AASHTO
AASHTO INNOVATION INITIATIVE

AASHTO Innovation Initiative

[Proposed] Nomination of Innovation Ready for Implementation

Sponsor

Nominations must be submitted by an AASHTO member DOT willing to help promote the innovation. If selected, the sponsoring DOT will be asked to promote the innovation to other states by participating on a Lead States Team supported by the AASHTO Innovation Initiative.

1. Sponsoring DOT (State): Georgia Department of Transportation

2. Name and Title: Emily Dwyer

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Innovation Description (10 points)

The term "innovation" may include processes, products, techniques, procedures, and practices.

3. Name of the innovation:

High-Risk CMV Notification Program

4. Please describe the innovation.

The High Risk Commercial Vehicle Notification Project was a 6 month pilot project. The intent of this project was to determine if pushing warning notifications to in-cab electronic logging devices (ELDs), ahead of areas with high rates of commercial motor vehicle (CMV) incidents, would have a positive effect on driver behavior. Ten locations around metro Atlanta were selected for this pilot based on an assessment of historical crash data. At each of these locations, specific messages were developed to be pushed to CMV drivers as they entered these predetermined, geofenced areas. Of the ten evaluated sites, eight demonstrated between 4% and 19% reduction in hard braking.

5. What is the existing baseline practice that the innovation intends to replace/improve?

Messaging to the traveling public through dynamic message signs (DMS). Prior to this project, Georgia did not have any baseline practice for messaging specifically to CMV drivers.

6. What problems associated with the baseline practice does the innovation propose to solve?

Prior to the execution of this pilot project, Georgia was only able to message drivers directly through (DMS). While these signs have been proven to be an effective way to communicate information to drivers, they are only deployed in fixed locations around the state and are an expensive infrastructure investment with high maintenance requirements.

Unlike the deployment of DMS, the ability to deploy operational improvements without physical hardware allows GDOT to expand the reach of current communications, provides the opportunity to deploy more quickly, enables modifications to different locations as needed, and does all of this at a fraction of the cost.

7. Briefly describe the history of its development.

In 2012, the Moving Ahead for Progress in the 21st Century Act, Section 32301(b) of the Commercial Motor Vehicle Safety Enhancement Act mandated what would become known as the ELD rule. This mandated regulations requiring ELD use in CMVs involved in interstate commerce, when operated by drivers who are required to keep records of duty status (RODS). By late 2017, these drivers were required to be incompliance by employing the use of an ELD in their vehicle to track hours of service RODS.

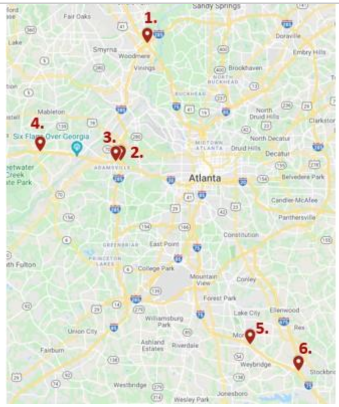
With these mandates in place, suddenly there was the presence of a guaranteed, connected device that could be used to communicate with drivers. This created a marketplace for companies like Drivewyze to provide a new type of services to DOTs: in-cab safety notifications to drivers.

Georgia DOT strives to be a good partner to CMVs traveling through the state and is always researching new ways to do more, with less. Deployments, such as Drivewyze, allow GDOT to expand its reach without the cost of physical infrastructure in the field. When presented with the opportunity to pilot this technology, GDOT believed that there was an opportunity to make lasting impacts to the safety of the traveling public. With this in mind, GDOT initiated the Drivewyze pilot project in 2020. After an initial six month program, GDOT found that the project was making significant strides towards improving driver safety and decided to continue pursuing this project through further investment and project expansion in 2021.

8. What resources—such as technical specifications, training materials, and user guides—have you developed to assist with the deployment effort? If appropriate, please attach or provide weblinks to reports, videos, photographs, diagrams, or other images illustrating the appearance or functionality of the innovation (if electronic, please provide a separate file). Please list your attachments or weblinks here.

At this time, GDOT has not produced any technical specification, training materials or user guides. However, at the conclusion of the initial six month pilot, GDOT and Drivewyze coordinated on a project report to demonstrate the effectiveness of this program. This report not only allows GDOT to leverage the initial pilot in requesting future support, but also allows GDOT to share this success with other agencies, who may need to demonstrate the project's success in order to gain necessary funding. Attached to this nomination form is the pilot report created by Drivewyze.

Attach photographs, diagrams, or other images here. If images are of larger resolution size, please provide as separate files.



Location #	Location	Message
1.	I-285 West at I-75 South I-285 East to I-75 North I-75 South to I-285 East I-75 North to I-285 West	Congestion Area Use Caution
2.	I-285 South to I-20 West	Sharp Curve Ahead Slow Down
3.	I-20 East to I-285 Merge I-285 North to I-20 East	Merging Traffic Ahead Right Lanes Use Caution
4.	I-20 West at Thornton Road	Slow Traffic Thornton Rd Use Caution
5.	I-75 South Near Morrow	Limited Visibility Use Caution
6.	I-675 South to I-75 South	Sharp Curve Ahead Slow Down

State of Development (40 points)

Innovations must be successfully deployed in at least one State DOT. The AII selection process will favor innovations that have advanced beyond the research stage, at least to the pilot deployment stage, and preferably into routine use.

9. How ready is this innovation for implementation in an operational environment? Please select from the following options. Please describe.

☐ Prototype is fully functional and yet to be piloted

☐ Prototype has been piloted successfully in an operational environment

☒ Technology has been deployed multiple times in an operational environment

☐ Technology is ready for full-scale implementation

Phase 1 included a 6-month pilot deployment at 10 locations. The pilot was launched in 2020. GDOT has since renewed the project for another year of operation.

10. What additional development is necessary to enable implementation of the innovation for routine use?

Additional locations and messaging at the new locations would need to be determined to expand its use. But the technology is capable of being deployed at additional locations from routine use.

11. Are other organizations using, currently developing, or have they shown interest in this innovation or of similar technology?? ☐ Yes ☒ No

If so, please list organization names and contacts. Please identify the source of this information.

Organization	Name	Phone	Email
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Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.
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Potential Payoff (30 points)

Payoff is defined as the combination of broad applicability and significant benefit or advantage over baseline practice .

12. How does the innovation meet customer or stakeholder needs in your State DOT or other organizations that have used it?

Through this project, GDOT is able to align with the Federal Highway Administration's Safe System Approach towards zero deaths and move the needle on driver safety on Georgia's roadways. In the 2018 Statewide Strategic Transportation Plan, the State has adopted six transportation goals: improve safety, maintain and preserve the system, improve reliability, relieve congestion, improve freight and economic development and improve the environment. The High Rish Commercial Vehicle Notification Project aligns with two of these goals directly by improving safety and freight development.

13. Identify the top three benefit types your DOT has realized from using this innovation. Describe the type and scale of benefits of using this innovation over baseline practice. Provide additional information, if available, using quantitative metrics, to describe the benefits.

Benefit Types	Please describe:
Improved Safety	Eight of the sites had between 4%-19% reduction in hard braking.
Choose an item.	Click or tap here to enter text.
Choose an item.	Click or tap here to enter text.

Provide any additional description, if necessary:

The results of the study showed there was an overall positive correlation between the push notifications and reduction in hard braking. Eight of the sites had between 4%-19% reduction in hard braking. In 2019, there were 114 fatal accidents that involved CMVs on Georgia Interstates. Rear end collisions were the leading cause of these fatal accidents. There is a clear connection between hard braking events and rear end collisions and by reducing hard braking by nearly 20% in some locations, this project has already saved lives. Every single death on the roadway matters.

14 How broadly might this innovation be deployed for other applications. in the transportation industry (including other disciplines of a DOT, other transportation modes, and private industry)?

This innovation can have broad implications as we move towards more connective vehicles. This technology could be expanded to send not just static messaging, but dynamic messaging to CMVs as congestion develops in real time. And eventually this technology could be used to push safety notifications to any connected vehicle on the roadway.

Market Readiness (20 points)

The AII selection process will favor innovations that can be adopted with a reasonable amount of effort and cost, commensurate with the payoff potential.

15. What specific actions would another organization need to take along each of the following dimensions to adopt this innovation?

Check boxes that apply	Dimensions	Please describe:
☐	Gaining executive leadership support	Click or tap here to enter text.
☒	Communicating benefits	Through GDOT's efforts, the ability to communicate the benefits of this technology would be extremely easy. Any DOT could provide the initial report as support for their own deployment. Additionally, the CMV safety challenges faced by Georgia are not unique and are representative of the CMV safety challenges faces by states around the country.
☒	Overcoming funding constraints	There is a very minor investment to initiate this project. The only funding challenge would be continued support of the program after the initial deployment phase.
☐	Acquiring in-house capabilities	Click or tap here to enter text.
☐	Addressing legal issues (if applicable) (e.g., liability and intellectual property)	Click or tap here to enter text.
☐	Resolving conflicts with existing national/state regulations and standards	Click or tap here to enter text.
☐	Other challenges	Click or tap here to enter text.

16. Please provide details of cost, effort, and length of time expended to deploy the innovation in your organization.

Cost: Pilot Cost - $164,320 and Annual Support and Maintenance (yearly) - $62,400

Level of Effort: This project required project management and initial data collection to determine the initial locations for deployment. After the kickoff and location assessment, there is very little effort required from the DOT.

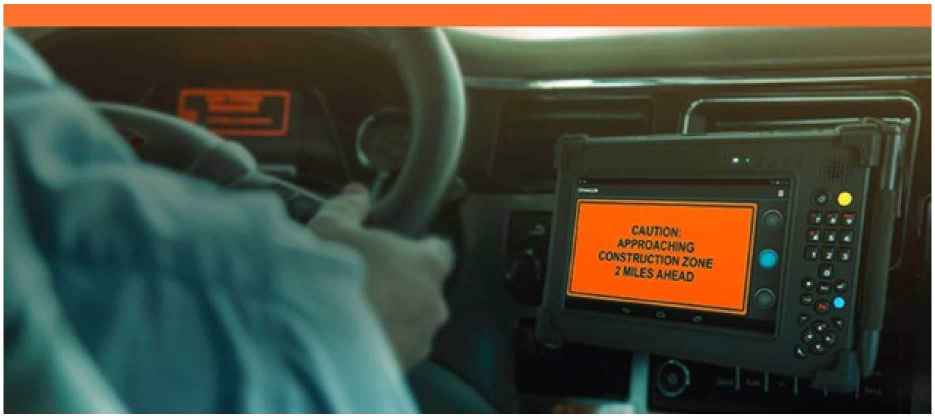
Time: The contract was executed by GDOT in April of 2020 and Drivewyze completed the pilot report with data analysis by December of 2020.

17. To what extent might implementation of this innovation require the involvement of third parties, including vendors, contractors, and consultants? If so, please describe. List the type of expertise required for implementation.

This deployment is a partnership between GDOT and a third party, Drivewyze. As a result, any expertise needed on ELD communications, messaging requirements, and other technical details were shared by Drivewyze. Though Georgia decided to move forward with Drivewyze, there are similar providers available that can likely offer similar services. The more providers engaged, the higher the density of drivers that these safety messages would reach.

Project Report

High-Risk CMV Notification Program in Georgia



6-Month Pilot Implementation Report

Prepared by Drivewyze

December 3, 2020

Drivewyze®

Abstract

This report represents the analysis and results of a 6-month pilot project in Georgia. Overall, 45 days of data was collected at 10 unique messaging points at 6 locations in the greater Atlanta area. Notifications of potential upcoming slowdowns and congested areas were given to commercial drivers enrolled in the Drivewyze Safety program. The overall intent of the initial phase of the project was to test that hypothesis that these notifications would have a positive effect on driver behavior and warrant continued operation of the messaging and notifications.

Over 500,000 unique vehicles visits were given notifications at these locations in the 45 days of operation. There was a positive response to the messages in all but 2 of the messaging points, with one being neutral and one showing a negative effect.

There was a strong positive correlation between alerts shown and earlier/reduced braking at most of the points, indicating that vehicles with alerts enacted less or had less severe hard breaking. This would indicate that drivers are approaching areas of slowdowns more cautiously.   Moreover, it is observed that the reduction in hard braking still occurs throughout the varying days of the week and continued throughout the duration of the pilot study. This leads to the conclusion that irrespective of road conditions and time, these alerts do deliver a value and help towards a larger state goal of drivers being more aware of upcoming potential hazards, and braking action further upstream of the areas of issue.

Contents

Introduction

Safety on Georgia's roads is the highest priority for GDOT. The State has worked toward zero deaths for years. With an increase in expected population, visitors, and licensed drivers, highway safety will remain a priority and concern for GDOT and all roadway users. The State's strategic plan brings together the State's leadership in engineering, education, enforcement, and emergency services to establish statewide goals and emphasis areas. GDOT has teamed with the Governor's Office to create the Georgia Strategic Highway Safety Plan7 to maximize and leverage the State's safety funding resources, in addition, to fulfill federal mandates and maximize the impact of the State's safety funding resources. The overriding goal of this plan is to reduce the number of fatalities and serious injuries that occur on the State's roadways.

In its 2018 Statewide Strategic Transportation Plan, through combining best practices and developing an understanding of customer needs, the State has adopted six transportation goals. Georgia's goals are to:

- Improve safety
- Maintain and preserve the system
- Improve reliability
- Relieve congestion
- Improve freight and economic development
- Improve the environment

The Department has developed a strategic approach to provide well-planned transportation investments to accommodate freight growth and logistics needs statewide. Freight and logistics demand and mobility are critical components in Georgia's economy. The State has committed to invest in mobility solutions in the major urban areas to more efficiently and safely move both people and freight. A major challenge has been to reduce fatalities and injuries in the face of increasing freight and passenger traffic.

Safety, Safety, Safety. Focus in on SAFETY = #1, reducing commercial vehicle-related injuries and fatalities is mutually the number 1 priority for GDOT and Drivewyze.

Drivewyze launched a recent program called Driver Safety Notification, which has been a huge success with fleets who are concerned about safety. This Program alerts the driver in advance of an unknown road condition (Speed limits/ Turns / Blind curve). This advance notification system has shown to be effective in reducing fatalities. This in-cab notification is the pivot intuition that drives this pilot project.

This report captures the results of a successful pilot project undertaken by GDOT and Drivewyze to address freight safety hotspots around Atlanta. The pilot project used Drivewyze in-cab messaging to notify drivers of potential hazards ahead with the primary goal of reducing crash rates and fatalities in high crash areas in Georgia.

Methodology

The general approach taken with the project was as follows:

1. Identification of sites to be studied
2. Assessment of sites and design of regions-of-interest
    a. Validation of regions with GDOT representatives
3. Initial collection of data for all vehicles travelling through the sites
4. Analysis of speed data to determine typical congestion patterns
5. Selection of fixed locations for safety alerts
6. Design and deployment of alert fences and data collection regions
7. Selection of driver populations for comparative study
8. Program operation
9. Secondary data derivation
10. Data analysis and reporting

The six sites to be studied were selected by the sponsoring agency (GDOT), based on data in their possession. The Drivewyze team examined each of the sites and determined probable regions of interest where driver behavior was to be monitored. Initial broad data collection geofences were designed and shared with GDOT, and then discussed in a joint call.

After finalizing the data collection regions, the geofences were deployed to the entire population of Drivewyze vehicles. For 45 days data regarding speed and location was gathered for over 500,000 vehicle visits.

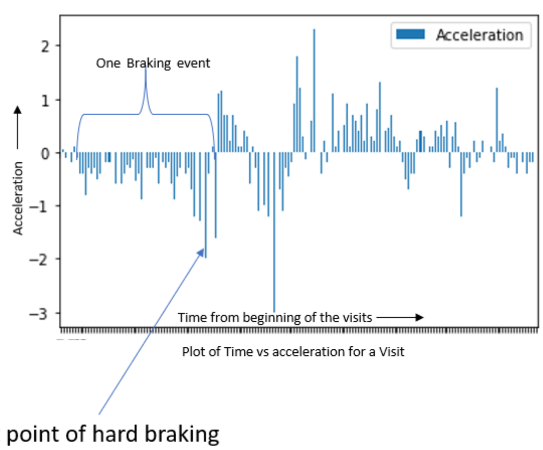


Figure 1 First hard braking event

Previous similar studies have been conducted using speed data to compare driver behavior with or without safety alerts from sign systems with inconclusive results. For the present project, the variability of traffic conditions at the selected sites was expected to produce much noisier speed data, so acceleration data was chosen as the study topic. This is consistent with other studies that have determined that harsh braking is a better indicator of the potential for crashes and other negative traffic effects.

For each driver/vehicle visit at one of the sites, a series of continuous acceleration values is computed. The first hard braking event, where the severity of braking exceeds -2 m/s^2, in each braking event was chosen (a continuous deceleration is considered as one braking event). Events of braking harder than -7m/s^2 were observed and identified as GPS anomalies. These events are outliers and were removed from the data set. Figure 1 illustrates the firsts hard barking event in the acceleration vs time.

The visualization of speed data showed typical patterns of congestion with reasonably consistent regions where braking occurred. Fixed locations for safety alerts were chosen to be deployed several hundred meters upstream from the typical (90th percentile) onset of congestion. The point for an alert fence was 600 -900 meters in advance of the hot spot for congestion. This distance would approximately give 20 seconds at highway speeds which are sufficient reaction time for the driver.

In Figure 2, we can see the development of the fences through the study for the site “Westhaven and Fairburn Site”. Figure 2 1 shows the initial data collection area, with various entry and exit fences that are mapping leading to more than one site. The density plot of the data collected in routes is shown in Figure 2 3. With the help of this density plot, deployed alert fences as shown in Figure 2 4

Figure 2 1: Data collection fence

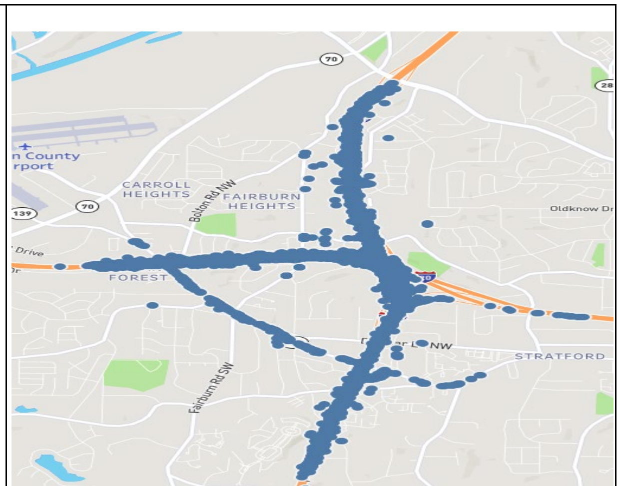


Figure 2 2: Hard braking events

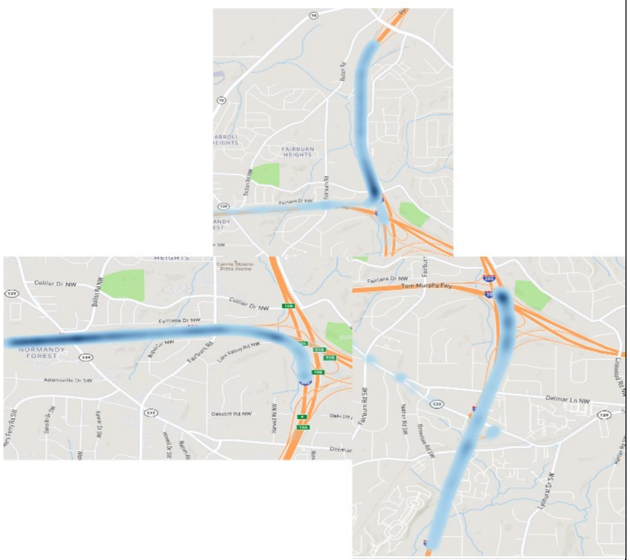


Figure 2 3: Density plot of hard braking events

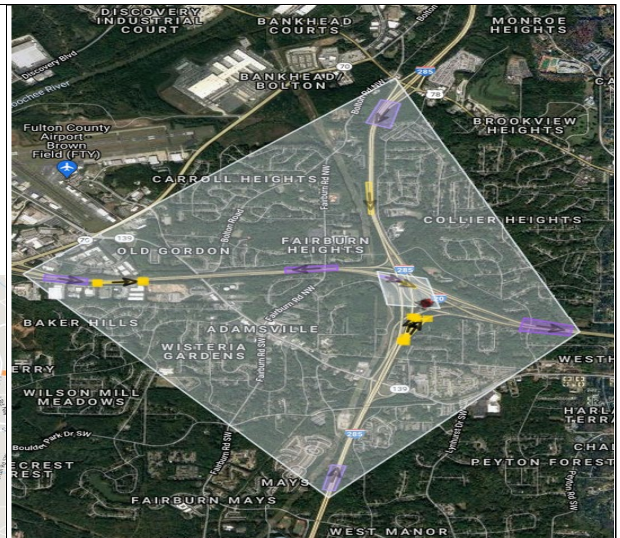


Figure 2 4: Location of alert fences

Figure 2: Development of the fences

The six selected sites have multiple routes (multiple entry and exits) and depending on the route taken each of the sites is further classified into many other sites and henceforth referred to as sites.

Alerts were designed according to GDOT specifications and deployed with trigger geofences. Adjustments to data collection fences were made to ensure that a generous amount of data would be available before the alert and well into the areas of typical congestion. All these elements were then deployed to the entire population of Drivewyze vehicles, but the display of the safety alert was predicated on a vehicle's membership in the Drivewyze Safety Program.

This method of dividing vehicles into two sets (safety membership / no safety membership) was chosen because it allowed the study to proceed quickly without the complication of notifying participating fleets. The safety alerts developed in this project are consistent with the goals of the existing Drivewyze safety program, so participating fleets could be shown the new alerts without requiring driver training or other onboarding complications.

Data examined included "number of vehicles having hard braking event per 100 vehicles", "number of hard braking events", and severity of braking in each group. The data was also analyzed as per the day of the week to understand any underlying pattern or biases that it might present.

Results and Discussion

This section will discuss the results of this pilot study, and the observed results. During this pilot, we showed 229, 942 alerts, and 107,970 no alerts in the span of 30 days from 31st July to 30th August 2020 distributed amongst ten sites.

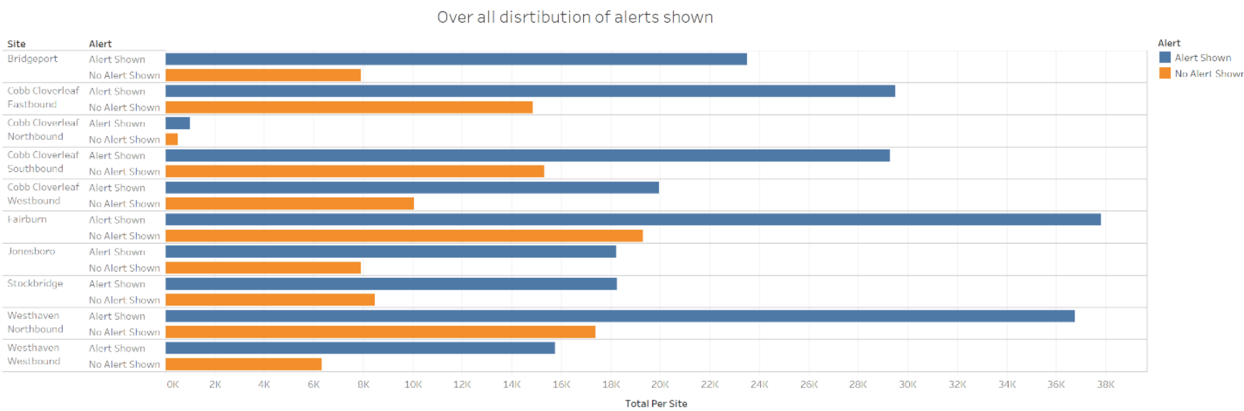
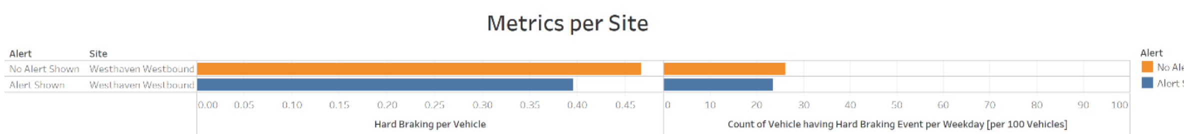


Figure 3 Distribution of alert shown vs no alert shown at different sites.

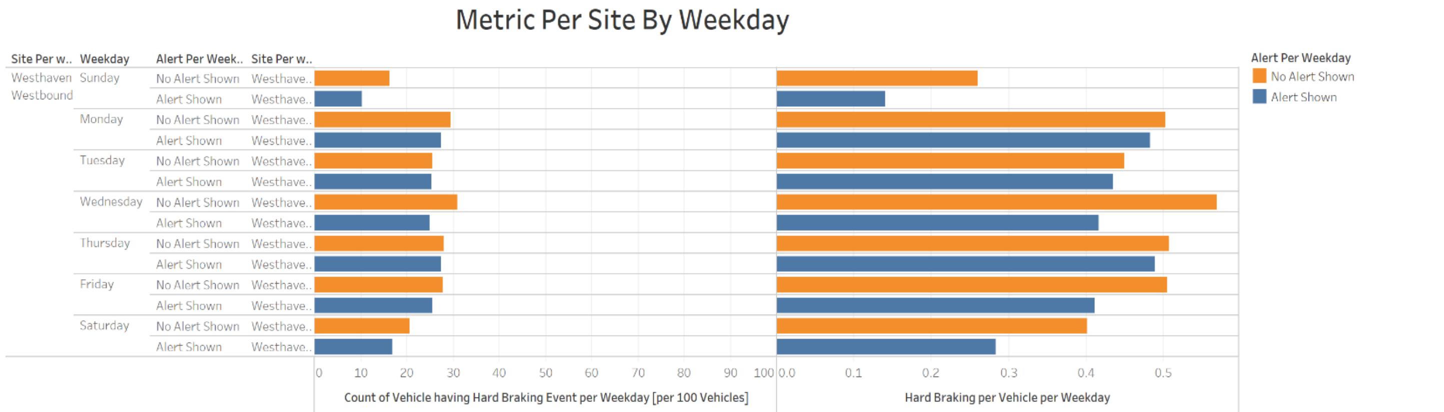
We observe that the ratio of vehicles that are shown alerts to vehicles that are not shown alert at each of the sites is in the range between 2 to 2.5; except for the site Bridgeport which is discussed later. Due to the large size of the population, this ratio does not skew the measures and effectiveness of the alert. Cobb Cloverleaf NW has a much smaller population of visits than the other sites.

For simplicity of discussion, we will discuss the results for all the vehicles visiting one of the chosen routes, i.e., Westhaven Westbound.



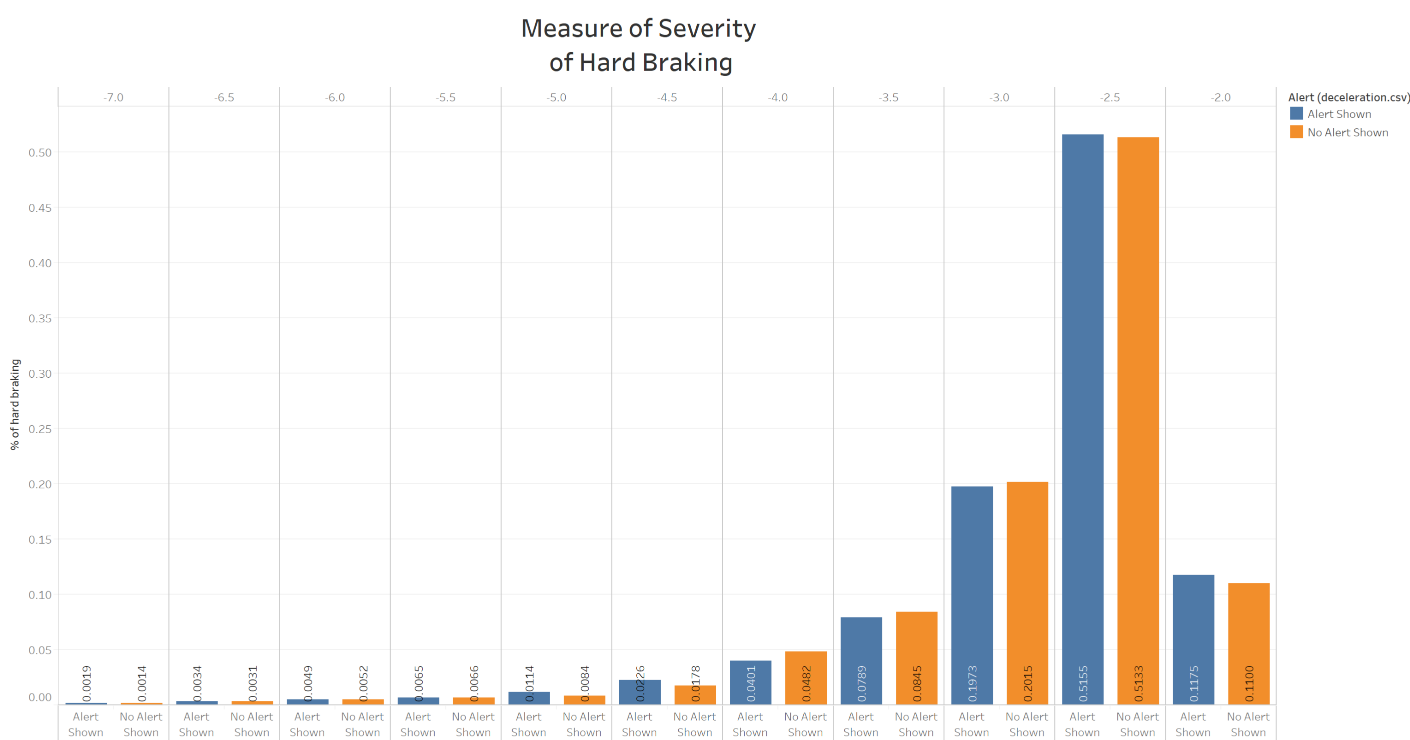
Graph 1: Hard braking metrics for the site of 'Westhaven Westbound'

From Graph 1 we observe that the number of drivers those who were shown alert had a lower number of hard braking event per vehicle/visit. Additionally, the number of vehicles experiencing hard braking events per 100 vehicles is lower than those who were not shown alert.



Graph 2: Metrics by weekdays for the site 'Westhaven Westbound'

Graph 2 illustrates measures along weekdays. It is observed that vehicles that are shown alerts have a consistently lower number of breaking events, and a lower number of vehicles experience (per 100) hard braking events. This leads to the point that despite varying traffic and road conditions throughout the week the effect of alerts on the drivers who were shown to drivers were uniform. It is also observed that there is a significant separation during the weekend than weekdays.



Graph 3: Measure of severity of deceleration for the site 'Westhaven Westbound'

From the histogram in Graph 3 titled "Measure of Severity of Hard Braking," it is observed that for both the groups (alert shown and no alert shown) majority of the hard braking ~50% is of the magnitude -2.5m/s^2 and belongs to the bin -2.5m/s^2 to – 3m/s^2. As the severity increases, it is observed that the percentage of hard braking belonging in that deceleration bin belonging to people who were not shown an alert is higher than people who were shown an alert. People who are not shown error experience more severe braking events than people who are shown error.

Site	**Alerted?**	**Total Visits**	**Total Hard Braking Events**	**Visits with Hard Braking Event**	**Hard Breaking Events per Visit**	**% of Visits With Hard Breaking Event**	**Improvement in Braking Behavior With Alert**
Bridgeport	YES	23510	10643	5728	0.453	24.4%	-19.6%
	NO	7892	3002	1610	0.38	20.4%	
Cobb Cloverleaf Eastbound	YES	29510	13121	8995	0.445	30.5%	+4.0%
	NO	14864	7624	4727	0.513	31.8%	
Cobb Cloverleaf Northbound	YES	980	61	49	0.062	5.0%	+50.0%
	NO	479	77	48	0.161	10.0%	
Cobb Cloverleaf Southbound	YES	29260	6948	4940	0.237	16.9%	+12.0%
	NO	15302	4289	2942	0.28	19.2%	
Cobb Cloverleaf Westbound	YES	19955	4568	2745	0.229	13.8%	+4.0%
	NO	10041	2289	1449	0.228	14.4%	
Fairburn	YES	37785	11843	6986	0.313	18.5%	-3.0%
	NO	19307	5796	3459	0.3	17.9%	
Jonesboro	YES	18213	3414	2168	0.187	11.9%	+18.0%
	NO	7909	1884	1151	0.238	14.6%	
Stockbridge	YES	18244	2325	1455	0.127	8.0%	+19.0%
	NO	8455	1397	836	0.165	9.9%	
Westhaven Westbound	YES	15748	6231	3689	0.396	23.4%	+10.0%
	NO	6324	2954	1650	0.467	26.1%	
Westhaven Northbound	YES	36737	9054	6258	0.246	17.0%	+13.0%
	NO	17397	5116	3407	0.294	19.6%	

Table 1: Raw Counts for All Sites

Table 1 contains the raw number of all the events captured on the road at these sites. From the column of interest is the percentage of vehicles/driver that will not experience any hard baking event when an alert is shown. This is calculated by:

$$\% \; improvement = \frac{NA - A}{NA}$$
$$Where \; NA = \% \; of \; Vehicle \; expiriencing \; hard \; braking \; when \; no \; alert \; is \; shown;$$
$$and \; A = \% \; of \; Vehicle \; expiriencing \; hard \; braking \; when \; an \; alert \; is \; shown$$

Equation 1: Equation to calculate gain

From Table 1 it is seen that for all sites there has been an improvement except for the site at Fairburn and Bridgeport. The improvement ranges from 4% to 19%. The 50% improvement at Cobb Cloverleaf Northbound has a small underlying data set.

Site	p-value	z-value	p-value <0.05	Hypothesis Rejected/ Accepted	Result
Bridgeport	7.504 e-15	7.776	Yes	Rejected	Significant: Negative correlation
Stockbridge	5.767 e-07	-4.999	Yes	Rejected	Significant: Positive correlation
Cobb Cloverleaf Eastbound	0.003	-2.998	Yes	Rejected	Significant: Positive correlation
Fairburn	0.116	1.571	No	Accepted	not significant
Cobb Cloverleaf Southbound	6.082 e-11	-6.542	Yes	Rejected	Significant: Positive correlation
Westhaven Northbound	4.837 e-13	-7.230	Yes	Rejected	Significant: Positive correlation
Westhaven Westbound	6.123 e-05	-4.008	Yes	Rejected	Significant: Positive correlation
Jonesboro	1.361 e-10	-6.420	Yes	Rejected	Significant: Positive correlation
Cobb Cloverleaf Westbound	0.0396	-2.057	Yes	Rejected	Significant: Positive correlation
Cobb Cloverleaf Northbound	0.0005	-3.468	Yes	Rejected	Significant: Positive correlation

Table 2: Z proportions test for each of the site

For statistical significance, we do A/B testing with the z-proportions test, where the null hypothesis states that there is “no statistically significant differences in the hard raking behavior between the two groups” (when an alert is shown or when no alert is shown). Table 2 has the z-value and p-value for the double-sided z proportions test. As the sample size is large enough there was no need to determine whether the sample size is adequate.

Bridgeport Anomaly

The anomalous result at the Bridgeport site calls for an explanation and likely further analysis or follow-up experimentation. Possible directions for this exploration might include:

- Error in fence placement, where the alert interacts negatively with features of the site such as other signage or driving conditions – a possible site visit to view and record general driver behavior at the site may provide further insight
- Measurement error such as mislabeling a cautious response as a hard braking event
- Error in alert text, where features of the site lead drivers to an incorrect interpretation of the alert and the correct safe behavior
- Unknown effect of there being a higher-than-average ratio of "alerts shown"
- Differences in the driver population at this site, such as a higher number of drivers from a particular fleet, or a higher or lower number if first-time drivers

Fairburn shows a slight negative improvement, but the statistical test suggests that there is no significant difference in the behavior suggest there might be a result of a physical road condition that affects all the drivers equally.

These two sites require further investigations and more studies with different time frames under observation. Additional investigation and analysis are called for but was not possible in the time frame of the present study.

Speed Analysis

Vehicle speed through the site was analyzed as an absolute measure. The hypothesis being tested was that the presence of a safety alert would not affect the driver's average or maximum speed through the site (rejection of the hypothesis would indicate a significantly measurable effect).

Unfortunately, the nature of the sites brings a large amount of variability to vehicle speed, possibly due to frequently changing conditions or to the presence or absence of a training effect on repeat drivers. The early statistics for absolute speed were very noisy, and any effect, if present, was masked by more dominant features of the environment. No sound conclusions can be drawn from this early examination.

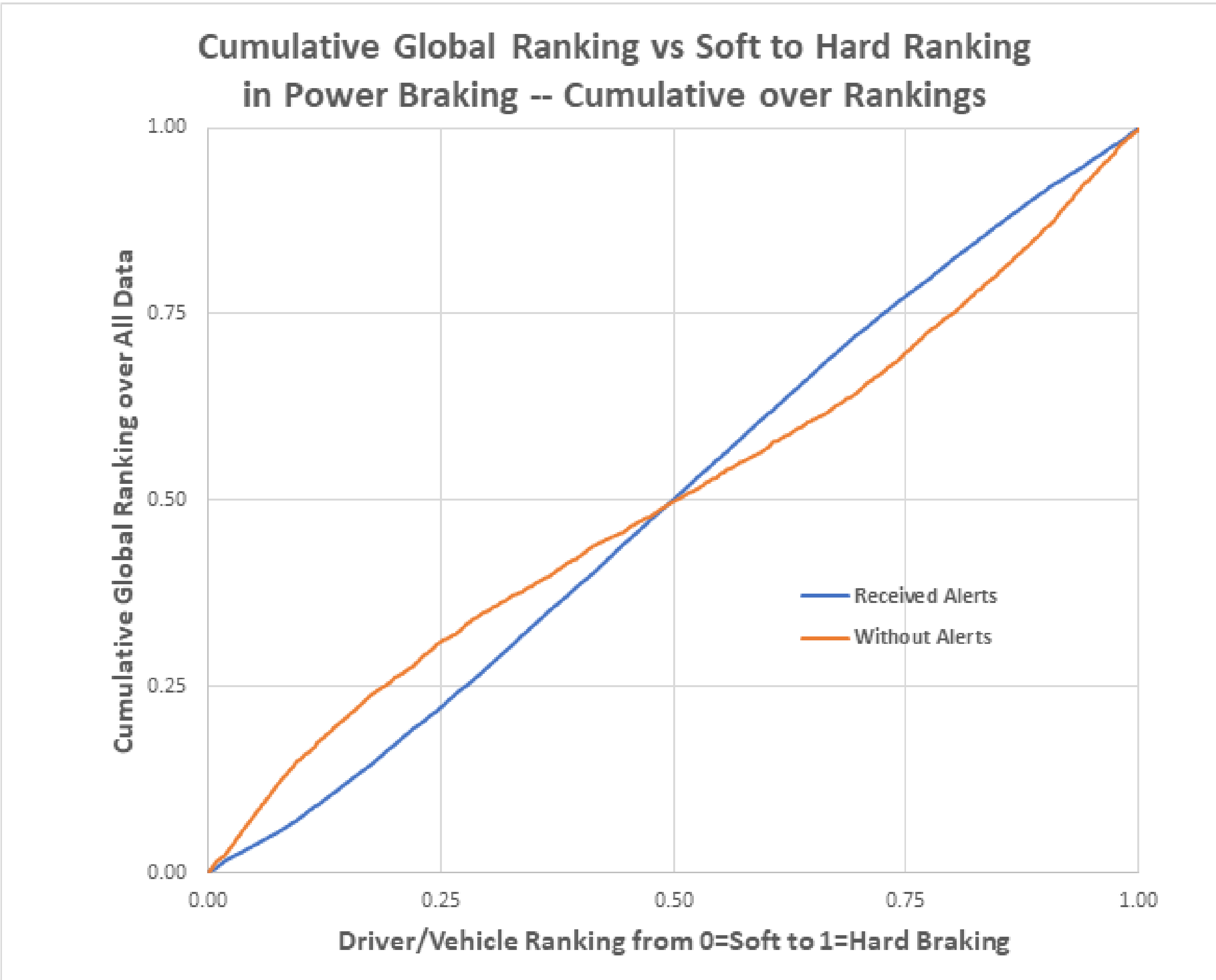
Follow-up treatments of speed that may be more promising might include:

- Non-parametric test based on a drivers' speed relative to a cohort of surrounding vehicles. We have not tested whether there is sufficient density data in small time slices to form such cohorts and perform the ranking tests.
- Examination of drivers' speed change immediately following an alert. While this might not lead directly to a conclusion about safety outcomes, it would perhaps show that the alerts are increasing driver attention if, for example, we can see the driver lifting his foot off the accelerator while he assesses conditions more closely.

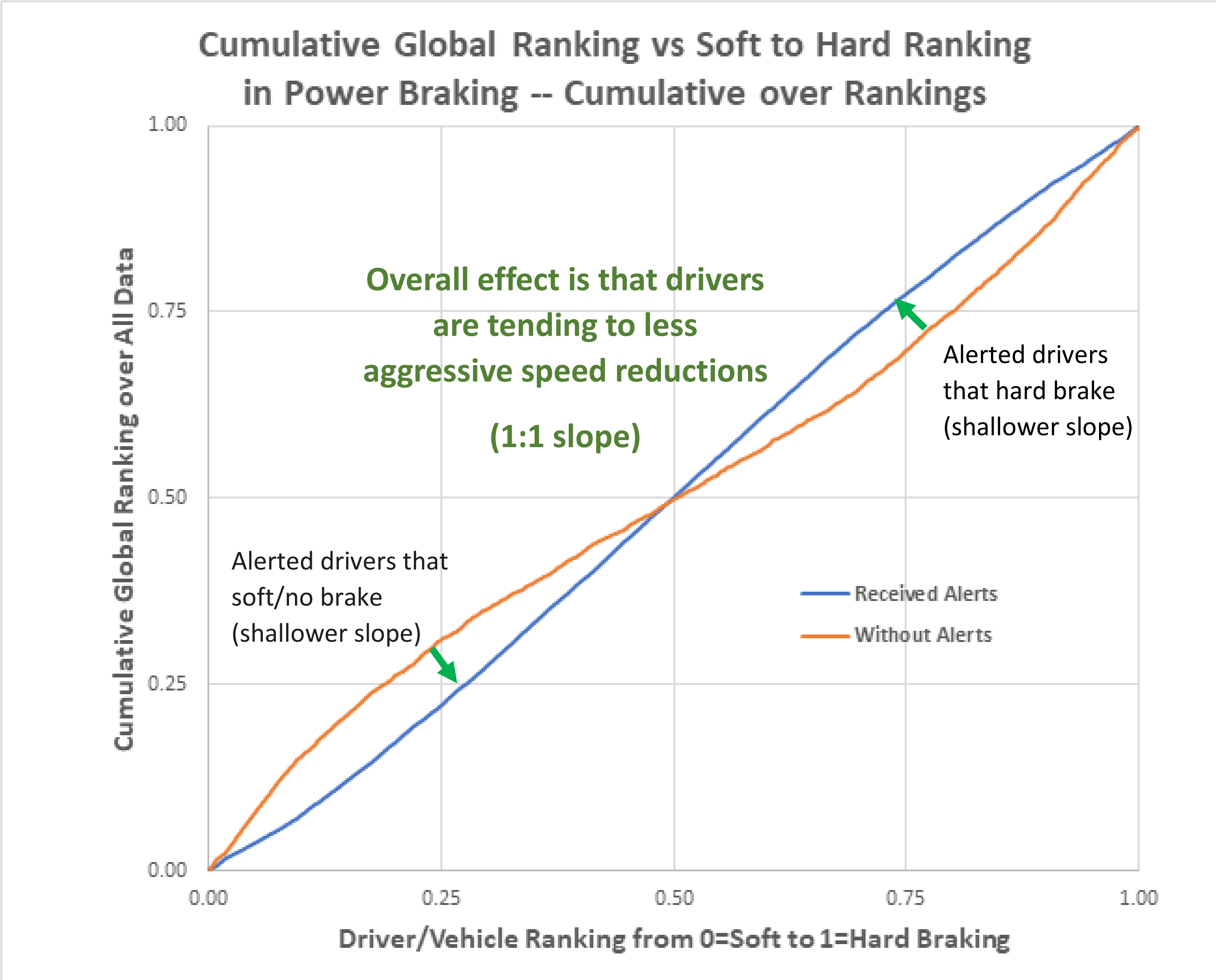
Non-Parametric Testing

The above analysis of absolute braking power behavior versus alerts revealed anomalous results at one site (Bridgeport) and no correlation at a second site (Fairburn). This finding led us to explore non-parametric testing as a method of reducing the effect of confounding factors such as highly variable road conditions. This result also confirms the difficulty of finding repeatable results across such a diverse set of circumstances and with a relatively small set of repeat data samples from the same drivers.

Running non-parametric analysis on raw braking deceleration over sites and over sites with bi-hourly time-of-day parsing, there is virtually no correlation over-all, and very tiny correlation for “good” light brakers and “bad” hard brakers. Using Amaxneg * Vmax, mild effects from Alerts become Apparent.



Graph 4 : Cumulative Alerts vs Braking Power



What you notice are the slopes in "Cumulative Alerts vs Cumulative Hard to Soft Power Braking" are slightly lower on both ends and slightly higher in the middle. This suggests that a portion of lower levels Alerts are correlated with low and high extremes in braking power, or Alerts are correlated with mid-range power deceleration. This is consistent with our hypothesis regarding the effect of Alerts: namely, early alerts correlate with moderate appropriate braking power applied after our warnings. Follow-up review of earlier results for raw braking deceleration over sites with bi-hourly time-of-day parsing showed similar but attenuated effects there too. The effect while small indicates there is a response that is correlatable and repeatable.

Interpretation

The above analyses, both of raw braking behaviour and non-parametric analysis, indicate mild to moderate effects of alerts on driver behaviour, but it is difficult to extract the effect from a very noisy data set. Raw braking deceleration versus alerting showed strong effects at some sites, but negative correlations at one site, which is troubling. Alerts seemed to encourage moderate braking power, which is consistent with improved driver attention. Poor attention might be indicated by low braking power followed by sudden high braking power when the driver finally encounters the changed conditions. High attention might be indicated by a cautious application of moderate braking power at the first sign of poor conditions.

Braking power is a measure of speed times negative acceleration (braking). This estimates how much of the vehicle's energy is being dissipated through the braking system. More severe braking (harder deceleration at higher speeds) can be directly connected to safety.

The graph above illustrates two effects of alerts. The lower slope of the line at the bottom-left and top-right extremes indicates fewer drivers in the "alerted" category are bunched into those two extremes, and the higher slope in the middle indicates more drivers in the "alerted" category are represented there. The lower extreme contains drivers that approach the site and then hit the brakes hard, a behavior we wish to avoid. The upper extreme contains drivers that approach the site and float through it without braking, also a behavior we wish to avoid. The central region represents moderate braking, which can be interpreted as contributing to smoother traffic flow through a troublesome region of congestion. The shift of drivers from the extremes to the central region of the graph is positive and significant.

This is an important finding, as our desire in alerting drivers is to promote exactly this smooth driving reaction, bringing drivers from both extremes more towards the center.

Assumptions and Bias

The assumptions which might have a varying amount of effect on the outcome of this pilot study are discussed below.

The vehicles examined are the population of Drivewyze vehicles, including those subscribing to a paid service and a proportion of vehicles operating Drivewyze in an "analytics" (pre-sales) mode. This is only a portion of the total vehicles traveling through the sites, but the population size is sufficient to support conclusions.

Alerts were shown only to drivers subscribed to Drivewyze safety service. Presumably, those fleets are more conscious of the importance of a safety program, and those drivers may be exposed to more safety training outside of the project. The population of drivers monitored but not shown an alert also belong to fleets that have expressed an interest in Drivewyze services, so there may be differences between those drivers and the typical driver on the road.

Alerted vehicles were consistent for the entire project period. There is some data available from the initial assessment period before alerts were placed, but comparisons of individual driver behavior at these two times were not attempted due to the sparseness of the initial data set.

Alerts were shown every time a selected driver passed through the site. There was no awareness of actual conditions at the time of the visit. Previous safety studies of a similar nature showed that alerts did not lose their effectiveness over time and repeated exposure.

Future Experimental Design

Some suggested directions for future experimental design could include:

- Observation of real-time congestion conditions, including the location of congestion onset, and separation of driver visits into congested and non-congested groups
- Comparison of same driver behavior in pre-alerted state and a post-training state after being exposed to several alerts at the same site
- Analysis of alert location versus typical onset of congestion, for each site
  - Adjustment of alert location, forwards or backwards
- Investigation (possible site visit) to the Bridgeport site to investigate potential reasons for the negative correlation/outlier results that were seen.
- Longitudinal study:
  - Desensitization over time
  - Training effect over time
  - Peak effect for drivers making first visit
  - Metric to understand the value of the alerts

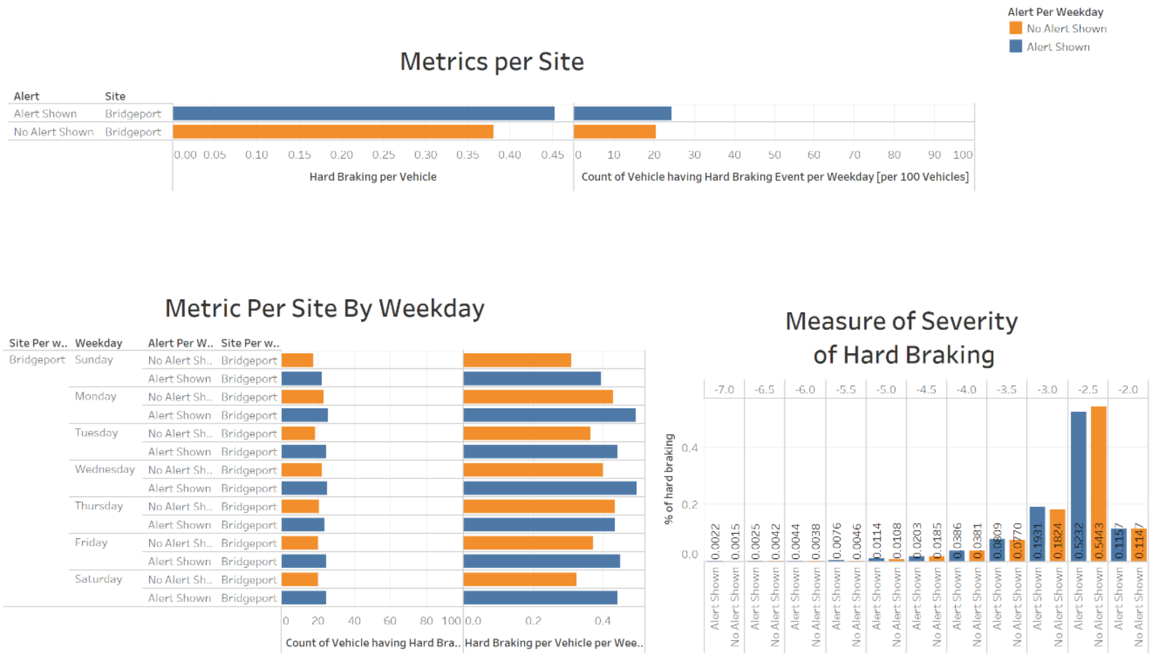
Real-time congestion data may be extracted from the GPS data collected in the study, or from other available data sets such as INRIX traffic data.

Conclusions

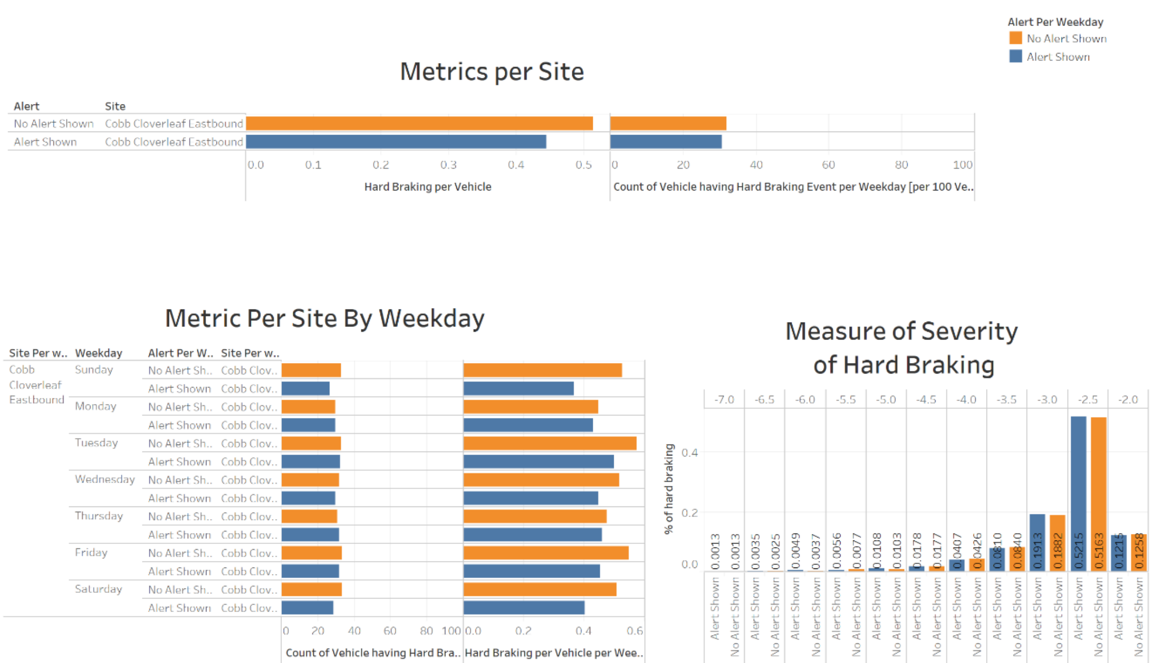
We observed a positive correlation between alerts shown and earlier/reduced braking on the road, indicating that vehicles with alerts enacted less or less severe hard breaking. This would indicate that drivers are approaching areas of slowdowns more cautiously. Moreover, it was observed that the reduction in hard braking still occurs throughout the varying days of the week and continued throughout the duration of the pilot study. This leads to the conclusion that irrespective of road conditions and time, these alerts do deliver a value and help towards a larger state goal of drivers being more aware of upcoming potential hazards, and braking action further upstream of the areas of issue.

In traffic management, these are considered positive results and have the potential to reduce crashes and potentially save lives.

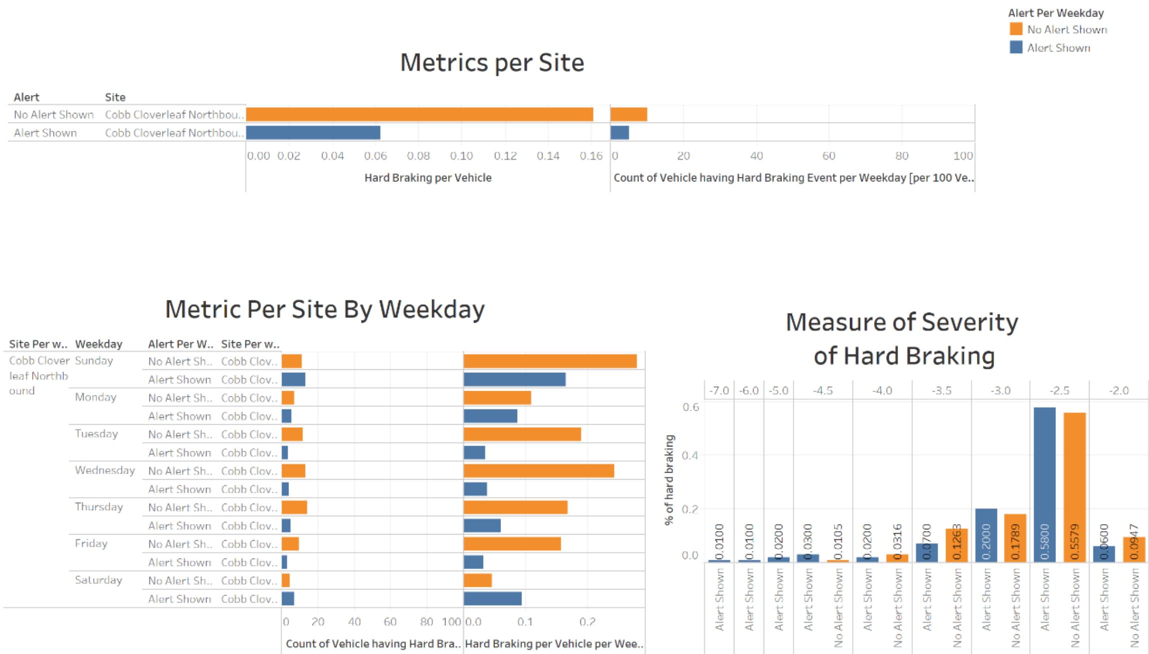
Appendix



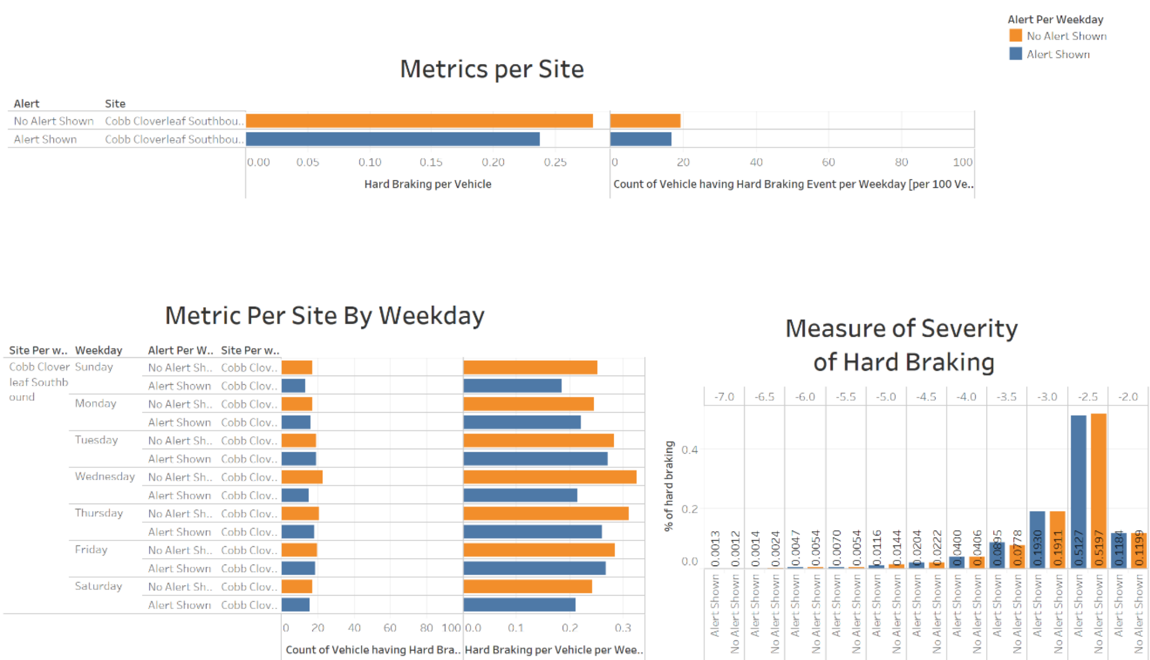
Graph 4: Metrics for the site Bridgeport



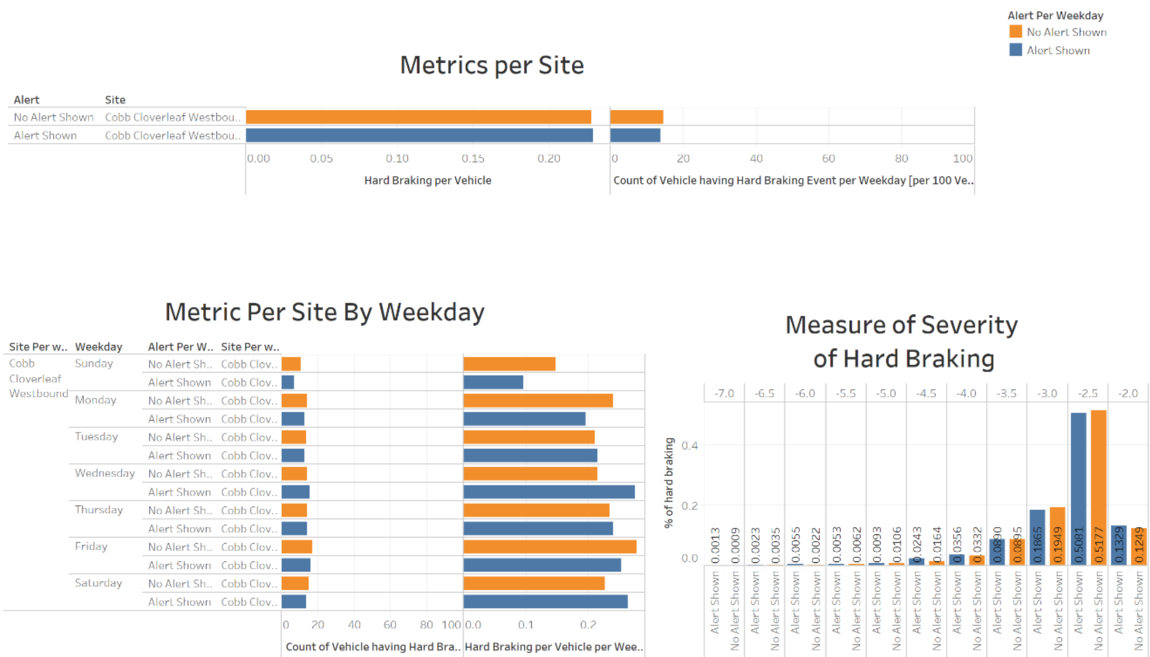
Graph 5: Metrics for the site Cobb Cloverleaf Eastbound



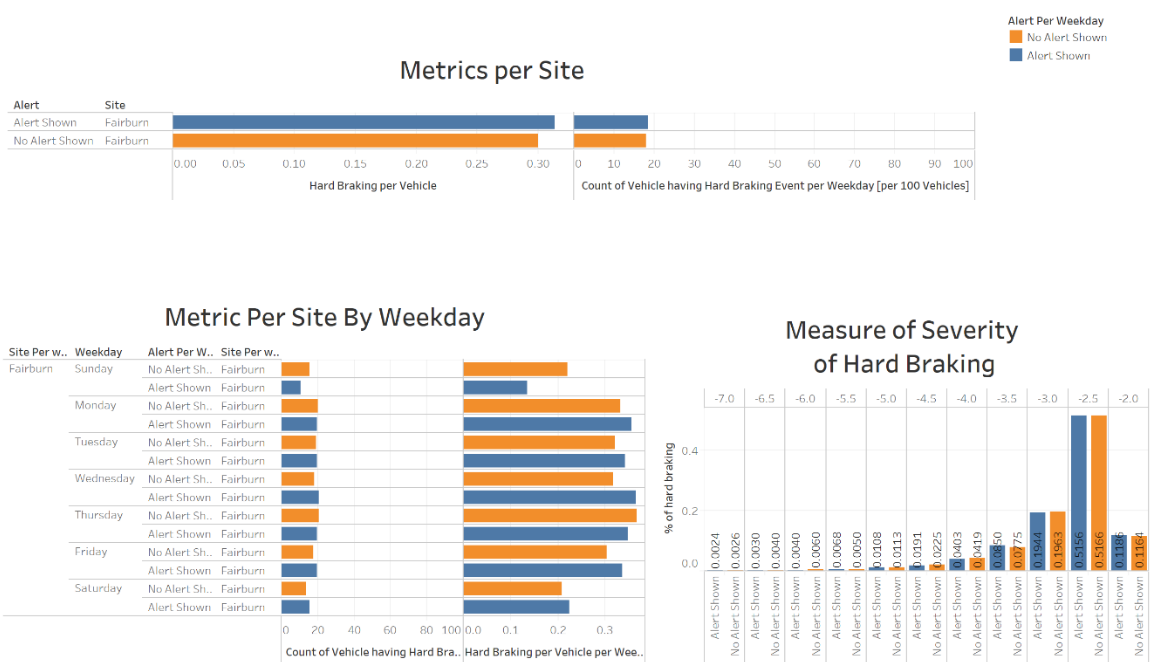
Graph 6: Metrics for the site Cobb Cloverleaf Northbound



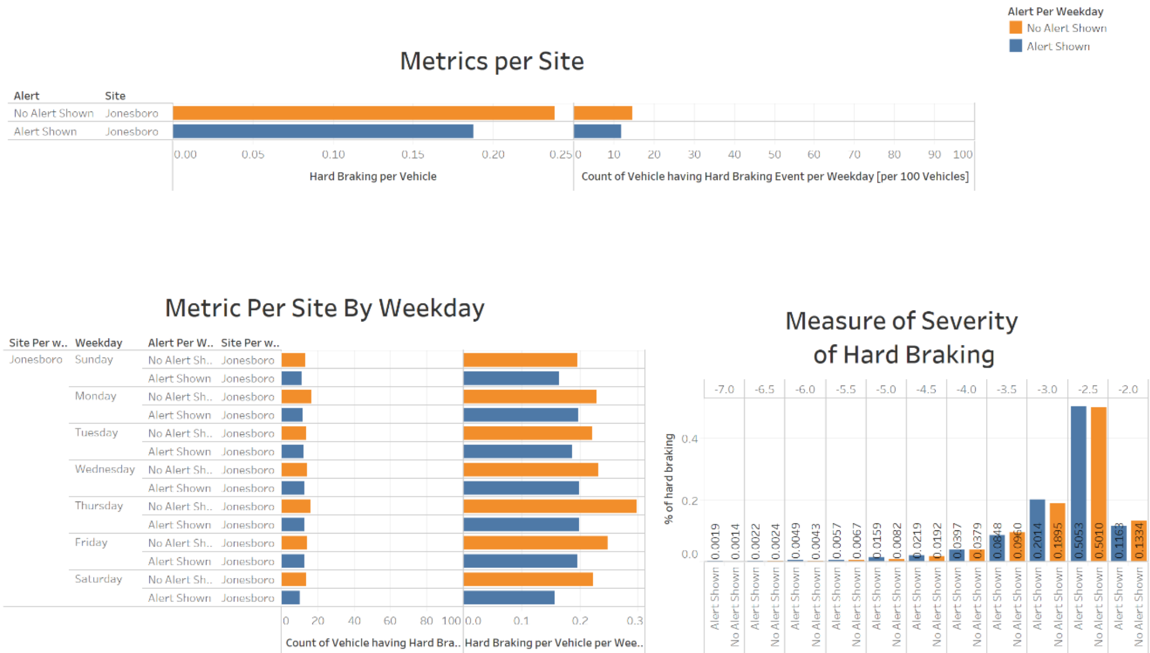
Graph 7: Metrics for the site Cobb Cloverleaf Southbound



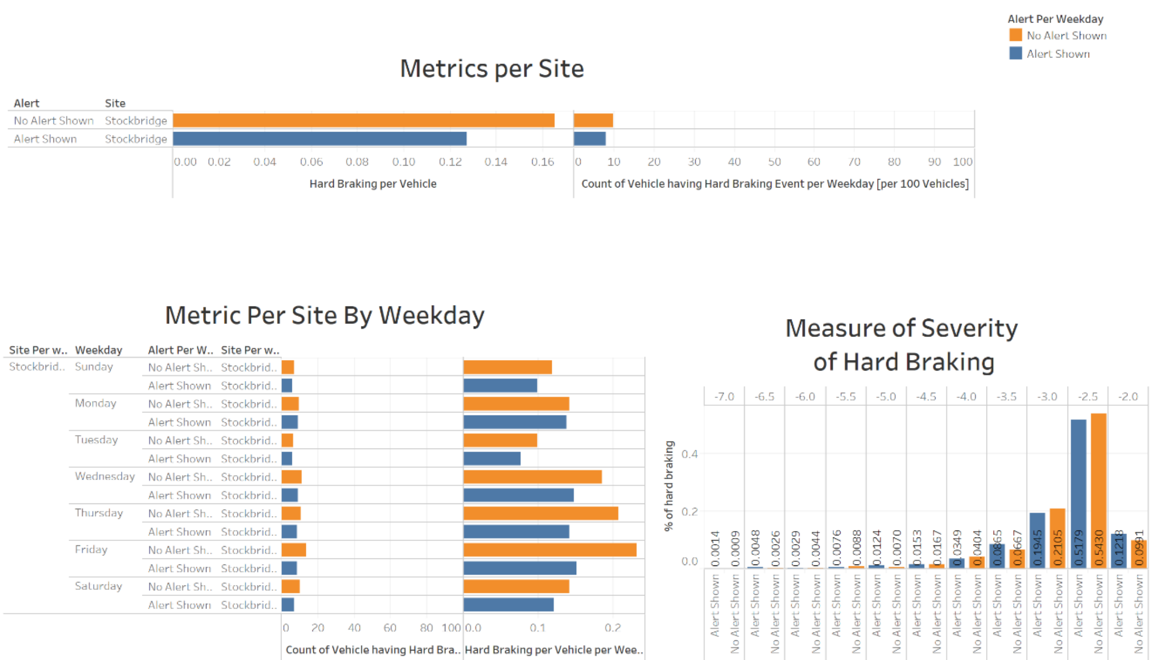
Graph 8: Metrics for the site Cobb Cloverleaf Westbound



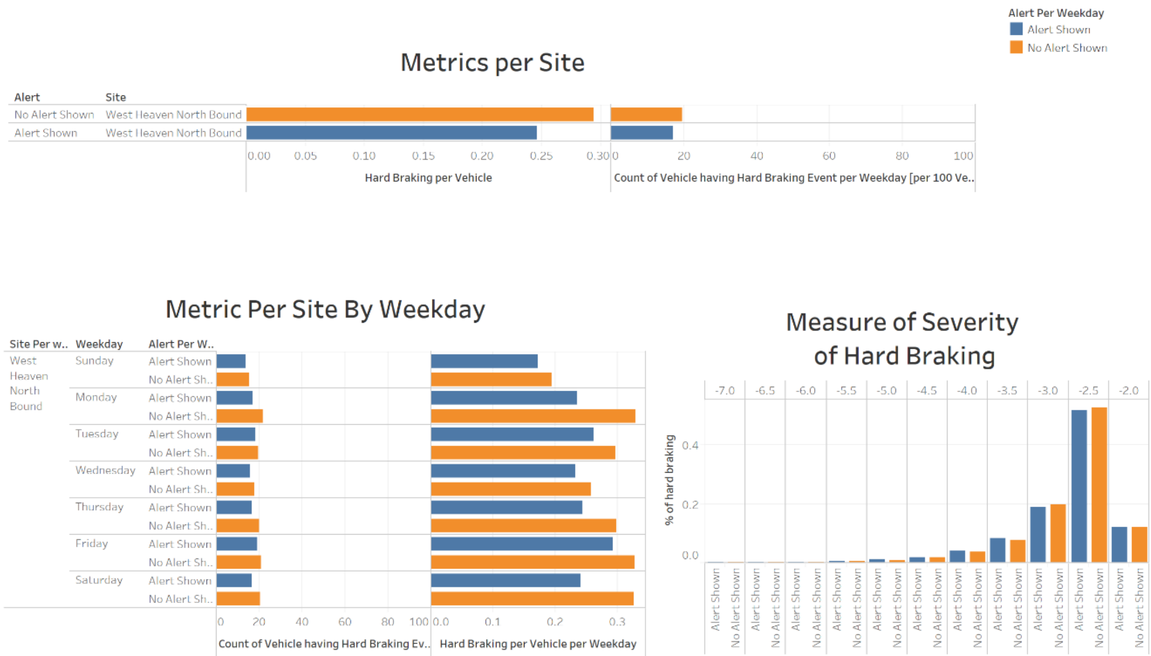
Graph 9: Metrics for the site Fairburn



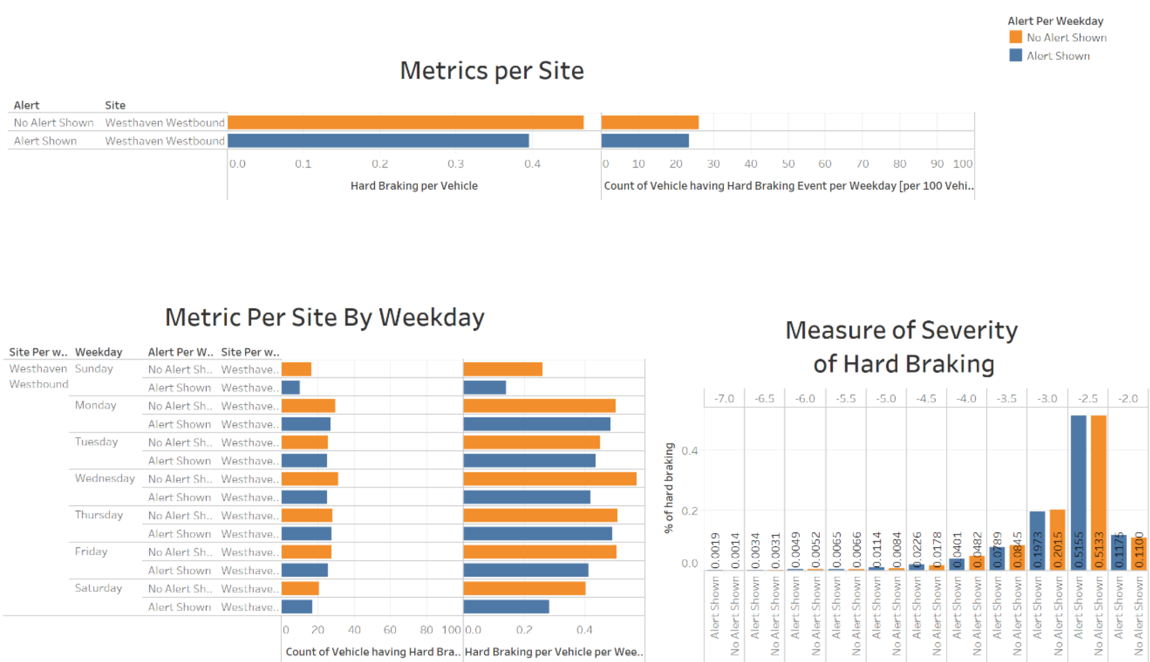
Graph 10: Metrics for the site Jonesboro



Graph 11: Metrics for the site Stockbridge



Graph 12: Metrics for the site Westhaven Northbound



Graph14: Metrics for the site Westhaven Westbound