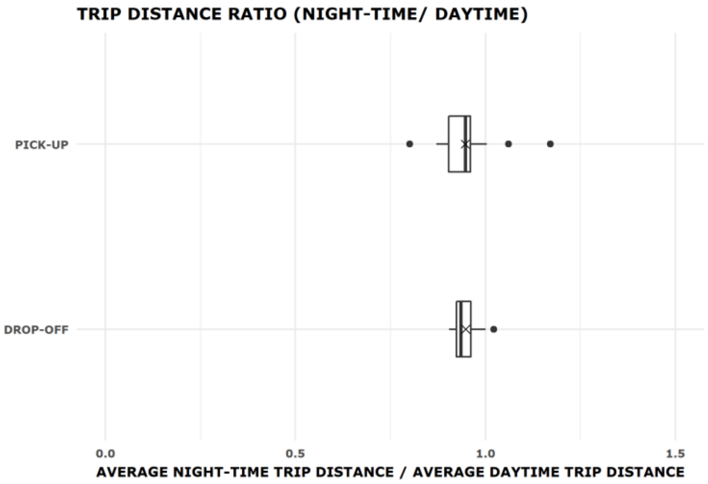
Lots Group, 2019, 'Civitas Eccentric 7.4 Night Delivery With Clean And Silent Vehicles: Transport Efficiency Evaluation'

KTH, 2016, 'Off-peak City Logistics – A Case Study in Stockholm'

Appendices

Distance ratio plot and table

This appendix shows the trip distance ratio plot and table results for night-time/daytime trips.



Type	Mean	Median	Q25	Q75	Min	Max	Standard.dev
PICK-UP	0.95	0.95	0.90	0.96	0.8	1.17	0.10
DROP-OFF	0.95	0.94	0.92	0.96	0.9	1.02	0.04

Scania environmental report

UPPFÖLJNINGSRAPPORT

M LOGISTICS SWEDEN AB

MÅNADSÖVERSIKT: SEPTEMBER

Förändrad bränsleförbrukning

+1 100 kg
Total förändring

+51,1 %
Procentuell förändring

Förändrade koldioxidutsläpp

+3 ton
Total förändring

+53 g/km
Genomsnittlig förändring

Total körsträcka

9 420 km

Totala utsläpp CO2

8,9 ton

Utrustning	Vägmätare (km)	Sträcka (km)	Scania Förarstöd (%)	Utrullning (%)	Tomgång (%)	Fortkörning (%)	Kraftiga inbromsningar (#/100 km)	Bränsle- förbrukning (kg/100km)	Koldioxid (ton)
MEDELVÄRDE	40 607	9 420	34	22,6	11	5	4	29,7	8,9
SPE621	40 607	↑ 9 420	↓ 34	22,6	11,4	↑ 4,8	4	29,7	↑ 8,9

Volvo environmental report

Dynafleet Online

M LOGISTICS SWEDEN AB

M LOGISTICS SWEDEN AB

Miljörapport

Rapport skapad:	2019-10-15 10:57
Datumintervall:	2019-09-01 00:00 - 2019-10-01 00:00
Urval:	HJT77B
Måttenhet:	totalt

Sträcka (km)	Bränsle totalt (l)	AdBlue totalt (l)
5 291,67	1 718,02	90,50

Emissioner							SO2 (g) med svavelhalt i bränslet på...				
Fordon	**Emissionsklass**	**CO2 (t)**	**CO (kg)**	**HC (kg)**	**NOx (kg)**	**PM (kg)**	**10 ppm**	**50 ppm**	**100 ppm**	**350 ppm**	**500 ppm**
HJT77B	Euro 6	4,52	0,17	0,10	1,55	0,02	5,72	28,59	57,18	200,11	285,88
Totalt		**4,52**	**0,17**	**0,10**	**1,55**	**0,02**	**5,72**	**28,59**	**57,18**	**200,11**	**285,88**
	Euro 3-ref.	4,52	13,74	5,15	34,36	0,69	5,72	28,59	57,18	200,11	285,88
	Euro 4-ref.	4,52	10,31	3,44	24,05	0,21	5,72	28,59	57,18	200,11	285,88
	Euro 5-ref.	4,52	1,72	1,80	12,03	0,17	5,72	28,59	57,18	200,11	285,88
	Euro 5 EEV-ref.	4,52	1,72	1,80	12,03	0,17	5,72	28,59	57,18	200,11	285,88
	Euro 6-ref.	4,52	0,17	0,10	1,55	0,02	5,72	28,59	57,18	200,11	285,88

Kommentarer:

- Utsläppen av SO2 beror på svavelhalten i bränslet. Se i kolumnen under den svavelhalt som motsvarar bränslekvaliteten i fordonet.
- Om förbrukningen av AdBlue inte anges omfattar kväveoxidutsläppen inte de ökade utsläppen vid körning utan AdBlue.
- Höga utsläppsnivåer kan bero på att fordonet körs med tom AdBlue-tank eller att SCR-systemet inte fungerar som det ska. I båda fallen blir resultatet höga nivåer av kväveoxidutsläpp.
- Rapporten tar inte hänsyn till den positiva effekt som det valfria Volvo-partikelfiltret har på Euro 5-motorer.
- Utsläppsinformation för andra fordon än Volvo sammanställs enbart i informationssyfte och beräknas enligt EU-standarden för maximala utsläppsnivåer.