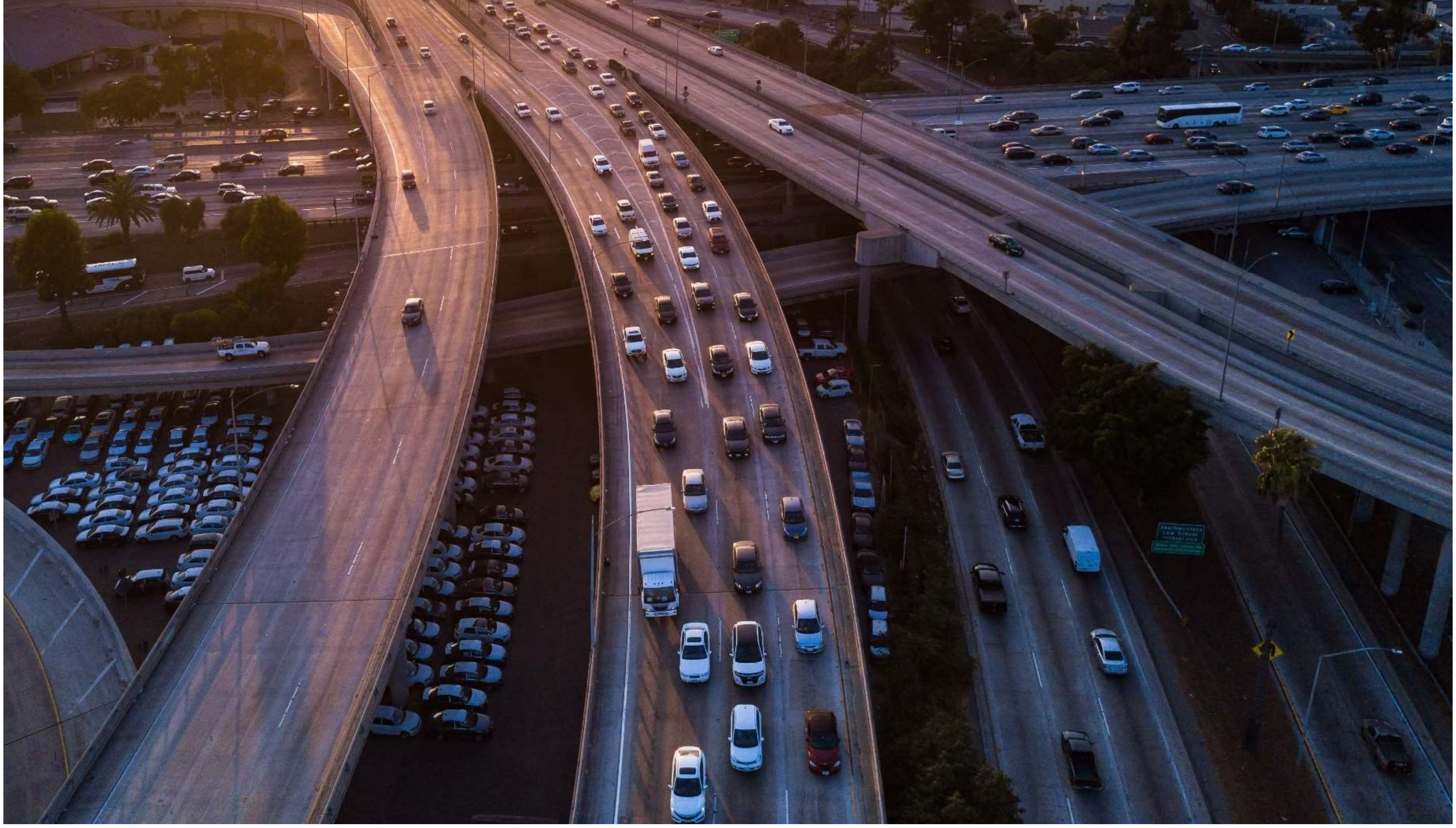

ClearWay™

A white paper providing comparison across roadway count technologies, focused on improving safety and efficiency on our roads.

NAVTECH RADAR

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A white paper providing comparison across roadway count technologies, focused on improving safety and efficiency on our roads.

Getting more from less: Utilising AID radar for more than just AID

Road operators around the globe count vehicles to monitor traffic flow, identify congestion patterns, and plan infrastructure improvements. This data informs road network optimisation, enhancing safety measures, and managing resources efficiently. By understanding traffic volume and trends, operators can implement targeted interventions to alleviate bottlenecks, reduce travel time, and enhance overall transportation systems.

But traditional technologies commonly offer only one measurement; meaning road operators have an increasingly diverse set of technologies deployed on the roadside which add to the burden of infrastructure, increasing costs and roadside risk.

Imagine reducing the number of independent pieces of technology on the roadside, bringing the ability to count vehicles accurately and consistently in combination with other road safety and efficiency requirements.

In this white paper, we'll discuss the roll of counting vehicles and share data on recent side-by-side comparisons to highlight some of the real-world benefits that could be achieved.

Reduce the number of independent traffic sensors on the roadside by utilising a single technology to deliver more.

- Improve Safety
- Reduce Infrastructure
- Enhance Coverage
- Drive Efficiency

COD – 1003 V2.0

NAVTECH RADAR

Technologies used to count vehicles:

There are several technologies commonly used to count traffic on roads, each with its own advantages and limitations. Some of the main technologies include:

- Inductive Loop Sensors: These are coils of wire embedded into the pavement at intersections or along roads. When a vehicle passes over them, it disrupts the electromagnetic field, allowing the sensor to detect the presence of a vehicle. They are relatively inexpensive and commonly used for traffic detection and counting.
- Piezoelectric Sensors: These sensors are similar to inductive loops but use piezoelectric materials instead. When a vehicle passes over them, it generates an electrical charge, which can be measured to detect the presence of a vehicle. They are often used in conjunction with inductive loops for traffic monitoring.
- Video Cameras: Video cameras can be mounted on poles or buildings overlooking roads to capture footage of traffic. Video analytics software can then be used to detect and track vehicles, counting the number of vehicles passing through a particular area. This method provides visual data and can be useful for analysing traffic patterns and behaviours.
- Side-Fire or flat panel Radar Sensors: single direction radar sensors which emit radio waves that bounce off vehicles coming toward or passing by, allowing them to detect the presence and speed of vehicles. They are commonly used for traffic management and can be installed on poles or integrated into existing infrastructure.
- Infrared Sensors: Infrared sensors detect vehicles by measuring the heat emitted by their engines or the body of the vehicle. They are often used in toll booths and weigh stations to count vehicles passing through.
- Bluetooth and Wi-Fi Detection: Some systems use Bluetooth or Wi-Fi signals emitted by vehicles to detect their presence and track their movements. This technology can provide valuable data on travel times and congestion levels.
- Satellite and GPS Technology: Satellite and GPS technology can be used to track the movement of vehicles over large areas. While not as commonly used for traffic counting as other methods, they can provide valuable data for analysing traffic patterns and trends.

With so many options available to road owners, developers and operators, there is a surprising lack of side-by-side data demonstrating the real-world application and output. We seek to remedy this covering two of the most prevalent technologies, alongside the Navtech ClearWay™ 360° Radar solution.

Technology Comparison

Traditional technologies used to monitor traffic volumes typically involve below road inductive loops or flat panel side fire radars. These are considered to be the most widely used around the world and are the focus of this document. To demonstrate ClearWay's capability, studies were carried out comparing ClearWay's count and classification against ground-based loops and side fire flat panel radar.

Both comparisons showed ClearWay performing favourably and demonstrate ClearWay as a fully viable count and classification system.

What is an Inductive Loop?

An inductive traffic loop, often referred to simply as a "traffic loop" or "inductive loop," is a type of sensor commonly used in traffic management systems to detect the presence of vehicles on roadways. These loops are typically installed beneath the surface of the road at intersections, highway toll booths, or other strategic points on the roadway network.

Inductive loops work based on the principle of electromagnetic induction. The loop is essentially a coil of wire embedded in the pavement in a rectangular or diamond shape. When a vehicle passes over the loop, it disrupts the electromagnetic field generated by the loop, causing a change in inductance. This change in inductance is detected by the traffic signal controller or monitoring system, which then interprets it as the presence of a vehicle.

Inductive loops are used for various purposes in traffic management, including:

- Vehicle detection: They provide real-time data about traffic flow and vehicle presence, allowing traffic signals to adjust their timing accordingly to optimize traffic flow.
- Traffic counting: By counting the number of disruptions to the electromagnetic field, traffic loops can provide data on traffic volume, which is valuable for traffic analysis and planning.
- Vehicle speed detection: By measuring the time it takes for a vehicle to pass between two consecutive loops, the speed of vehicles can be estimated.

Overall, inductive traffic loops currently play an integral role in modern traffic management systems, helping to improve traffic flow, enhance safety, and optimize transportation infrastructure. They do however have some drawbacks:

- Installation and Maintenance Costs: Installing inductive loops requires cutting into the road surface, which can be time-consuming and expensive. Additionally, maintenance may be required over time due to wear and tear from traffic, weather, and other factors.
- Sensitivity to Environmental Factors: Inductive loops can be affected by changes in environmental conditions such as temperature, moisture, and electromagnetic interference. These factors can sometimes lead to false detections or unreliable data.
- Limited Detection Range: The detection range of inductive loops is typically limited to the area directly above the loop. This means that vehicles must pass directly over the loop for detection to occur, which may not always be practical or feasible in certain traffic situations.
- Inaccuracy with Non-Metallic Objects: Inductive loops primarily detect changes in electromagnetic fields caused by metallic objects. They may not reliably detect non-metallic objects such as bicycles or pedestrians, leading to potential inaccuracies in traffic data or signal control.
- Difficulty in Retrofitting: Retrofitting existing roadways with inductive loops can be challenging and costly, especially in densely populated urban areas or areas with complex road layouts.
- Vulnerability to Damage: Inductive loops installed in roadways are vulnerable to damage from construction activities, road maintenance, and other factors. Damage to the loops can disrupt their functionality and require repairs, leading to downtime and potential traffic disruptions.

Despite these drawbacks, inductive traffic loops remain a valuable tool in traffic management systems, especially when used in conjunction with other technologies to supplement their capabilities and address their limitations.

What is a Flat-Panel Radar?

In the context of roads and highways, side-fire radar systems are primarily used for traffic monitoring and management purposes. These radar systems are typically installed alongside or above roadways and are employed for various applications, including:

- Traffic Monitoring: Side-fire radar systems are used to monitor traffic flow, density, and speed on roads. By detecting vehicles passing by, these radars provide real-time data.
- Speed Enforcement: Side-fire radar units can be used for speed enforcement by measuring the speed of vehicles passing through their detection area. Law enforcement agencies may deploy these radars to monitor speeding violations and enforce speed limits.
- Incident Detection: Side-fire radar systems can help in detecting traffic incidents such as accidents, vehicle breakdowns, or debris on the roadway.
- Automated Toll Collection: In toll road systems, side-fire radar units can be used for automated toll collection by detecting vehicles as they approach toll booths or gantries. This enables seamless toll payment without the need for manual intervention, improving traffic flow and reducing congestion at toll plazas.
- Vehicle Classification: Side-fire radar systems can also classify vehicles based on size, length, or type as they pass by. This information is useful for traffic management purposes, toll collection systems, and transportation planning.

Overall, side-fire radar systems provide valuable data on vehicle movements, speed, and traffic conditions, helping to improve safety, efficiency, and mobility on roadways and whilst side-fire radar systems offer various benefits for traffic monitoring and management, they also have some drawbacks:

- Limited Detection Range: Side-fire radar systems typically have a limited detection range, especially when compared to front-facing radar systems. This limitation may result in blind spots or gaps in coverage along roadways, reducing the effectiveness of traffic monitoring and enforcement.
- Accuracy Issues: Side-fire radar systems may encounter accuracy issues, particularly in complex traffic environments with multiple lanes, curves, or obstructions. These factors can affect the radar's ability to accurately detect and track vehicles, leading to potential errors in speed measurements or vehicle classifications.
- Cost and Maintenance: Deploying and maintaining side-fire radar systems can be costly, requiring investment in infrastructure, equipment, and ongoing maintenance which includes cleaning. Additionally, regular calibration and upkeep are necessary to ensure the accuracy and reliability of the system over time.

Despite these drawbacks, side-fire radar systems remain valuable tools for traffic management and enforcement, offering a means to monitor traffic conditions, enforce regulations, and enhance road safety. However, it's essential to acknowledge and mitigate these limitations to ensure the effective and responsible use of radar technology in traffic management.

What is 360° FMCW Imaging Radar?

A 360-degree radar system, when placed on the side of the road, typically refers to a radar unit capable of scanning the surrounding area in all directions horizontally, covering a full 360-degree field of view. These radar systems are often mounted on poles or structures alongside roadways and highways.

Here are some features and applications of a 360-degree FMCW radar system when positioned on the side of the road:

- Comprehensive Coverage: A 360-degree radar system offers complete coverage of the area surrounding the roadside installation. This allows for the detection of vehicles, pedestrians, and other objects approaching from any direction, providing comprehensive situational awareness.
- Traffic Monitoring: By continuously scanning the surrounding area, a 360-degree radar system can monitor traffic flow, density, and speed in all directions. This data is valuable for traffic management, congestion analysis, and planning purposes.
- Wide Range Monitoring: This type of radar covers both directions on the roadway, across all lanes, including (where visible) on off ramps detecting vehicles travelling in all directions, helping to improve safety and efficiency. They can assist in driver awareness being integrated into wider Traffic Monitoring Systems (TMS).
- Incident Detection: 360-degree radar systems are effective in detecting traffic incidents such as accidents, vehicle breakdowns, or debris on the roadway. By monitoring the entire area around the roadside installation, these radar systems can quickly identify disruptions in traffic flow and alert authorities for prompt response and management.
- All Weather: Frequency Modulated Continuous Wave (FMCW) radar works well in all weather conditions primarily due to its unique operating principle and modulation technique.
- High sensitivity and resolution: FMCW radar can achieve high sensitivity and resolution, allowing them to detect and track targets with high accuracy even in adverse weather conditions. The continuous wave operation and frequency modulation enable precise range and velocity measurements, contributing to the radar's performance in all weather conditions.

Overall, a 360-degree radar system positioned on the side of the road provides versatile functionality for traffic monitoring, ramp monitoring, incident detection, speed enforcement, and toll collection, contributing to improved safety, efficiency, and mobility on roadways.

ClearWay™

Introduction to ClearWay™

Navtech Radar's ClearWay technology is a multi-functional system with a suite of capabilities available due to the unique way the radar tracks objects on the road. ClearWay's world-class AID capability is already the trusted incident detection backbone for several critical systems across the world. Alongside the ability to quickly alert road operators to the occurrence of an incident, vehicles being tracked on the road can also be counted and classified according to their length.

ClearWay™ Count & Classify

Count and classification is offered as a core capability of the system and importantly is accomplished from the same sensor as the AID monitoring. This means both counting and automatic incident detection can be achieved without the installation and integration of additional technology. The radars do not need cleaning, servicing, or adjusting once commissioned and the direct drive motor inside the radar has a design life of more than 10 years, delivering increased value for money over the lifecycle of the product.

Applications

ClearWay's count, classification and carriageway statistics functionality can be applied to various traffic analysis requirements. For example:

- Volume, Average Speed & Occupancy by lane
- Dynamic toll pricing
- Ramp performance and KPI data supply
- Journey times
- Traffic statistics: speed and volume along the entire monitored road space
- "Carriageway Empty" reporting

Outputs

Data update rates are entirely configurable, with typical update rates of 1-15 minutes depending on requirements. Integration of data feeds can be done via Navtech's ICD001 XML data stream or via OPC-UA or Modbus.

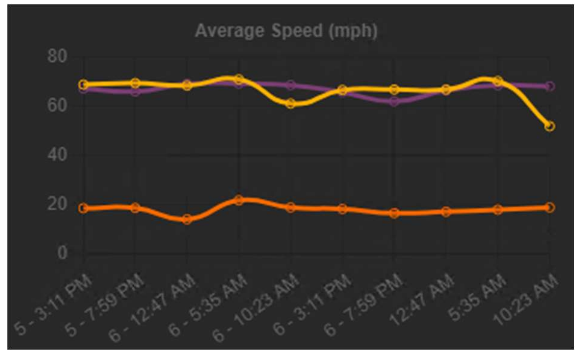

Figure 1 - Average speed plot for 48 hours via Situational Awareness

Snapshots of carriageway performance can also be seen through our web based Situational Awareness interface.

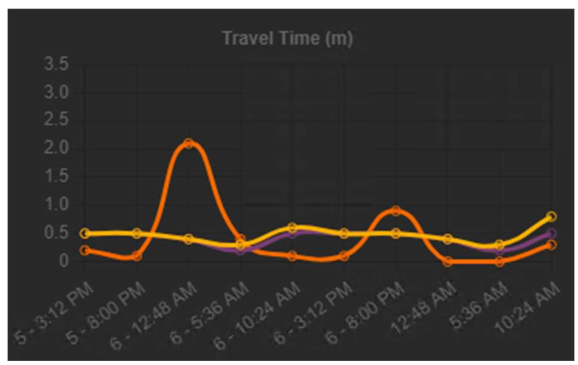

Figure 2 - Travel time plot for 48 hours via Situational Awareness

Navtech's CTS (76Ghz) and KTS (35Ghz) model radars can be mounted on existing road-side infrastructure and do not require additional hardware in the cabinet other than a connection into the road-side network switch.

ClearWay™

Inductive Loop Comparison

A side-by-side comparison was performed against a set of loop detectors in the same road space that a Navtech CTS (76Ghz) radar was monitoring. Data was captured from both systems for the same time period and analysed for comparison.

4 classification categories were specified.

- Small = Cars
- Medium = Small Trucks/Buses
- Large = Large Trucks/Buses
- Extra Large = Combination vehicles

Radar technology classifies vehicles based on lengths. The following lengths were specified to capture the above for categories:

- [S] 0.0m < length ≤ 5.5m
- [M] 5.5m <length ≤ 11.0m
- [L] 11.0m < length ≤ 17.0m
- [EL] >17.0m length

The following comparisons were each undertaken for 1 hour in heavy and light traffic conditions.

Northbound	S	M	L	EL	Total	Diff	Error
Manual	292	9	6	37	344		
Loops	285	15	5	35	340	4	1.2%
ClearWay	294	11	4	35	344	0	0.0%

Table 1 - Data comparison in light traffic

Northbound	S	M	L	EL	Total	Diff	Error
Manual	1727	131	74	18	1950		
Loops	1858	103	32	24	2017	67	3.4%
ClearWay	1637	174	70	34	1915	35	1.8%

Table 2 - Data comparison in heavy traffic

Performance in light traffic was very similar. In heavy traffic ClearWay slightly undercounted (1.8% error) whereas Loops were overcounting by a greater margin (3.4% error) as compared to the manual count.

A 48-hour comparison of loops and ClearWay show that they both follow the same traffic patterns, but as noted in the 1-hour comparison, loops appear to be overcounting in heavy traffic.

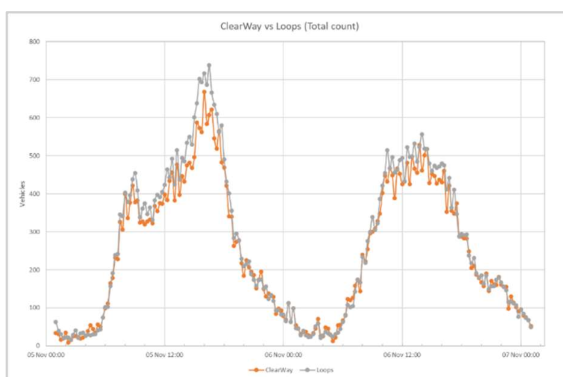

Figure 3 - 48-hour comparison

Comparison with Flat Panel

Navtech were given the opportunity to compare count performance on a US highway against an installed Flat Panel radar device. The road layout included two express lanes by the median in each direction plus four general purpose lanes in each direction, giving a total of 12 lanes.

Navtech's KTS (35Ghz) radar was deployed and connected to a ClearWay software system.

Navtech were able to access a short period of Flat Panel radar data, which was then used to compare against ClearWay output and against a manual lane-by-lane count.

Northbound

	Manual	ClearWay		Flat Panel Radar	
	Ground Truthing	Count	Variance from manual	Count	Variance from manual
NB Toll Lanes	130	132	1.5%	125	-3.8%
NB Main Lanes	675	695	2.9%	701	3.7%

Table 3 - 10-minute data comparison Northbound

Southbound

	Manual	ClearWay		Flat Panel Radar	
	Ground Truthing	Count	Variance from manual	Count	Variance from manual
SB Toll Lanes	108	105	-2.7%	107	-0.01%
SB Main Lanes	791	771	-2.5%	798	0.1%

Table 4 - 10-minute data comparison Southbound

ClearWay count performance on the Northbound carriageway shows good agreement. There is slightly more variance on the Southbound carriageway both from ClearWay and Flat Panel. This was put down to the fact the count site was just upstream from an off-ramp exit, meaning there was an increased level of lane switching in the vicinity of the counting area.

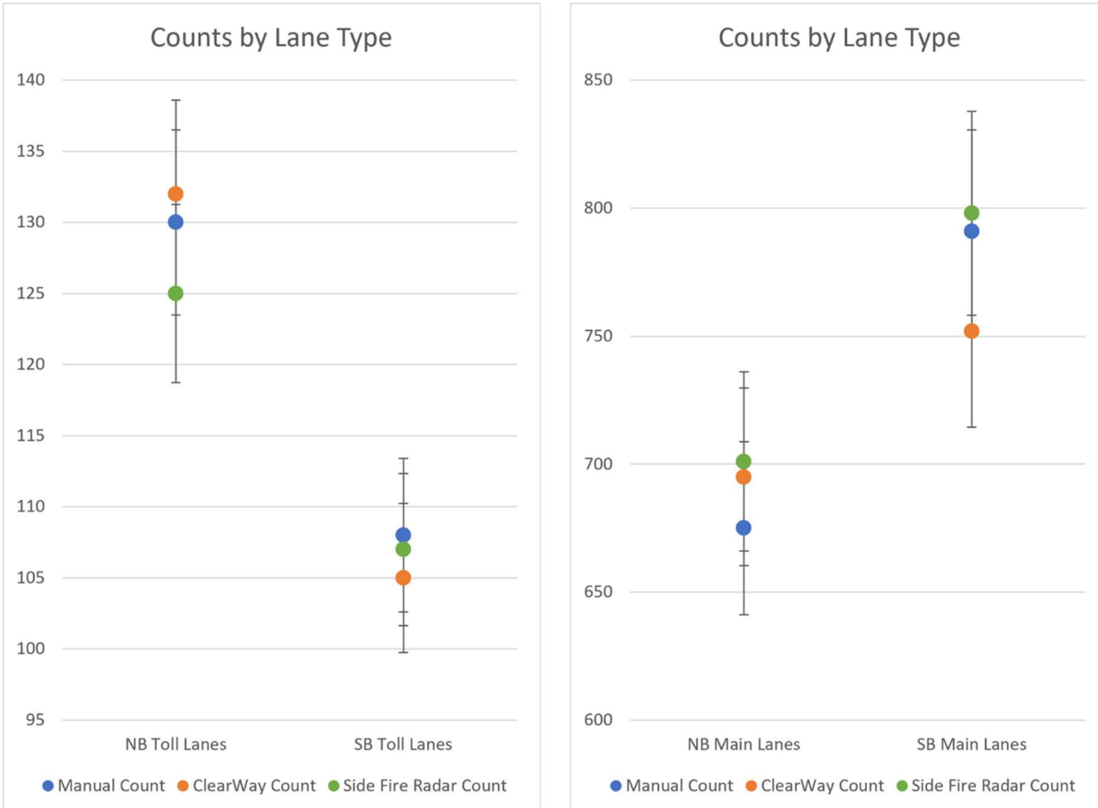

Figure 3 - Graph of aggregated comparison counts

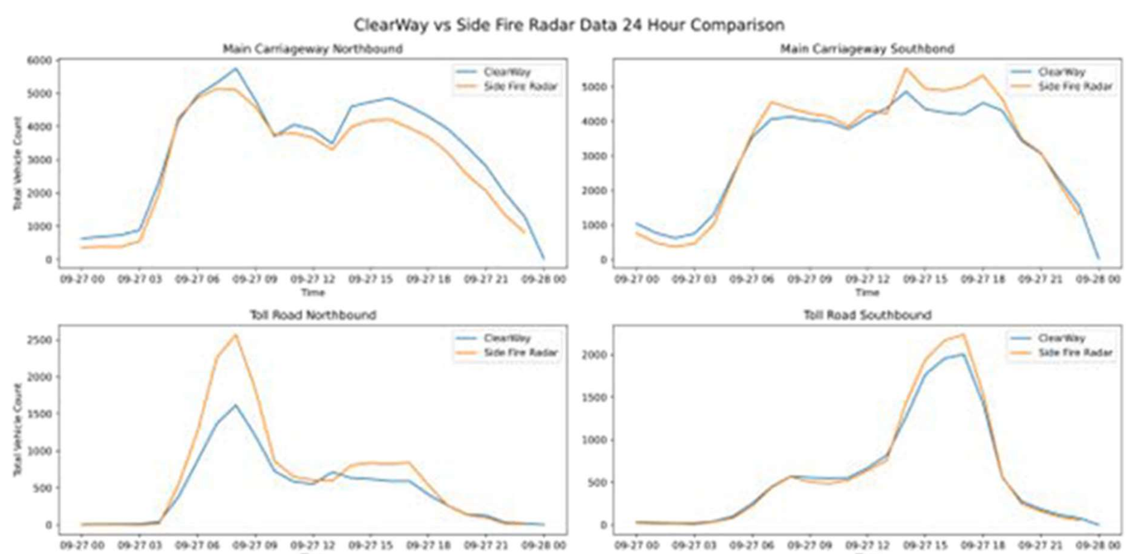

Figure 4 - Graph of vehicle count over time

ClearWay™

Conclusion

ClearWay™ count and classification comparisons with ground-based loops showed good agreement in both total count and classification comparisons. It was seen that loops tended to over count in heavy traffic. Looking deeper into the data it could be seen that loops were undercounting longer classification vehicles and counting them as multiple shorter vehicles in periods of heavy traffic. ClearWay was still able to keep the distinction between vehicle classes in heavy traffic.

The comparison with Flat Panel radar was for a shorter period, due to the limitations of the data able to be accessed. Despite this, good agreement was found between ground-truthed data and ClearWay on a lane-by-lane basis. Lane switching was found to affect all count methods in the vicinity of the count location in terms of lane count accuracy and is certain to have been present in the manual count, although this wasn't initially identified until data was being compared. Navtech were constrained to the trial location, but lane switching will clearly be a consideration when doing any lane-by lane count comparisons with any method.

Summary

The above comparisons show that the count and classification functionality of ClearWay compares favourably to industry standard methods of counting and classifying vehicles. When deploying ClearWay AID functionality for Wrong Way Driving, Stopped Vehicle Detection, Pedestrians or Debris it would be an extremely cost-effective consideration to deploy ClearWay's count functionality at the same time. In doing so you can avoid further costs of deploying additional devices and integration with the peace of mind that the functionality deployed meets the accuracy requirements you already expect.

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