Vivacity Sensor Performance Monitoring:

June 2022 data

Technical Note

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Cambridgeshire County Council

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2 Executive Summary

2.1 Background

Cambridgeshire County Council and partners use Vivacity traffic sensors to collect classified traffic flow data to form an evidence-base for decision-making across the county. Vivacity sensors use artificial intelligence to count and classify motor vehicles, pedestrians and pedal cycles within the sensor's field of view and can also be configured to collect travel times.

Vivacity devices were installed following a tender process to begin replacing the historic network of vehicle and cycle detectors that are installed across the county. These historic counters rely on detector loops being cut into the road surface / footway and require regular maintenance to preserve data accuracy over time. The historic sensors use a magnetic field to detect metallic objects such as cars and bicycles but they do not capture pedestrians. The historic sensors also pose some difficulties for the capture and classification of emerging modes such as e-scooters, e-bikes and e-mopeds.

Vivacity sensors were first installed in Cambridge in 2019 to monitor the impact of the Mill Road Bridge trial closure. By June 2022, there were 32 Vivacity sensors installed across Cambridge and South Cambridgeshire. Throughout 2022, a further 60 Vivacity sensors have been approved, and are being installed across the county.

As more Vivacity sensors are installed across Cambridgeshire, it becomes increasingly important to be confident in the accuracy of their counting and classifying abilities. For this reason, a one-day, 24-hour validation exercise was undertaken on 16th June 2022 to compare the data collected by the Vivacity sensors with a more traditional manually classified traffic count. 17 Vivacity sensors across Cambridge were checked with the locations selected to reflect a range of traffic volumes, modal splits and Vivacity hardware versions.

2.2 Overall findings

Motorised vehicles were generally captured well by the Vivacity sensors, but active travel modes (pedestrians, pedal cycles and e-scooters) showed more variation across the sites and a lower degree of accuracy. This suggests that the sensors selected struggled to count active travel modes more so than motorised vehicles.

Cars, LGVs, buses and HGVs are well captured by the Vivacity sensors, with 93% of motorised vehicles captured across all sensors and 98% captured by the newer V2 hardware sensors. Pedestrians are likely to be underestimated by the V1 sensors, with only 58% of the Pedestrians being captured across all Vivacity sensors whilst 114% of Pedestrians were captured by the V2 sensors. Similarly, just 71% of manually counted Pedal Cycles were captured across all Vivacity sensors whilst 101% of Pedal Cycles were captured by the V2 sensors. Heavy motorised vehicles were captured better than light vehicles, possibly due to their distinctive shapes and sizes.

The Vivacity sensors were also able to capture hourly flow profiles quite well with peak periods being well reflected, albeit at a slightly underestimated volume.

There was a significant loss of Vivacity sensor data between 18:45 and 20:30 due to an outage of 10 of the Vivacity sensors during this period, including all of the V1 (older) hardware sensors. Vivacity explained that the outage was due to a loss of signal from

the SIM provider network. As the Vivacity sensors do not store any video footage, the missing data could not be processed retrospectively, and data was therefore lost.

2.3 Thematic analysis

The age of the sensor hardware was found to significantly affect its performance, with the capture rate of older V1 sensors being lower than the newer V2 sensors, particularly in locations with high traffic volumes. Pedestrian and Pedal Cycle capture rates were significantly better for the newer V2 sensors which have better peripheral vision detection, improved software and the ability to define multiple countlines.

Sensor placement was also found to be key to achieving accurate and reliable data collection. Two of the sensors have recently been impacted by vegetation growth and a third was affected by parked cars. Ensuring new sensors are located away from vegetation and other potential obstructions such as bus stops and parked vehicles will be important for data-continuity and reducing the need for remedial work.

A new e-scooter classification is currently being tested by Vivacity which should help to more accurately classify active modes and prevent e-scooters from being incorrectly counted as pedestrians.

2.4 Recommendations and next steps

- Decide whether to upgrade or retire the six remaining V1 sensors to V2 hardware to avoid collecting poor quality active mode data.
- Carefully consider the placement of any new sensors before installation, to prevent obstruction from trees, bus stops, parked vehicles etc impacting data quality.
- Begin using the e-scooter category and consider using the other new beta classifications once Vivacity are able to verify their accuracy.
- Work with Vivacity to make sure sensor faults and data quality issues are highlighted on the Vivacity data download site to prevent poor quality data from being unknowingly used.
- Work with Vivacity to identify a pro-active sensor fault alert system to minimise the amount of lost and discarded data.
- Identify sensor owners so that all parties are clear who is responsible for the maintenance of each sensor.

3 Introduction

3.1 Vivacity Sensors

As of June 2022, Cambridgeshire County Council had 32 Vivacity traffic sensors installed on the local road network within Cambridge and South Cambridgeshire. These sensors provide real-time and historical classified traffic flow data with the intention of helping to form an evidence base for decision making.

The Vivacity sensors use artificial intelligence to review video footage collected at each location and count the number of motorised vehicles, cycles and pedestrians passing by. When configured to do so, the sensors can also collect travel times between sensors using automatic number plate recognition.

The Vivacity sensors were first installed in Cambridge in the summer of 2019 to monitor the impact of the Mill Road bridge closure. Multiple sensors were installed for approximately 18 months to gather traffic and modal split data before, during and after the bridge closure. Due to the wealth of data the Vivacity sensors provided, additional sensors have since been installed across the city, and more recently in South Cambridgeshire, with plans to add a further 60 sensors to the network across the county.

Having permanently installed sensors helps to provide a long-term data set that can be called upon to provide historic and recent data. It also saves time and money when compared to commissioning ad-hoc traffic surveys. The data collected by the Vivacity sensors is used widely across the Council and has been vital for monitoring long-term trends across the city, for example relating to active travel and COVID-19 recovery. Data sourced from some of the longer-term Vivacity sensors is also available to the public on the Cambridgeshire Insight data portal: Cambridge City Smart Sensor Traffic Counts | Cambridgeshire Insight Open Data.

3.2 Manually Classified Traffic Survey

As more Vivacity sensors are installed across Cambridgeshire, it becomes increasingly important to be confident in the accuracy of their counting and classifying abilities. For this reason, a Vivacity sensor validation exercise has been undertaken to compare the data collected by the Vivacity sensors with a more traditional manually classified count.

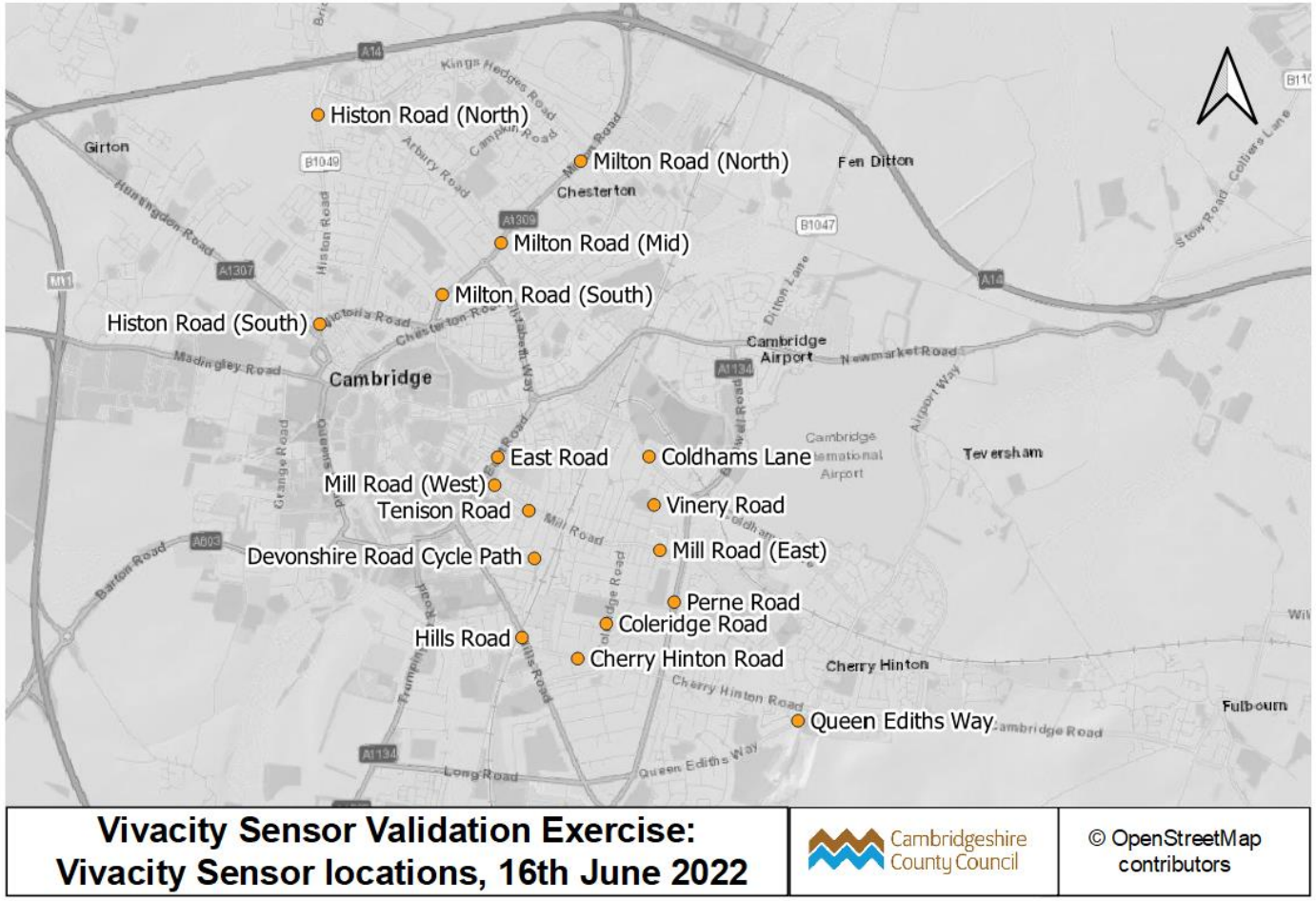
On Thursday 16th June 2022, a series of 24-hour manually classified traffic surveys were conducted at 17 of the Vivacity sensor locations across Cambridge. The manual survey data was collected by a series of video cameras installed near the Vivacity sensors. The camera footage was reviewed by a human enumerator who manually counted and classified all vehicles and pedestrians, according to the prescribed classification system (see Appendix 2: Vehicle Classification). The classification system for the manual count was designed to match the Vivacity sensor classification system, with the addition of an E-scooter category.

The aim of the manual surveys was to collect reliable classified flow data to compare against data from the Vivacity sensors to investigate the accuracy of the Vivacity sensors in counting and classifying vehicles. It is hoped the results will give increased confidence in the data from the Vivacity sensors, whilst helping to highlight any possible weaknesses in the sensor data which can then be accounted for in future projects and analyses.

3.3 Validation Sites

17 Vivacity sensors across Cambridge were chosen to be validated during the manual survey (Figure 1). The locations were chosen to reflect a range of traffic volumes, modal splits and Vivacity hardware versions. More details about the locations, and technical information about the Vivacity sensors at these locations, can be found in Appendix 1: Survey Locations.

Figure 1: 17 Vivacity Sensor locations across Cambridge were used during the validation exercise.



4 Objectives

4.1 General analysis

The validation exercise is intended to provide a general investigation of the level of accuracy of the Vivacity sensors at this point in time, as presented in sections 5.1 to 5.3.

4.2 Other Analysis Themes

In addition to this, six specific areas of analysis were also identified based on known and/or speculated weaknesses of the Vivacity sensors. These will be explored in section 5.4 but are summarised as follows:

1. Data continuity

Intermittent technical faults have led to losses of data from Vivacity sensors in the past. These data losses have varied in length from minutes to weeks and have occurred across single sensors or sometimes multiple sensors concurrently. The technical faults often result in total loss of data as the Vivacity sensors do not store video footage and missing data therefore cannot be re-processed at a later date. The validation survey will assess the impact of any technical faults across the 17 sites.

2. Age of hardware

Cambridgeshire County Council currently has two types of Vivacity sensor installed – V1 and V2 hardware. The V1 sensors use older technology. Vivacity has advised that upgrading all the sensors to V2 hardware would allow a software update to be installed which would improve the peripheral vision of the sensor, in turn improving footway detection, and also improve the sensor's detection in the dark. The validation survey will investigate the accuracy of both V1 and V2 hardware sensors.

3. Sensor placement

A number of data quality issues have been diagnosed by Vivacity as relating to the placement of the sensor and/or sensor countlines. One example of this is the sensor on Cherry Hinton Road which was placed on a lamp post near to a small tree. Over time this tree has grown considerably, and its branches partially obstructed the sensor in spring 2022 and entirely obstructed the sensor in summer 2022. The sensor is due to be rotated on 25th July 2022 with a view to providing a clearer field of vision.

Another example of this is the sensor on Queen Edith's Way whose countlines were placed in a location which contained parked vehicles. The presence of a parked vehicle on a countline has been noted to result in flows being significantly overestimated. The countlines were adjusted in March 2022.

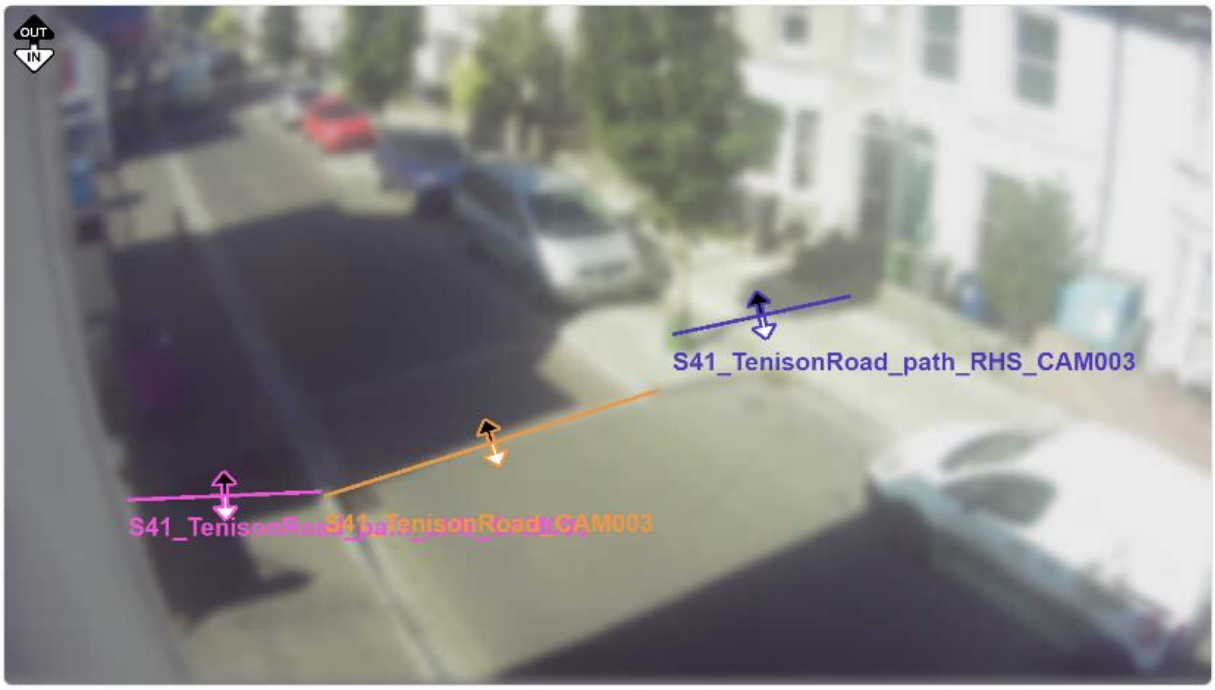
The validation exercise will assess the performance of the sensor on Cherry Hinton Road, which at the time of writing was significantly obscured by tree branches. It will also assess whether the sensor on Queen Edith's Way is now accurately counting vehicles following the adjustment of its countlines to avoid parked vehicles.

4. Single or multiple countlines

Vivacity sensors count traffic passing through one or more 'countlines'. A countline is a virtual line drawn across the road or footway in the sensor's field of view. When a vehicle, pedestrian or cyclist crosses this virtual line, they are counted and classified

by the sensor. For single countline sensors, the countline extends across the road and footway(s). For multiple countline sensors, different countlines are created for the road and for the pavements on each side (see example in Figure 2). Vivacity has advised using multiple countlines as it helps to improve data collection, particularly on pavements where it is possible to move countlines so they have as clear a view as possible of pavement users (e.g. not blocked by parked cars, trees, bus stops etc.). The validation exercise will compare the accuracy of sensors that use single and multiple countlines.

Figure 2: The Tenison Road sensor field of view. The sensor has three countlines: a main road countline and two pavement countlines (Tenison Road S41, Lens 1 view, Vivacity dashboard, 08.07.2022).



5. Darkness

Problems were identified with the data being collected by the Milton Road (South) sensor in autumn 2021 when evening peak flows suddenly decreased. The timing of this decrease coincided with the changing of the clocks, meaning that the evening travel peak occurred in darkness hours. This suggested the sensor had limited ability to count in the dark. The validation exercise will investigate whether the Vivacity sensors are able to count as accurately in the dark as they are during daylight hours.

6. E-scooters

E-scooters are becoming increasingly popular in Cambridge as a result of the Voi e-scooter scheme and increasing levels of private ownership. In June 2022, Vivacity did not have a separate e-scooter class, although in September 2022 a beta classification was released by Vivacity (see Figure 3) for a select group of sensors for testing and development purposes. Vivacity suggested that without an e-scooter category, e-scooters were probably being classified by their sensors as pedestrians. The validation exercise will aim to understand the volume of private and hired e-scooters that are missed or mis-classified by Vivacity sensors where an e-scooter class is not available (V1 hardware) or not being utilised.

Figure 3: Vivacity's description of the new 30-Class Beta.

NEW CLASSES

We have developed a new model that expands our current offering to 32 distinct classes, with many of these new classes being subsets of the above. The full range of classes will be available via both the API and Dashboard.

Traffic 32 Accuracy

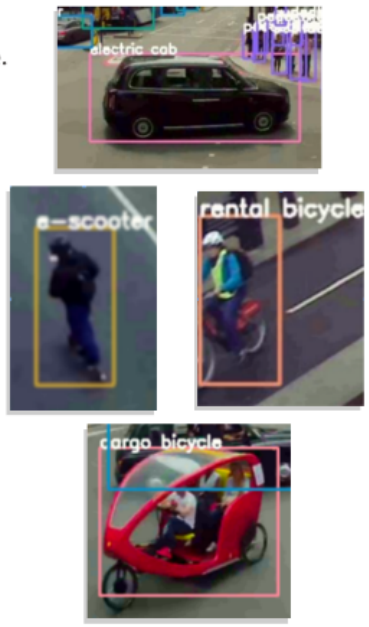
This diagram shows the title classifications and extended subclasses.

Cyclist	Motorbike	Bus	OGV1
Cyclist	Motorbike	Bus	Rigid
Cargo Courier Bike		Bus Coach	Fire Engine
Rental Bike		Bus London	Tractor
		Minibus	Agricultural Vehicle

Pedestrian	Car	LGV	OGV2
Pedestrian	Car	Van	Truck
Jogger	Taxi	Emergency Van	
Mobility Scooter	Emergency Car	Van Small	
Wheelchair	Taxi Electric	Van Luton	
E-scooter	Taxi Other		
Push Scooter	Towed Trailer		
Pushchair			

Other
Dog
Horse

High Accuracy *Improving Accuracy*



Graphical representation of the list with accuracy indications - more detail to be added

Please be aware, this is currently a beta feature and we are continuing to train our models and improve accuracy levels.

4.3 Caveats and assumptions

Caveat 1: The analysis only compares the two datasets across a single 24-hour period.

- A 24-hour period was surveyed to ensure periods of daylight and darkness were included and different volumes of traffic were captured.
- Thursday 16th June was chosen as a neutral day (i.e., not a weekend, not in the school holidays, not in a week containing a bank holiday) likely to be representative of typical Cambridge traffic.

Caveat 2: Only 17 Vivacity sensor locations were surveyed in the manual survey.

- The locations were chosen to reflect a range of traffic volumes, modal splits and Vivacity sensor models
- The manual survey aimed to include sensor sites with known or speculated problems (e.g., the Cherry Hinton Road sensor obscured by a tree).

Assumption 1: Manual survey counts and classifications are correct.

- The survey company received a clear classification chart which was designed to line up with the existing Vivacity classification system, with the only addition being an e-scooter category (Appendix 2: Vehicle Classification).
- Counts and classifications by enumerators will always be susceptible to human error but the ability to pause and rewatch videos should help to ensure a high level of accuracy across the sites.

Assumption 2: The field of view is comparable.

- There may be some small discrepancies between the sensor countline locations and the manual count camera angles which mean the counts could differ slightly. The manual counts have been deliberately aligned with the Vivacity sensor locations to minimise this as much as possible.

5 Analysis

The analysis presented in section 5.1 to 5.3 totals the counts across all sensors to give an overall picture. Disaggregated counts by site are presented in Appendix 4: Individual Site Performance Stats.

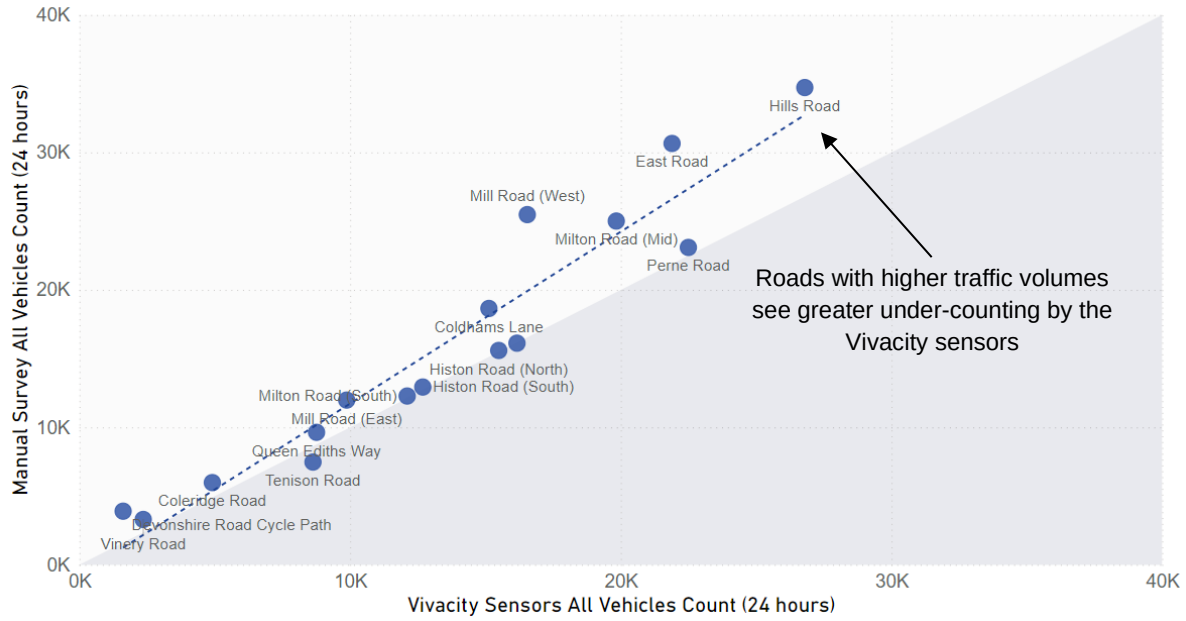
At the time of writing, the Cherry Hinton Road sensor was being obscured by a tree and its performance was therefore poor. This sensor was found to be skewing the overall combined performance of the sensor network so has been excluded from the combined total analysis. See section 5.4 for further details on the Cherry Hinton Road sensor.

5.1 Daily Flow Analysis

By plotting the Vivacity daily count against the respective manual survey daily count for each location, it is possible to determine the degree of correlation in the daily flows reported by the two methods.

Vivacity sensors generally underestimate daily flows, except for the Tenison Road and Milton Road (North) sensors which slightly overestimated the manual survey counts (see Figure 4). The trendline (blue dashed line on Figure 4) shows that the manual count is typically higher than the Vivacity count. The data also suggests that the higher the traffic volume, the larger this discrepancy becomes in absolute terms. Roads with lower traffic volumes show better correlation between the Vivacity count and the Manual Survey count.

Figure 4: The total Vivacity sensor count plotted against the total manual survey count for each location.



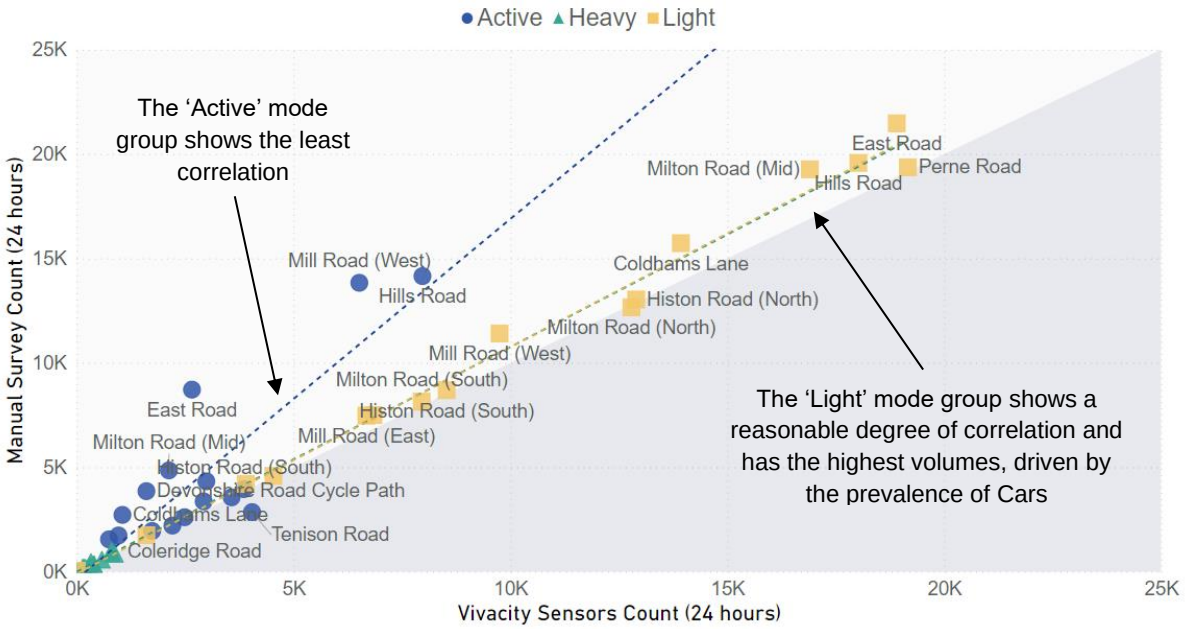
The counts on each road have also been split into three mode groups: Active (Pedestrians, Pedal Cycles, E-scooters), Heavy (Bus, OGV1, OGV2) and Light (Cars, Motorcycles, LGVs), as presented in Figure 5. The Light mode group is the largest category on most of the 16 roads, driven by the prevalence of cars. The Heavy mode

group is the smallest category, with all roads registering less than 1,000 heavy vehicles across the 24-hour period.

Heavy and Light vehicles are generally slightly underestimated by the Vivacity sensors but show a good positive correlation between the two traffic flow collection methods, suggesting that motorised vehicles are well counted and classified by the Vivacity sensors. However, as traffic volumes increase, Vivacity sensor accuracy decreases in absolute terms.

The Active group shows a more varied picture with some sensors counting active modes very well (e.g. Histon Road (North)), some overestimating active mode volumes (e.g. Tenison Road) and some significantly underestimating active flows (e.g. Mill Road (West)). The Active mode group shows a much lower degree of correlation than the other groups, indicating that some of the sensors are struggling to accurately count Pedestrians and/or Pedal Cycles.

Figure 5: The Vivacity sensor count plotted against the manual survey count for each location by type of vehicle.



Vivacity sensors are better at counting some modes than others (see Table 1 and Figure 6). Pedestrians are particularly likely to be underestimated, with only 58% of the Pedestrians in the manual survey count being picked up by the Vivacity sensors across the 24-hour period. Similarly, just 71% of manual survey Pedal Cycles were counted by the Vivacity sensors.

E-scooters do not have their own Vivacity class and, as a result, the Vivacity sensors achieve a 0% E-scooter capture rate at present. Based on the manual counts, a total of 2,886 E-scooters were recorded at the 16 locations on 16th June. These E-scooters will have been missed or mis-classified by the Vivacity sensors.

The Vivacity sensors are more accurate for Motorised Vehicles, which means that the most popular mode of transport is being well detected (see Figure 6). The capture rate for Car is 93% whilst the rate for LGV, Bus and OGV1 is around 100%, possibly due to their large size and distinctive shapes. OGV2 volumes are underestimated by the

Vivacity sensors with a capture rate of 70%, however total volumes of OGV2 in Cambridge are very low.

A more detailed break-down by location is presented in Appendix 4: Individual Site Performance Stats and Appendix 5: Individual sensor summary.

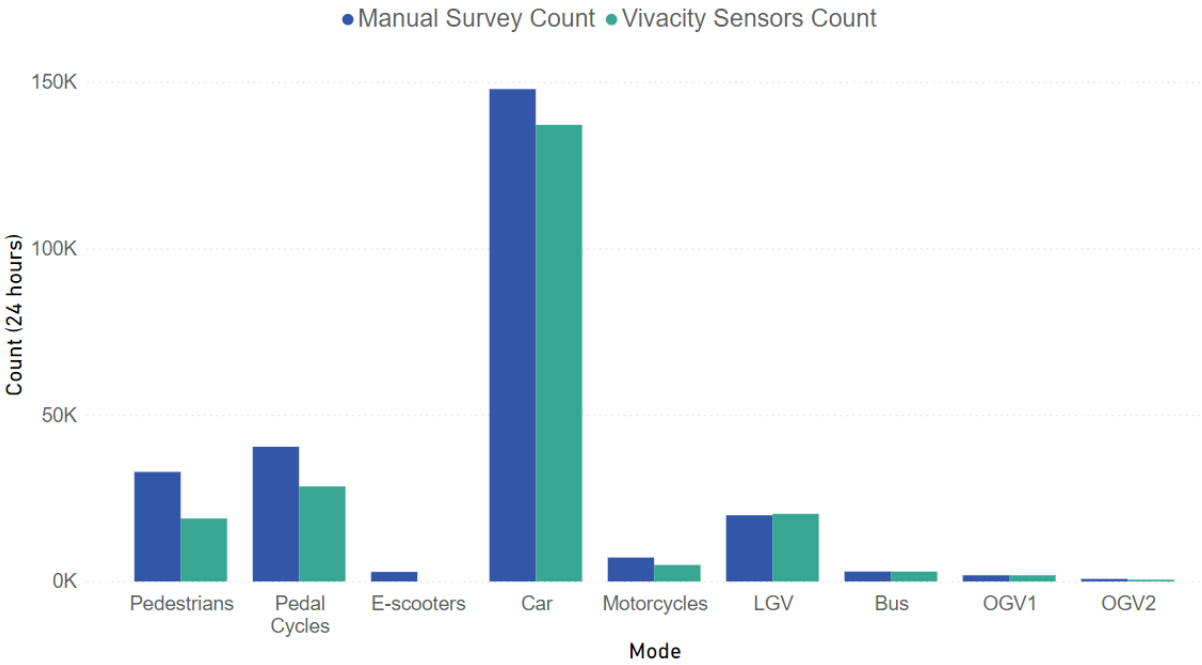
Table 1: Percentage of manually counted vehicles detected by the Vivacity sensors, by mode of transport – based on the sum of the total daily count across all 16 locations.

The colour scheme reflects the performance of the Vivacity sensor. Good accuracy = within +/- 10% (green highlight), Moderate accuracy = within +/- 30% (orange highlight) and Poor accuracy = above +/- 30% (red highlight).

Mode	Vivacity Sensor Count as % of Manual Survey Count
Pedestrians	58%
Pedal Cycles	71%
E-scooters*	0%
Cars	93%
Motorcycles	69%
LGVs	102%
Buses	100%
OGV1s	99%
OGV2s	70%

* E-scooter not currently a Vivacity class so capture rate is therefore 0%.

Figure 6: The total count for the manual survey and the Vivacity sensors by mode – total daily count across all 16 locations.



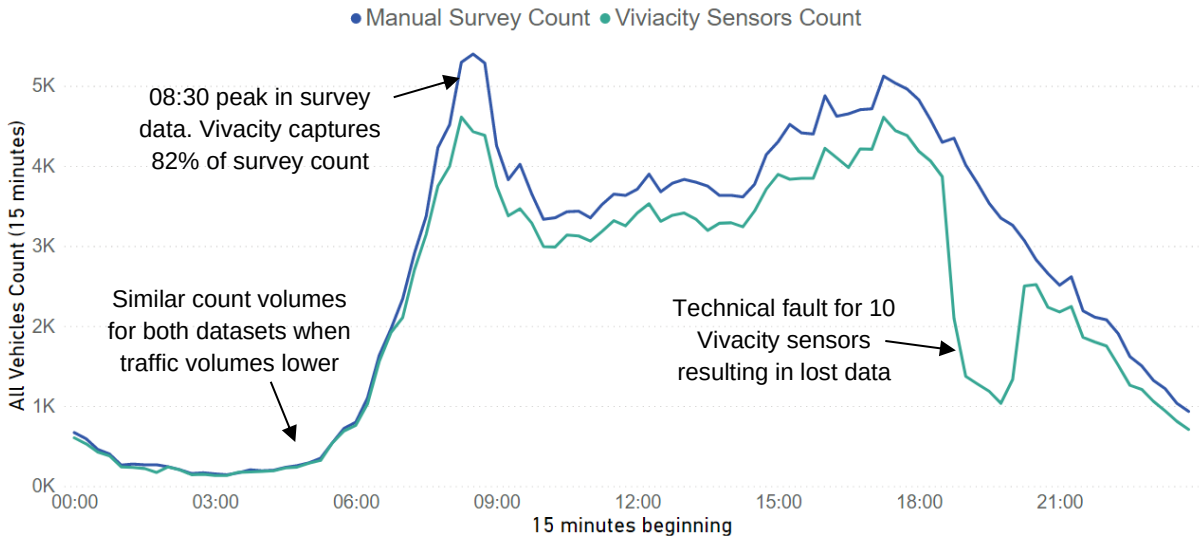
5.2 Hourly Flow Analysis: All Vehicles

Classified flow data from the Vivacity sensors can be downloaded in 5-minute, 15-minute, 1-hour or 1-day time intervals. The Vivacity data downloaded to inform this exercise was downloaded in 15-minute intervals. The manual survey data was also collected in 15-minute intervals to allow a direct comparison to be made.

The Vivacity sensor total count across all 16 sites in 24-hours (215,259) represents 84% of the total survey count (256,842). However, upon closer inspection of the hourly counts it was apparent that some of the Vivacity sensors had been inactive between 18:45 and 20:30 which resulted in no data being collected at 10 of the 16 Vivacity sensors during this period. This data problem was not apparent from viewing the daily counts alone which has highlighted the importance of reviewing the hourly and daily data before use. Further analysis of the data loss is provided in Figure 9. If the data collected from 18:45 to 20:30 is excluded from the total count, the Vivacity count (204,461) represents 88% of the total survey count (231,493).

When the two datasets are plotted in 15-minute intervals, the profile of traffic flow throughout the day are similar, although the Vivacity sensors show lower volumes at most times of the day (see Figure 7). This undercounting is particularly notable in the morning peak, where the Vivacity sensor count is 82% of the survey count, and also between 18:45 and 20:30 due to the Vivacity sensor technical fault. When total traffic volumes are lower, for example during the night and early morning, the survey and Vivacity counts are more similar (e.g. 95% at 06:30).

Figure 7: The survey and Vivacity counts plotted by time of day for 16th June.



The accuracy of the Vivacity sensor counts across the day varies greatly by site (individual site graphs and statistics are provided in Appendix 4: Individual Site Performance Stats and Appendix 5: Individual sensor summaryAppendix 3:). Several factors, which will be discussed later in this report, may affect the success of the Vivacity count and classification including the proportion of active travel, presence of technical faults and the age of the sensor hardware.

5.3 Hourly Flow Analysis: By Vehicle Type

Vivacity sensors classify traffic into 7 classes which are based on the Standard UK Vehicle Classification: Pedestrians, Pedal Cycles, Motorbikes, LGV, OGV1, OGV2, and Buses. The manual survey classified traffic into the same classes as the Vivacity sensors (see Appendix 2: Vehicle Classification), with the addition of an E-scooter category.

Figure 8 presents the hourly flow by vehicle types and helps to demonstrate that the Vivacity sensors capture some vehicle types more accurately than others. On 16th June 2022, the Vivacity sensors captured Cars, LGVs, Buses and OGV1 very well across all hours with the exception of 18:45 – 20:30 when the technical fault occurred. This is supported by the capture rates presented in Table 2. The hourly profiles of these sites support this finding, showing good trend correlation between the Vivacity sensor counts and the manual survey counts (see Figure 8).

The older V1 Vivacity sensors underestimate pedestrians throughout the day, whilst Pedal Cycles are most significantly underestimated during the AM and PM peak periods. An average of 62% of active modes (Pedestrians, Pedal Cycles and E-scooters) are successfully captured across all sensors whilst the active mode capture rate increases to 102% when the V2 sensors are considered in isolation (see Table 2).

Motorcycles are also not well classified by the V1 sensors at just 61% and their significant increase between 18:30 and 20:30 unfortunately coincides with the Vivacity sensor fault. As such, all the Vivacity sensors capture only 69% of the manually surveyed Motorcycle counts, or 76% if the period of technical fault is excluded. If the V2 sensors are considered in isolation, the motorcycle capture rate is 88% regardless of whether the fault period is included or excluded.

Whilst OGV2 numbers are consistently low (total of 786 counted in the manual survey across the 24 hours), the Vivacity sensors do appear to be missing some of these vehicles or perhaps misclassifying them, particularly when these vehicles are at their highest volumes in the middle of the day.

Whilst the absolute volumes for some modes of transport (especially active travel) are underestimated, particularly by the V1 Vivacity sensors, the hourly profile for all modes of transport are generally similar to the manual survey trends. This indicates that whilst absolute volumes may not be reliable for all modes of transport across all sensors, time of day trends are reasonable. For example, although Pedal Cycle volumes are significantly underestimated by the V1 sensors, the sensors still capture the distinct morning and evening peaks and a decrease in cycle flows between 10:00 and 14:00 (see Figure 8).

Figure 8: Total traffic count summed across all 16 sensors by time of day and mode. Note each graph is on a different y-axis scale.

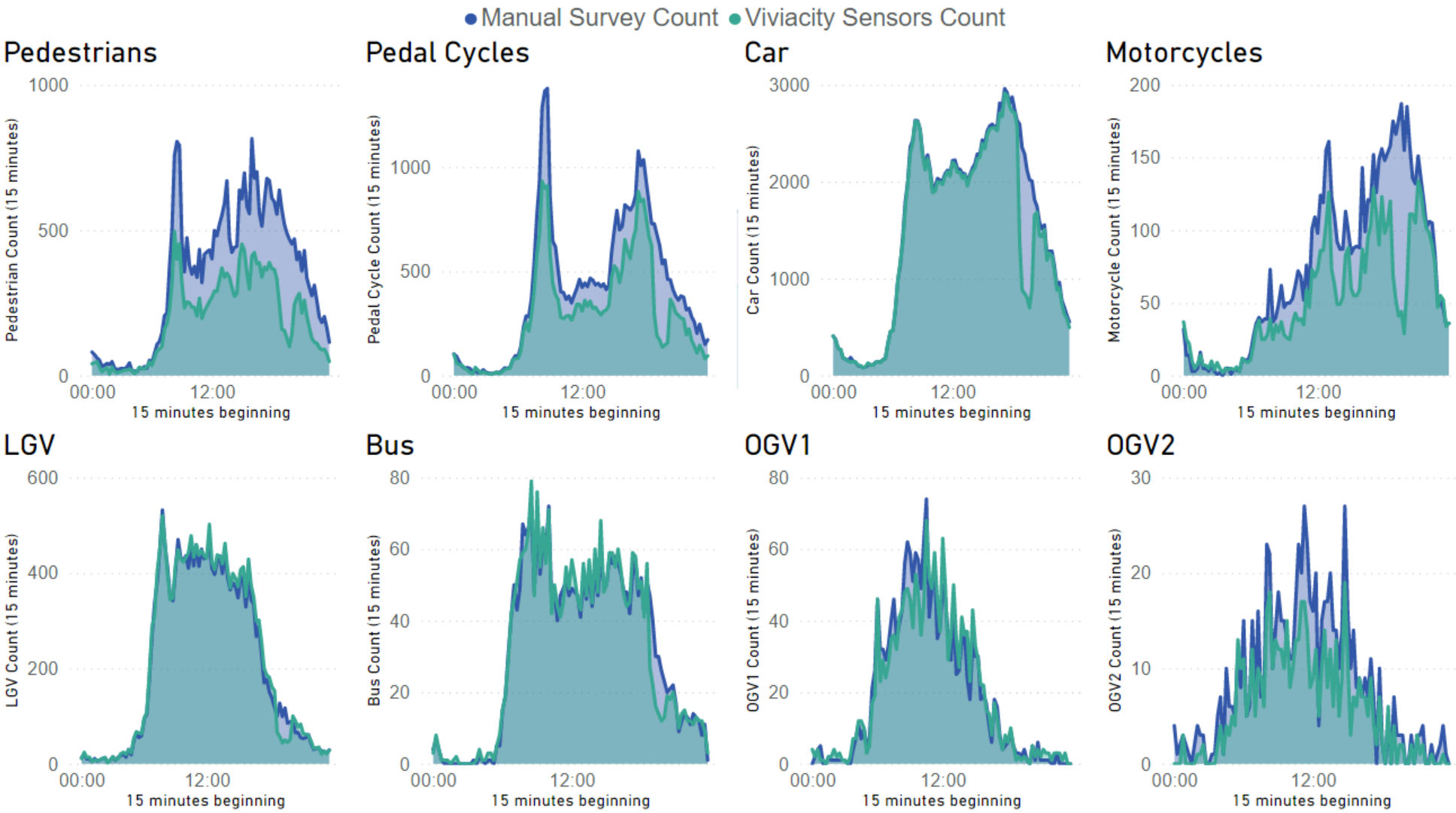


Table 2: Vivacity daily count as a proportion of the manual survey daily count across all 16 sites by mode, mode group and overall, including (top) and excluding (bottom) the period of sensor down time (i.e. excluding data from 18:45 to 20:30).

The colour scheme reflects the performance of the Vivacity sensor. Good accuracy = within +/- 10% (green highlight), Moderate accuracy = within +/- 30% (orange highlight) and Poor accuracy = above +/- 30% (red highlight). **Includes e-scooters.*

Including period of sensor technical fault (V1 and V2 hardware sensors):

Mode	Pedestrians	Pedal Cycles	Car	Motorcycles	LGV	Bus	OGV1	OGV2
Vivacity count % of survey count	58%	71%	93%	69%	102%	100%	99%	70%
Mode Group	Active*	Heavy	Light					
Vivacity count % of survey count	62%	95%	93%					
Overall	All Traffic*	Motor Vehicles	Active Travel*					
Vivacity count % of survey count	84%	93%	62%					

Excluding period of sensor technical fault (V1 and V2 hardware sensors):

Note: Nine V1 sensors and one V2 sensor was affected by the technical fault

Mode	Pedestrians	Pedal Cycles	Car	Motorcycles	LGV	Bus	OGV1	OGV2
Vivacity count % of survey count	61%	74%	98%	76%	104%	103%	99%	70%
Mode Group	Active*	Heavy	Light					
Vivacity count % of survey count	66%	97%	98%					
Overall	All Traffic*	Motor Vehicles	Active Travel*					
Vivacity count % of survey count	88%	98%	66%					

Including period of sensor technical fault (V2 hardware sensors only):

Mode	Pedestrians	Pedal Cycles	Car	Motorcycles	LGV	Bus	OGV1	OGV2
Vivacity count % of survey count	114%	101%	98%	88%	106%	110%	99%	97%
Mode Group	Active*	Heavy	Light					
Vivacity count % of survey count	102%	105%	98%					
Overall	All Traffic*	Motor Vehicles	Active Travel*					
Vivacity count % of survey count	99%	98%	102%					

Excluding period of sensor technical fault (V2 hardware sensors only):

Note: Only one V2 sensor was affected by the technical fault

Mode	Pedestrians	Pedal Cycles	Car	Motorcycles	LGV	Bus	OGV1	OGV2
Vivacity count % of survey count	114%	101%	98%	88%	106%	110%	99%	98%
Mode Group	Active*	Heavy	Light					
Vivacity count % of survey count	102%	105%	99%					
Overall	All Traffic*	Motor Vehicles	Active Travel*					
Vivacity count % of survey count	100%	99%	102%					

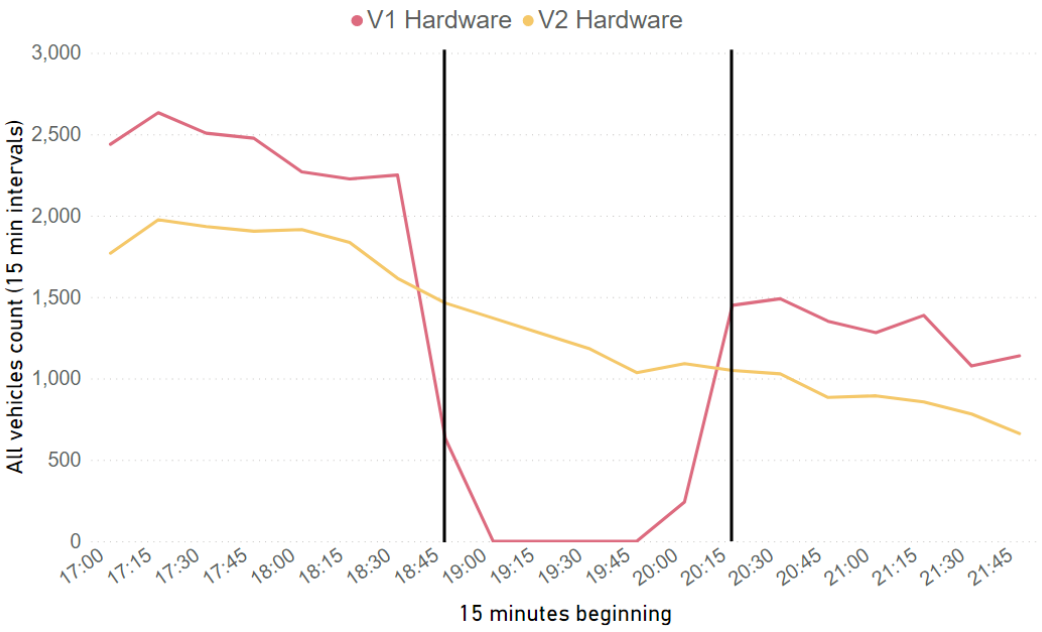
5.4 Other Analysis Themes

1. Data continuity

As mentioned previously, a technical fault affecting 10 of the 16 Vivacity sensors occurred between 18:45 and 20:30 on Thursday 16th June resulting in a total loss of data from these sensors during this period. Vivacity explained that the data loss was due to an "outage on the stream sensors" due to a loss of signal from the SIM provider network. As the Vivacity sensors do not store any video footage, it is not possible to retrospectively collect missing data when faults occur, so this data is not recoverable.

Interestingly, the outage on 16th June seems to have affected mainly the V1 hardware sensors, with the exception of the Queen Edith's Way V2 sensor (see Figure 9). This could indicate the V2 hardware is less susceptible to data loss during SIM provider outages, further supporting the upgrade to V2 recommended by Vivacity. Several V1 sensors which were affected by the technical fault are in the process of being upgraded from V1 to V2 which may help to improve data continuity moving forward. This is detailed further in Section 6.3.

Figure 9: Total traffic count for the V1 and V2 hardware sensors from 17:00-22:00 on 16th June.

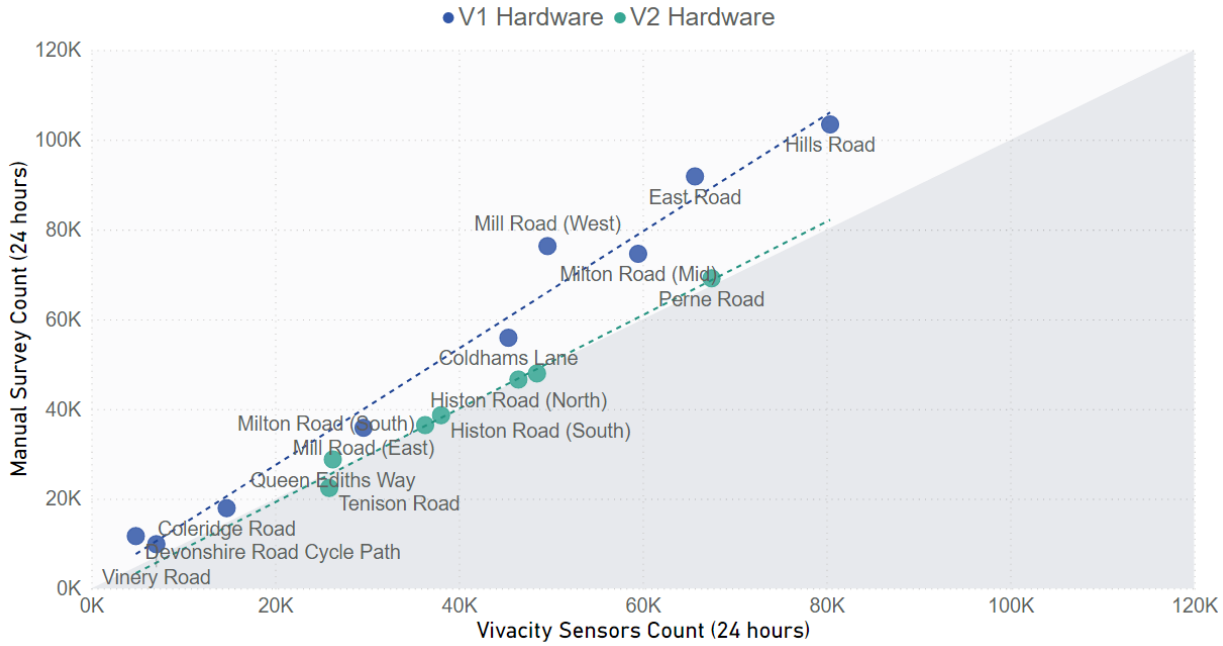


2. Age of hardware (V1 vs. V2)

By analysing the performance of a mixture of V1 and V2 hardware sensors, it has been possible to compare the relative performance of the V1 and V2 sensors, noting that site specifics may also have an impact.

By plotting the Vivacity daily count against the respective manual survey daily count for each site, it is possible to see how the two hardware versions compare (see Figure 10). The V2 hardware shows much better correlation with the manual count than the V1 hardware (i.e. the dashed trendline is closer to x=y). The V1 hardware sensors increasingly undercount as the total survey count increases whereas the V2 hardware sensors remain consistent across all traffic volumes and road types.

Figure 10. The Vivacity sensor count plotted against the manual survey count for each location by Hardware type.

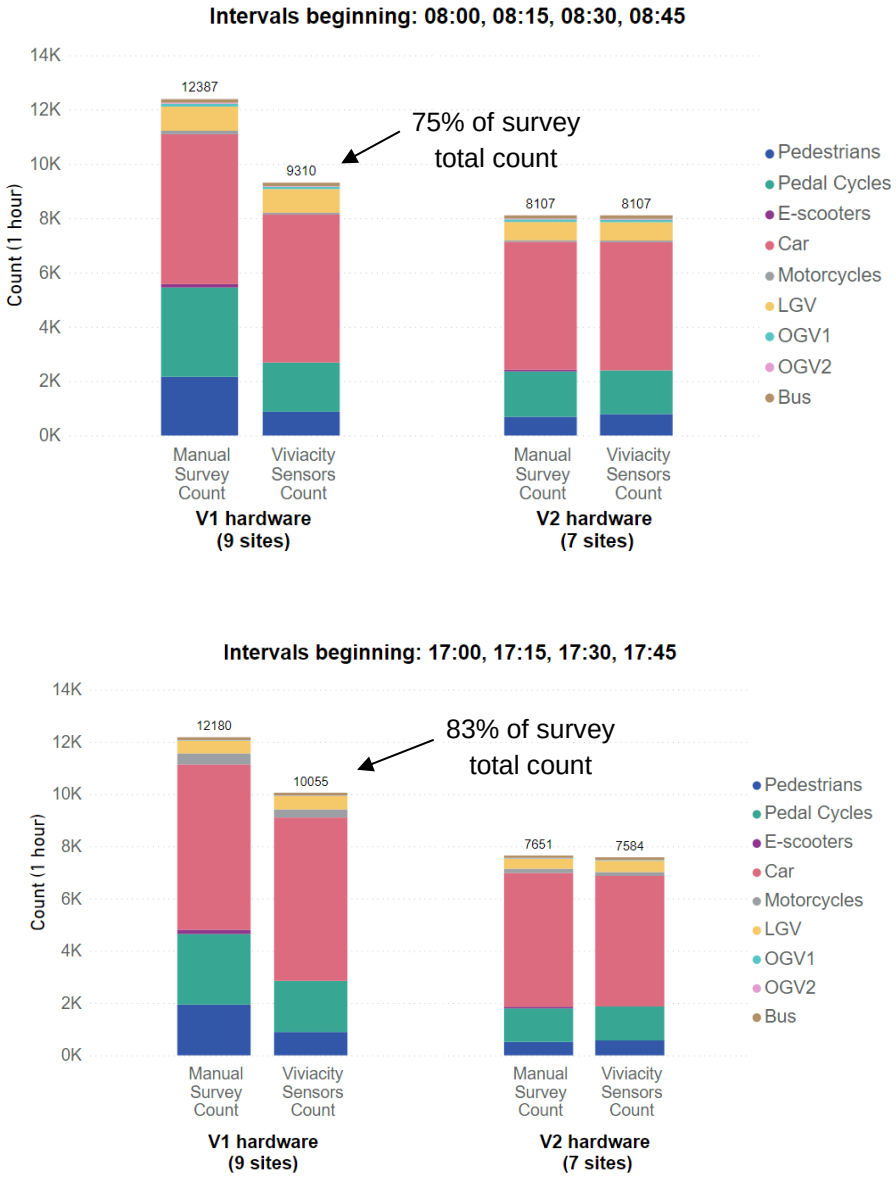


To allow a more in-depth comparison of the counting performance of the V1 and V2 sensors, analysis of the morning and evening peak hours (08:00-09:00 and 17:00-18:00) has been conducted. These periods deliberately exclude the period during which the technical fault occurred. When the V1 and V2 hardware are compared, the V2 hardware greatly outperforms the V1 hardware in terms of both counting and classifying traffic (see Figure 11). The Vivacity V1 hardware sensors capture just 75% of the survey total count from 08:00-09:00. In comparison, the V2 hardware captures 100% of total traffic. A similar trend is seen from 17:00-18:00 with the V1 hardware capturing 83% and the V2 hardware capturing 99% of the survey total.

In addition, there is less discrepancy between the modal split of the traffic count when using the V2 hardware, especially for active modes. For example, in the hour beginning 08:00, 48% of Active Travel (Pedestrians, Pedal Cycles and E-scooters) were counted by the V1 sensors, whilst 99% were counted by the V2 sensors. Similarly, in the hour beginning 17:00 the V1 hardware counted 59% of Active Travel, compared to 101% for the V2 sensors. The V2 hardware also shows slight improvements in Motorised Vehicle counts; for example, in the hour beginning 08:00, the V1 sensors count 97% of Motor Vehicles whilst the V2 sensors count 100%.

Four of the V1 hardware sensors are in the process of being upgraded from V1 to V2 which should help to improve active travel counts in future, as detailed in Section 6.3.

Figure 11: The modal split for the hours beginning 08:00 and 17:00 for the V1 and V2 hardware respectively, compared to the manually surveyed counts.

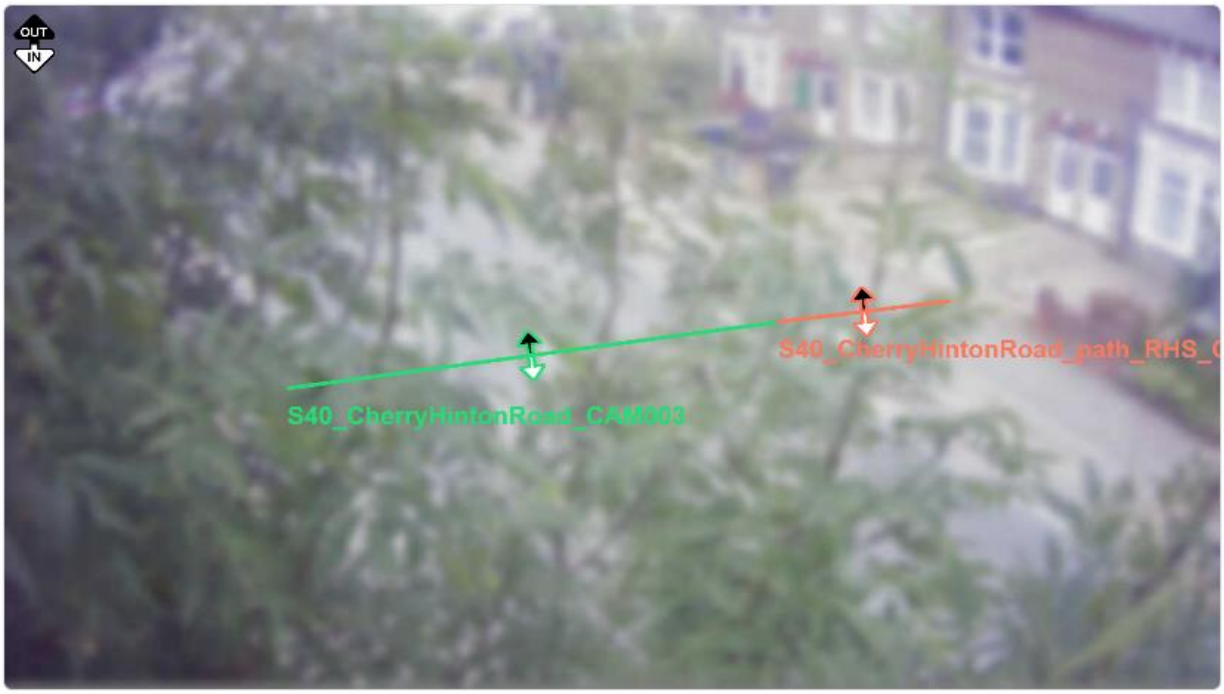


3. Sensor and countline placement

The Vivacity sensor on Cherry Hinton Road was initially installed in May 2019 and made use of V1 hardware. The sensor was upgraded to V2 hardware in August 2020 and received a software update in April 2022.

Despite having the latest hardware and software available, the sensor is currently struggling to count flows due to tree branches obscuring its field of vision (see Figure 12).

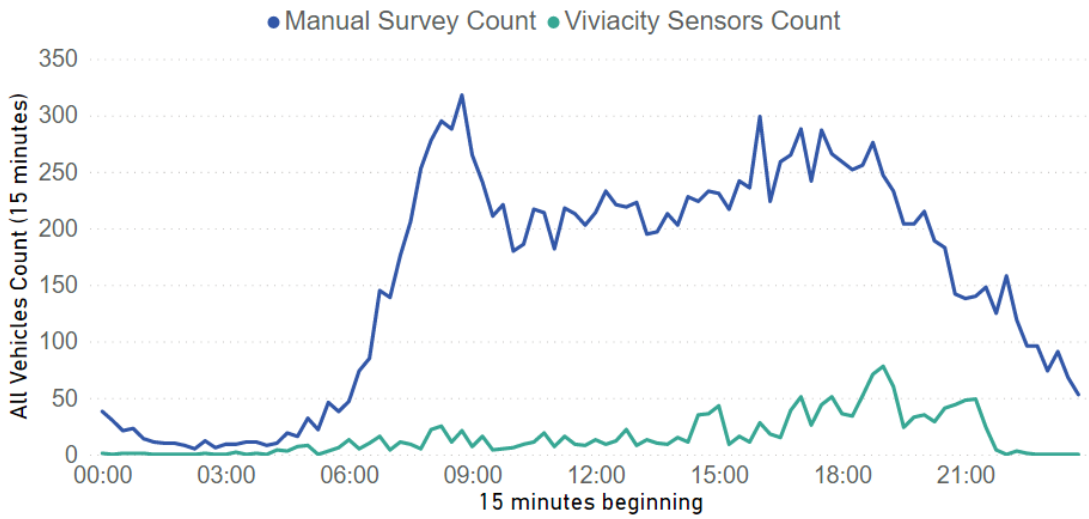
Figure 12: The view from the Cherry Hinton Road sensor - Lens 1, S40, Vivacity dashboard (as captured on 30/06/2022).



A comparison of the manual and Vivacity counts shows that across the 24-hour period, the Vivacity sensor captured a total of 1,518 movements, just 10% of the manual count total of 14,899 (see Figure 13). As the data from this sensor is particularly poor due to the tree growth, it has been excluded from all other analysis within this note to avoid biasing the conclusions.

Unsurprisingly the tree growth has significantly impacted the sensors' ability to both count and classify vehicles. The tree in question is located on private land and is therefore not able to be trimmed under the council's maintenance programme. The City Council's arboricultural officer has also advised that pruning the branches would affect the tree structure in maturity and would be best avoided. As a result, Vivacity have rotated the sensor by 90 degrees to achieve a clearer view of the road and footways and the sensor is now detecting significantly more movement.

Figure 13: A comparison of the Cherry Hinton Road manual and Vivacity counts, by time of day.



In addition to sensor placement, countline placement is another factor that can affect the quality of data. The countlines at the sensor on Queen Edith's Way were adjusted to avoid a parked vehicle in March 2022 after some unusually high flows were recorded, in particular on the left-hand-side (LHS) footpath countline. Prior to the countline being moved, the LHS footpath countline was picking up an average of 949 motorised vehicles per day, primarily cars, in February 2022. After the countline was moved in March, the LHS footpath countline picked up an average of 8 Motorised Vehicles a day in April 2022. In addition, the number of pedestrian and pedal cycle captured increased after the countline was better positioned, although this increase is likely in part due to expected seasonal increases in active travel modes.

Table 3. Changes in the left-hand side footpath counts on Queen Edith's Way before and after the countline was moved, January - June 2022.

Month	**Average daily count for Motorised Vehicles**	**Average daily count for Pedestrians and Pedal Cycles**
January 2022	872	68
February 2022	949	84
March 2022 *(countline moved)*	230	103
April 2022	8	229
May 2022	9	293
June 2022	9	262
% change from February to April	-99%	+173%

As the Vivacity sensor network continues to expand, it is recommended that sensors are located on lampposts with a low risk of being obscured by vegetation and/or other features such as bus stops, loading bays, road-side parking etc.

4. Single and multiple countlines

By analysing the performance of both single countline and multi-countline sensors, it has been possible to estimate the data accuracy benefits of using multiple countlines.

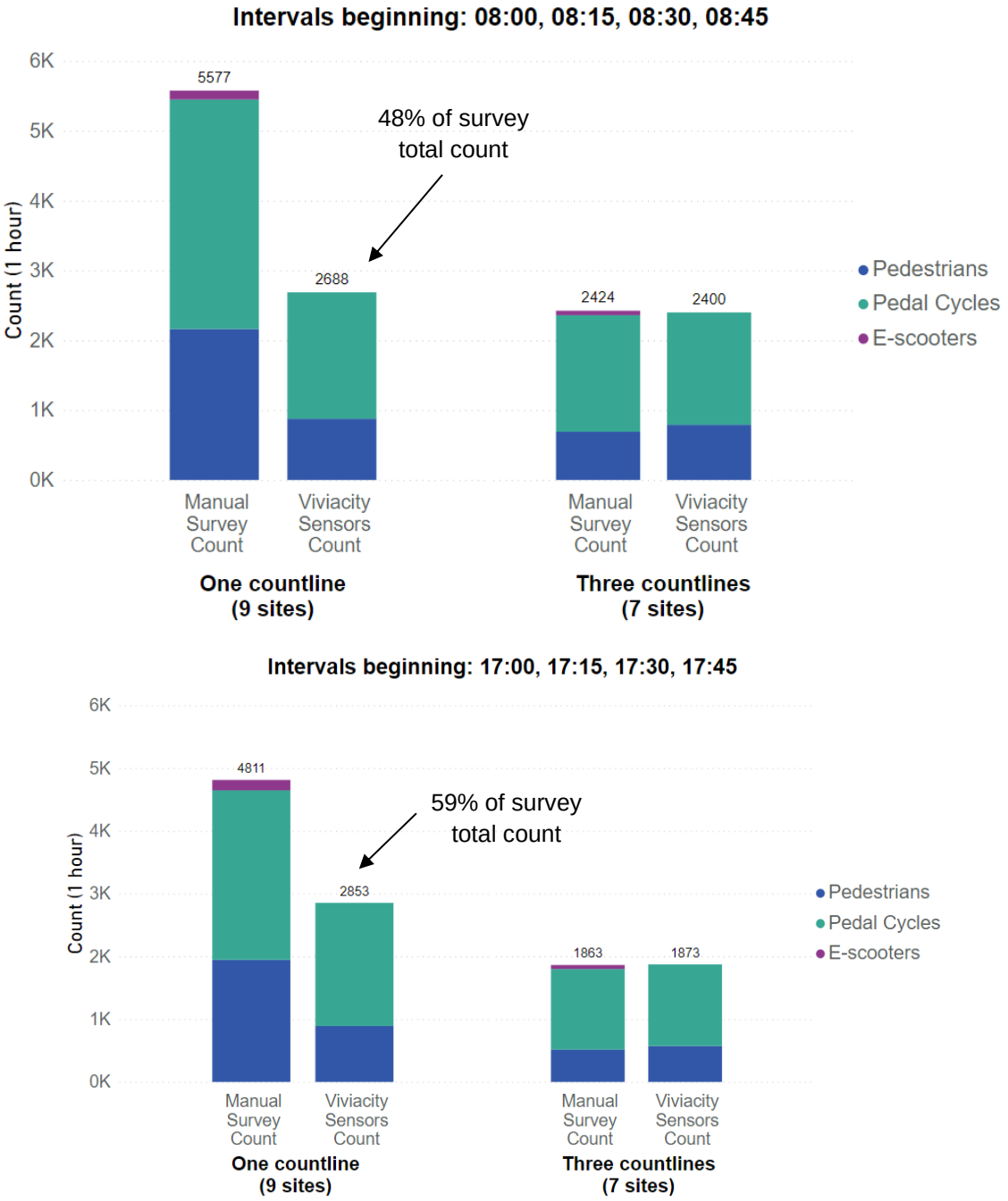
To allow a more in-depth comparison, analysis of the morning and evening peak hours (08:00-09:00 and 17:00-18:00) has been conducted to deliberately exclude the period during which the technical fault occurred.

As the V1 hardware sensors all use a single countline and the V2 sensors all use multiple countlines, the findings here are closely linked to the 'Age of hardware' analysis above. However, the key benefit of using multiple countlines relates to improved peripheral vision and better footway and cycle lane capture. This section therefore focuses on the benefits to active travel counts which are most likely to see an improvement from multiple countlines.

Comparing the Active Travel counts (Pedestrians, Pedal Cycles and E-scooters) for sensors using a single countline with sensors using multiple countlines suggests that using multiple countlines increases the accuracy of Active Travel counting (see Figure 14). In the hour beginning 08:00, the sensors using a single countline (9 sites) captured a total of 2,688 Active Travel movements which is equivalent to 48% of the total captured by the manual survey. However, the sensors using three countlines (7 sites) captured 99% of the manual survey Active Travel total. Similarly, in the hour beginning 17:00, the V1 sensors account for 59% of active travel counts, compared to 101% for the V2 sensors.

This discrepancy between multiple and single countline sensors is particularly distinct for pedestrians. The single countline sensors account for just 41% of pedestrians in the hour beginning 08:00, whilst the multiple countline sites overestimate pedestrian volumes at 114% of the survey count. This overcounting of pedestrians during the PM peak could be the result of misclassification of E-scooters, as presented in Figure 18.

Figure 14: A comparison of Active Travel counts for sensors using single and multiple countlines (08:00-09:00 and 17:00-18:00).



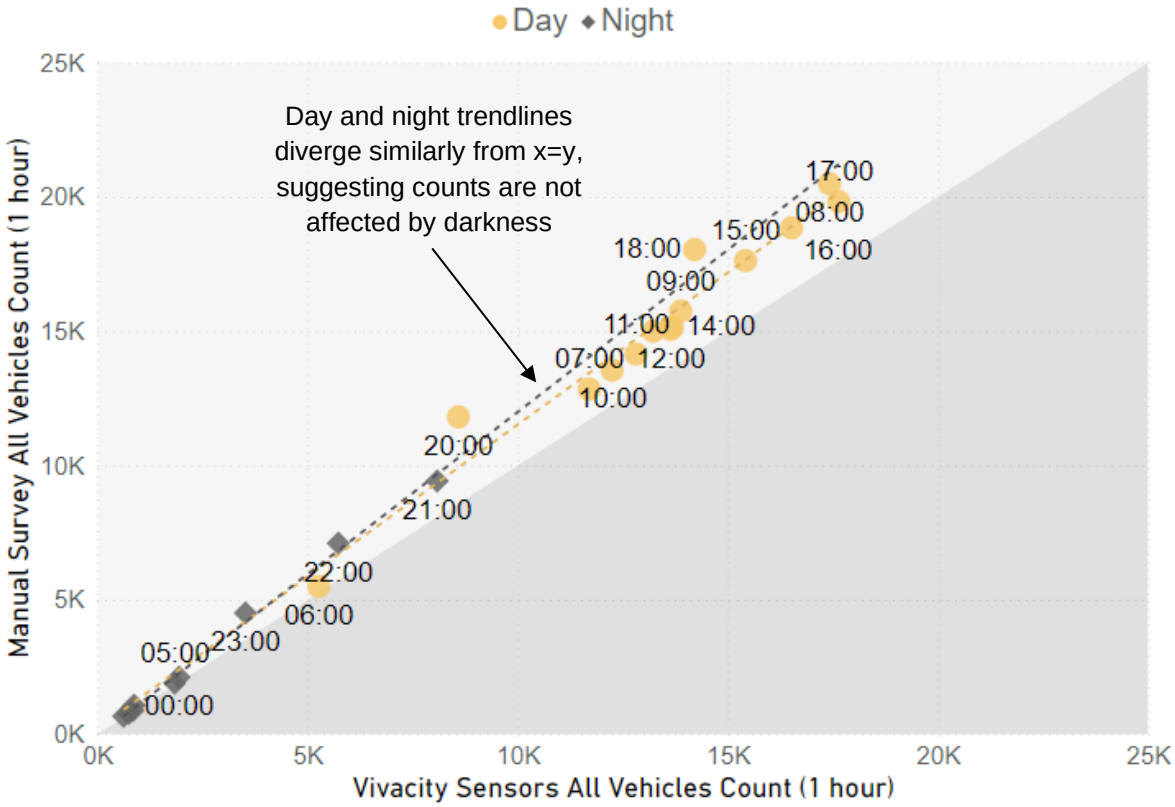
5. Darkness

A 24-hour period has been assessed to allow periods of daylight and darkness to be compared. A comparison of counts during the day (daylight hours) and at night (after sunset) has been undertaken in Figure 15. The analysis shows that the accuracy of counts is not significantly impacted by periods of darkness.

It is possible that the lower overall traffic volumes, and in particular active travel volumes, overnight also help to keep sensor accuracy high as both these lead to sensor inaccuracies, particularly for V1 hardware sensors.

All 16 sensors of the sensors being considered in this exercise are in urban areas in locations with street lighting. Whilst all of these sites are lit, the intensity of the lighting does vary as some sensors benefit from an additional lamp on the opposite side of the road whilst others do not. The ability of these sensors to count after dark cannot be assumed to be replicable in less well-lit or rural locations.

Figure 15: The correlation between the Vivacity sensor counts and the manual survey counts by time of day, categorised by 'Day' and 'Night'. Data for all 16 sites, excluding the hour beginning 19:00 which was most affected by the technical fault in V1 sensors.

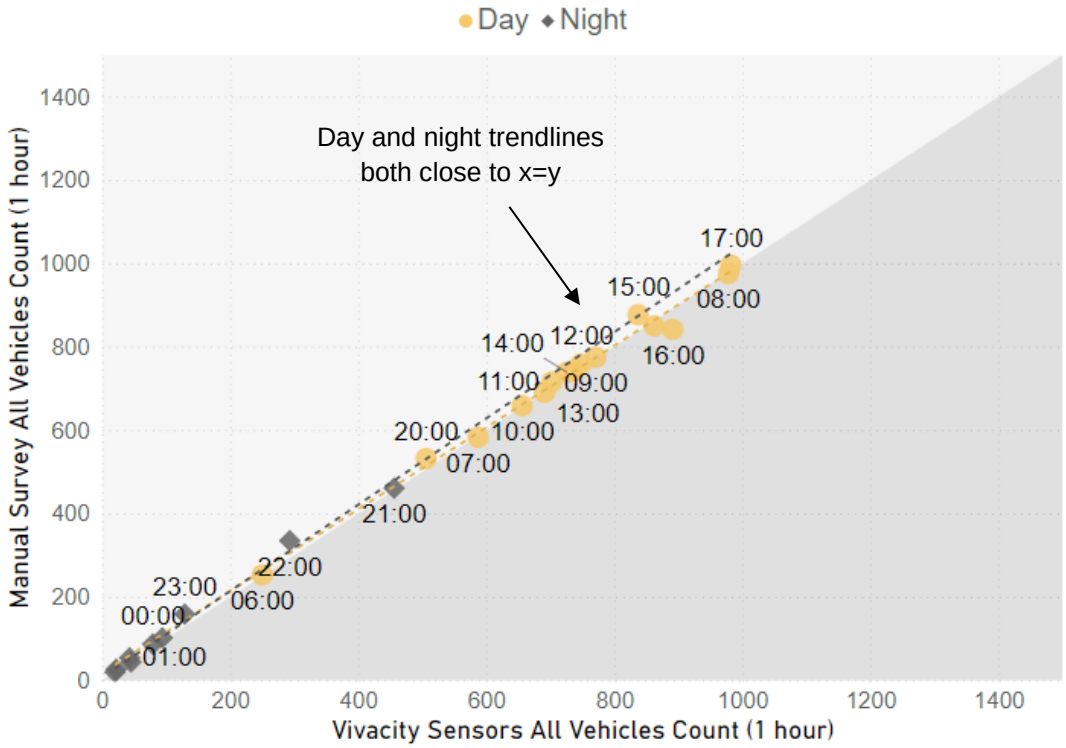


The Milton Road (South) Vivacity sensor was identified as struggling to count in the dark in autumn 2021 as flows were found to be decreasing rather than increasing during the peak period (16:00 to 19:00). This was particularly noticeable after the clocks went back in October 2021 when PM peak flows (now in darkness) decreased significantly. Vivacity speculated that the error was likely the result of the location not being well-lit at night and the sensor's angle meaning that the headlights of oncoming vehicles were affecting the sensor's counting capability. Due to concerns with the data,

CCC asked for the sensor to be hidden from the Vivacity dashboard to prevent anyone unknowingly using poor quality data.

On 11th June 2022, the Milton Road (South) sensor was upgraded to V2 hardware with the latest software. Figure 16 shows data from the upgraded sensor on 16th June which is no longer having trouble counting vehicles at night. The Vivacity counts are similar to manually surveyed counts during day and night suggesting that the hardware upgrade has resolved the problems at this location.

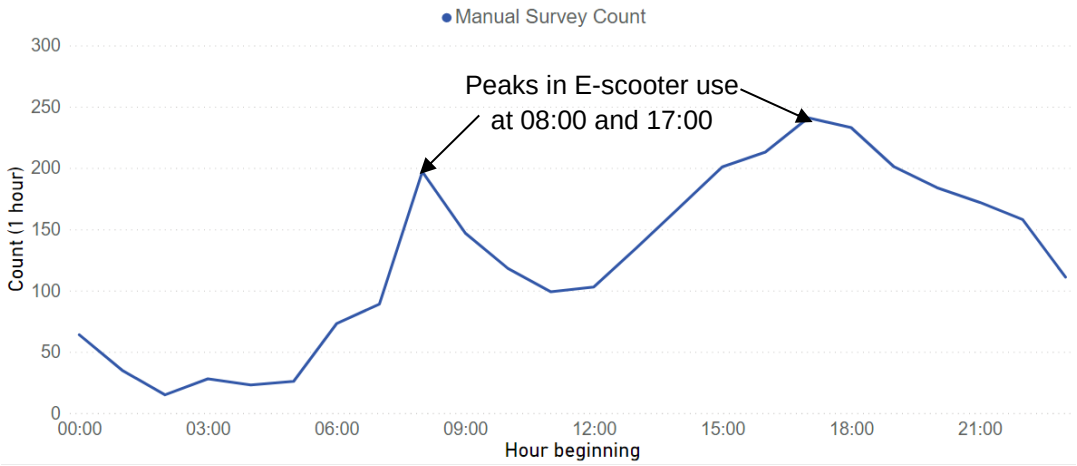
Figure 16: Milton Road (South) Vivacity and manual count correlation by time of day, categorised into 'Day' and 'Night' for the location.



6. E-scooters

At the time of the June 2022 survey, Vivacity did not classify E-scooters into their own category. The manual survey undertaken for this analysis included a separate classification for E-scooters in order to assess how many were potentially being missed or mis-categorised by the Vivacity sensors. The total count of E-scooters in the manual survey across the 16 sites over 24 hours was 2,886, with significant peaks at 08:00 and 17:00 (see Figure 17).

Figure 17: Manual survey E-scooter counts across the 16 sites.

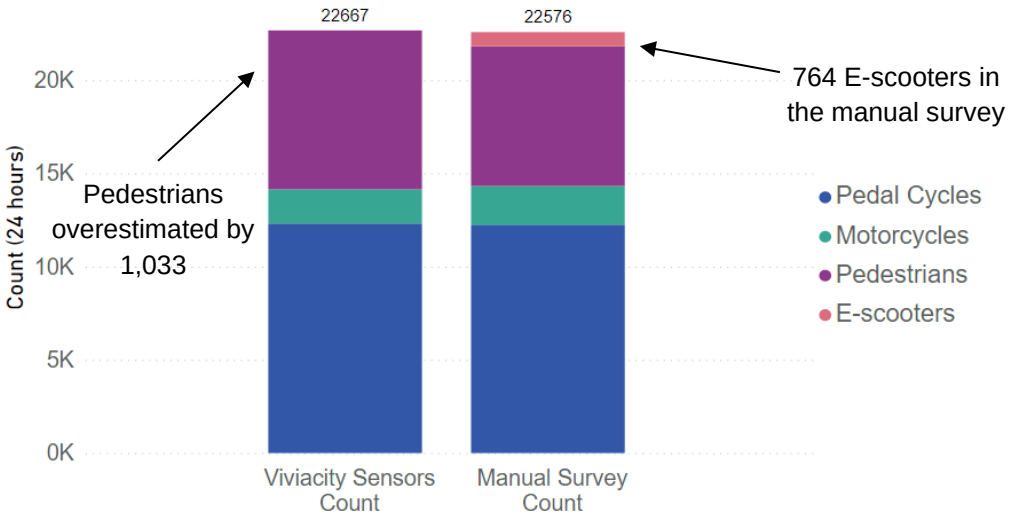


Vivacity have advised that until their E-scooter classification is tested and released, E-scooters are most likely being categorised as pedestrians. This is supported by our analysis.

Only the 7 sensors which use three countlines were used in the following analysis, as they are more accurate at counting and classifying Active Travel and pavement users (see the Single and Multiple Countlines analysis above, Figure 14). Volumes of pedal cycles and motorcycles recorded by the 7 multi-countline V2 sensors are very similar to the manually counted volume. However, pedestrian volumes recorded by the V2 hardware sensors are being overestimated by approximately 1,000 across the 24 hours (see Figure 18) which is similar to the number of E-scooters manually counted at the 7 sites - 764 per day. The distinct overestimation of pedestrians in comparison to the accuracy of the other modes suggests that some or all of the E-scooters are likely to be mis-classified as pedestrians under the current 8-mode Vivacity classification system.

In September 2022, a beta E-scooter category was released by Vivacity for testing on some of the V2 sensors (see Section 6.3 for more information) but this remains under development.

Figure 18: Pedal cycles, motorcycles, pedestrians and E-scooter mode split at the 7 V2 hardware sites. Pedestrians are over-estimated by a similar amount that E-scooters are not captured.



6 Summary

6.1 Key Findings

- The V1 Vivacity sensors generally underestimate traffic counts in most locations with 81% of total movements being detected (excluding the fault period). Motorised vehicle detection is good (97%) but active mode detection is poor (52%).
- The V2 Vivacity sensors are good at capturing traffic in most locations with 100% of movements being detected when the fault period is excluded, although there are some small discrepancies in classifying these movements. Motorised vehicle detection is good (99%) and active mode detection is also good (102%).
- Despite the presence of some undercounting, particularly with the V1 sensors, the hourly flow profiles are generally similar to that of the manual survey for each mode of transport (with the exception of the technical fault period) suggesting they are reliable for time-of-day trend analysis.
- The V2 hardware sensors, which use multiple countlines, count and classify more accurately than the V1 hardware sensors, especially for active modes and pavement-users and on higher traffic volume roads.
- The Vivacity sensors count as accurately during periods of darkness and in daylight hours, although the sensors in this report are all located in well-lit, urban locations. Upgrading from V1 to V2 hardware resolved the Milton Road (South) sensor issue with counting in the dark.
- The lack of a reliable E-scooter classification means thousands of E-scooters were either not counted or misclassified (probably as pedestrians) by the Vivacity sensors. As E-scooters increase in popularity, this misclassification could become increasingly significant. The release of a new beta e-scooter category released by Vivacity for some V2 sensors is hoped to address this but accuracy testing will be required.
- Vivacity sensors are heavily reliant on having a clear field of vision. They should be placed to avoid things which could obstruct or interfere with the camera's field of view such as vegetation, bus stops and parked vehicles.
- As of June 2022 the Vivacity sensors are not able to distinguish between pedal cycles and e-bikes nor between motorbikes and e-mopeds.

6.2 Recommendations

Upgrade all V1 hardware to V2

Excluding the fault period, the V1 Vivacity sensors captured 81% of the total survey count, whilst the V2 Vivacity sensors captured 100% of the total survey count. The difference in counts is particularly notable for Active Travel, which is likely due to the improved hardware, updated software and the ability to use multiple countlines with the V2 sensors.

Guidance: *If you require absolute counts for a project, it would be best to use data from the V2 hardware sensors, particularly if the project focuses on active travel.*

Note: As of June 2022, nine of the sensors still used V1 hardware with a single countline. Absolute flows from these sensors should be used with care:

- Mill Road (East)*
- Mill Road (West)*
- East Road*
- Milton Road (Mid)*
- Coleridge Road
- Vinery Road
- Coldham's Lane
- Devonshire Road (Carter Bridge)
- Hills Road

*Three sensors that were using V1 hardware during summer 2022 have been subsequently upgraded to V2 hardware and were re-calibrated in September 2022. Upgrading of the Milton Road (mid) sensor is also planned once the current phase of roadworks are complete. See more in section 6.3.

Upgrade all sensors to use multiple countlines

Linked with the above point, implementing multiple countlines will help to improve the sensor's view of footways and should significantly improve active travel counts.

Guidance: *If active travel is your primary focus and you require absolute counts, it would be best to use data from sensors with multiple countlines.*

Sensor placement

Vivacity sensors are heavily reliant on having a clear field of vision which has been highlighted by the impact of tree growth in front of the Cherry Hinton Road sensor. A similar problem with tree growth has since been identified at the Devonshire Road site. It is recommended that sensors are located on lamp columns with a low risk of being obscured by vegetation, bus stops, loading bays, road-side parking etc.

Being aware of unusual activities (e.g. roadworks, road closures, events) at/near each sensor can also help to determine whether unusual data is a result of an observable event or due to sensor issues.

Guidance: *If you are concerned that a sensor may be miscounting, the field of view of V2 sensors can be checked in the Vivacity dashboard and local events / roadworks should be checked.*

Make use of the E-scooter classification once it has been tested and approved

Nearly 3,000 e-scooters were counted in the manual 24-hour survey on 16th June across the 16 Vivacity locations. The continuation of the Voi e-scooter rental scheme in Cambridge, and potential new government legislation for the ownership and use of private e-scooters means that e-scooter usage could become increasingly commonplace in the county.

Guidance: *If e-scooters are of particular interest to you, a manual survey will be required until Vivacity's e-scooter classification (currently under beta testing) is released.*

Establish a data loss alert system

It is recommended that any daily data being extracted should be checked for validity by reviewing the hourly flow data too. During the course of this exercise, it was not clear that some of the Vivacity daily flow volumes on 16th June were missing approximately 2 hours of data until the hourly profiles were reviewed. Vivacity have advised that they are working on an alerting system that will send push notifications to clients when data loss happens.

Guidance: *A manual check to ensure the data looks reasonable at a daily and hourly level is recommended before using Vivacity data.*

6.3 Next Steps

- 60 new V2 hardware Vivacity sensors are currently being installed on behalf of CCC, the GCP and the CPCA which will help to provide data for more locations and across a variety of settings. This expansion of the network will allow continuous, long-term traffic flow trends to be monitored across the county.
- Upgrades from V1 to V2 are planned in autumn 2022 for three of the nine remaining V1 sensors in the Cambridgeshire network - East Road, Mill Road (West) and Mill Road (East). Upgrading V1 hardware to V2 will allow for the implementation of new software updates and the use of multiple countlines, in turn improving the sensor's field of view, count and classification accuracy, especially for active travel modes. As of the end of September 2022, the new East Road and Mill Road sensors have been installed and there are plans to upgrade the Milton Road (mid) sensor once the Milton Road transport improvements are complete.
- Consideration should be given to identifying a responsible party for the five remaining V1 sensors and they should be upgraded to V2 as soon as possible (statistics below exclude fault period):
    - Coleridge Road - capturing 100% motorised and 62% active modes
    - Vinery Road - capturing 100% motorised and 52% active modes
    - Coldham's Lane - capturing 96% motorised and 42% active modes
    - Devonshire Road Cycle Path (Carter Bridge) - capturing 44% active modes (also affected by vegetation growth).

    - Hills Road - capturing 99% motorised and 60% active modes.

- Vivacity have indicated that bush/tree growth is starting to impact the Devonshire Road Cycle Path sensor (railway station cycle bridge). Vivacity have stated that they can "*try and move the countline slightly to try and counteract but trimming/removal would be best*". This is the second sensor that has been affected by vegetation growth during 2022. To get the best from the Vivacity sensor network, sensor maintenance and troubleshooting should be prioritised. This is particularly important given that the sensor network will have doubled in size by the end of 2022.
- At the beginning of September 2022, a selection of new beta mode classes were released by Vivacity on some of its sensors (see Figure 3). These new classes will undergo a period of development and testing by Vivacity. CCC hope to carry out sense-checks on the data where possible, for example on the E-scooter data. Once their level of accuracy is known, plans to make use of the new classes will be made for the V2 sensors.
- As a matter of priority, sensor status information should be made readily available within the Vivacity dashboard so that all users are aware of any new / on-going data quality issues. Information such as software and hardware version, number of countlines, a log of when adjustments were made to the sensor (so that step-changes in the data can be explained) and a list of any current problems should be readily available within the dashboard to prevent inappropriate comparisons from being made or poor-quality data from being unknowingly used. Sensor status alerts are also essential to allow CCC and partners to use the data provided with confidence. At present most data quality issues are identified retrospectively by data analysts hoping to use the data rather than proactively which does not help to minimise data loss.
- Further investigation could be conducted, for example:
    - Investigating whether any of the new sensors that are located in less well-lit areas (i.e. less urban locations) have difficultly counting / classifying after dark.
    - Investigating whether data quality differs by flow direction. In other words, are the flows being captured furthest from the sensor of lower quality in terms of volume and/or classification. A previous validation exercise conducted by CCC for the Milton Road sensor in July 2019 indicated that this may be the case, however the upgrade to V2 hardware is expected to reduce this effect.

7 Appendix 1: Survey Locations

Road number	Road Name	Lat	Long	Vivacity Sensor Number*	Sensor Hardware Version	No. of countlines
A603	East Road	52.20407	0.13294	10	V1**	1
A1134	Milton Road (Mid)	52.22063	0.13416	13	V1	1
A1307	Hills Road	52.19008	0.13534	14	V1	1
A1134	Perne Road	52.19247	0.154626	44 (16)	V2	3
A1309	Milton Road (North)	52.22678	0.144505	60 (18)	V2	3
B1040	Histon Road (North)	52.23096	0.111544	62 (20)	V2	3
B1040	Histon Road (South)	52.21476	0.111022	63 (21)	V2	3
C	Mill Road (East)	52.19651	0.15303	1	V1**	1
C	Mill Road (West)	52.20192	0.13245	2	V1**	1
C	Coleridge Road	52.19095	0.145999	3	V1	1
C	Coldhams Lane	52.20377	0.15201	7	V1	1
C	Cherry Hinton Road	52.18832	0.14227	40	V2	2
C	Queen Edith's Way	52.18301	0.169781	43 (30)	V2	3
U	Vinery Road	52.20002	0.15247	4	V1	1
N	Devonshire Road Cycle Path	52.19617	0.137192	12	V1	1
U	Tenison Road	52.19987	0.13666	41 (5)	V2	3
A1132	Milton Road (South)	52.21677	0.12656	61 (19)	V2	3

*Numbers in brackets indicates any historic sensors previously in use at this location

** Upgraded to V2 in autumn 2022.

8 Appendix 2: Vehicle Classification

Vehicle Type	Description	Examples
Pedestrians	All pedestrians	
Pedal Cycles	All non-motorised bicycles including bicycles being pushed.	
E-scooters*	All electrically powered push scooters.	
Motorcycles	Includes motorcycles, mopeds and mobility scooters.	
Cars	Includes all cars and taxis including three wheeled cars, land rovers and range rovers. Cars towing trailers or caravans are counted as one vehicle.	
Light Goods Vehicles (LGV)	Light Goods Vehicles are goods vehicles up to 3.5 tonnes gross vehicle weight. This category includes all transit style vans including those with twin wheels at the rear, and small pickup vans. Also included are small vans similar to cars but with no rear windows.	
Ordinary Goods Vehicle 1 (OGV1)** Rigid with 2 Axles Rigid with 3 Axles	These categories of HGV cover all rigid vehicles over 3.5 tonnes, including road rollers and HGV tractor units without trailers with **up to 3 axles.**	
Ordinary Goods Vehicle 2 (OGV2)** Rigid with 4 or more Axles Articulated with 3 Axles Articulated with 4 Axles Articulated with 5+ Axles Articulated with 5+ Axles	This category covers all rigid vehicles over 3.5 tonnes, including road rollers and HGV tractor units without trailers with **4 or more axles**. It also includes all tractor and trailer unit style OGVs and all vehicle and tow bar style lorries.	
Buses	Public service vehicles include double-decker buses, single-decker buses, coaches and minibuses. Minibuses are defined as vehicles capable of carrying 16 or more passengers (in effect transit size or larger).	

* The E-scooter category is included in the manual survey classification only.

** Some axles may be off the ground. Only axles that are in use should be counted.

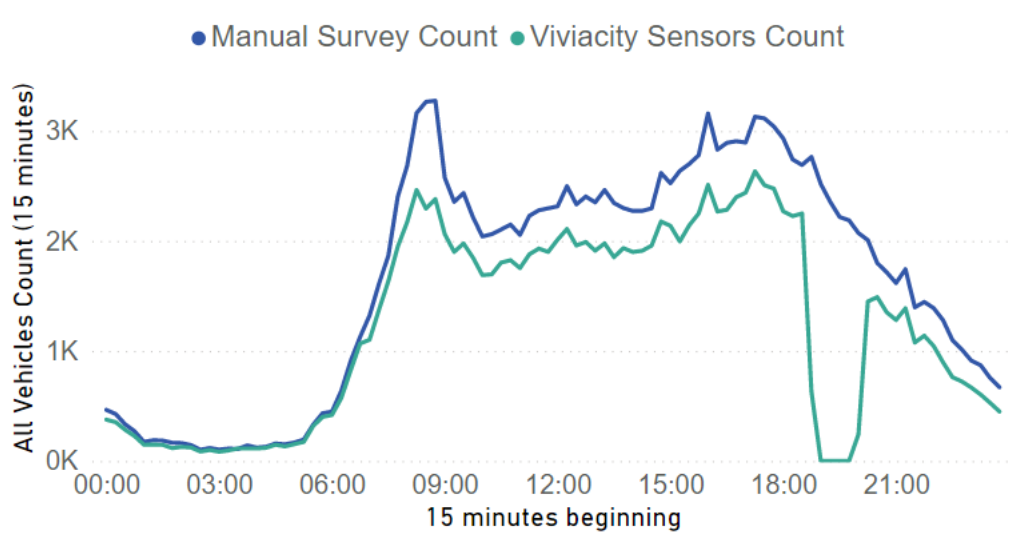
9 Appendix 3: Hardware Version Performance Stats

9.1 All V1 Hardware Sensors

Number of countlines: all V1 sensors have 1 countline.

The V1 hardware sensors are only able to use one countline and are not able to be updated to the latest software version. On 16th June, all the V1 sensors in this exercise were affected by a period of down-time leading to loss of data between 18:45 and 20:30 (Figure 19). The Vivacity daily count represents just 74% of the manually surveyed count, but 81% when this period is excluded. Pedestrians, Pedal Cycles and OGV2 are not accurately counted by the V1 sensors (Figure 20). Counts for this period are particularly poor during peak hours (Figure 21).

Figure 19: Total traffic counts for the manual survey and Vivacity sensors by time of day.



Period **including** sensor fault	Period **excluding** sensor fault
Vivacity **Total count** as a proportion of survey count: **74%**	Vivacity **Total count** as a proportion of the survey count: **81%**
Vivacity **Motorised count** as a proportion of survey count: **89%**	Vivacity **Motorised count** as a proportion of survey count: **97%**
Vivacity **Active count** as a proportion of the survey count: **48%**	Vivacity **Active count** as a proportion of the survey count: **52%**

Figure 20: The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

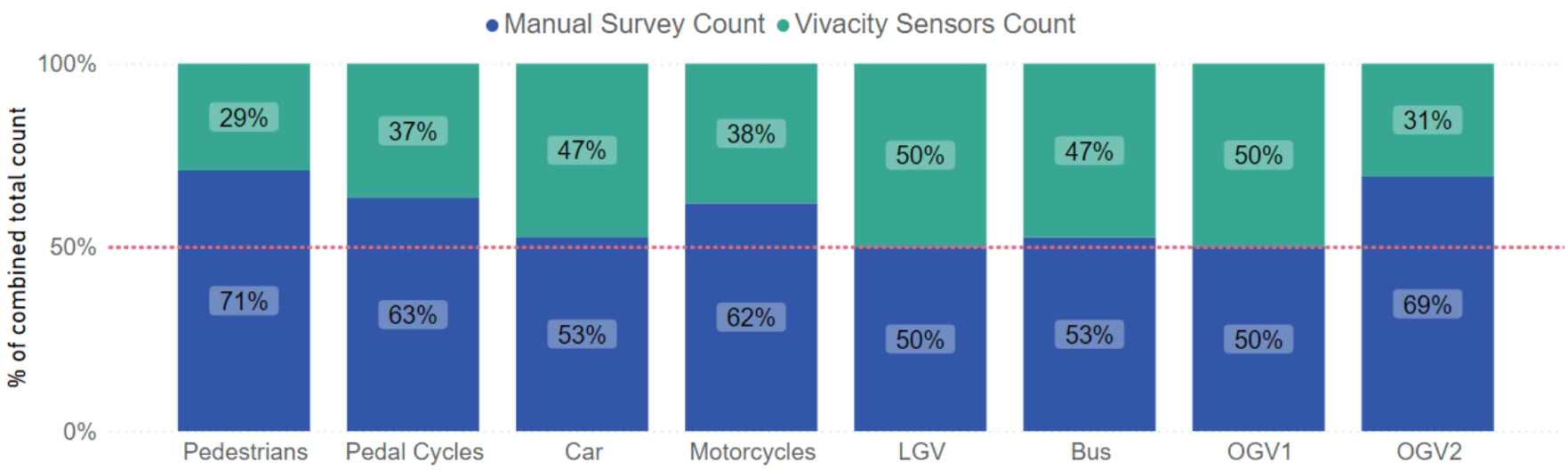
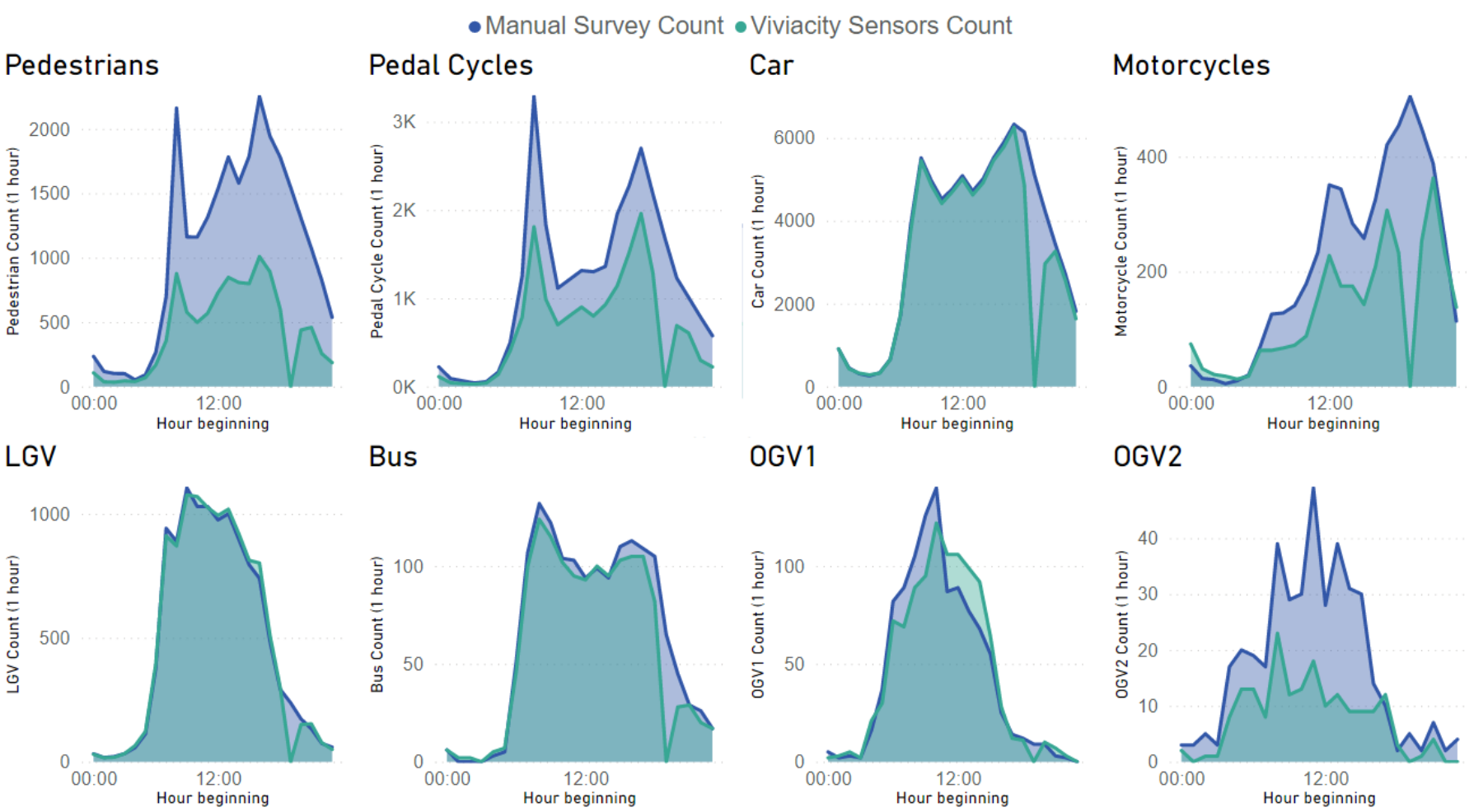


Figure 21 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



9.2 All V2 Hardware Sensors (excluding Cherry Hinton Road)

Number of countlines: all V2 sensors have 2 or more countlines.

The V2 hardware sensors use multiple countlines and are updated to the latest software version. This analysis excludes Cherry Hinton Road which was affected by tree growth, but includes Queen Edith's Way which was the only V2 sensor affected by the technical fault between 18:45 and 20:15. Across the day, the V2 sensors compare very closely to the survey count, counting 99% of the survey count overall (Figure 22). Counts for all modes are close to the manual survey counts, close to a 50:50% split (Figure 23). Pedestrians, LGVs and Buses are all slightly overcounted by the Vivacity sensors (>50% proportion). Motorcycles and OGV1s are undercounted during their peak hours (Figure 24).

Figure 22: Total traffic counts for the manual survey and Vivacity sensors by time of day (excluding Cherry Hinton Road).

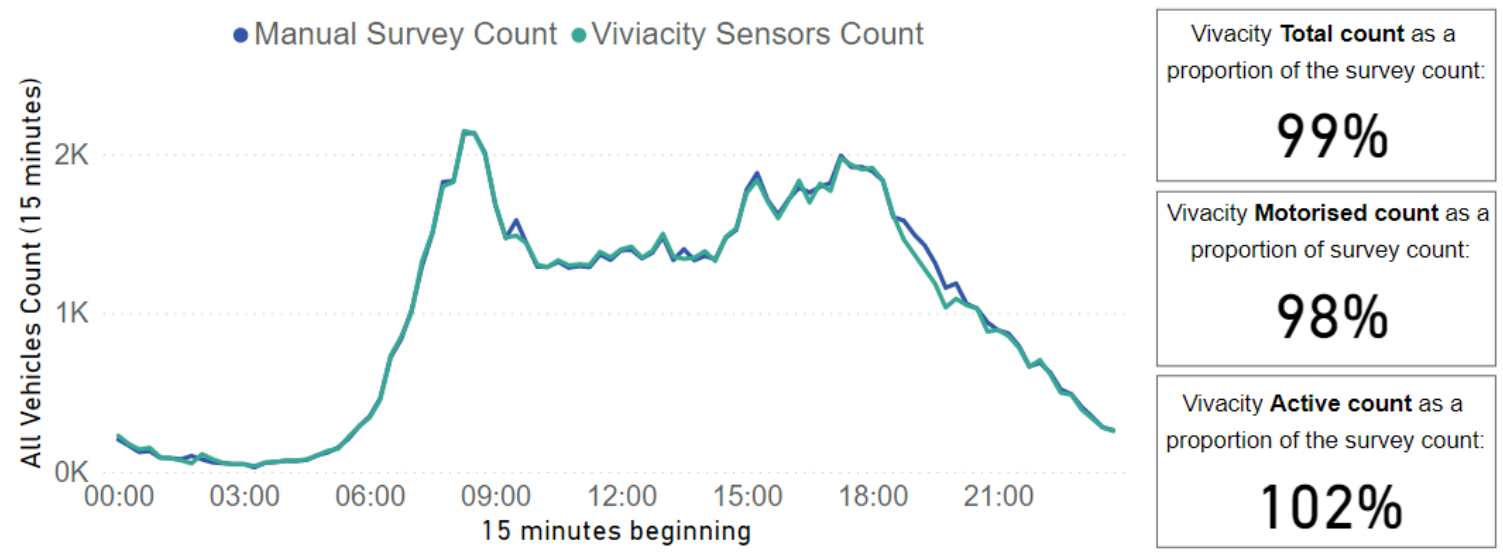


Figure 23: The proportion of the total combined Vivacity and survey count (excluding Cherry Hinton Road). A 50%:50% split means the counts are the same.

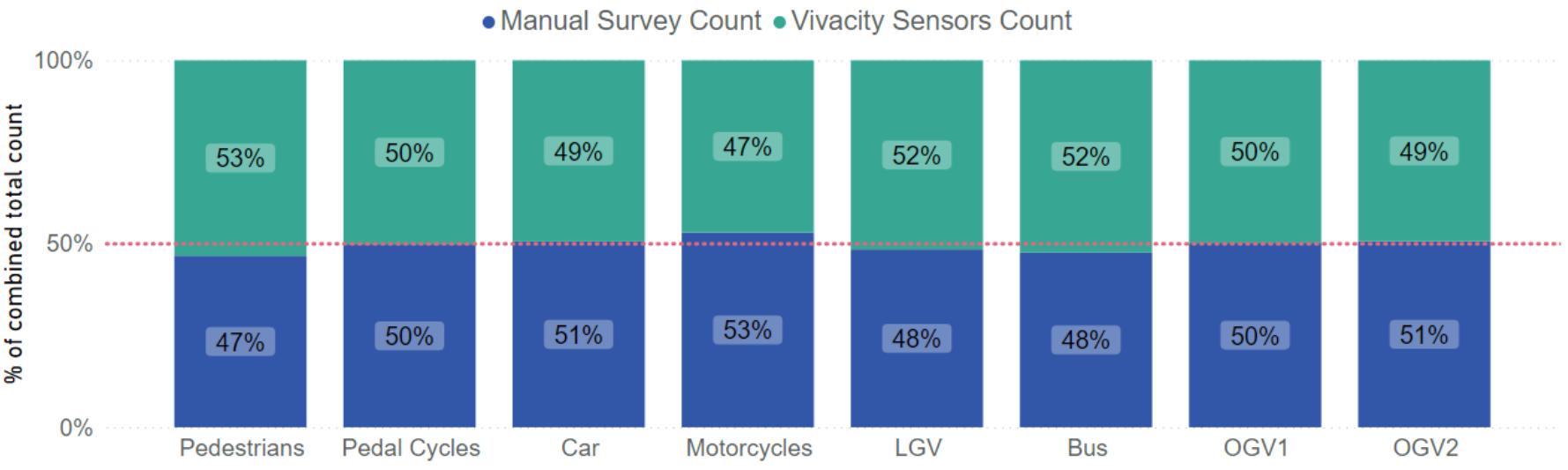
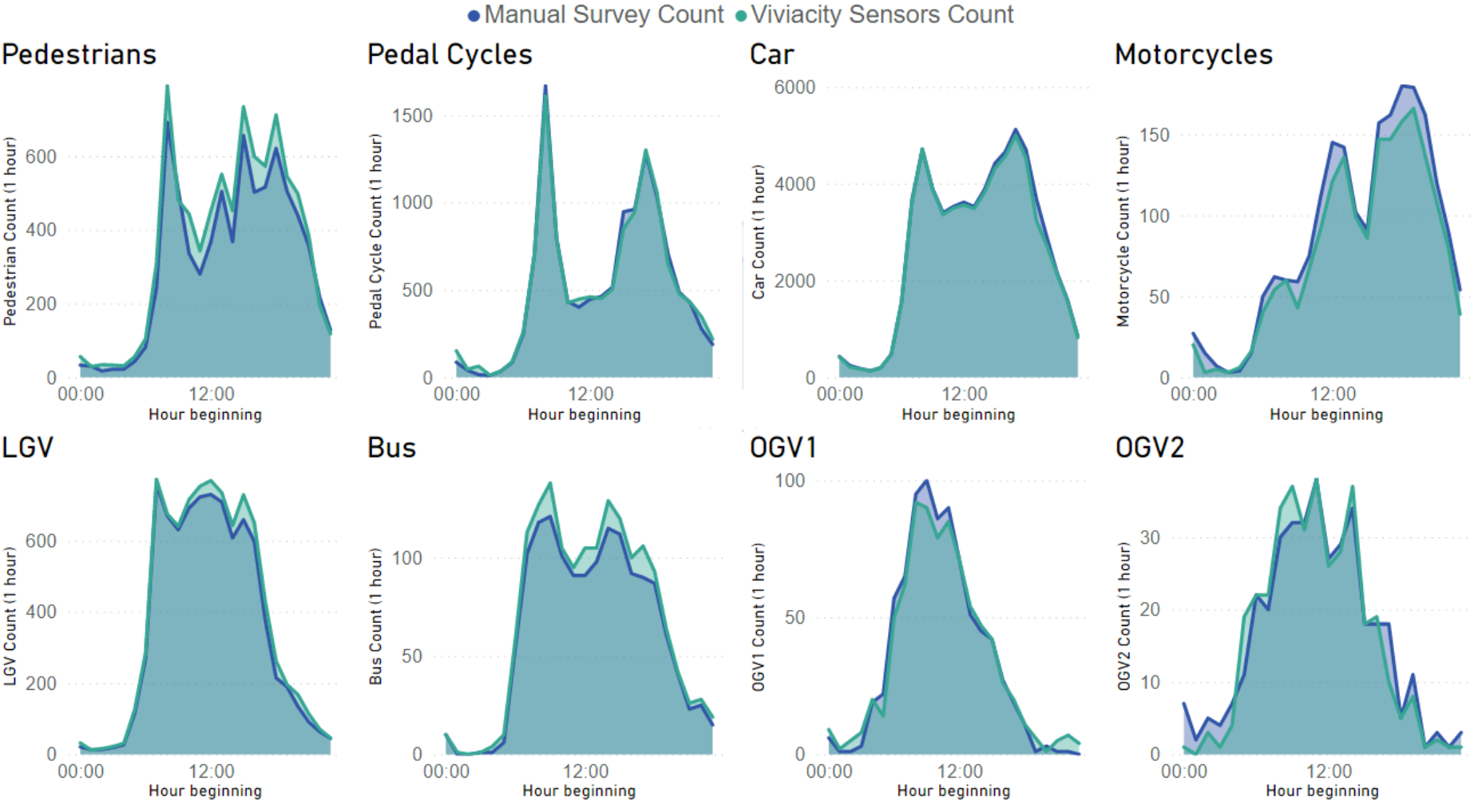


Figure 24 Traffic counts by time of day for each Vivacity classification mode (excluding Cherry Hinton Road). Note each graph is on a different y-axis scale.



10 Appendix 4: Individual Site Performance Stats

10.1 Cherry Hinton Road

Sensor Hardware Version: V2
Number of countlines: 2

The Cherry Hinton Road sensor is currently obscured by a tree so traffic counts at all times of day are significantly lower than the survey count (Figure 25). The Vivacity daily count represents 10% of the manually surveyed count. The Vivacity sensor primarily counted Pedestrians and Cars (Figure 26), largely due to the majority of the sensor's field of view being obscured by tree branches. The majority of Car and Pedestrian counts were captured between 17:00 and 20:00 (Figure 27). As of September 2022, Vivacity have rotated the sensor and it is capturing approximately 12,000 vehicles a day which is more similar to the 16,000 captured in the manual survey on the 16th June.

Figure 25: Total traffic counts for the manual survey and Vivacity sensors by time of day.

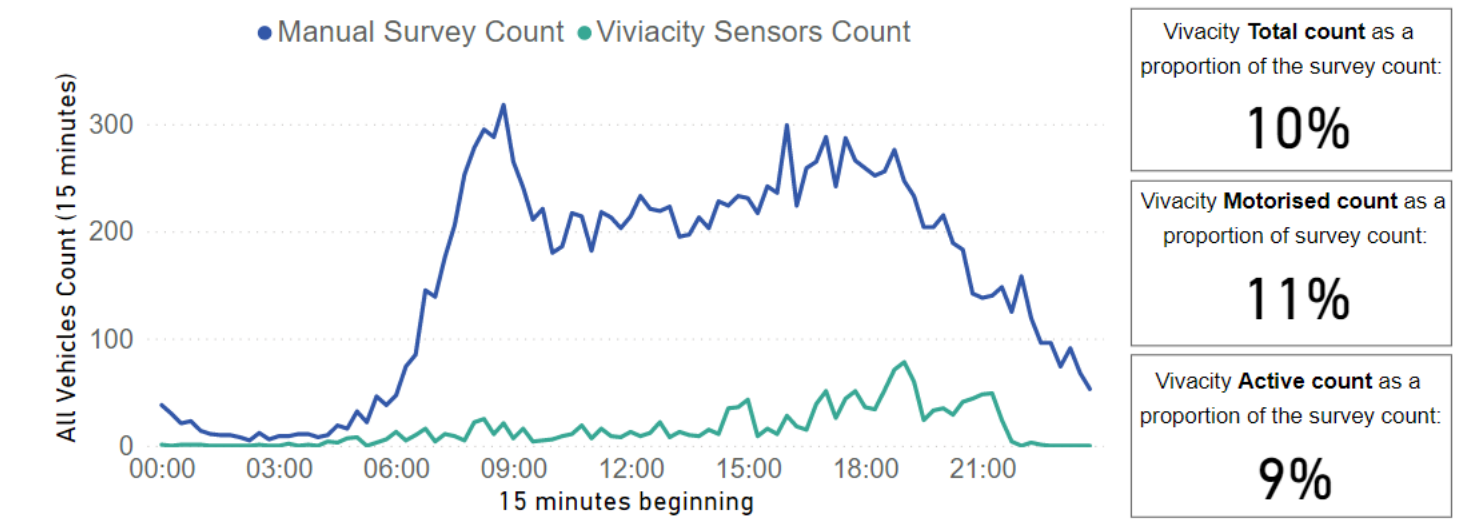


Figure 26: The proportion of the total combined Vivacity and survey count. A 50%:50% split means the two counts are exactly the same.

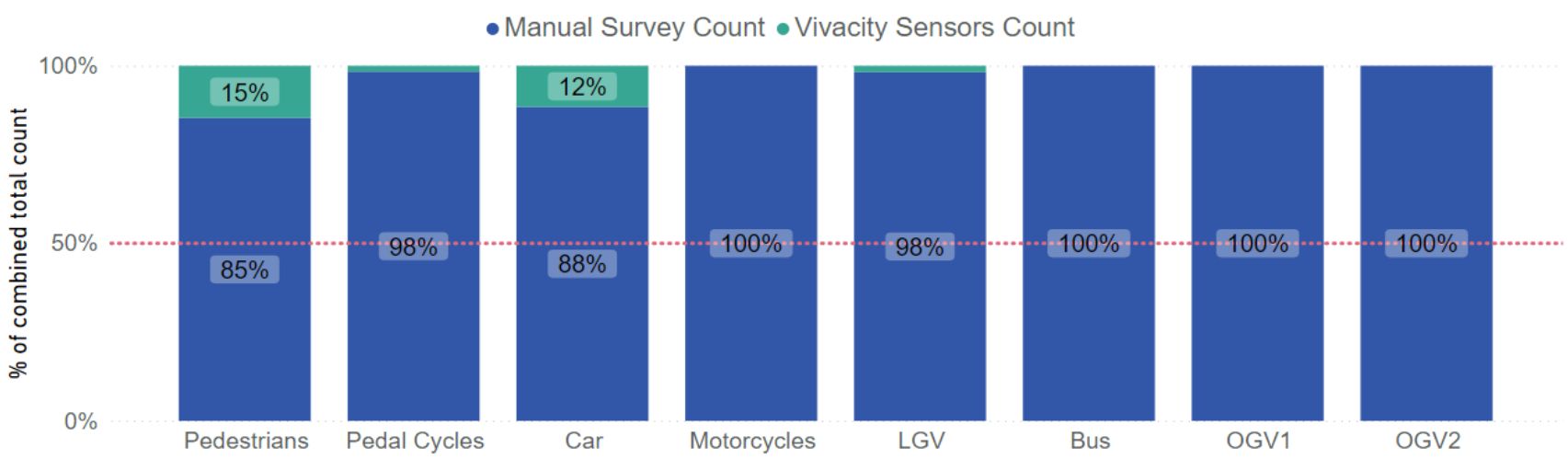
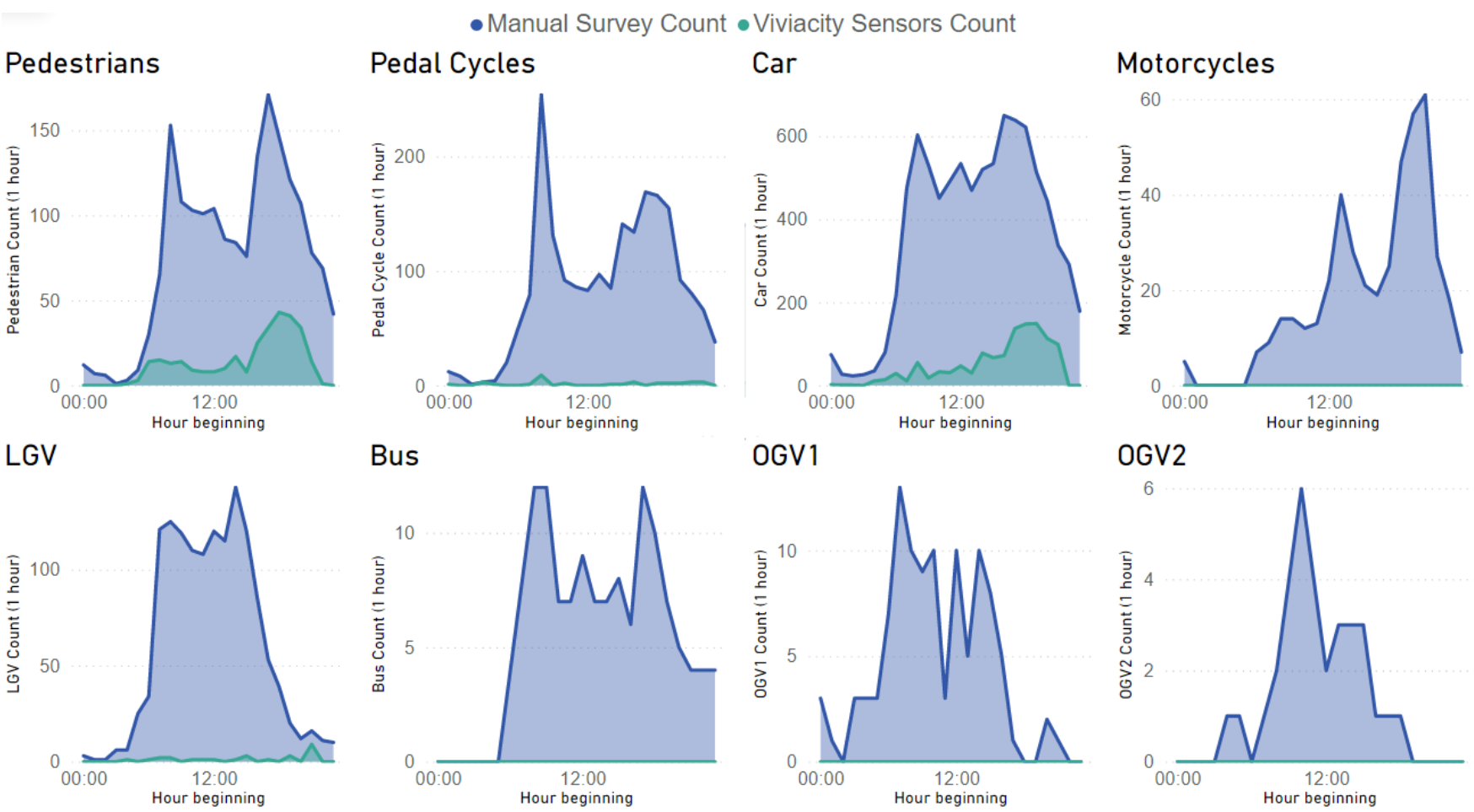


Figure 27 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



10.2 Coldham's Lane

Sensor Hardware Version: V1
Number of countlines: 1

Coldham's Lane Vivacity counts show a similar profile to the manual counts but underestimate across the day (Vivacity counts 81% of survey count) (Figure 28). The site is also affected by the technical down-time 18:45 – 20:30. Excluding this period, the Vivacity count is 88% of the survey total. Motorised Vehicle counts on Coldham's Lane are closer to the survey count, but many Active Travel counts are missed by the sensors and 112 E-scooters are missed or mis-categorised (Figure 29). Pedestrians, Pedal Cycles and Motorcycles are all underestimated, particularly at peak hours (Figure 30).

Figure 28 Total traffic counts for the manual survey and Vivacity sensors by time of day.

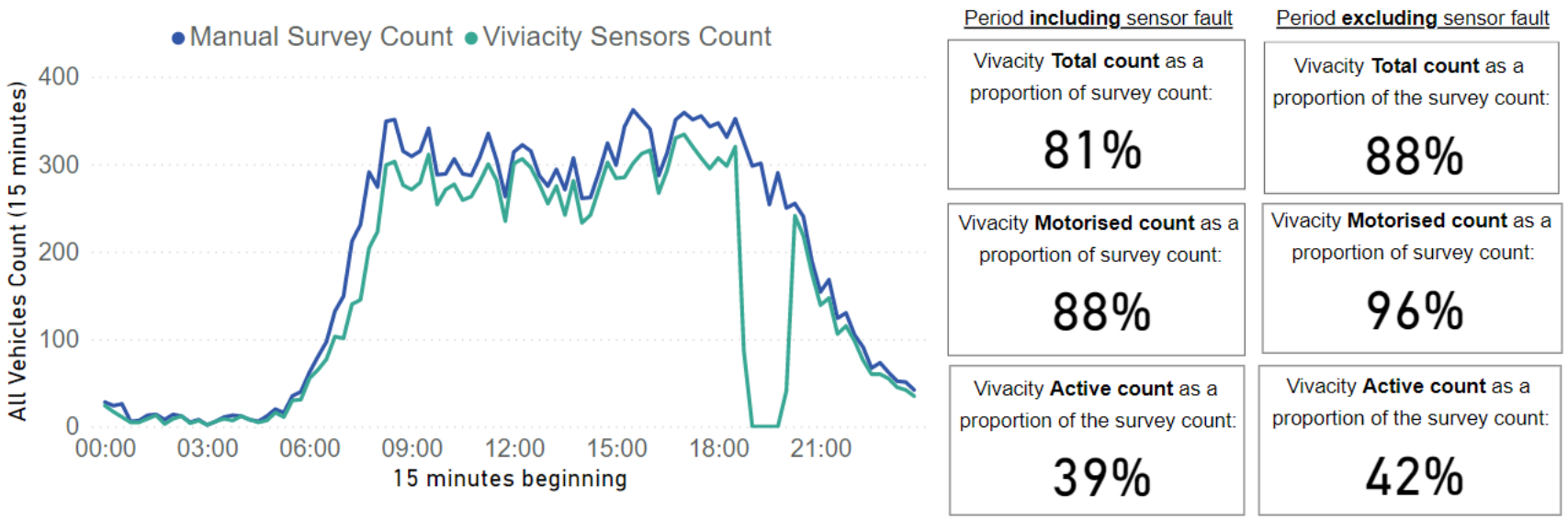


Figure 29 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

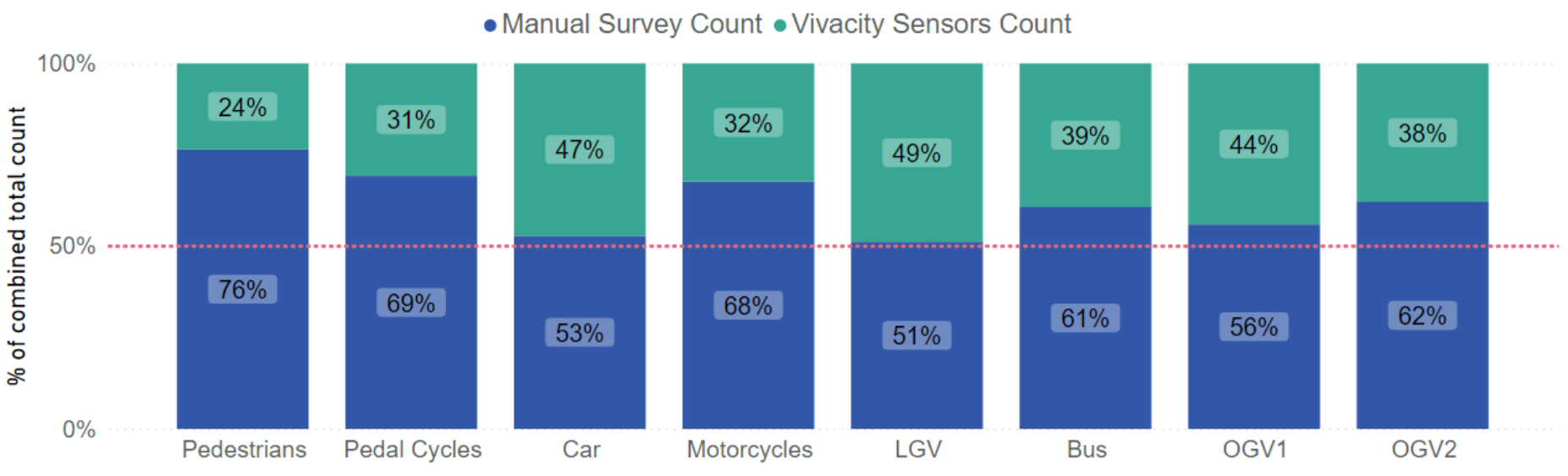
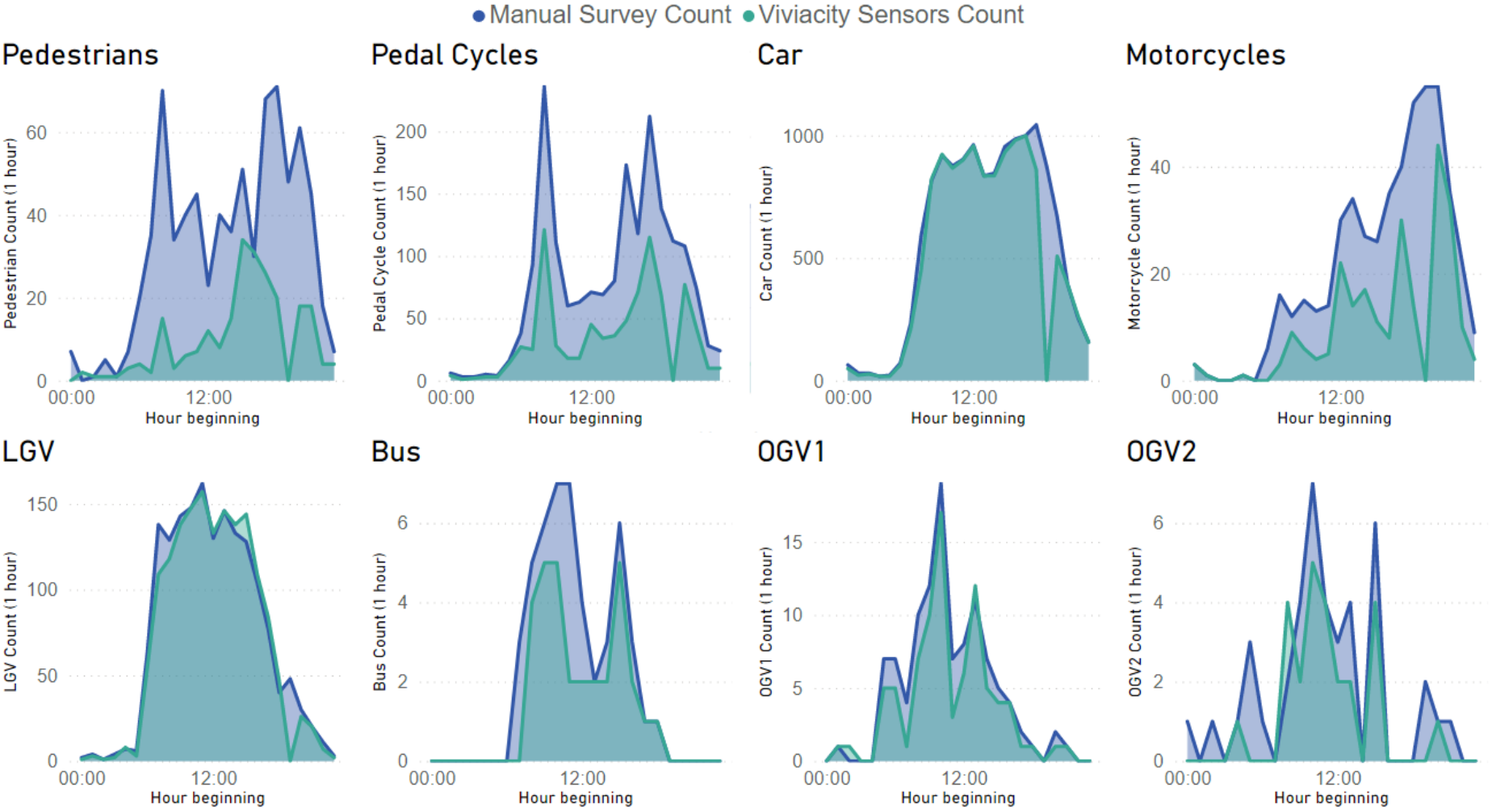


Figure 30 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



10.3 Coleridge Road

Sensor Hardware Version: V1
Number of countlines: 1

Coleridge Road Vivacity counts show a similar profile to the manual counts but underestimate across the day (Vivacity counts 82% of survey count) (Figure 31). The site is also affected by the technical down-time 18:45 – 20:30. Active Travel counts are poor (Vivacity at 62% of manual survey excluding sensor fault period), especially Pedestrian counts (Figure 32). In addition, 70 E-scooters are missed or mis-categorised. Few Buses or OGVs are counted in the Vivacity or manual survey totals (Figure 33).

Figure 31 Total traffic counts for the manual survey and Vivacity sensors by time of day.

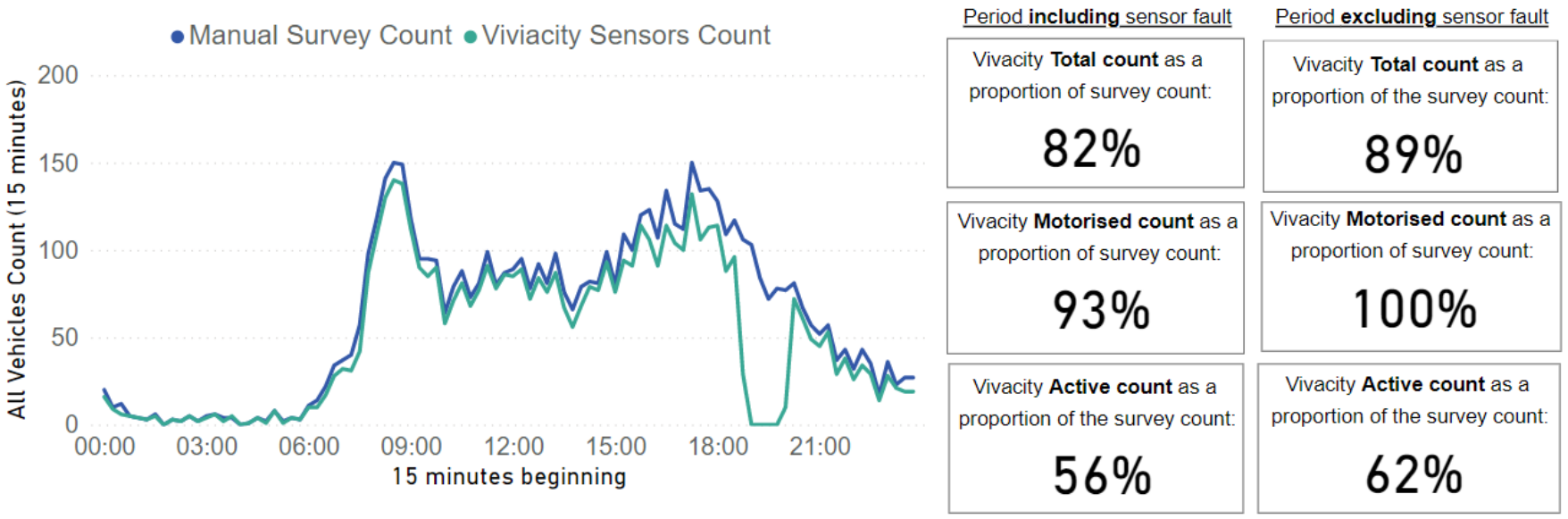


Figure 32 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

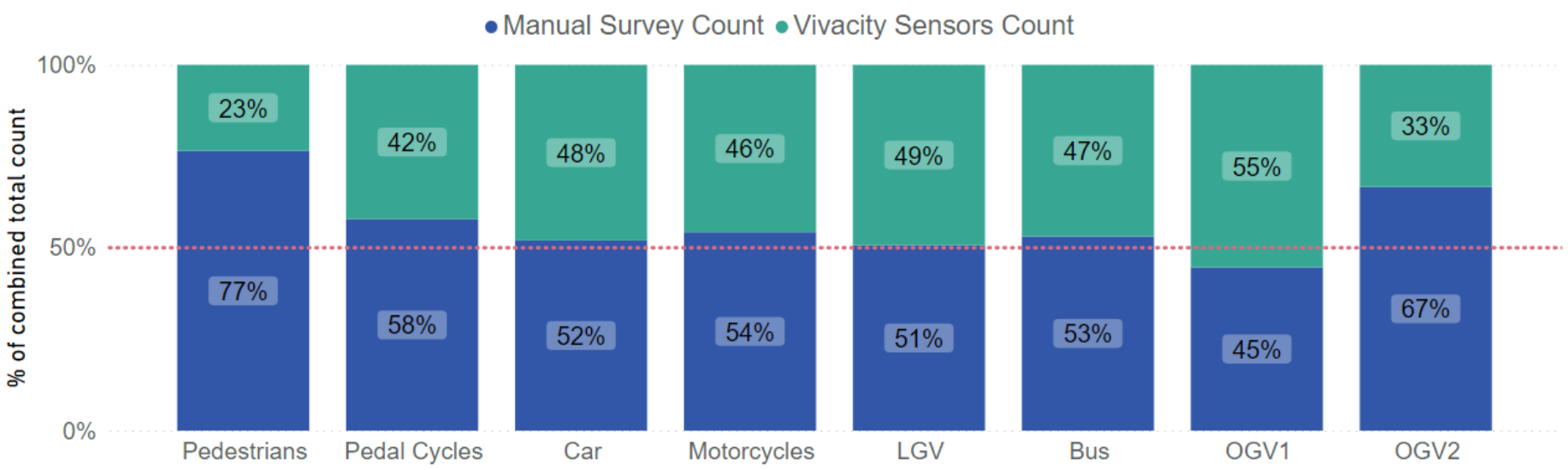
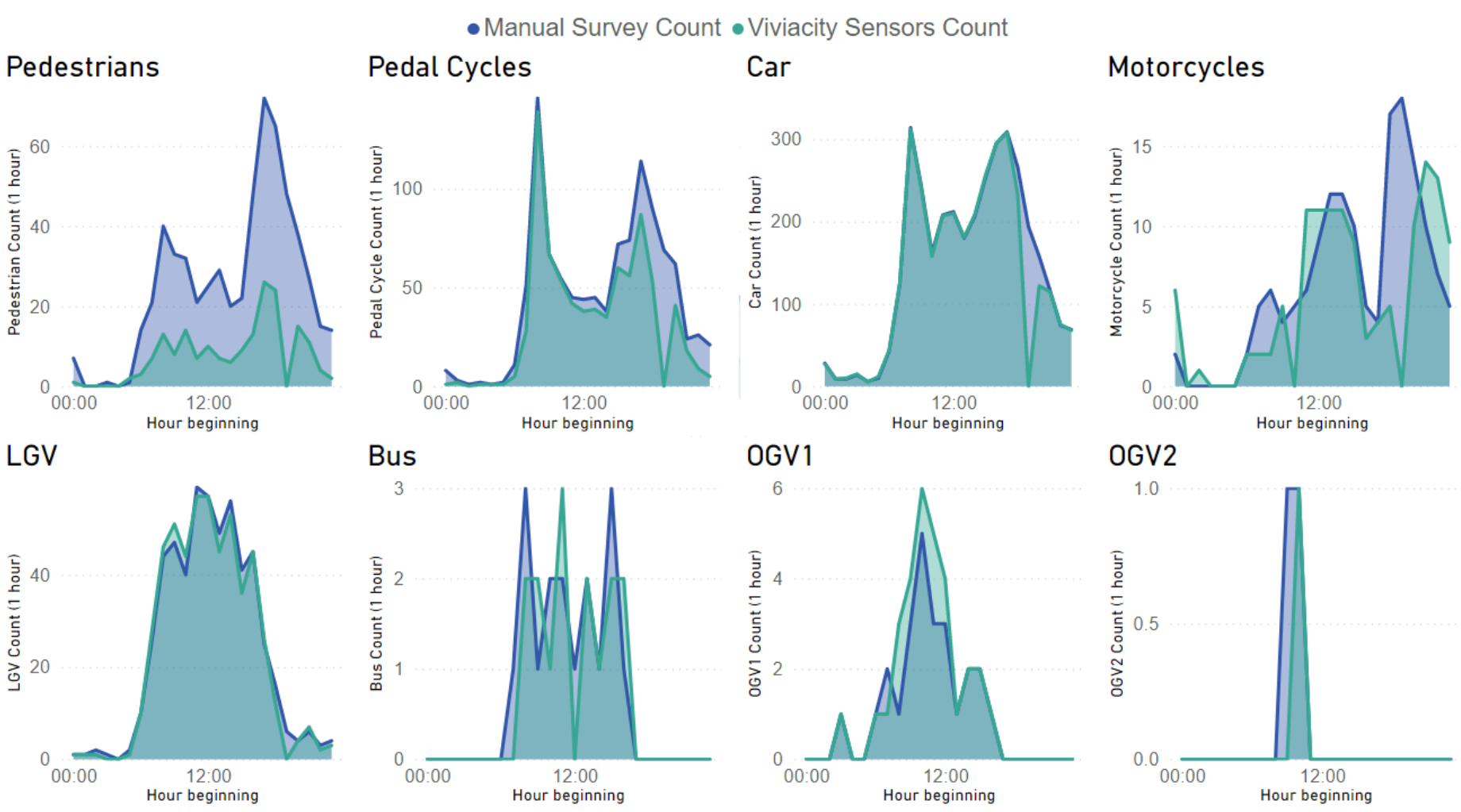


Figure 33 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.

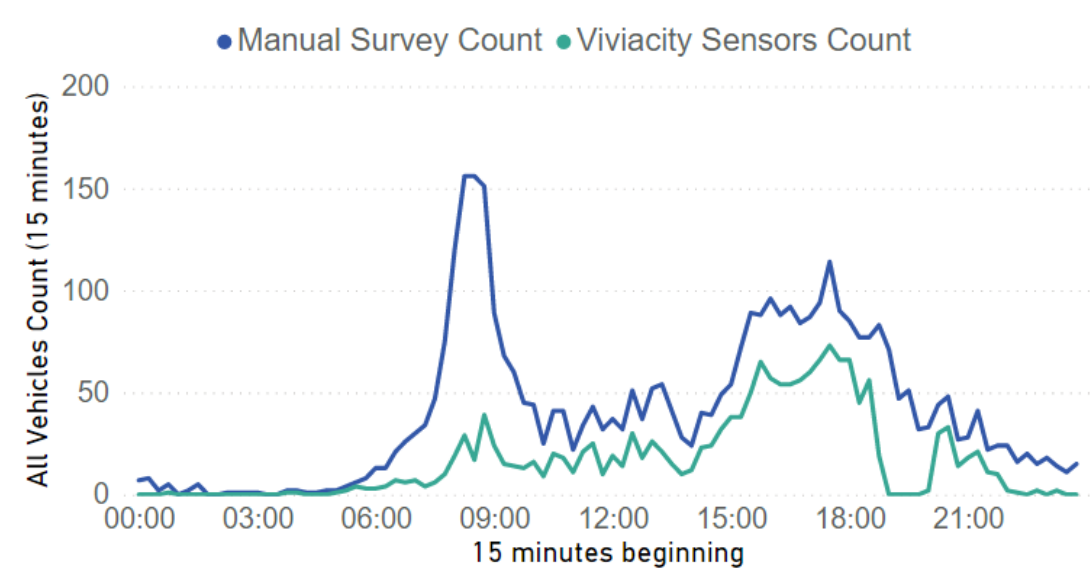


10.4 Devonshire Road Cycle Path

Sensor Hardware Version: V1
Number of countlines: 1

Devonshire Road Cycle Path Vivacity counts are much lower than the manual survey counts and account for just 44% of total manual survey count, even when the period of technical fault is excluded from the analysis (Figure 34). Pedal Cycles in particular are significantly undercounted by the V1 sensor (Figure 35) which is likely being exacerbated by near-by tree growth. In addition, 127 E-scooters are missed or mis-categorised and many vehicles classified in the manual survey as Motorcycles (likely e-bikes/e-mopeds) are missed entirely. The peak in the manual survey for Pedal Cycles (~08:30) is missed by the Vivacity sensors (Figure 36). Vivacity indicate that bush/tree growth is starting to affect the quality of data being collected at this location.

Figure 34 Total traffic counts for the manual survey and Vivacity sensors by time of day.



Period **including** sensor fault	Period **excluding** sensor fault
Vivacity **Total count** as a proportion of the survey count: **41%**	Vivacity **Total count** as a proportion of the survey count: **44%**
Vivacity **Motorised count** as a proportion of survey count: **11%**	Vivacity **Motorised count** as a proportion of survey count: **14%**
Vivacity **Active count** as a proportion of the survey count: **42%**	Vivacity **Active count** as a proportion of the survey count: **44%**

Figure 35 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

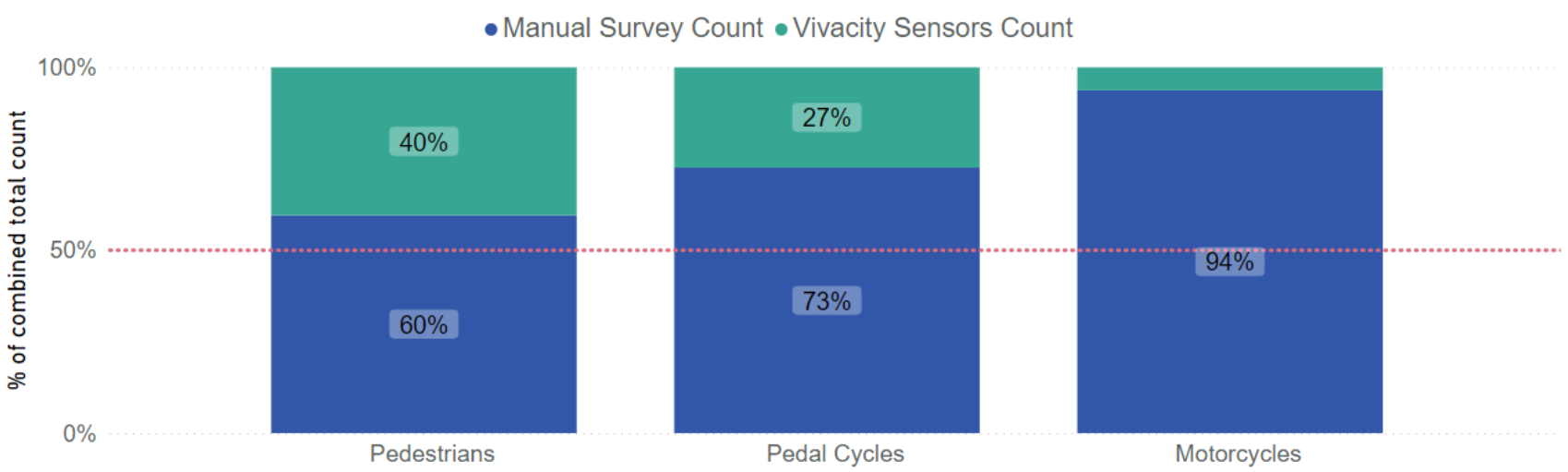
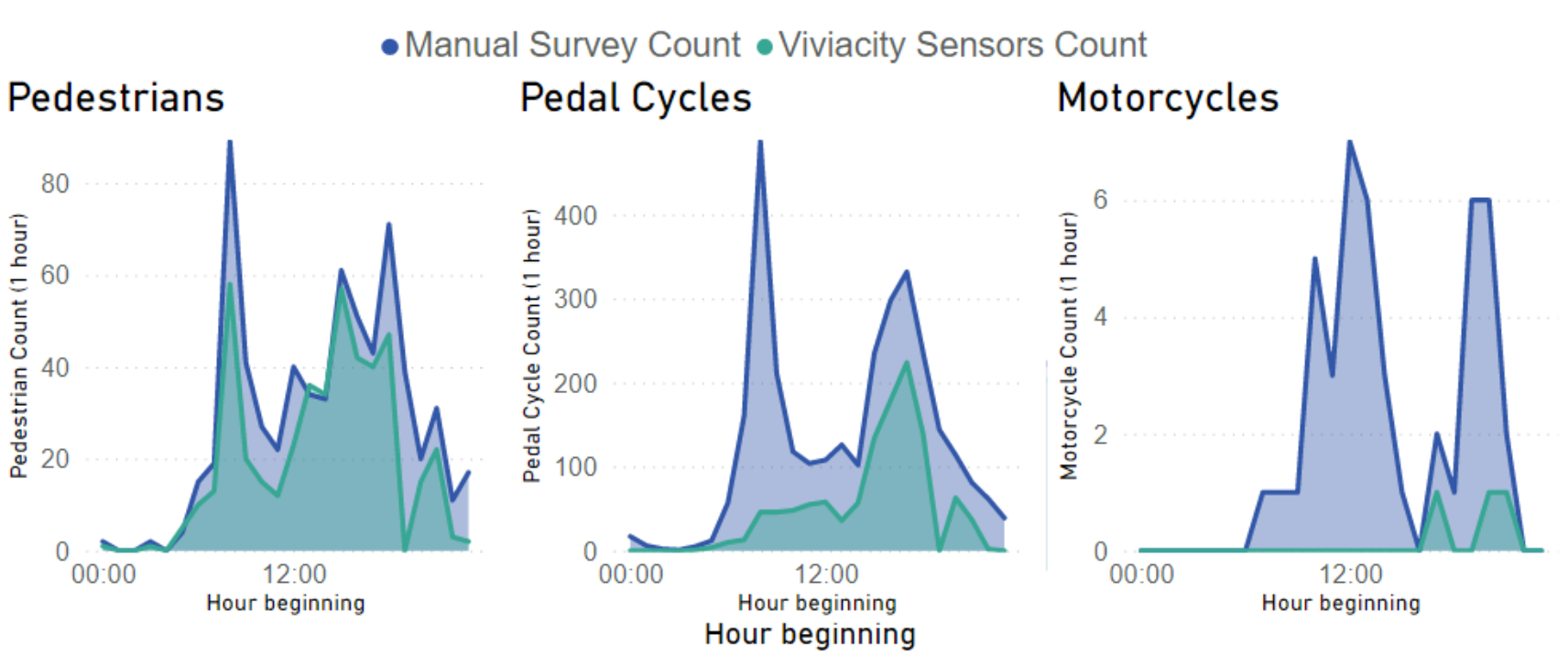


Figure 36 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



10.5 East Road

Sensor Hardware Version: V1 – due to be upgraded to V2 in Autumn 2022.
Number of countlines: 1

East Road Vivacity sensors count Motorised Vehicles quite well (96% excluding sensor fault period) but do not count Active Travel successfully (33% excluding sensor fault period) (Figure 37). Pedestrians in particular were underestimated by the Vivacity sensors, as well as Pedal Cycles, Motorcycles and OGV2s (Figure 38). In addition, 331 E-scooters are missed or mis-categorised. Active Travel modes are particularly under-counted during the morning peak (Figure 39).

Figure 37 Total traffic counts for the manual survey and Vivacity sensors by time of day.

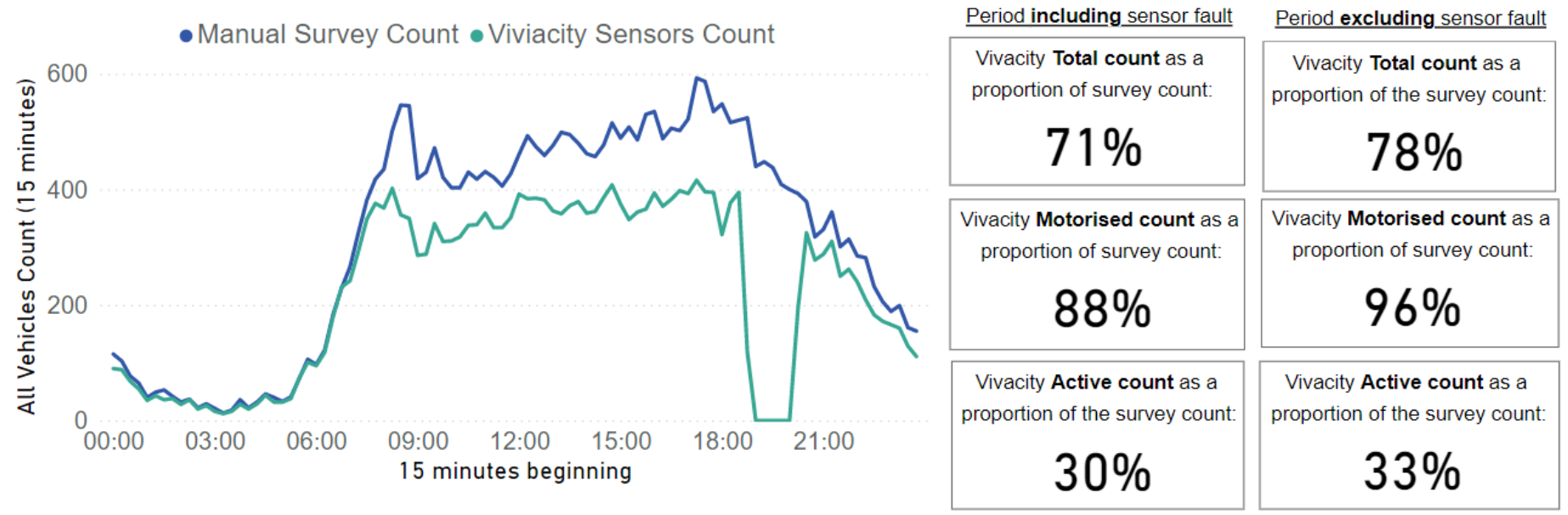


Figure 38 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

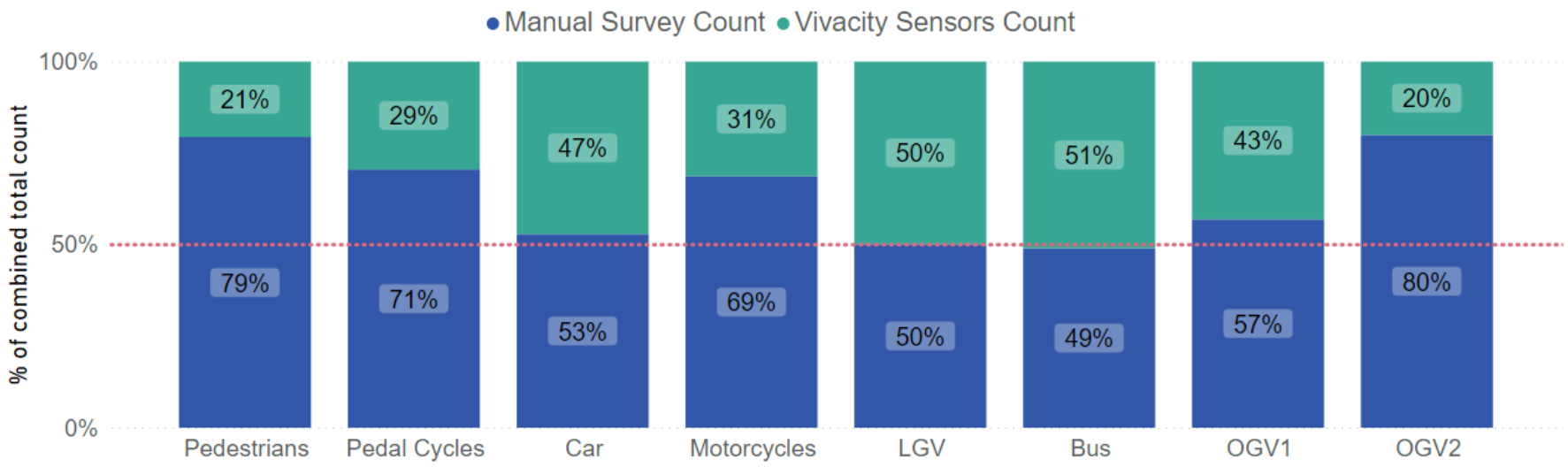
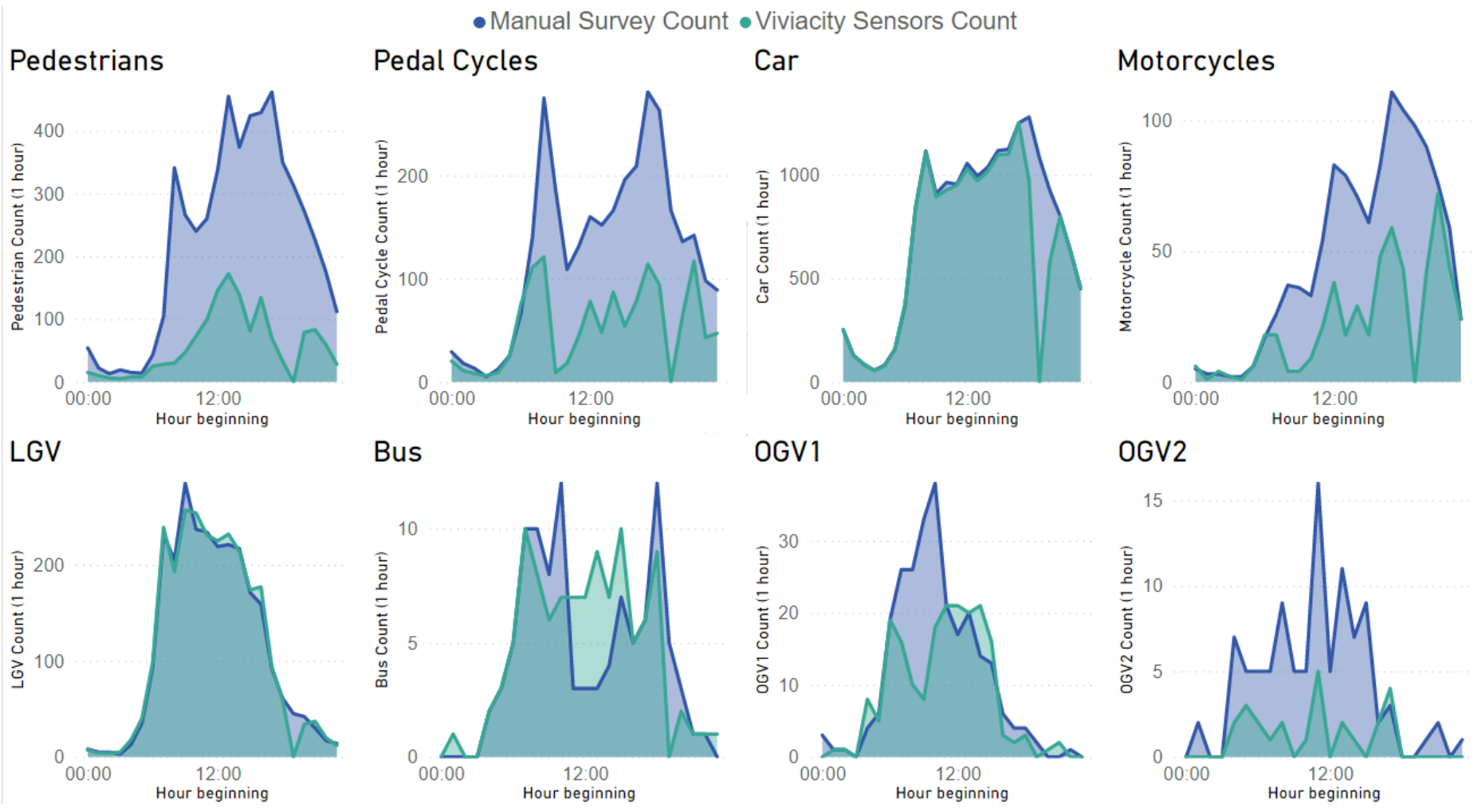


Figure 39 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.

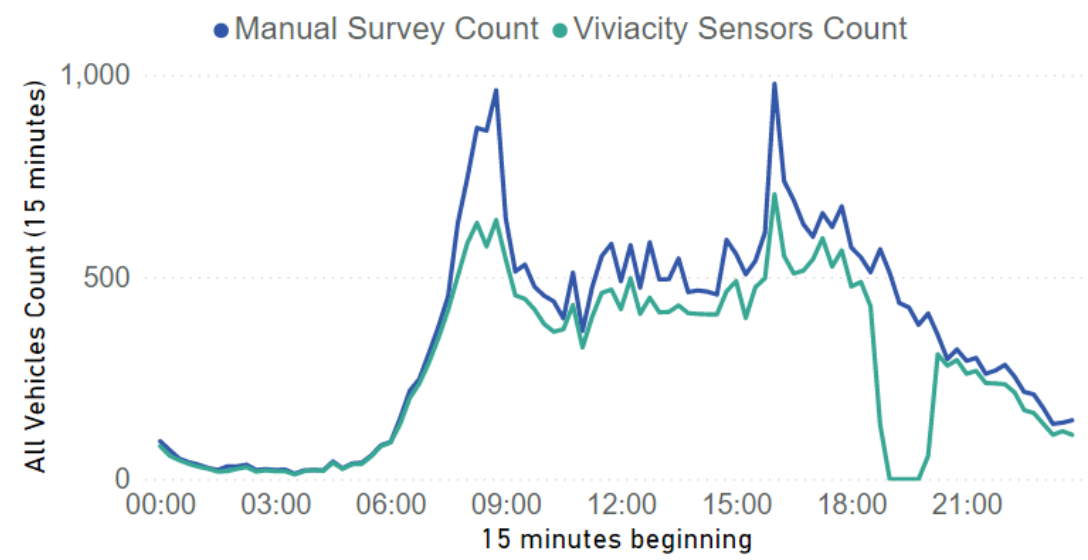


10.6 Hills Road

Sensor Hardware Version: V1
Number of countlines: 1

Hills Road Vivacity sensors show good accuracy in motorised vehicle counts, in particular when the sensor fault period is excluded (99%) though active travel counts are underestimated (60%) (Figure 40). Pedestrians, Pedal Cycles and Buses are underestimated by the Vivacity sensors in particular (Figure 41). In addition, 471 E-scooters are missed or mis-categorised across the 24 hours. The morning and afternoon peaks are distinctly undercounted for pedestrians whilst the sensor down-time led to under-counting for motorcycles during their peak hours (Figure 42).

Figure 40 Total traffic counts for the manual survey and Vivacity sensors by time of day.



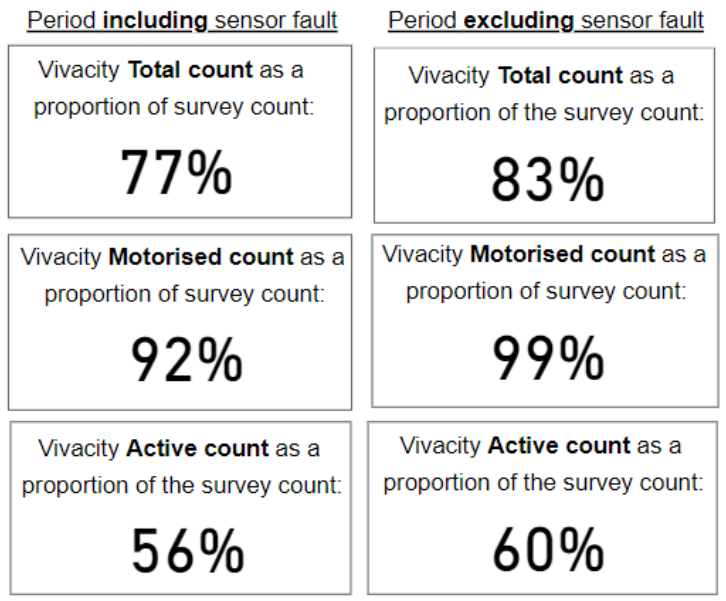


Figure 41 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

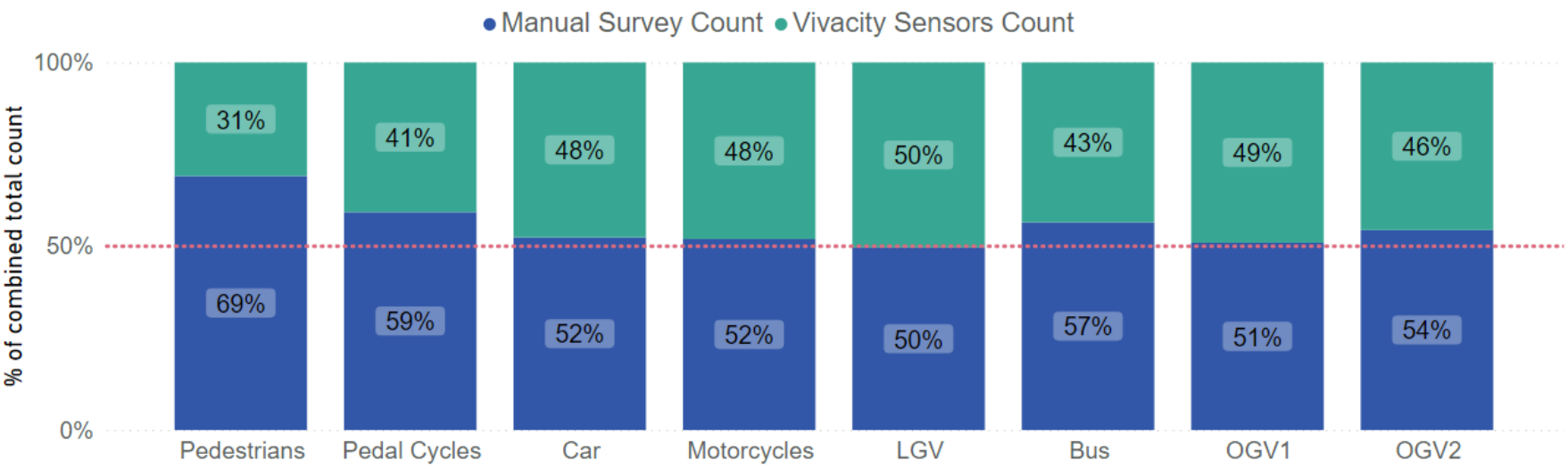
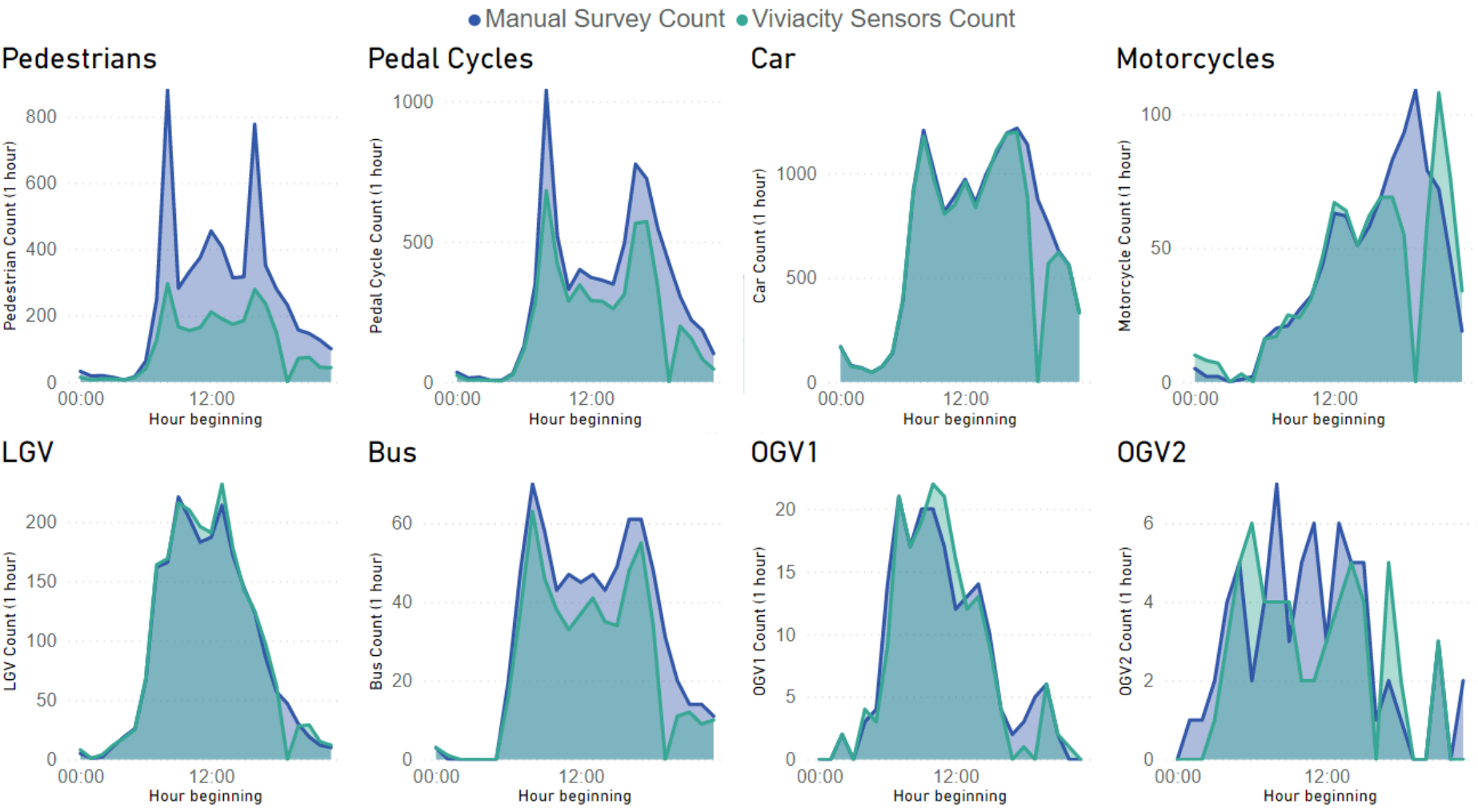


Figure 42 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



10.7 Histon Road (North)

Sensor Hardware Version: V2
Number of countlines: 3

The V2 Histon Road (North) sensors show good accuracy in both Motorised Vehicles and Active Travel counts, at 99% and 100% respectively (Figure 43). All modes display a similarity between the manual and Vivacity sensor counts, except for Pedestrians which are overcounted by the Vivacity sensors (Figure 44). This overcounting of Pedestrians could be in part linked to the 62 E-scooters counted by the manual survey (see Figure 18). The primary mode classifications on Histon Road (North) are Car and Pedestrian (Figure 45).

Figure 43 Total traffic counts for the manual survey and Vivacity sensors by time of day.

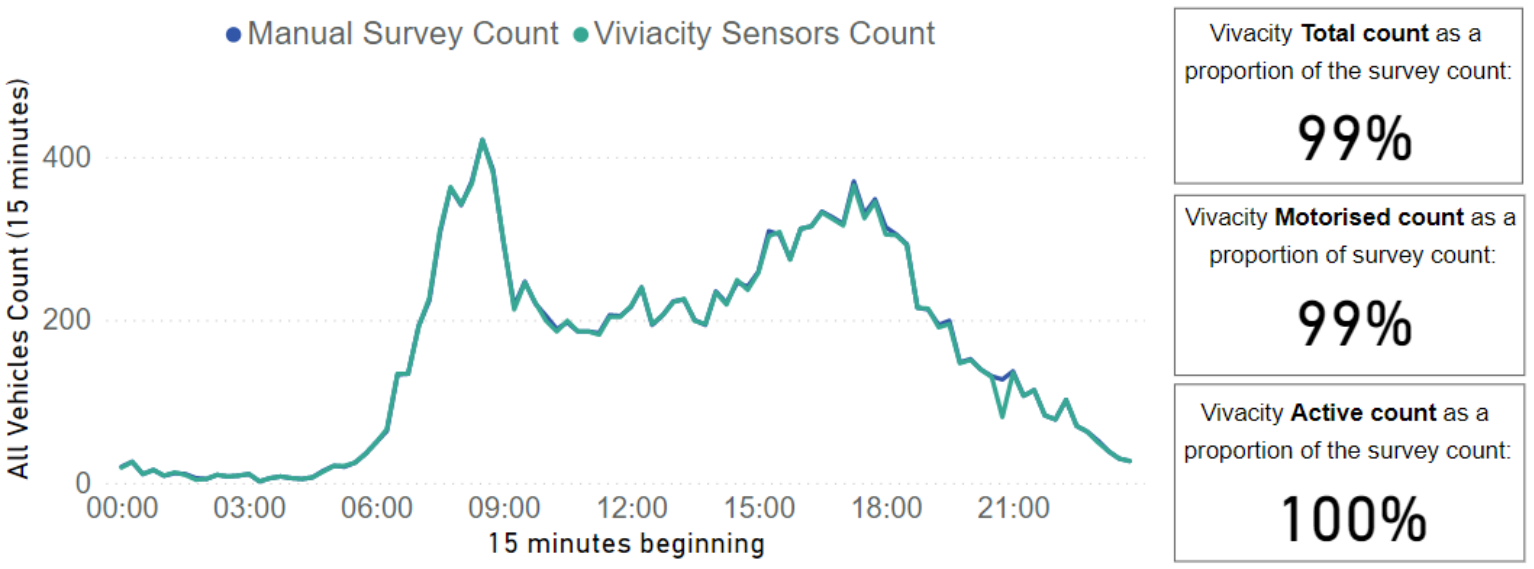


Figure 44 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

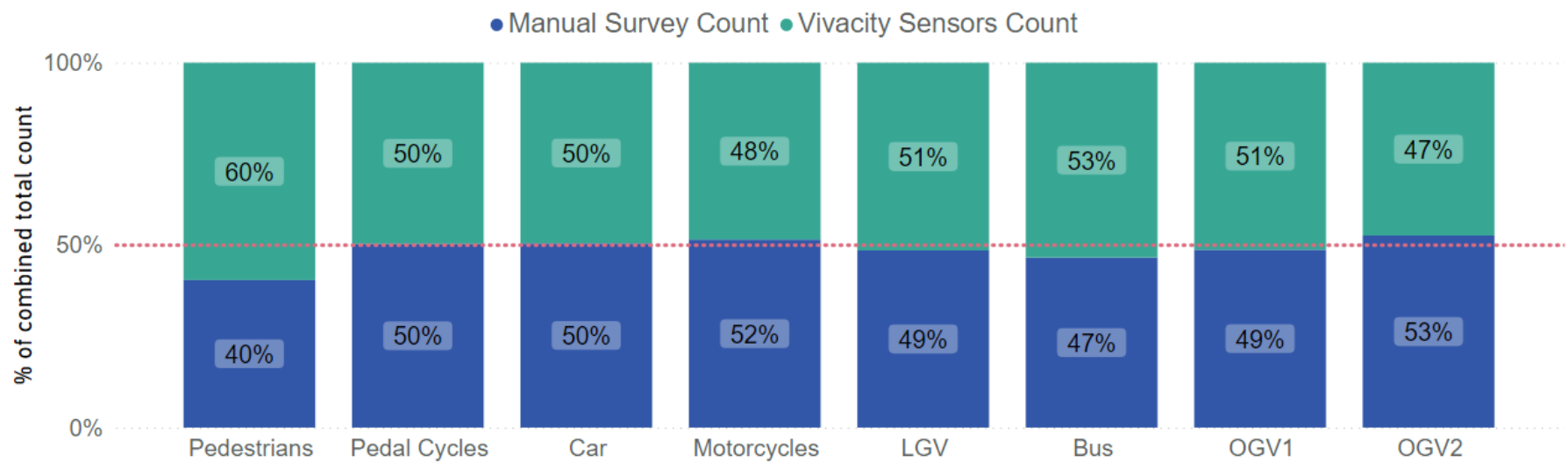
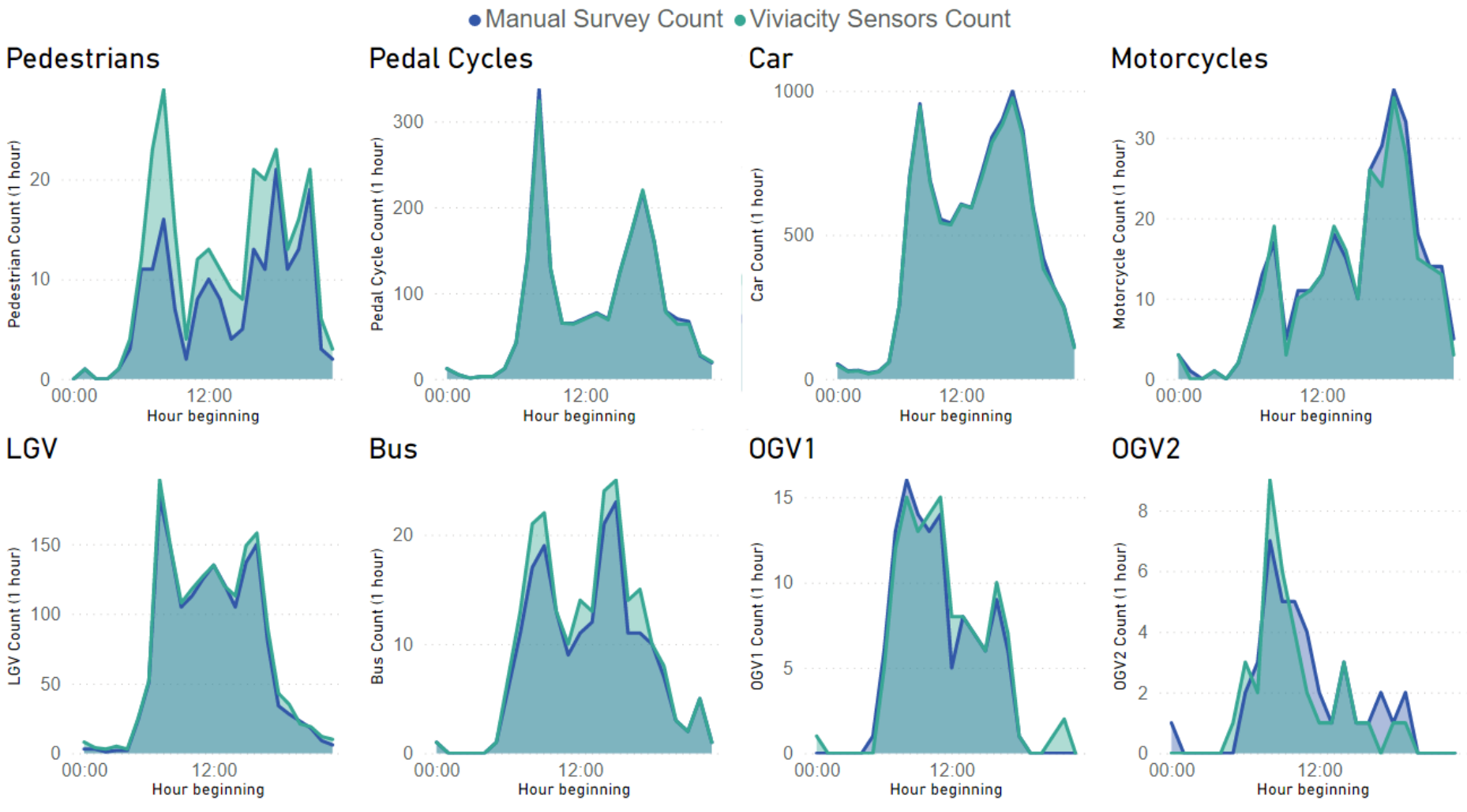


Figure 45 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



10.8 Histon Road (South)

Sensor Hardware Version: V2
Number of countlines: 3

The V2 Histon Road (South) sensors show good accuracy in both motorised vehicle and active travel counts, with both at 98% of the manual survey count (Figure 46). All modes display a similarity between the manual and Vivacity sensor counts, expect for OGV2s which are overcounted by the Vivacity sensors, though overall volumes of OGV2s are very low (Figure 47). 154 E-scooters are missed or mis-classified by the Vivacity sensors. Cars are the primary mode of transport on Histon Road (South) (Figure 48).

Figure 46 Total traffic counts for the manual survey and Vivacity sensors by time of day.

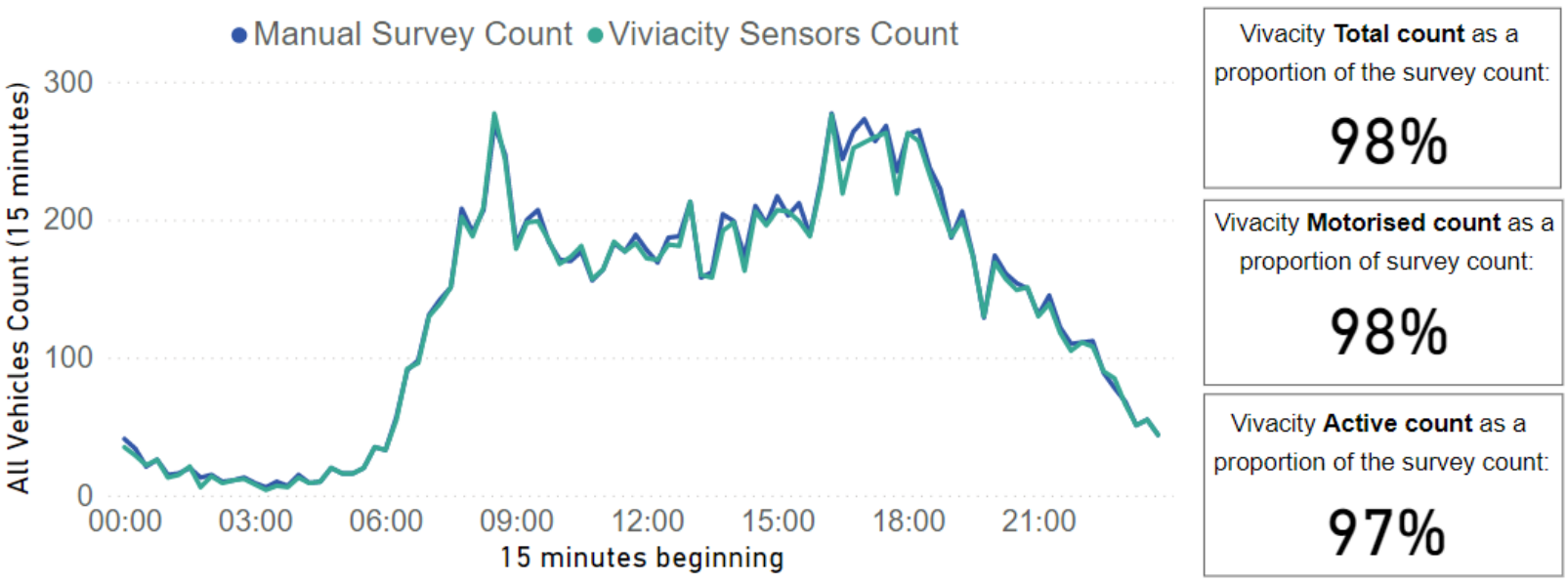


Figure 47 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

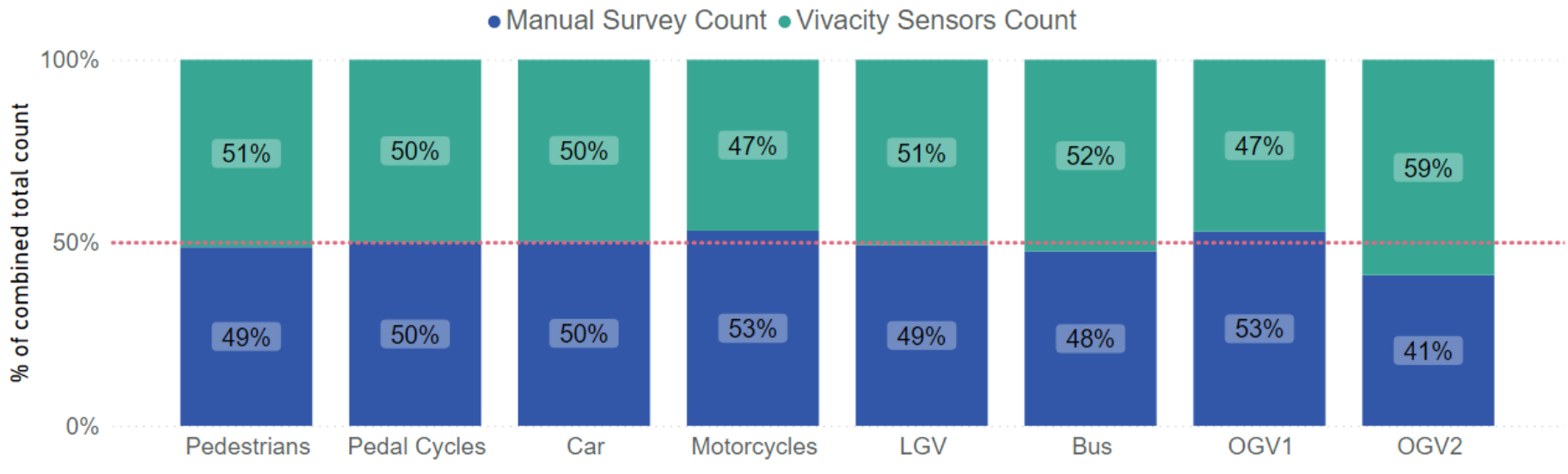
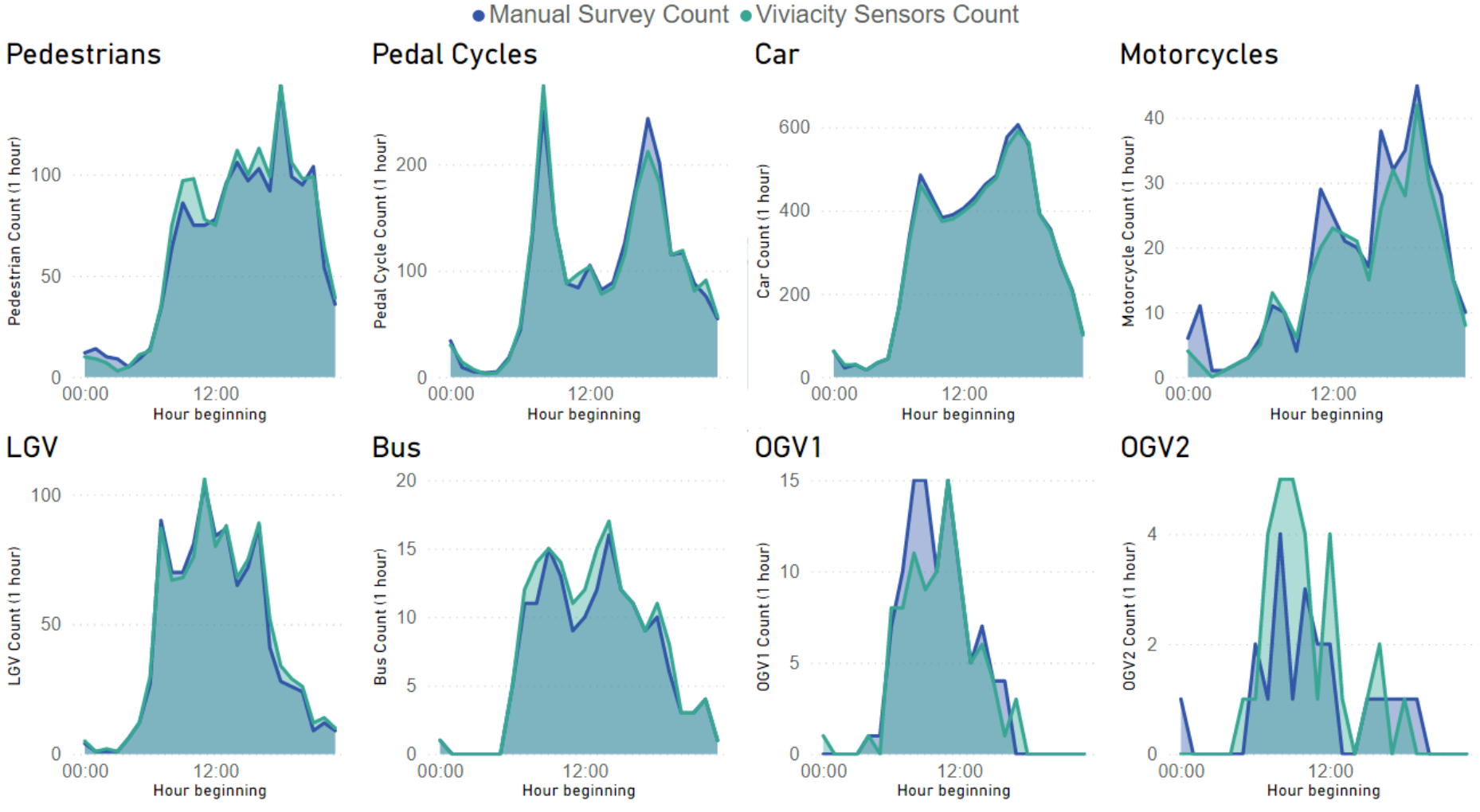


Figure 48 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



10.9 Mill Road (East)

Sensor Hardware Version: V1 – due to be upgraded to V2 in Autumn 2022.
Number of countlines: 1

The Mill Road (East) sensors accurately count motorised vehicles (98% excluding the sensor fault period) but do not perform so well for active travel (76%) (Figure 49). Most modes are slightly underestimated by the Vivacity sensors, though Buses and OGV1s are overestimated which could correlate to the underestimation (and therefore potential misclassification) of OGV2s (Figure 50). 220 E-scooters are missed or mis-classified by the Vivacity sensors. The afternoon peaks in Pedestrians and Motorcycles are poorly captured in the Vivacity data, attributable in part to the technical fault period (Figure 51).

Figure 49 Total traffic counts for the manual survey and Vivacity sensors by time of day.

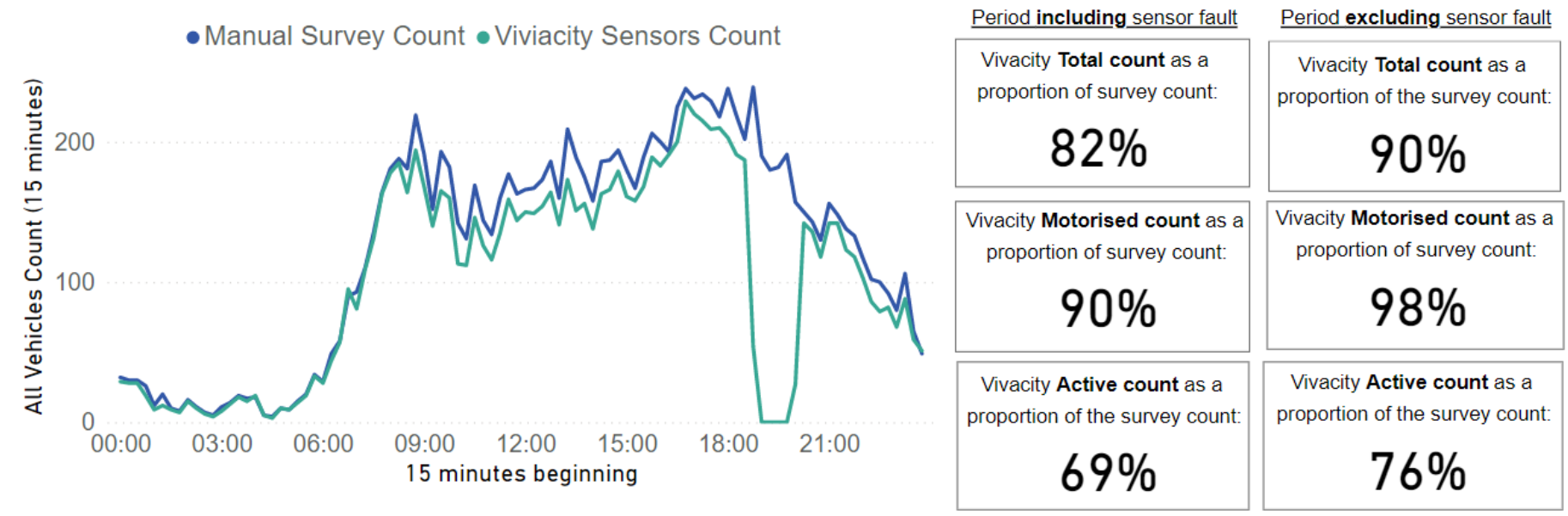


Figure 50 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

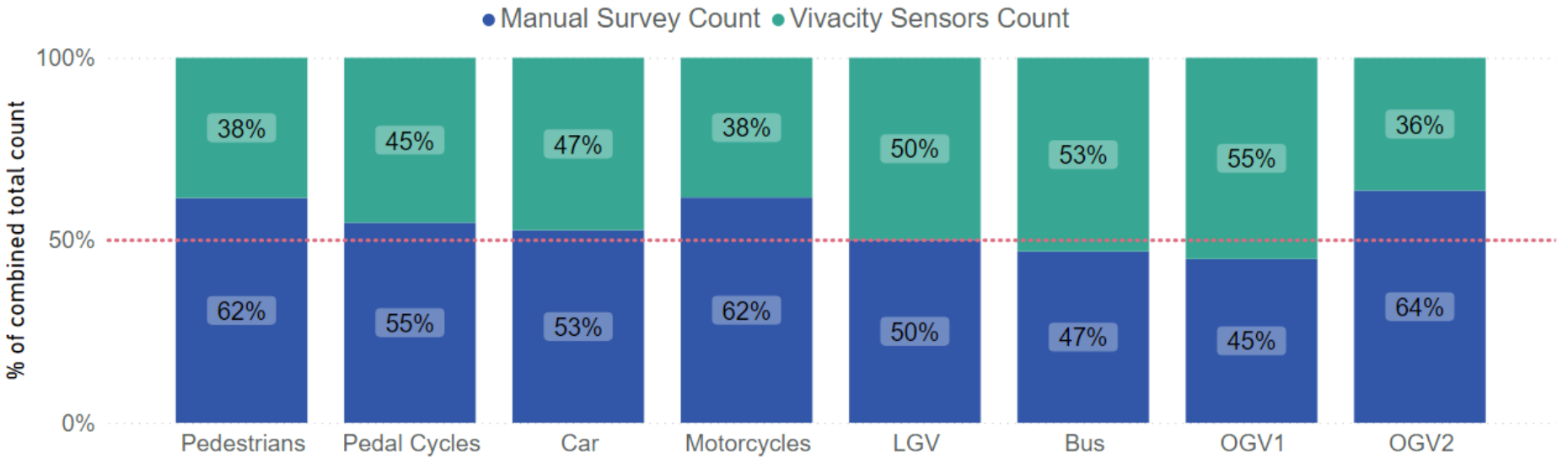
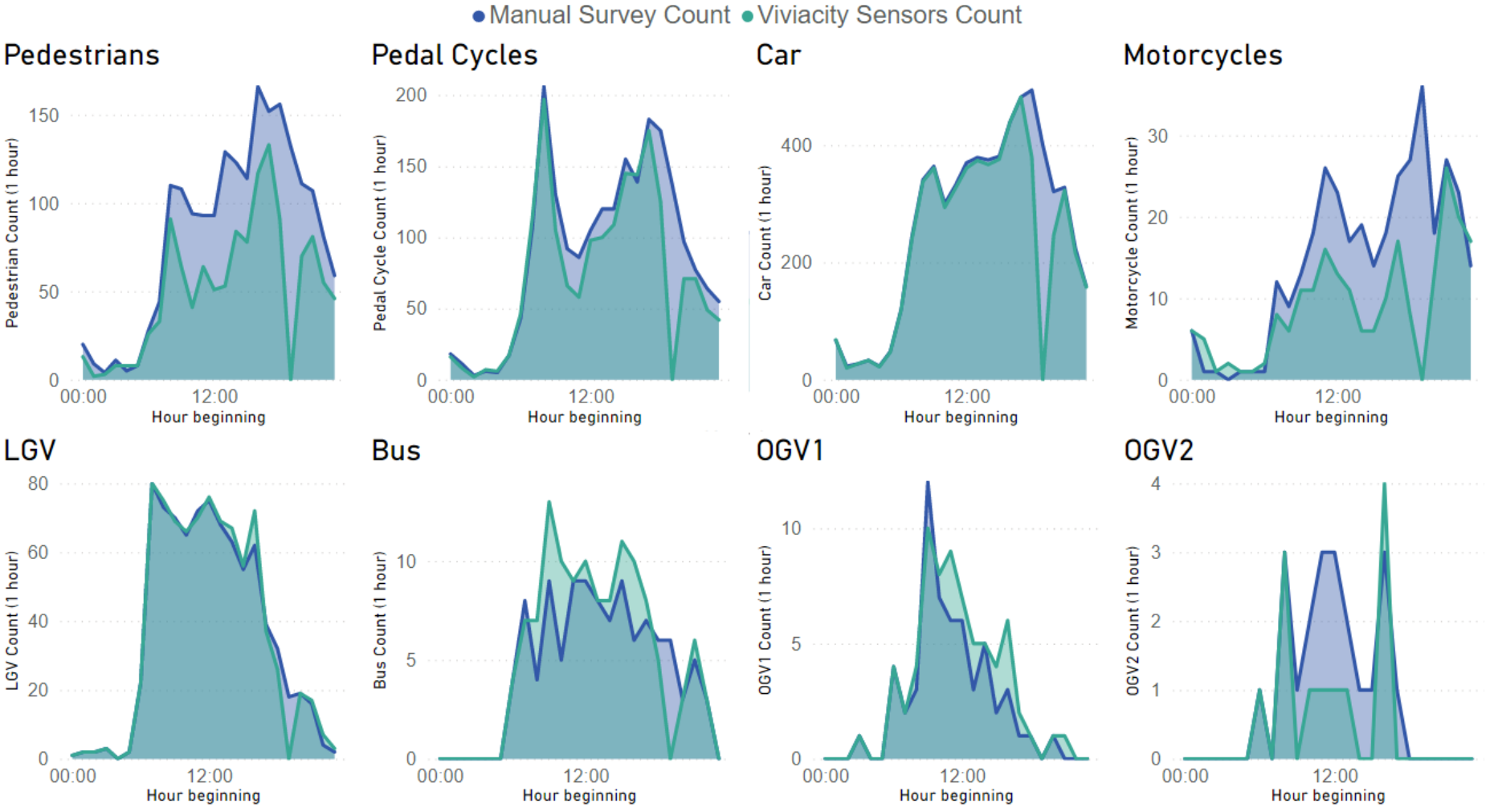


Figure 51 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



10.10 Mill Road (West)

Sensor Hardware Version: V1 – due to be upgraded to V2 in Autumn 2022.
Number of countlines: 1

The Mill Road (West) sensors do not perform so well as the Mill Road (East) sensors, capturing 94% of motorised vehicles and 53% of active travel when the sensor fault period is excluded (Figure 52). Active and Light modes are underestimated, in particular Pedestrians, whilst several of the heavy modes (e.g. Buses) are overestimated (Figure 53). This site sees the highest number of E-scooters missed or mis-classified at 556 in 24 hours. Pedestrians, Pedal Cycles, Car and Motorcycles are all most noticeably underestimated during the afternoon (12:00 onwards), likely in part affected by the V1 sensor fault period (Figure 54).

Figure 52 Total traffic counts for the manual survey and Vivacity sensors by time of day.

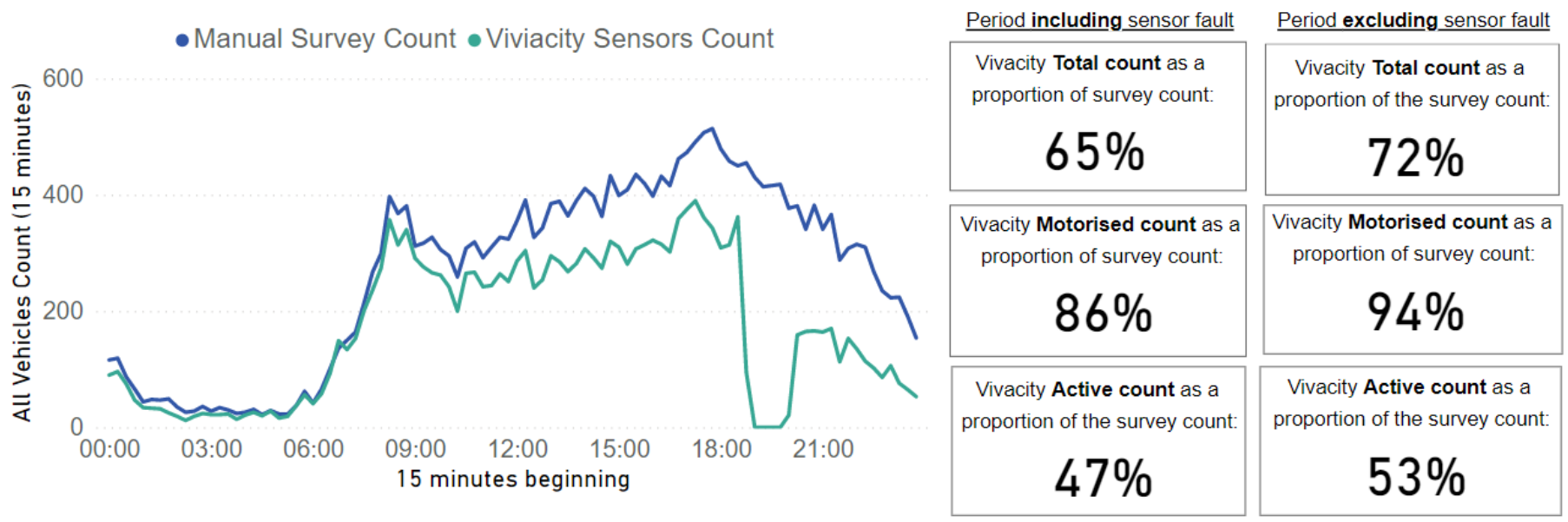


Figure 53 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

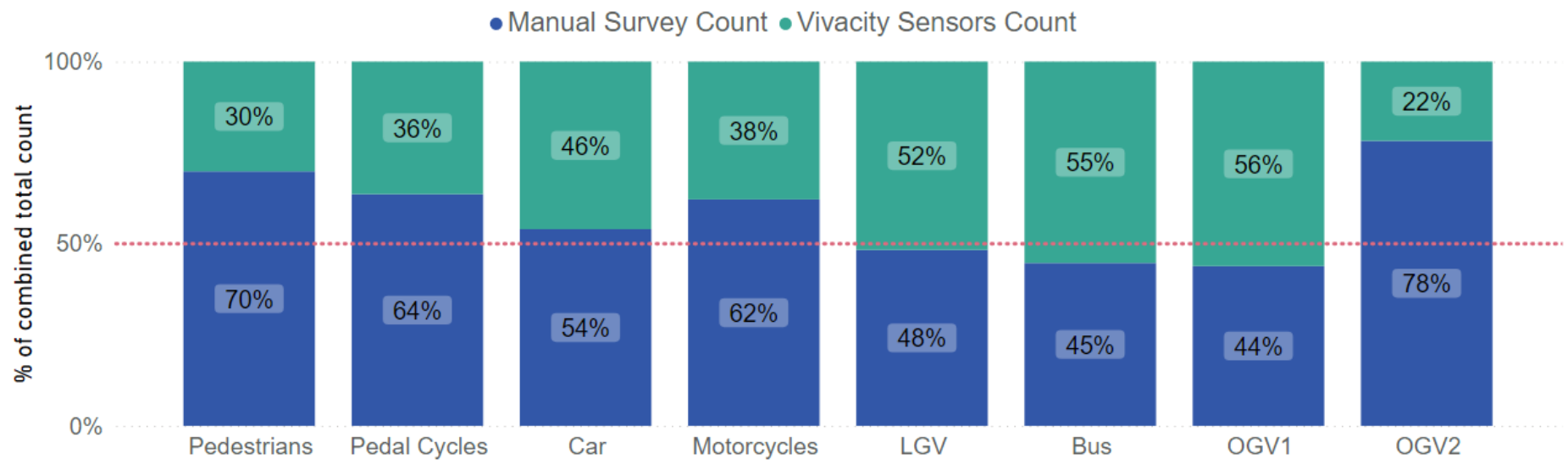
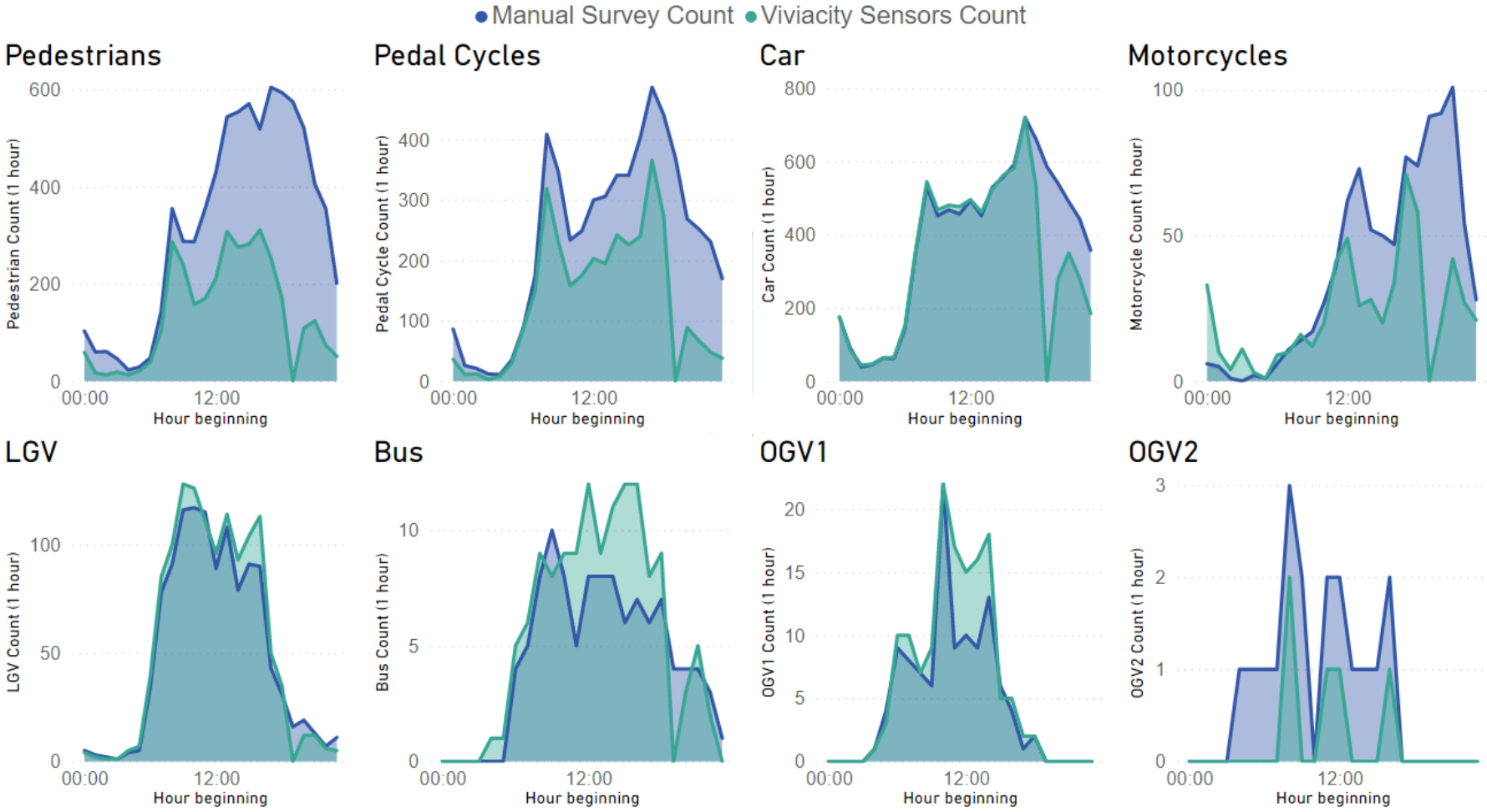


Figure 54 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



10.11 Milton Road (Mid)

Sensor Hardware Version: V1
Number of countlines: 1

The Milton Road (Mid) performs better for motorised vehicles than active travel but consistently underestimates throughout the day (Figure 55). Active travel modes and OGV2s are very underestimated by the Vivacity sensors, whilst OGV1s are slightly overestimated (potentially linked to misclassification of OGVs) (Figure 56). In addition, 181 E-scooters are missed or mis-classified in the 24 hours. The distinct morning peak in Pedestrians and Pedal Cycles seen in the manual survey data is almost entirely missed in the Vivacity data (Figure 57).

Figure 55 Total traffic counts for the manual survey and Vivacity sensors by time of day.

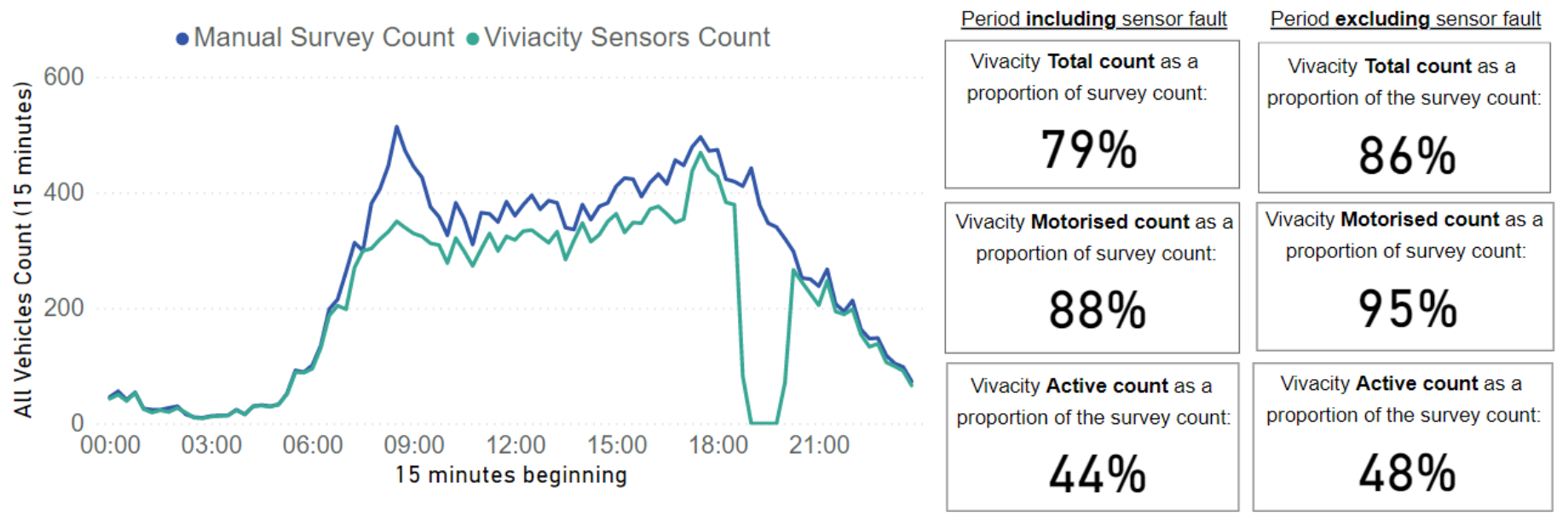


Figure 56 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

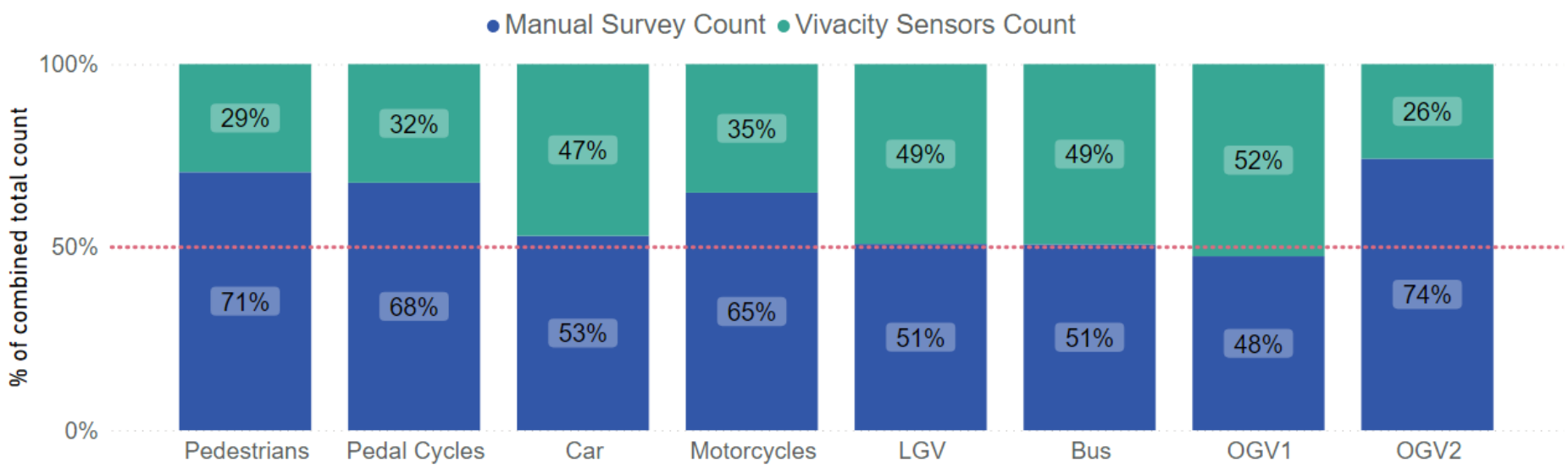
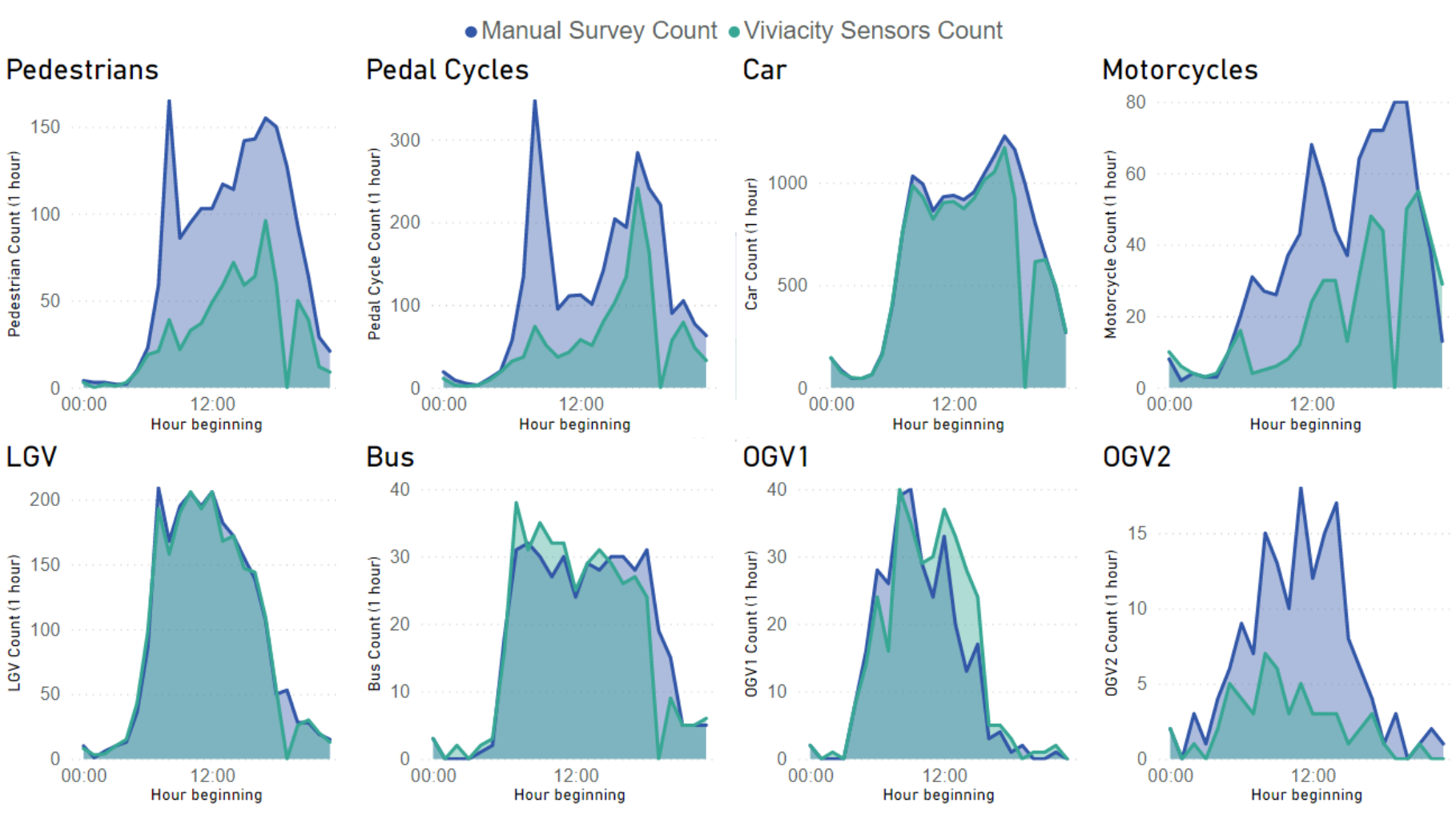


Figure 57 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



10.12 Milton Road (North)

Sensor Hardware Version: V2
Number of countlines: 3

The Milton Road (North) sensors are very accurate in terms of both motorised and active travel trends (101% and 95% of the manual count respectively) (Figure 58). All modes of transport are close to 50:50%, including active travel modes (Figure 59). The slight overestimation of Pedestrians by the Vivacity sensors could be attributed in part to the 135 missed or mis-classified E-scooters. Cars are by far the largest mode of transport at this location, with hourly volumes above 500 between 07:00 and 19:00 (Figure 60).

Figure 58 Total traffic counts for the manual survey and Vivacity sensors by time of day.

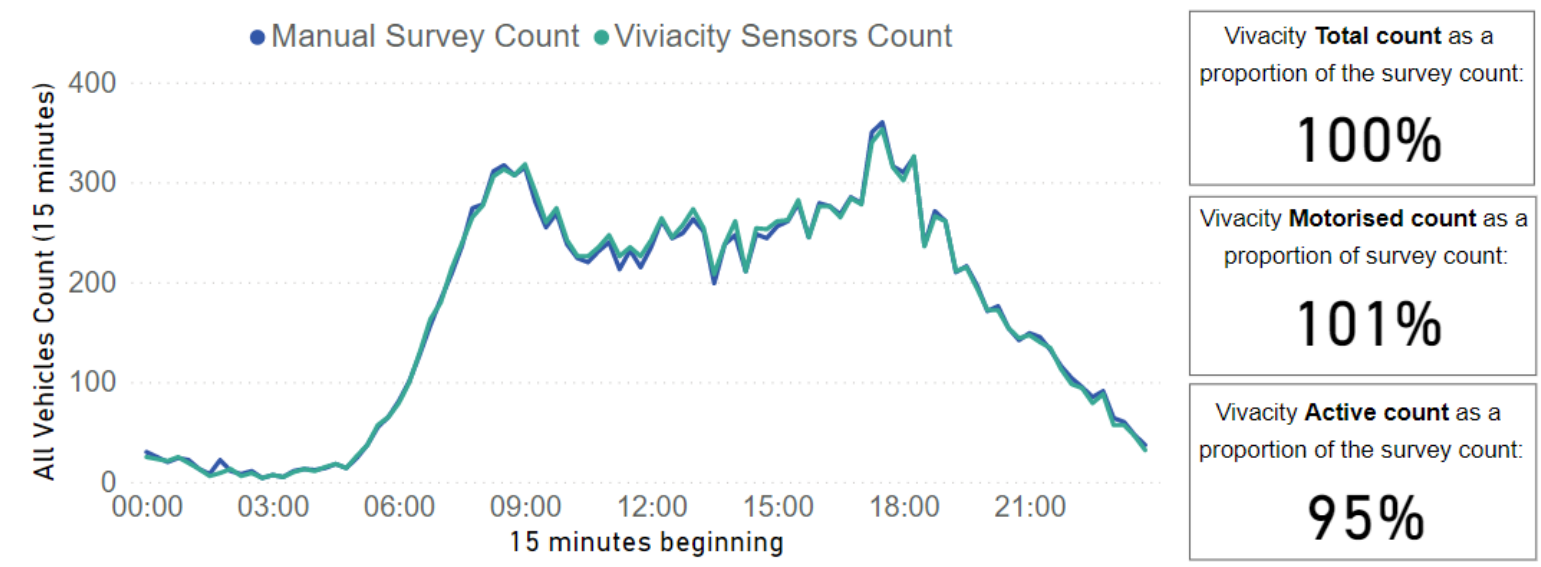


Figure 59 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

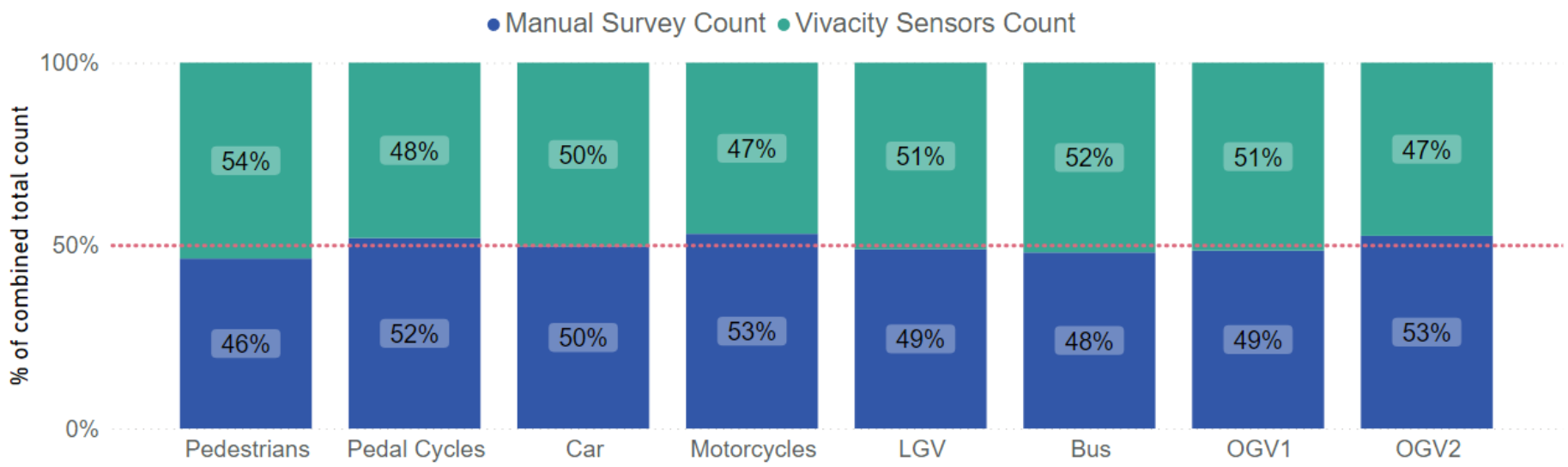
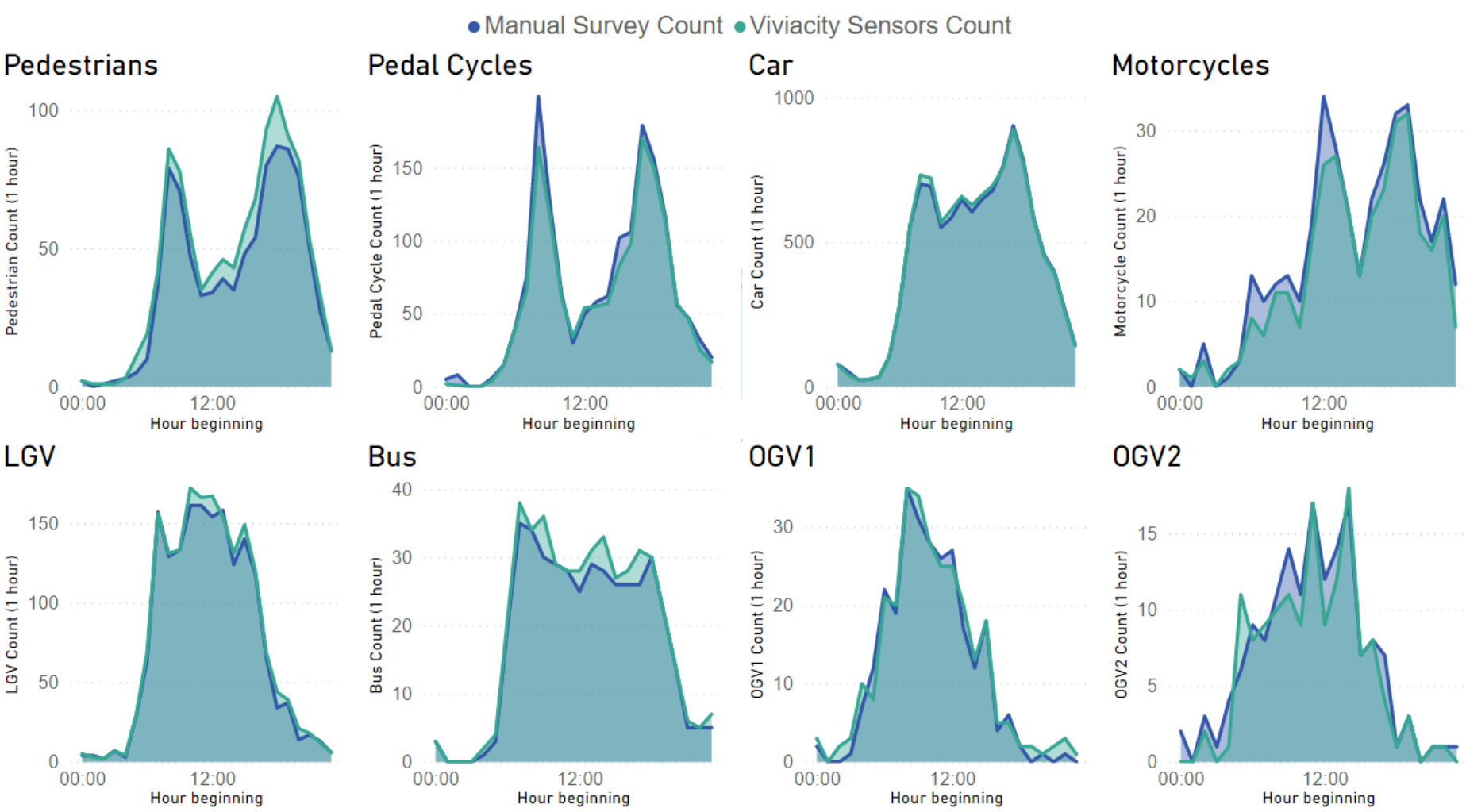


Figure 60 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



10.13 Milton Road (South)

Sensor Hardware Version: V2
Number of countlines: 3

The Milton Road (North) sensors are very accurate in term of both motorised and active travel trends (98% and 100% of the manual count respectively) (Figure 61). All modes of transport are close to 50:50% excluding Motorcycles which are undercounted by the Vivacity sensors (Figure 62). 140 E-scooters are missed or misclassified at this site across the 24 hours. Hourly profiles are very similar for most modes of transport except for Pedestrians, which the Vivacity sensors overestimate at peak hours (08:00, 13:00 and 16:00) and Motorcycles which are underestimated during their 12:00 and 20:00 peaks, though generally volumes are low across the day (Figure 63).

Figure 61 Total traffic counts for the manual survey and Vivacity sensors by time of day.

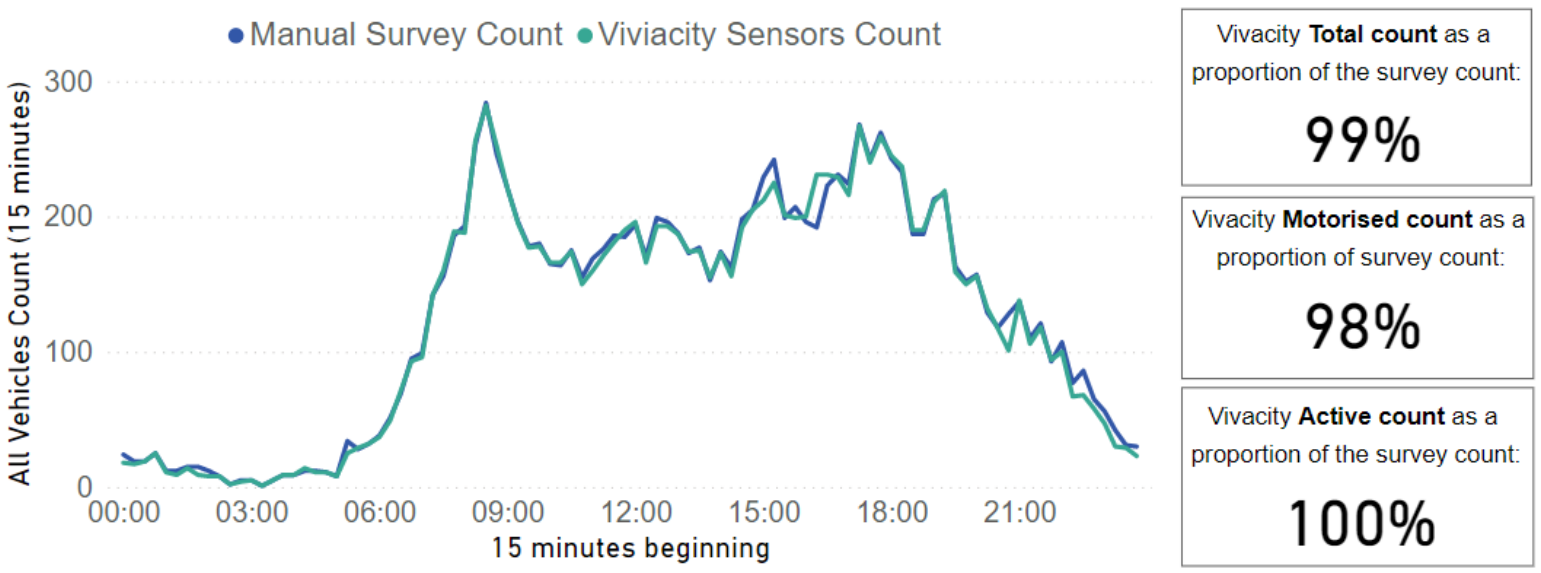


Figure 62 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

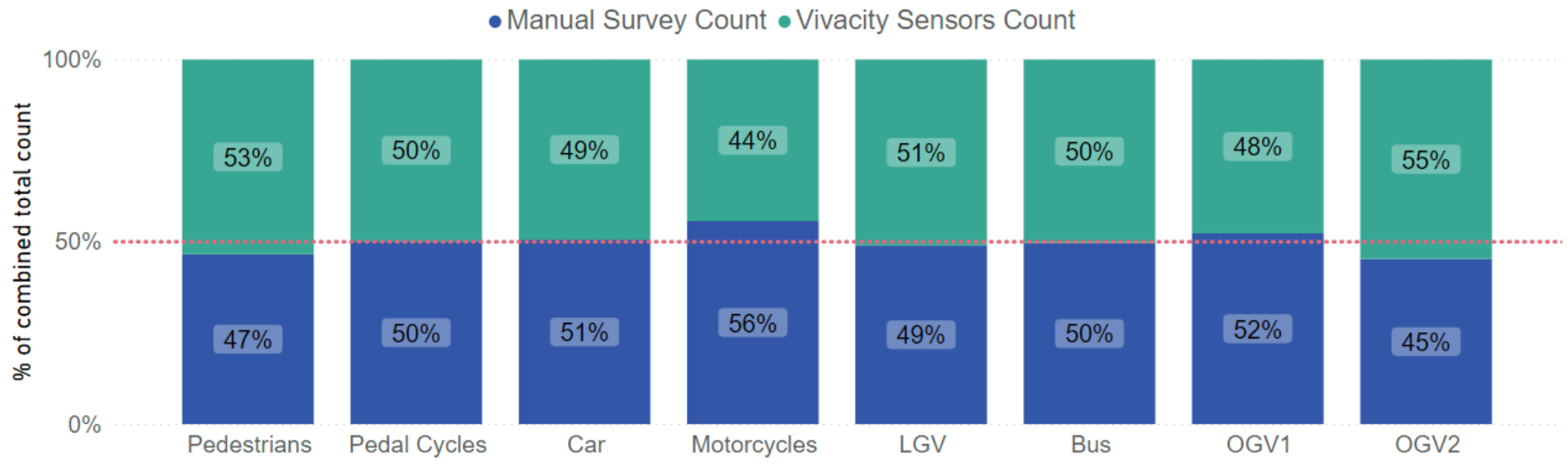
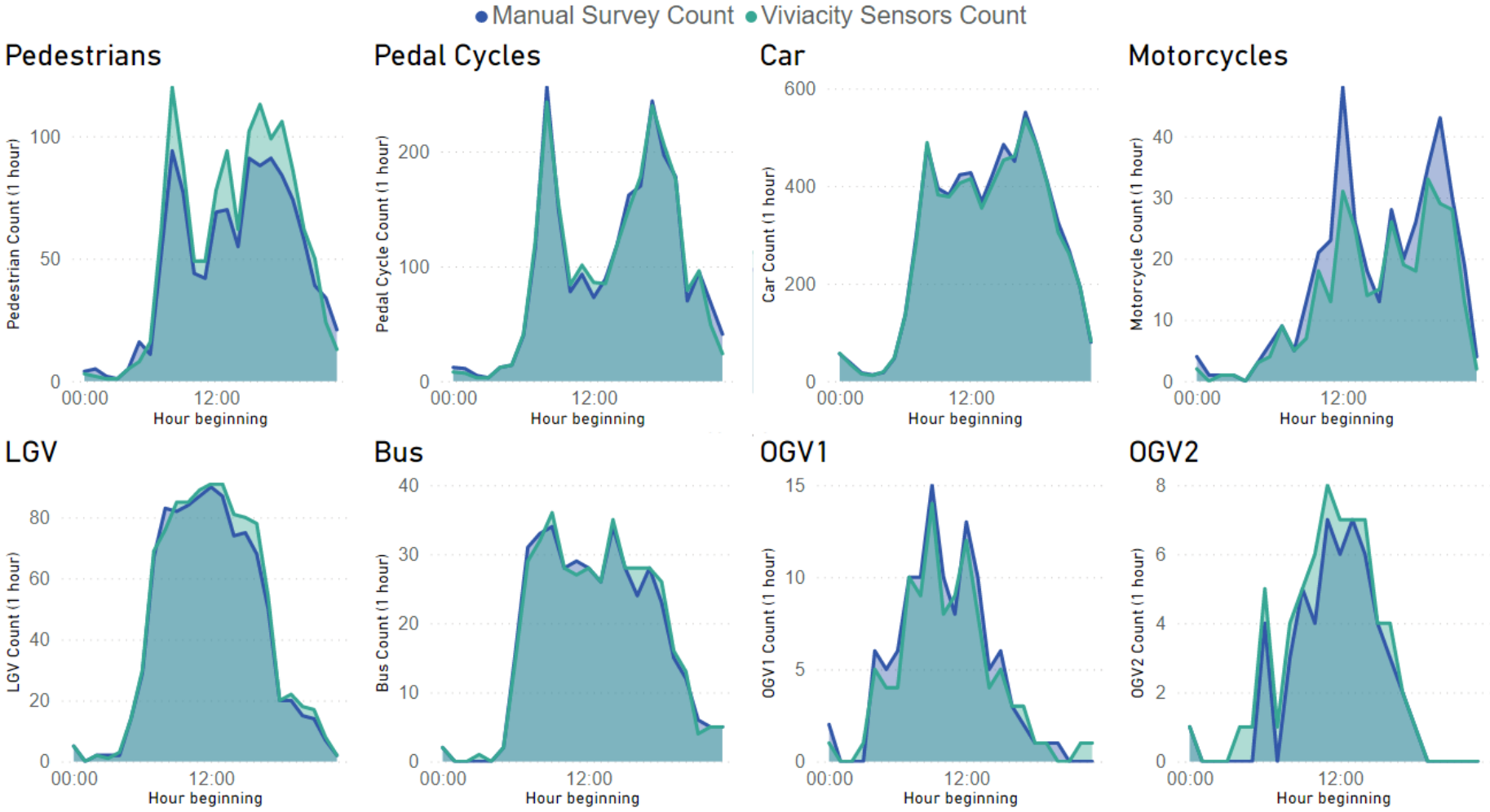


Figure 63 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



10.14 Perne Road

Sensor Hardware Version: V2
Number of countlines: 3

The Perne Road sensors are very accurate for motorised vehicles (99% of manual survey count) though does not capture active travel as well as some of the other V2 sensors (87%), perhaps linked to the Vivacity sensors missing peaks in traffic at 09:30 and 13:30 (Figure 64). Most modes are close to the manual survey count, except for Buses which are overestimated, perhaps at the expense of OGV2 counts which are underestimated, though volumes for both are low across the day (Figure 65). 113 E-scooters are missed or misclassified at this site across the 24 hours. The distinct increase in Pedestrians at 13:00 in the manual count is missed in the Vivacity survey which counts 63 rather than 153 Pedestrians in the hour beginning 13:00 (Figure 66).

Figure 64 Total traffic counts for the manual survey and Vivacity sensors by time of day.

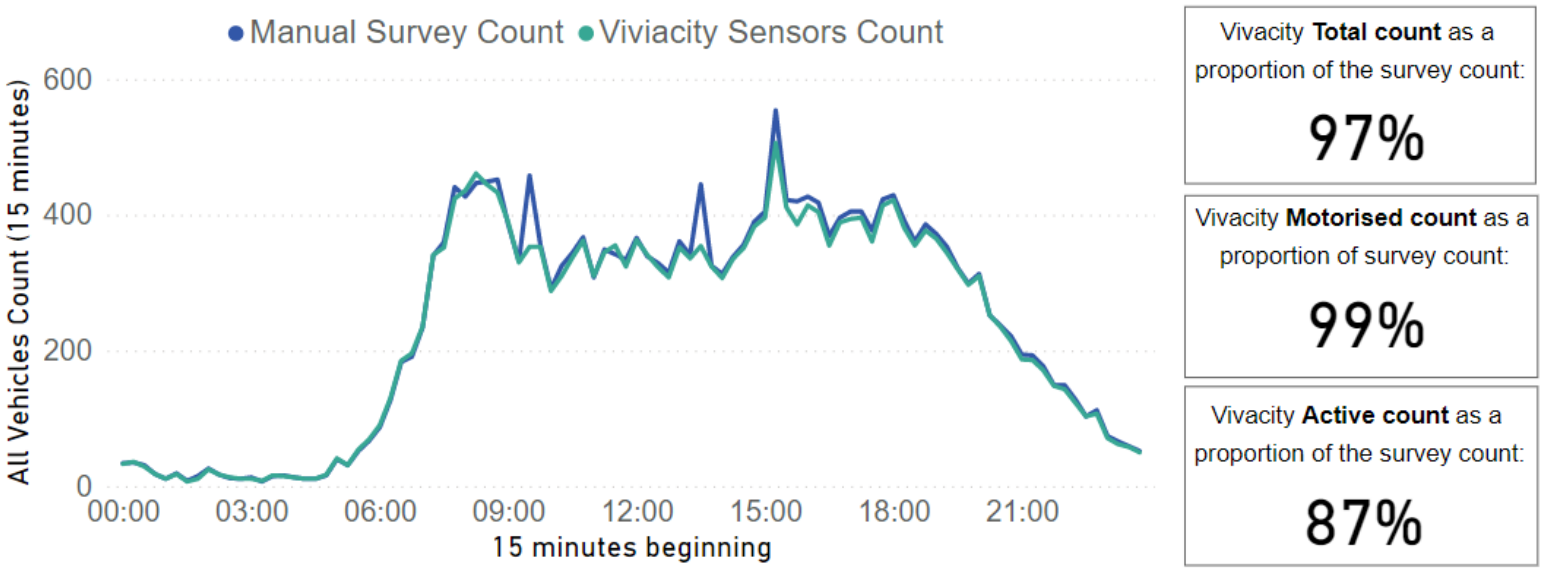


Figure 65 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

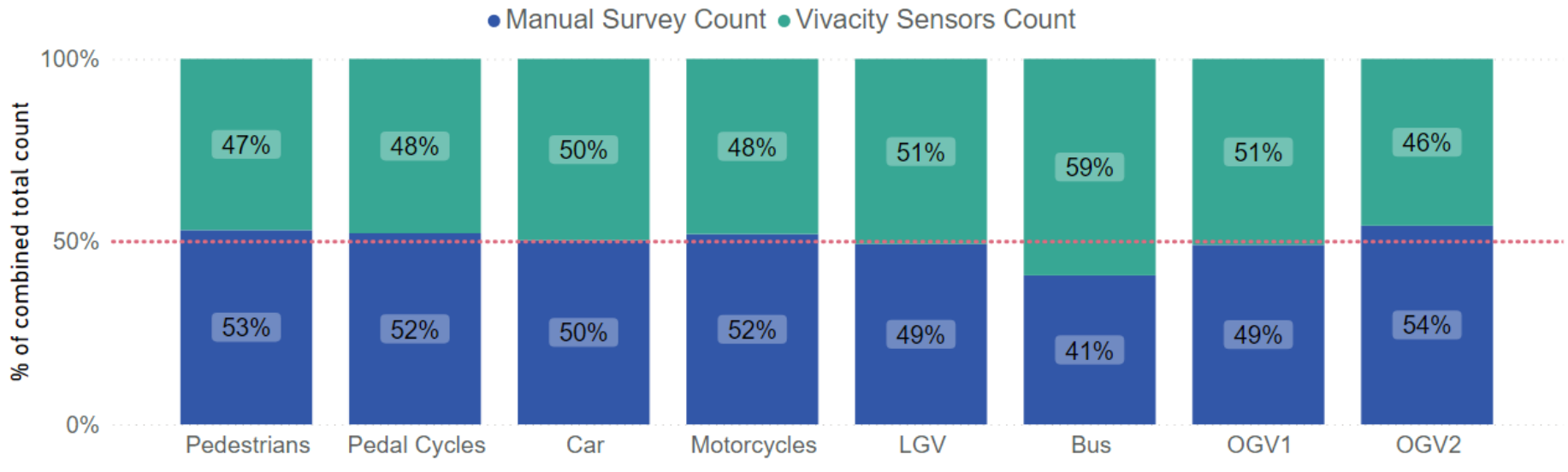
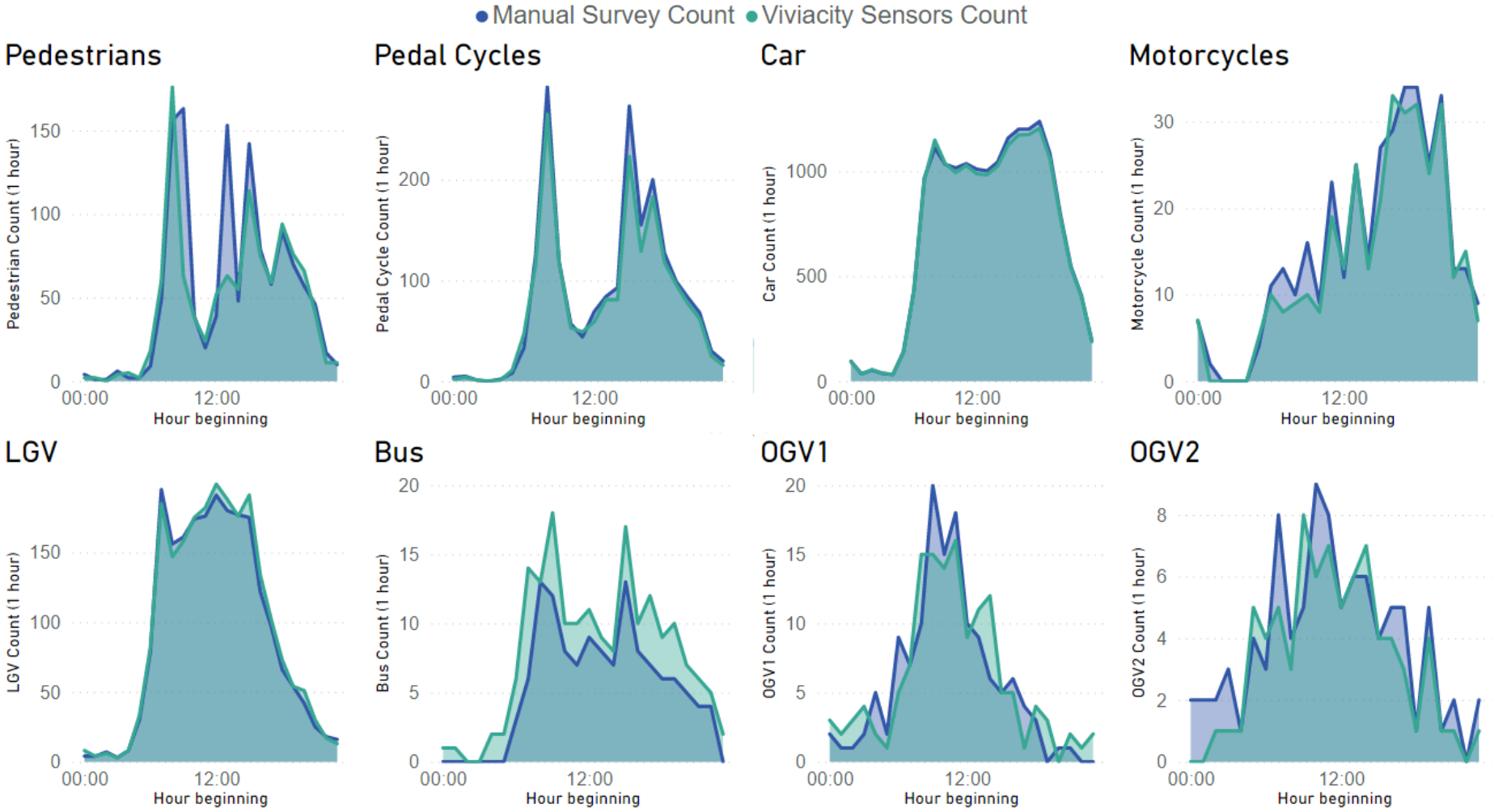


Figure 66 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



10.15 Queen Edith's Way

Sensor Hardware Version: V2
Number of countlines: 3

The Queen Edith's Way sensor is the only V2 sensor to experience the technical down-time between 18:45 and 20:30. Excluding this sensor fault period, the sensor is very accurate, recording 99% and 97% of motorised vehicles and active travel counts respectively (Figure 67). Most modes are close to the manual survey count, except for OGV1 which is underestimated by Vivacity and OGV2 which is overestimated, most likely the result of misclassification of OGVs (Figure 68). Only 36 E-scooters are missed or misclassified at this more peripheral site. Hourly flow trends are similar between the two survey types excluding the sensor fault period (Figure 69).

Figure 67 Total traffic counts for the manual survey and Vivacity sensors by time of day.

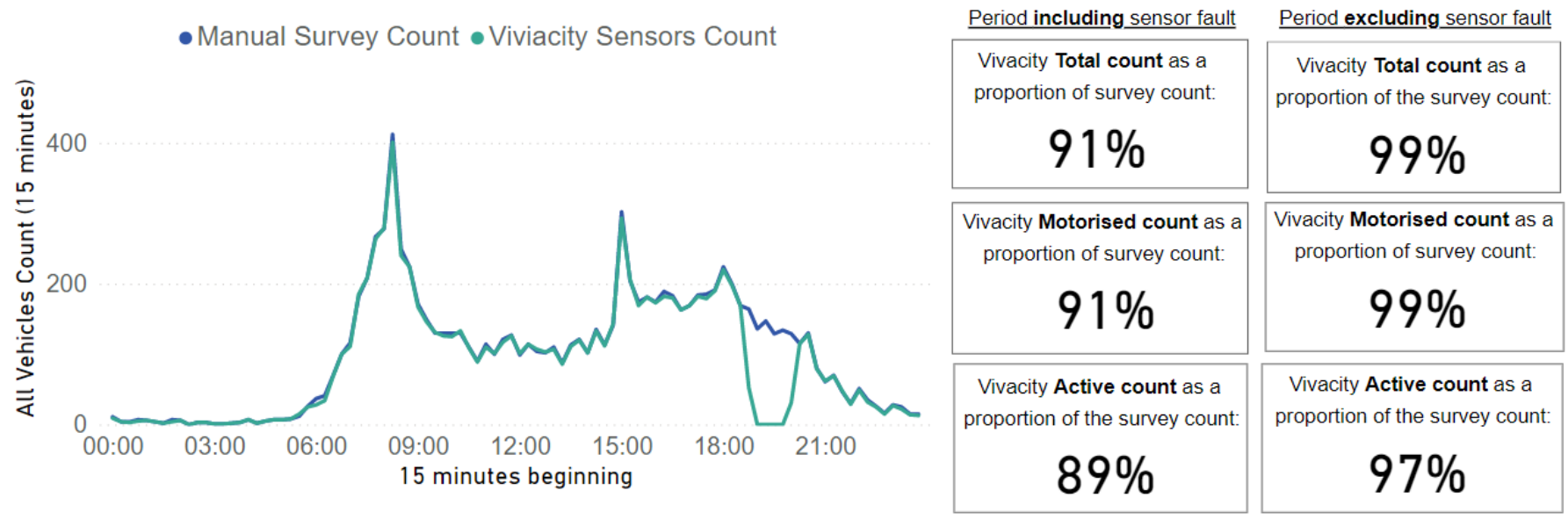


Figure 68 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

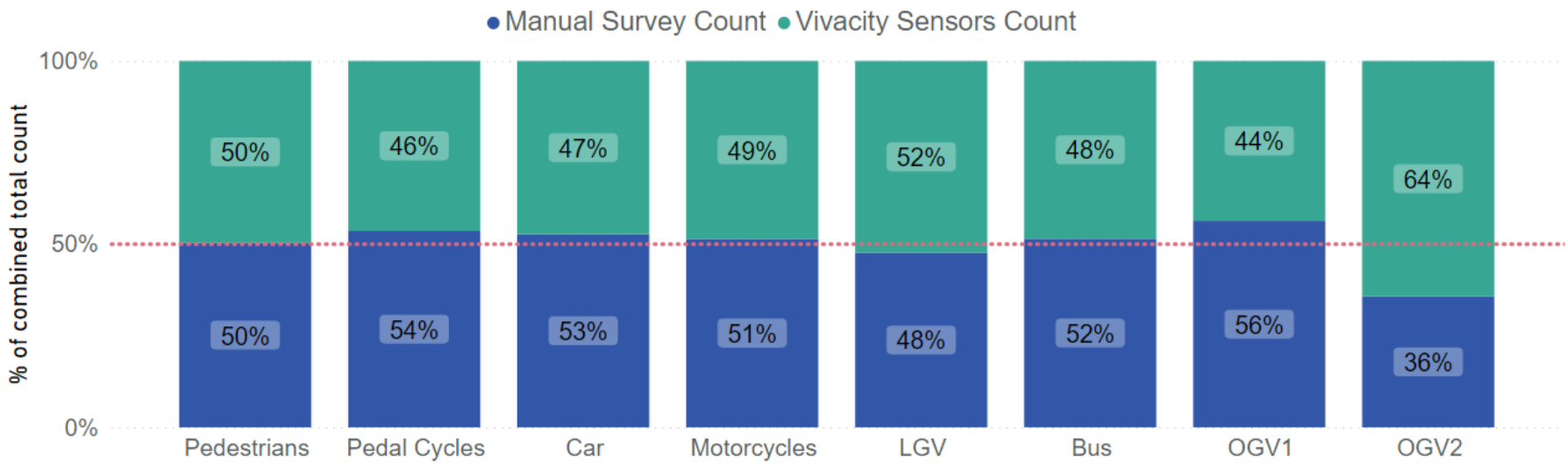
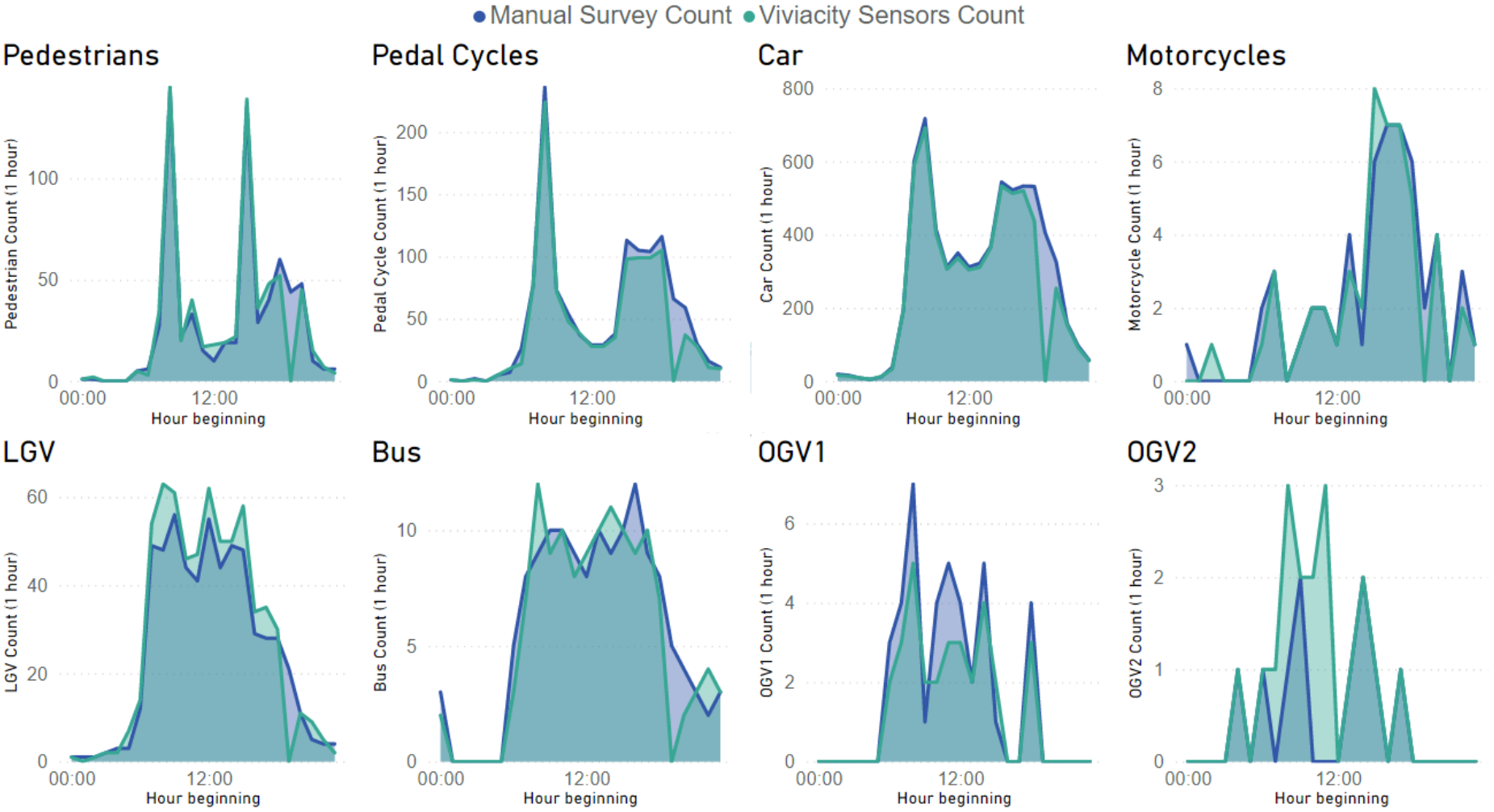


Figure 69 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



10.16 Tenison Road

Sensor Hardware Version: V2
Number of countlines: 3

The Tenison Road sensor is the only site to consistently overcount when compared to the manual survey, in particular for active travel in which Vivacity counts measure at 142% of the manual survey total (Figure 70). Several modes are overestimated, including Pedestrians, Pedal Cycles, LGVs (Figure 71). Heavy vehicles are overestimated but very low volumes, for example OGV2 sees one count in the manual survey. 124 E-scooters are missed or misclassified at Tenison Road. The highest volume classifications at this site are Pedestrians, Pedal Cycles and Cars. The daily profile for Cars are similar to the manual counts but the active travel is significantly overestimated throughout the day (Figure 72).

Figure 70 Total traffic counts for the manual survey and Vivacity sensors by time of day.

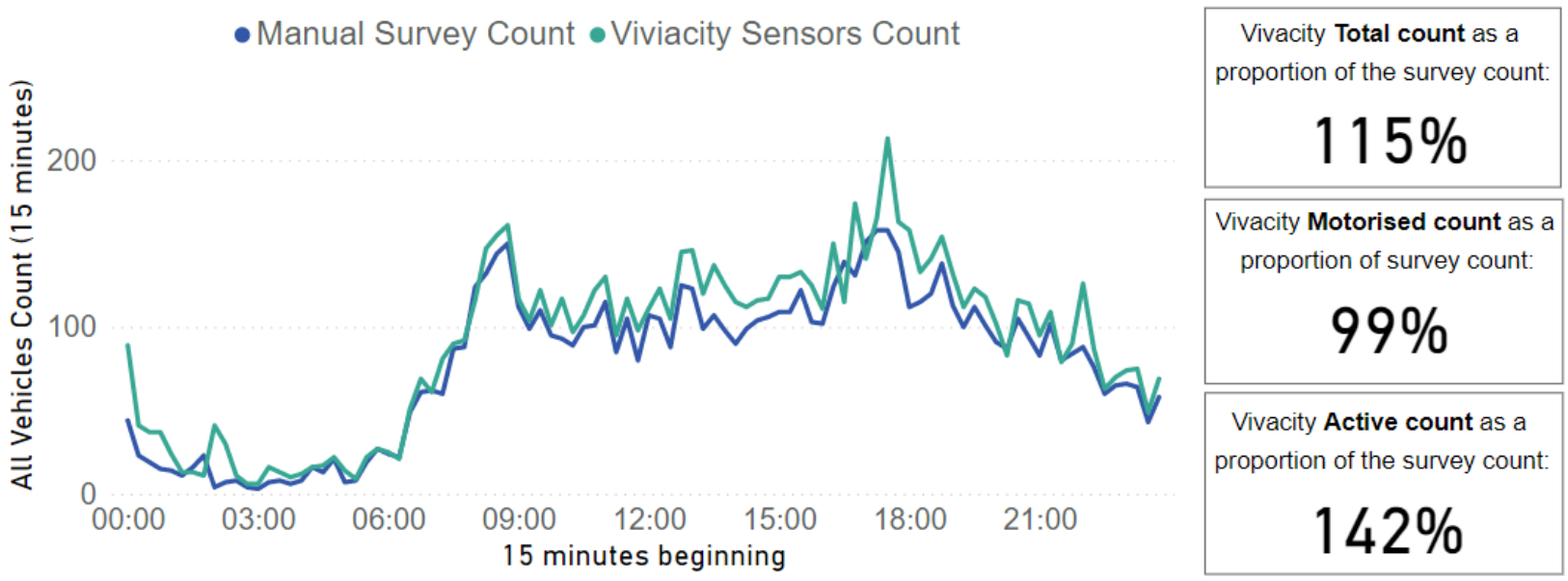


Figure 71 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

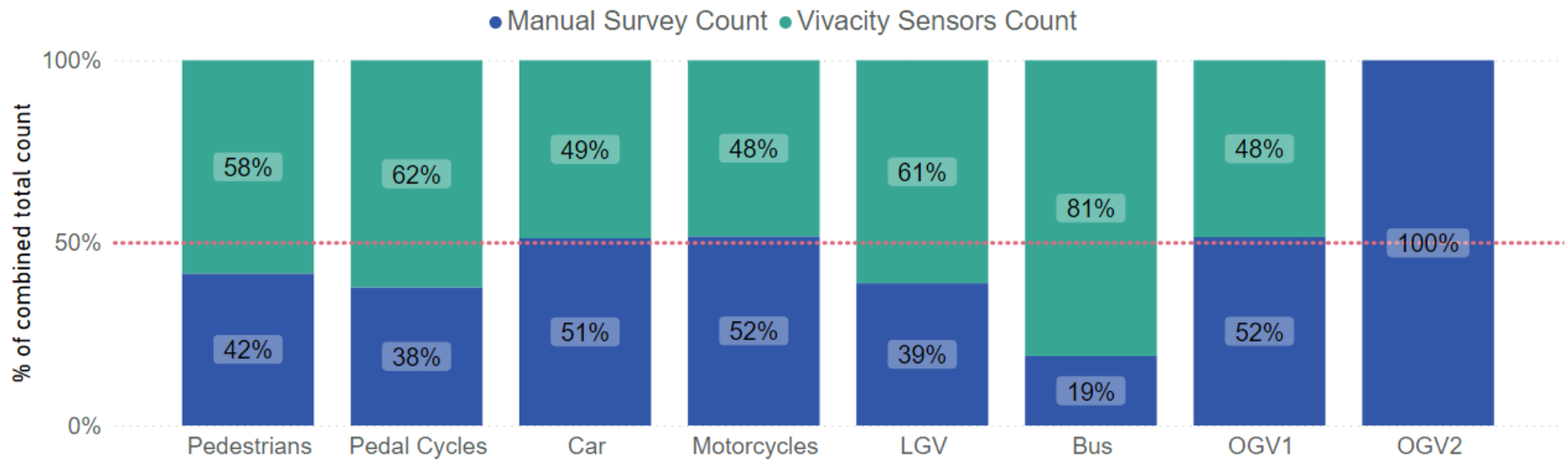
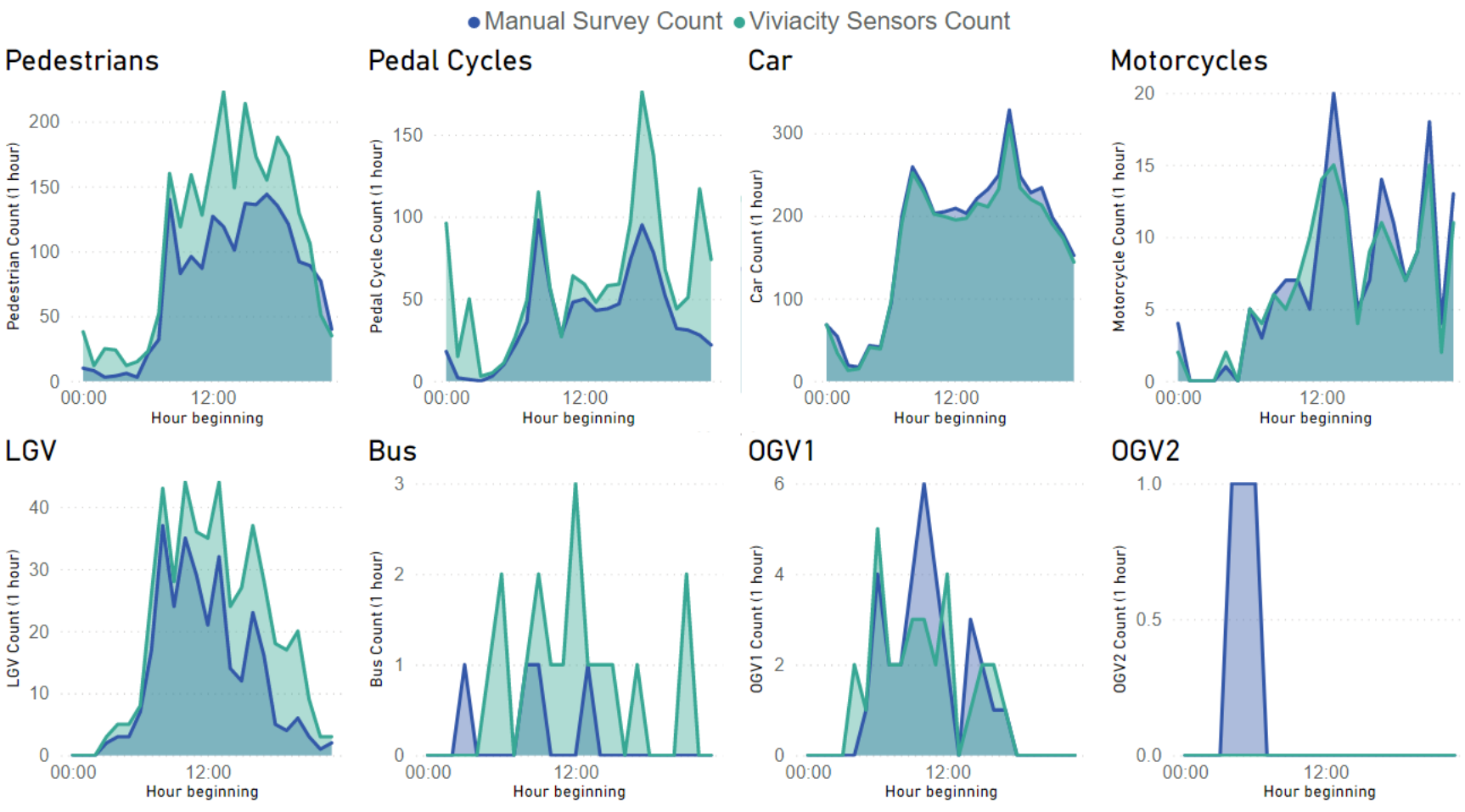


Figure 72 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



10.17 Vinery Road

Sensor Hardware Version: V1
Number of countlines: 1

The Vinery Road sensor is affected by the sensor fault between 18:45 and 20:30. Excluding this period, it accounts well for Motorised Vehicles (100% of manual survey) but poorly for Active Travel counts (52% of manual survey)(Figure 73). Pedestrians are the most significantly underestimated mode on Vinery Road, whilst OGVs 1 and 2 only see very small counts so proportion trends are not representative (Figure 74). 54 E-scooters are missed or misclassified. The morning Pedestrian peak is distinctly undercounted by the Vivacity sensors whilst the afternoon Pedestrian peak (~16:00) is almost entirely missed (Figure 75).

Figure 73 Total traffic counts for the manual survey and Vivacity sensors by time of day.

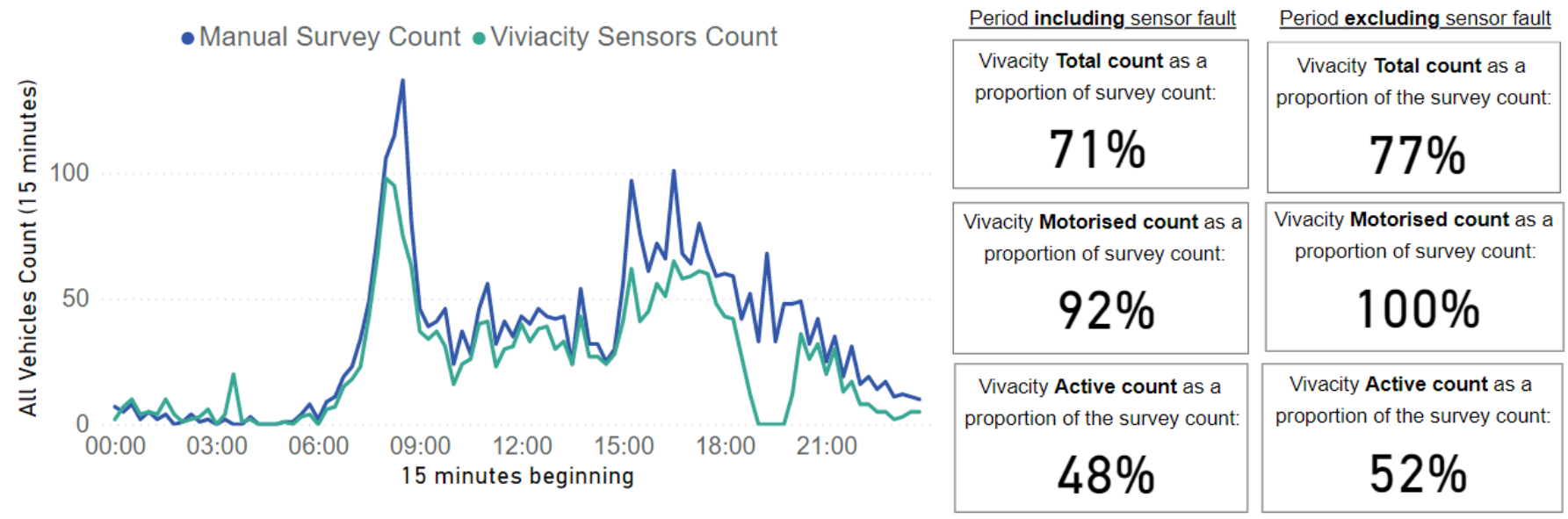


Figure 74 The proportion of the total combined Vivacity and survey count. A 50%:50% split means the counts are the same.

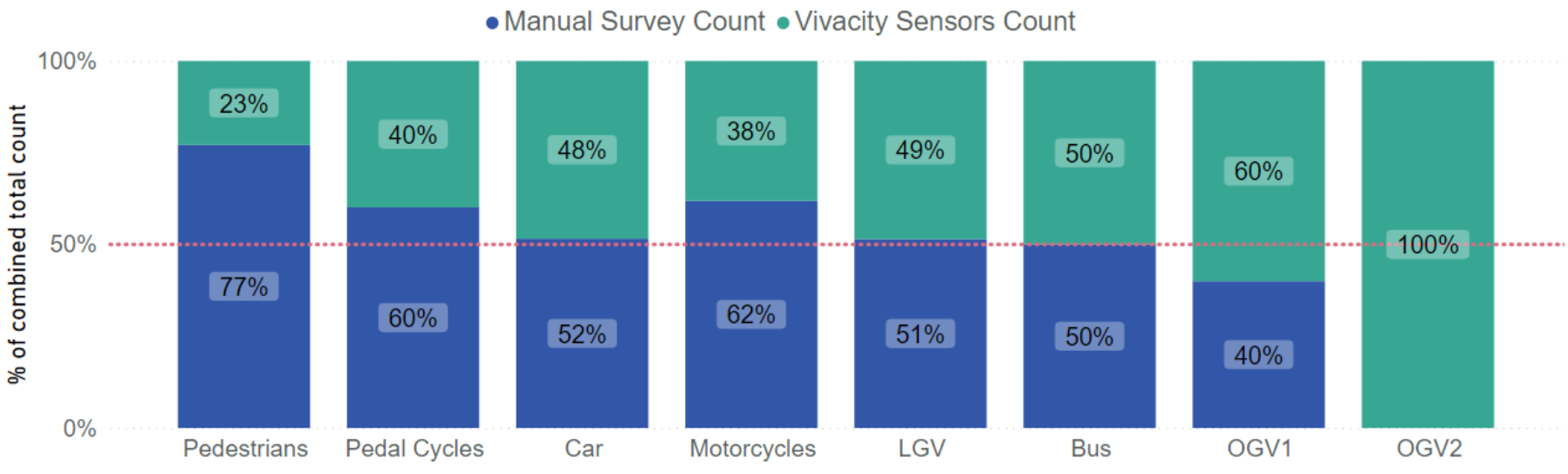
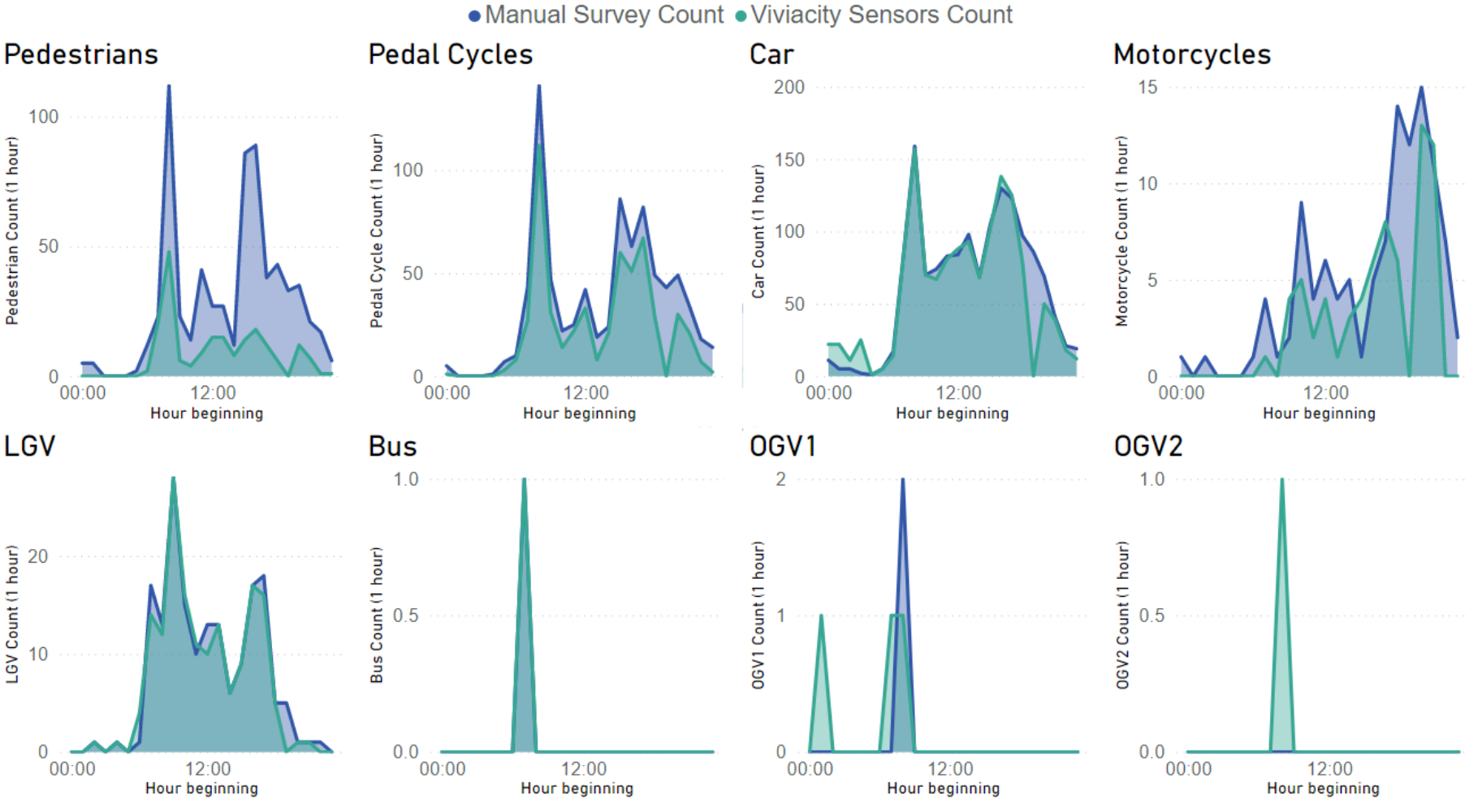


Figure 75 Traffic counts by time of day for each Vivacity classification mode. Note each graph is on a different y-axis scale.



11 Appendix 5: Individual sensor summary

Figure 76 Capture rate by vehicle type (excluding the fault period 18:45-20:15 inclusive) – total Vivacity counts as a proportion of total manual survey counts.

The colour scheme reflects the performance of the Vivacity sensor. Good accuracy = within +/- 10% (green highlight), Moderate accuracy = within +/- 30% (orange highlight) and Poor accuracy = above +/- 30% (red highlight).

Road Name	Hardware Version	All Traffic	Motor Vehicles	Active Travel	Pedestr-ians	Pedal Cycles	Car	Motor-cycles	Bus	LGV*	OGV1*	OGV2*
Cherry Hinton Road[$]	V2	9%	9%	8%	15%	2%	11%	0%	0%	2%	0%	0%
Coldhams Lane	V1	88%	96%	42%	34%	47%	98%	55%	65%	99%	79%	64%
Coleridge Road	V1	89%	100%	62%	34%	80%	100%	101%	88%	99%	124%	50%
Devonshire Road Cycle Path[%]	V1	44%	14%	44%	74%	40%	0%	8%	0%	0%	0%	0%
East Road	V1[£]	78%	96%	33%	28%	45%	98%	52%	114%	102%	76%	25%
Hills Road	V1	83%	99%	60%	47%	74%	98%	111%	82%	104%	100%	84%
Histon Road (North)	V2	99%	99%	100%	151%	99%	98%	94%	115%	106%	105%	92%
Histon Road (South)	V2	98%	98%	98%	105%	99%	98%	87%	109%	102%	88%	150%
Mill Road (East)	V1[£]	90%	98%	76%	69%	90%	98%	70%	121%	103%	123%	57%
Mill Road (West)	V1[£]	72%	94%	53%	49%	63%	94%	71%	133%	109%	128%	28%
Milton Road (Mid)	V1	86%	95%	48%	46%	53%	97%	61%	104%	99%	111%	35%
Milton Road (North)	V2	100%	101%	95%	116%	91%	101%	86%	109%	104%	105%	90%
Milton Road (South)	V2	98%	98%	100%	114%	99%	98%	78%	101%	104%	91%	121%
Perne Road	V2	97%	99%	86%	85%	91%	99%	91%	143%	102%	101%	84%
Queen Edith's Way	V2	99%	99%	97%	109%	94%	97%	100%	100%	115%	79%	180%
Tenison Road	V2	116%	99%	144%	140%	169%	95%	93%	425%	151%	94%	0%
Vinery Road	V1	77%	100%	52%	31%	72%	102%	70%	100%	98%	150%	0%

**Please note that the 24-hour volumes of LGVs and OGVs on many of the roads across Cambridge are low. As such, the percentage capture rate is very sensitive. The extremely high or low percentages are likely the result of a small volume where a discrepancy of 1 or 2 vehicles represents a large percentage difference.*

[$] *Cherry Hinton Road sensor impacted by tree growth. Sensor has since been rotated to avoid tree branches.*

[£] *Upgraded to V2 in Autumn 2022.*

[%] *Vivacity indicated that bush/tree growth is likely affecting the Devonshire Road Cycle Path sensor.*