



Spectrum  
Traffic Insights

miovision  
rethink traffic



## ABOUT MIOVISION

Miovision empowers transportation professionals, through data and infrastructure, to improve the transportation experience for everyone. With over 650 customers in 50 countries across the world, Miovision provides meaningful solutions to real challenges facing today's traffic systems.

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## INTRODUCTION

Operating a modern traffic system requires the ability to not only manage the asphalt, concrete, steel, and electronics that make up road infrastructure, but also to understand the data produced by it.

As a provider of intelligent traffic signal management solutions, Miovision knows first-hand how traffic teams can leverage the power of traffic data to improve congestion, safety, and operating efficiency.

This document provides an overview of the role of data in traffic operations today and describes how cities are using Miovision's Spectrum solution to collect, understand, and utilize traffic data. Spectrum is a turnkey signal connectivity and management solution built to let cities embrace the principles of data-driven traffic operations.

# THE EVOLUTION OF DATA-DRIVEN TRAFFIC OPERATIONS

A transformational change is underway in public sector traffic agencies. Cities are awakening to the power of traffic data as a foundational element of how they plan, build, and operate their road networks. The advent of enabling technologies – remote connectivity, vehicle detection, and software tools – is helping drive this change. Another key driver is public pressure for agencies to be accountable and measurable in using taxpayer dollars.

Traffic teams are already realizing significant benefits from being more data-driven in their operations and decision-making. Teams are now empowered by data to respond more quickly to public safety issues, optimize existing infrastructure to reduce congestion, and more effectively deploy limited budget dollars. However this transformation is by no means complete, as agencies continue to face challenges in making this shift.

## The Obstacles to Data-Driven Traffic Operations

Despite the recognized benefits of agencies moving to a more data-driven framework, three main obstacles are hindering the transition.

### Supporting Infrastructure

Historically, two pieces of supporting infrastructure are needed to generate signal performance metrics: a controller capable of producing high-resolution data and remote connectivity. Traffic controllers supporting hi-res data are limited to only the latest generation of devices, and according to a recent Miovision survey, remote connectivity is lacking in over 50% of North America's traffic cabinets. The lack of this infrastructure has limited the rollout of data-driven practices in many agencies.

### Data Analysis Tools

Generating actionable insights from large volumes of traffic data requires analytical software tools. The Advanced Traffic Management System (ATMS) or central software systems in place in most agencies today aren't equipped to perform sophisticated analysis of traffic data. The software systems that do support advanced data analysis are typically limited to modeling signal performance data, without the ability to analyze network-level trends, arterial performance, or maintenance metrics.

### Technical Expertise

Leveraging data-driven tools for traffic operations has historically been complex and required expertise in two areas: technical IT to maintain sophisticated server systems for data processing and traffic engineering to interpret and understand the resulting data metrics. Many small and medium sized traffic agencies have continued to struggle to deploy traffic data analysis systems due to a lack of expertise in these areas.

## The Four Benefits of Enhanced Traffic Operations

Spectrum's Traffic Insights tools are helping agencies solve these obstacles by utilizing performance measures and data analysis to enhance traffic operations. Agencies that can effectively collect, understand, and utilize data have shown the ability to enhance traffic operations in four main ways.

### Network Monitoring

Agencies are able to leverage real-time data to understand when congestion is occurring and if these events are normal or indicate an issue in the traffic network. This is helping operations teams develop traffic plans using accurate and timely traffic data, as opposed to approximate models based on sporadic and potentially out-dated engineering studies.

### Optimizing Intersection Performance

Agencies are able to leverage signal performance metrics that quantify and analyze intersection flow from a number of perspectives. These tools are helping engineers to not only identify coordination or configuration issues, but also significantly reduce the time that it takes to diagnose and solve traffic issues.

### Measuring Impact and ROI

Assessing the impact of a change to road design, a timing plan, or a traffic policy has historically been challenging, time consuming, and expensive. Data-driven traffic agencies are able to leverage the power of "before/after" analysis immediately after making a change, so that the true impact and return-on-investment of an initiative can be determined.

### Data-Driven Decision Making

Agencies are not only using data to optimize traffic flow; they are using data to optimize strategic decision-making. Capital and operating investment decisions are areas of traffic strategy increasingly influenced by data-driven objectives. Agencies can report on their fiduciary responsibility to council and the public with assurance that tax dollars and resources are being optimally allocated.

## Data-Driven Answers to Practical Traffic Operations Questions

An effective way to gauge an agency's need for data-driven traffic operations tools is to consider the questions they are struggling to answer. If the questions below seem familiar, your traffic agency is likely a good candidate for increasing the use of data-driven operations.



Based on complaints, we've re-timed and coordinated a major corridor – is it working?



Our staff and budget are decreasing, how can we maintain our service level with fewer resources?



I'm not sure that our maintenance contractor is meeting our agreement service standards – how can I know for certain?



I know my signals need to be re-timed, but how can I prove the need with hard data?



How can I make a stronger argument for support in my funding applications, backed by real performance data?



Is my signal green-time being optimally allocated?

# SPECTRUM TRAFFIC INSIGHTS

Miovision's Spectrum is a turnkey solution for remote traffic signal management. Spectrum provides the entire range of solutions that needed to be in place for a traffic team to collect, monitor, and understand their traffic signals. This includes a managed cellular connection, and tools for signal monitoring, video streaming, maintenance alerts, and traffic data insights.

## Core Components of Spectrum Include:



### Spectrum SmartLink and Interface Hardware

Spectrum hardware provides instant remote access to any traffic cabinet through a fully managed cellular connection. It also acts as an interface to the traffic controller, detectors, and additional cabinet devices. This allows Spectrum to capture and transmit the data required to generate real-time signal performance metrics.

Spectrum hardware also includes a built-in Wi-Fi travel time probe. This generates vehicle re-identification data that allows travel time, speed, and delay to be calculated through a corridor. All data is securely transmitted over wireless LTE to Spectrum's cloud server using a private VPN.



### Miovision Signals Software

Spectrum includes Miovision Signals, a cloud-based software package that provides a full suite of tools for remote signal monitoring. Signals enables web and mobile monitoring of signal activity, video streaming, and maintenance alerts. Miovision Signals is also the dashboard for reviewing Spectrum traffic insights, including signal performance metrics, travel time, arterial performance, and maintenance metrics.



### Traffic Insights

Spectrum traffic insights help traffic agencies make better operating and maintenance decisions to move people and goods more efficiently and safely. Spectrum's analytical tools and reports generate actionable information from the raw traffic intersection data.

## Leveraging Traffic Data with Spectrum Traffic Insights

Traffic Insights are different than traditional traffic data analysis systems in two ways: the depth of analysis being performed and how the service is delivered to agencies.

### Easy to Get Started

Spectrum Traffic Insights enables an agency to quickly start experimenting with and evaluating performance measures. The software system is fully hosted, with no servers to configure, and no additional hardware to purchase. Miovision Solution Engineers are available to train agency staff and help them start using the data tools immediately.

### Compatible with Every Intersection

Spectrum is fully compatible with nearly all traffic cabinets and the same is true with Traffic Insights. Modern controllers and detectors are not required for Traffic Insights to function. Regardless of existing infrastructure in a city, Spectrum can start generating valuable data insights right away.

### A Complete Data View

Traffic Insights provides agencies with the most complete view of their traffic network of any available solution. The system generates insights related to intersections, arterial and network performance, as well as metrics related to maintenance incidents and service levels.

### Ready to Go Out-of-the-Box

Spectrum is already in use by dozens of state and municipal agencies across North America for signal connectivity, telemetry monitoring, and alerts. Traffic Insights can be activated on any Spectrum installation with no additional setup or hardware installation.

### More than Charts and Numbers

Traffic Insights is built to deliver more than charts and tables. It can be challenging to extract meaning and actionable information from huge volumes of data. Spectrum solves that with embedded analyses and easy-to-understand graphs, which explain the actionable details in your city's traffic data.

### Built for the Whole Traffic Team

Spectrum Traffic Insights is built with an agency's entire traffic team in mind. Tools have been created specifically for maintenance technicians, traffic engineers, planners, and city executives. Raw data or analyzed graphs are easily downloaded, exported and shared with different stakeholders.

Spectrum Traffic Insights are organized into three functional areas:

1

#### Signal Performance Metrics (SPM)

Intersection-level reporting of key metrics like:

- Vehicle volumes
- Wait times
- Problem detection

2

#### Arterial Performance Metrics (APM)

Corridor-level reporting:

- Travel time
- Signal coordination
- Optimization schemes

3

#### Maintenance and Infrastructure (M&I)

Network-wide reporting:

- Equipment failures
- Contractor performance
- System uptime



# SIGNAL PERFORMANCE METRICS

Signal performance metrics (SPM) help traffic agencies answer the following questions:



Are my traffic signals working?



Do we have an appropriate allocation of green time between movements?



What kind of traffic volumes are we seeing?

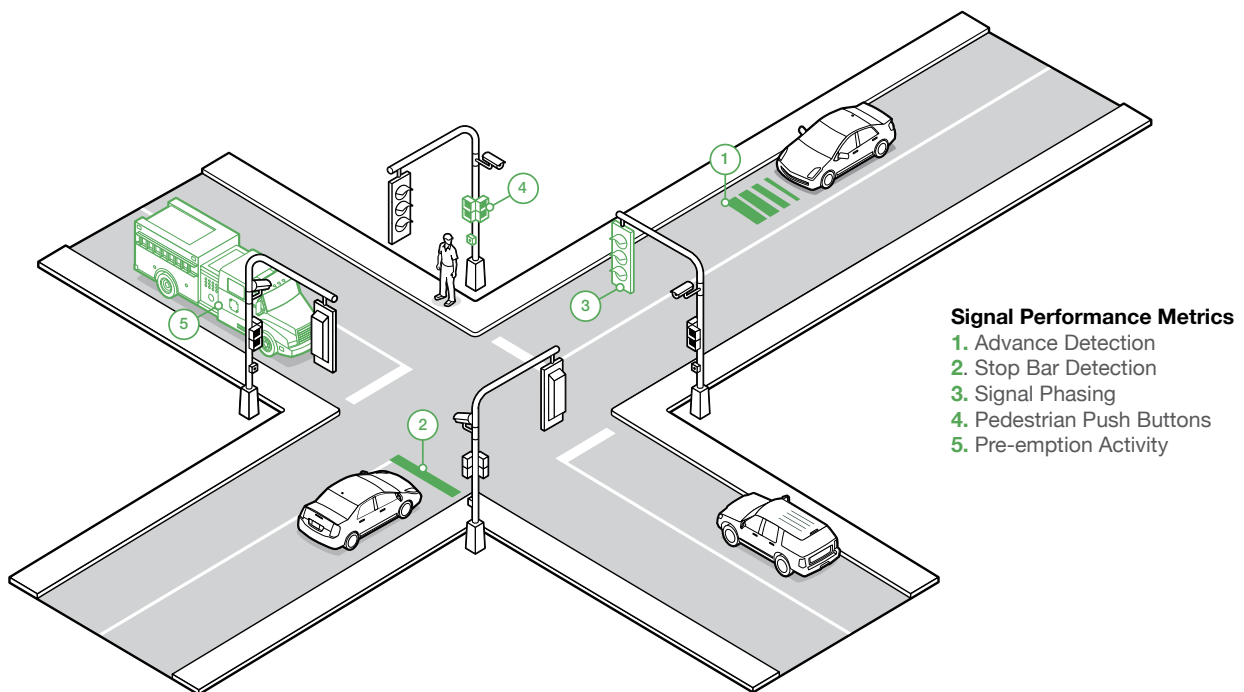


Are we meeting our goals on vehicle wait times at rush hour?

Signal performance metrics are a set of metrics and visualizations that help engineers design, tune, and troubleshoot traffic intersections.

## How Signal Performance Metrics Are Generated

Spectrum captures data from the traffic controller, detectors and other cabinet devices to provide event data including: signal state, pre-emption, and detector actuations from stop-bar and upstream count detectors, and pedestrian call button actuations. Spectrum's cabinet hardware is able to generate this data, even in cabinets housing older traffic controllers not typically able to produce high resolution reporting. The raw data is securely stored in Spectrum's cloud, where analysis is performed to extract meaningful information and actionable insights.



## Infrastructure Requirements for Signal Performance Metrics

Although Spectrum Traffic Insights can be useful at an intersection with no detection, the set of available analytics is greatly expanded with detector data. Signal performance metrics generated by Traffic Insights are grouped below based on intersection infrastructure required.

### No Detectors Required

Red/Green Allocation	The proportion of green time allocated to each approach and movement.
Pre-emption Summary	Reports of pre-emption events, durations and triggers, including railroad crossings or emergency vehicle pre-empts.

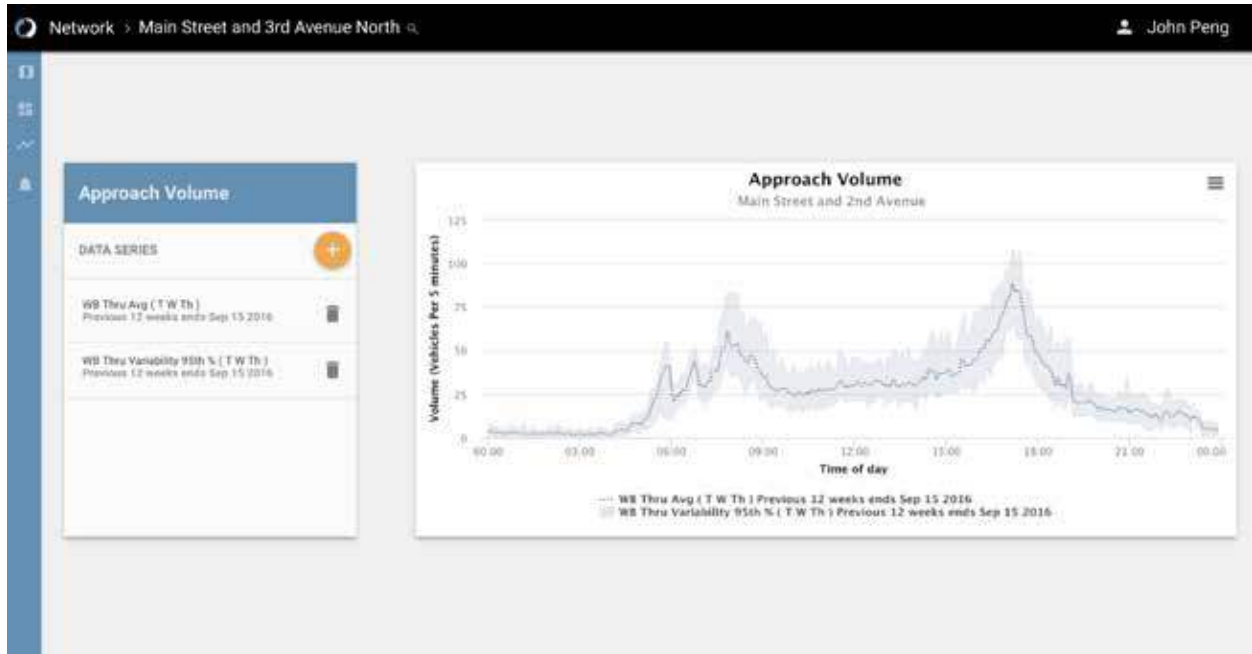
### Stop-Bar Detection Required

Red and Green Occupancy Ratio	Gauges the demand for the various phases based on the ratio of time that vehicles are present in the associated movements. This allows for tuning of split times between phases.
Purdue Split Failure	Industry-standard metric that charts the frequency of split failure occurrences, an incident where green signal time fails to meet the vehicle volume demand.
Simple Delay	Simplified approach delay measures the time between detector activation during red and movement service at start of green. Simple delay approximates the overall delay experienced by intersection users.

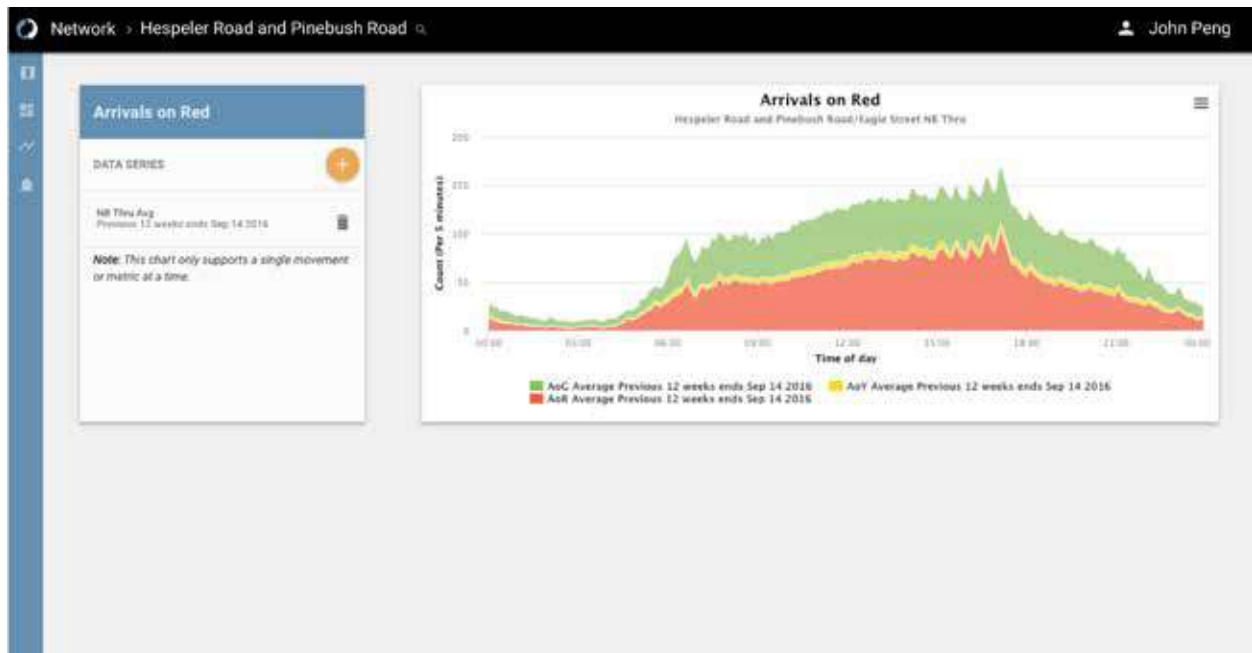
### Advanced/Upstream Detection Required

Approach Volumes	Counts of total vehicle traffic through an intersection from each approach.
Arrivals-on-Red vs. Arrival-on-Green	Counts of total vehicle volume arriving during red or green, giving a rough indication of progression quality for the given movement.
Purdue Coordination Diagram	A graphical representation of individual vehicle arrivals relative to cycle time (red, yellow, and green), highlighting arrival characteristics and platoon progression quality.
Average Delay	The length of time vehicles are delayed at a congested intersection.

## Sample Signal Performance Metrics in Traffic Insights



**Approach Volume** chart showing the volumes for the chosen day compared to the previous 12-week weekday average and variability bands.



**Arrivals-on-Red/Green** over a 12-week period showing the average volume of traffic arriving at the intersection during the red or green phases at different times of the day.



**Red and Green Occupancy Ratio** chart showing the stop bar occupancy ratio during red, green, and first 5 seconds of subsequent red (ROR5) for each cycle of a selected movement.

## ARTERIAL PERFORMANCE METRICS

Arterial performance metrics (APM) help traffic planners answer the following questions:

- ① Are my intersections in a corridor well coordinated?
- ② Did that new timing plan adjustment fix my progression problems?
- ③ Is traffic flowing normally in my main corridors right now?

Corridor traffic flow (a.k.a. arterial traffic performance) measures travel times across heavy volume arteries in a city, a critical factor in the level of citizen satisfaction. Traditionally, legacy arterial performance systems were only able to measure performance of sequential intersections, and were required to stitch together this data to get corridor-level views. Traffic Insights solves this with accessible arterial assessment tools.

These structured reports are instrumental in turning real-time data into actionable insights. Instead of actively monitoring corridors continually, Spectrum enables alerts for out-of-tolerance performance measures.

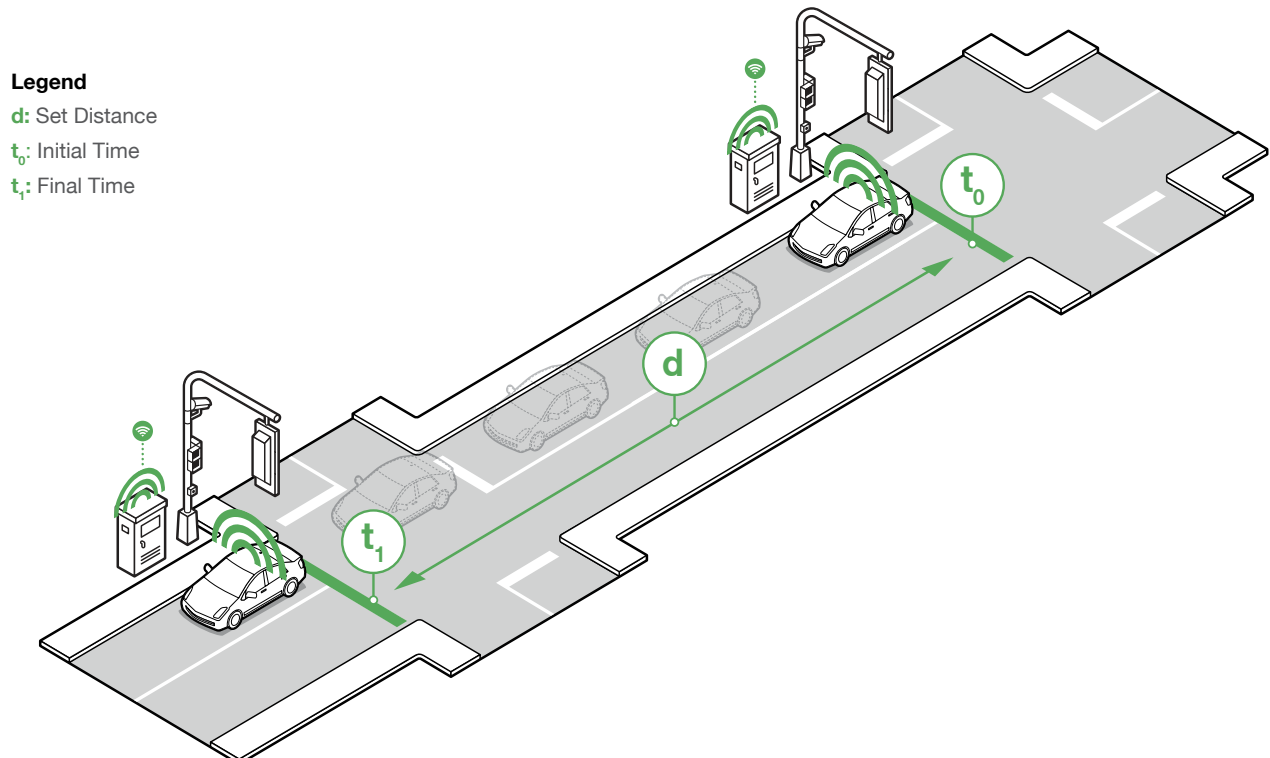
These alerts provide traffic operations team with immediate awareness of issues or delays that are unusual or unexpected.

## How Arterial Performance Metrics Are Generated

Arterial performance metrics reliably quantify the congestion, delay, and progression speeds throughout a traffic network. To accomplish this, Spectrum leverages a technology called wireless vehicle re-identification.

Included with the Spectrum hardware at each traffic cabinet is the antenna used to transmit data back to the traffic management center using cellular LTE. This antenna also supports Wi-Fi signal discovery and is used to monitor the presence of Wi-Fi devices passing thru the intersection, such as mobile phones or even “smart” vehicles.

Each Wi-Fi device has a distinct identifier called a MAC address. The Spectrum antenna constantly scans the intersection for Wi-Fi devices in its vicinity, and reads and records addresses within the active range. By scanning continuously at all intersections, Spectrum can recognize or “re-identify” a MAC address as it enters and then exits the readable range. Comparing the multiple identifications of the same device, Spectrum can calculate how long it takes for vehicles to travel between two intersections, otherwise known as the “travel time.”



Naturally, not every vehicle has a Wi-Fi device and even then not every Wi-Fi device is detected by Spectrum’s antenna. Normally, Spectrum is able to calculate travel times for 5% to 10% of all vehicles travelling along a route, which produces a statistically accurate model of the true traffic conditions.

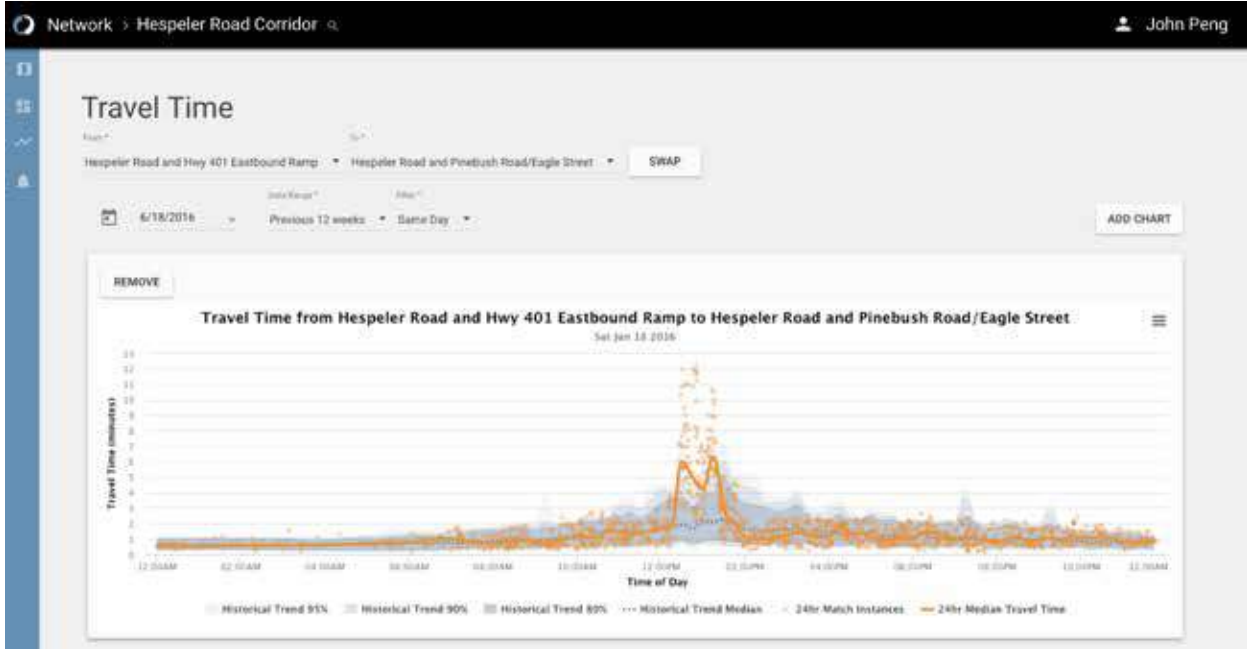
Spectrum then performs sophisticated data analyses and filtering to combine the individual records to produce a total Travel Time Index for an arterial. This analysis indicates how the commute time, delay, and congestion varied throughout the day, as well as easy comparison between different time periods.

While arterial performance metrics are a powerful tool, driver privacy can’t be sacrificed. Traffic Insights have been developed with privacy protection and security as a primary consideration. MAC addresses do not contain personally identifiable information, but they could be used to “track” a specific vehicle in ways that violate citizen privacy. As soon as Spectrum detects a Wi-Fi MAC address, it is hashed, or scrambled, using an algorithm that does not allow the original MAC address to be reverse engineered. The hash key is changed every 24 hours to ensure that a single driver’s commutes cannot be correlated over time.

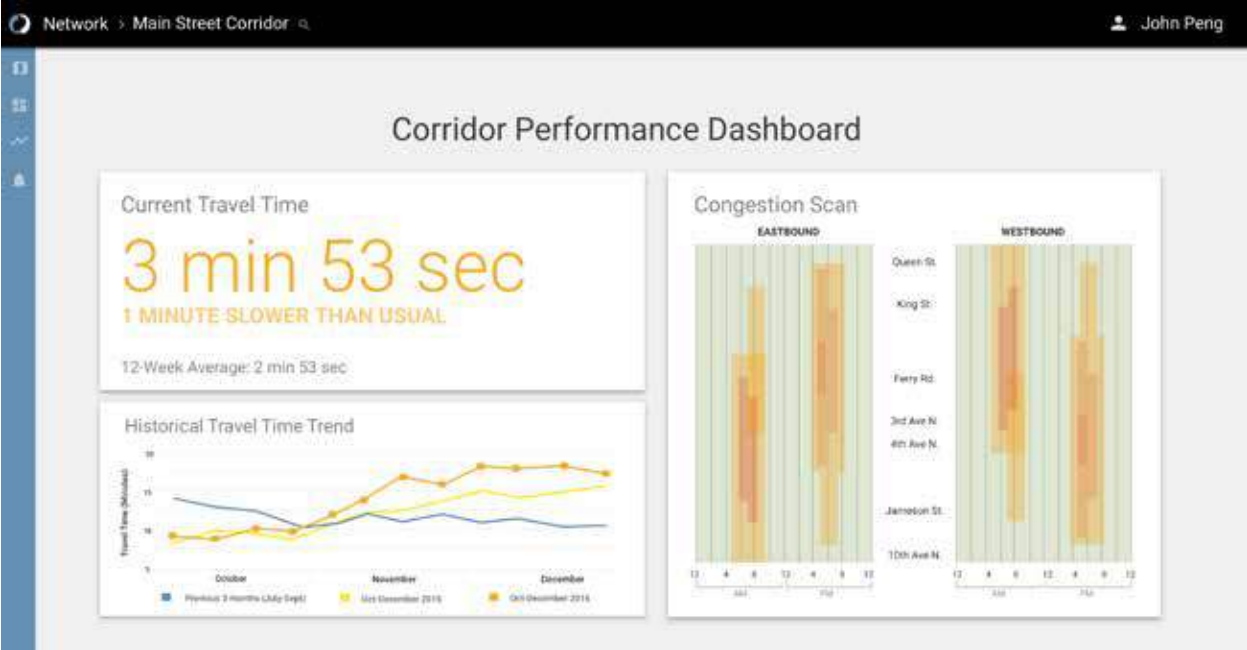
### Arterial Performance Metrics in Spectrum Traffic Insights

Point-to-Point Travel Time	Comparison of travel time between two points throughout the day, with ability for comparison to historical averages.
Corridor Congestion Plot	Analysis of where and when delay is occurring in a corridor.
Travel Time Index	Median travel time along a corridor expressed as an index relative to the free-flow travel time.
Planning Index	95th percentile travel time presented as an index relative to the free flow travel time. This metric indexes the typical worst-case scenario that a traveller should plan.
Buffer Index	Difference between the Planning Index and Travel Time Index. This provides an indication of the perceived additional time a traveller should plan for above and beyond the average travel time. This metric is a good indicator of Travel Time Variability.
Progression Tools	Use of various Signal Performance Metrics for the collection of intersection probe data along a corridor and presented in ways that help evaluate the quality of progression along the corridor.

# Sample Arterial Performance Metrics in Traffic Insights



The **Travel Time** graph shows the selected single day’s travel time (orange) vs. the 12-week historical trend (blue). The 24-hour data is presented as individual vehicle captures (dots) and the associated median travel time (orange line). The trend is presented as median (blue dotted line) and variability bands of 80th, 90th, and 95th percentile travel times are shown for the selected comparison window.



**Congestion Scan** shows the travel time index for different segments of the corridor and for various times during the day. This can highlight not only when, but also where congestion is building.

# MAINTENANCE AND INFRASTRUCTURE METRICS

Maintenance & Infrastructure (M&I) metrics help traffic planners answer the following questions:

- How can I remotely determine if my maintenance contractors have resolved the signal issue to my satisfaction?
- Which detectors appear to be performing unreliably?
- Where are the trouble spots for equipment failures in my network?
- How frequently are signal issues occurring?

## How Maintenance and Infrastructure Metrics Are Generated

Spectrum hardware constantly monitors the intersection for indications of maintenance issues or infrastructure failure. Data sources include the traffic controller, detection systems, power supplies including UPS systems, and pre-empt systems. As part of Spectrum's core signal management module, this information is programmed to generate and distribute maintenance alerts to the appropriate technicians or contractors. All event data associated with infrastructure or service issues are logged in Spectrum's cloud database.

Spectrum's built-in battery backup system ensures that issues can be reported even in the case of power outages to the intersection. Once an issue has been resolved it is logged in Signals in order to track event resolution time accurately.

Infrastructure event data is then subjected to complex analyses to determine maintenance trends and performance metrics.

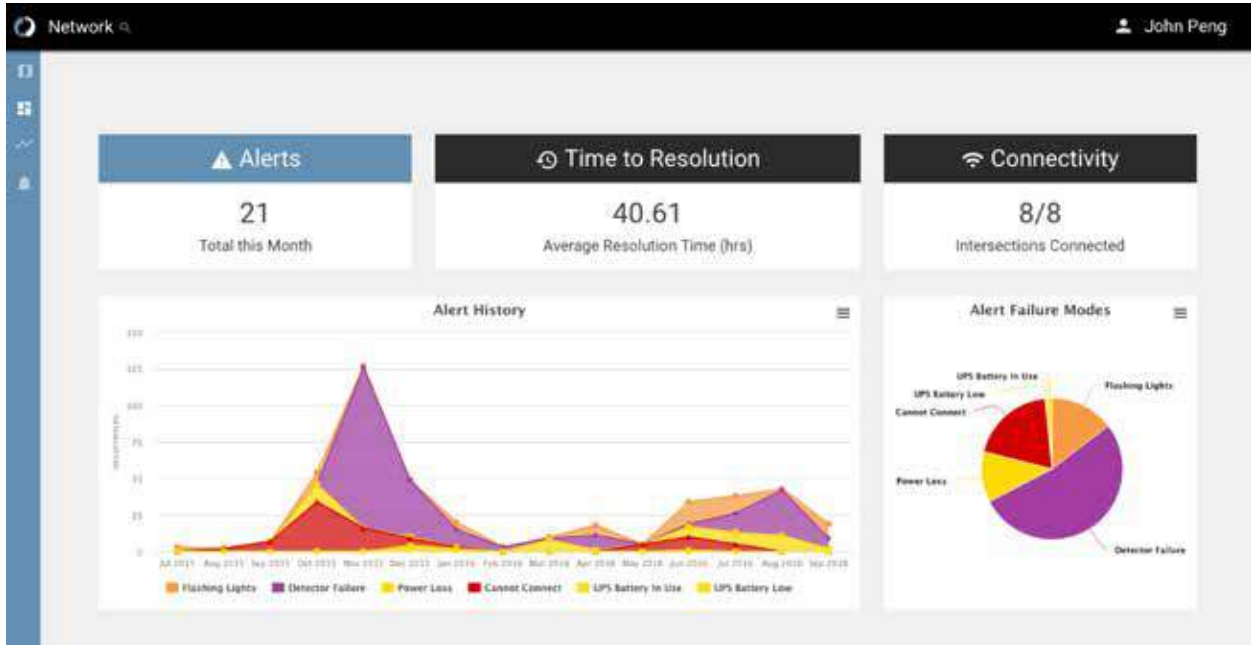
### Maintenance & Infrastructure Metrics in Spectrum Traffic Insights

Exception Reports	These include roll-up views to occurrences of power loss, signal flash, detector failure, pre-emption failure, connection failure, and UPS activity.
Maintenance Ticket Management	Reporting and tracking of average open ticket time from incident alert to resolution.
Intersection Maintenance Profile	Intersection history including overall uptime, summary of persistent maintenance issues, and performance rankings of maintenance teams.



These insights can be used to forecast and justify maintenance and operating budgets across the city. They also provide traffic managers with reliable data to determine the time and resources required to elevate system performance.

## Sample Maintenance & Infrastructure Metrics in Traffic Insights



An annual **summary of alerts** highlights monthly statistics for a given intersection, broken out by maintenance category and time-to-resolution.



A pre-emption summary for a given intersection shows the history of pre-empts, including those that remain active beyond the alert threshold (not shown here).

# OPERATIONS SCENARIOS WITH TRAFFIC INSIGHTS

Data-driven traffic agencies are effective at utilizing performance measures in a wide variety of operational areas. The following five examples demonstrate how Spectrum Traffic Insights are currently being used by agencies to solve real traffic problems.

## Monitoring and Understanding Congestion

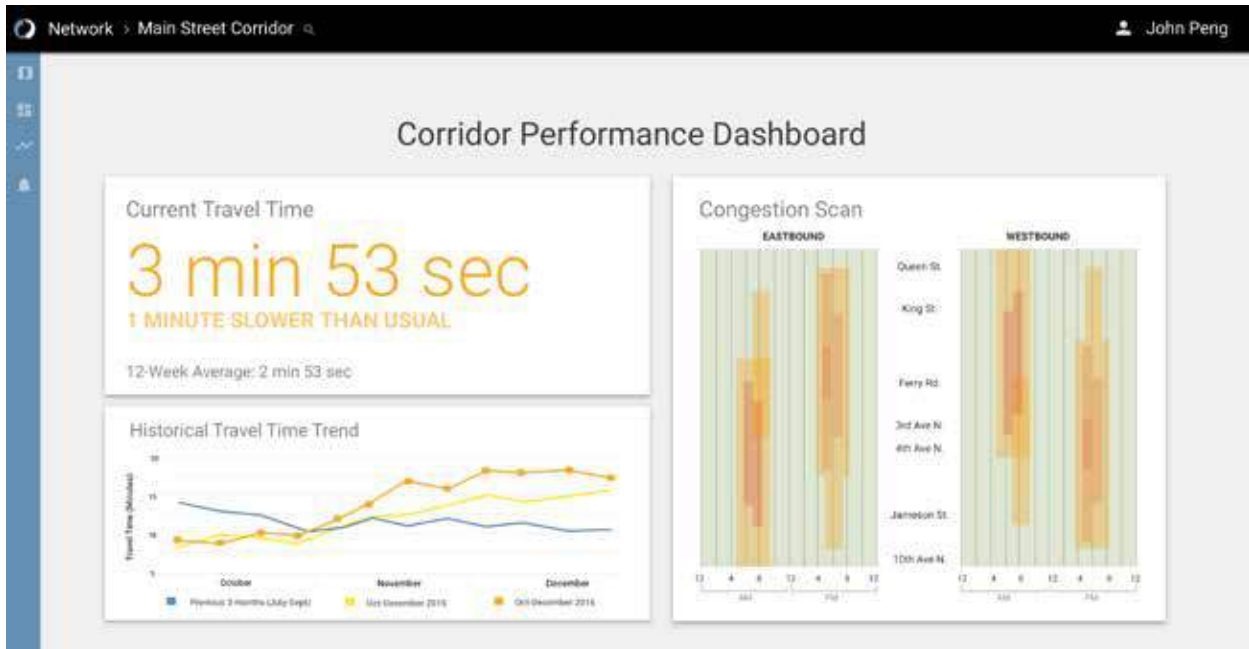
Most travel time products are focused on evaluating absolute conditions by providing indications of slower traffic speed. But this is an expected event every day during morning and afternoon rush hour. Without context, this information amounts to little more than a distraction for the traffic operations team.

By capturing data about the traffic network all the time and everywhere, it is possible to build up knowledge of the expected traffic patterns and highlight exceptions from that norm rather than simply indicating when traffic is moving at a speed slower than the posted limit.

A “corridor performance dashboard” can highlight those exceptions, providing contextual insight into the situation. In the example below, the headline statistic indicates that today’s travel time has deteriorated 30% compared to the 12-week average. In addition, the historical trend shows this pattern has established itself over the last 8 weeks when compared against both the previous three months and the same three months in the previous year.

A congestion scan provides a detailed overview of the segments within the corridor, and helps identify how congestion evolves through time and space along the corridor.

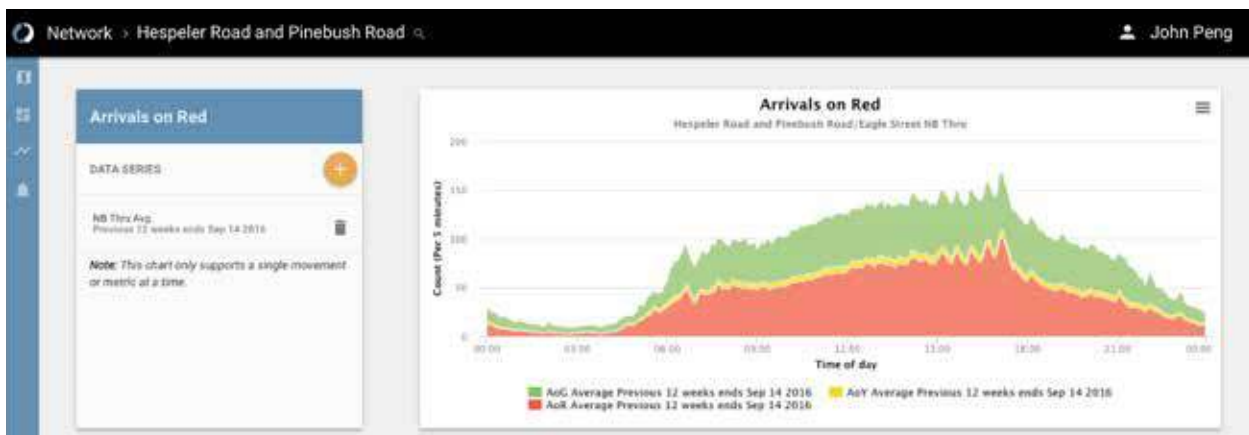
A congestion scan can be tailored to show absolute short-term 24-hour data, deviations of the 24-hour data from the trend, or worst-case percentiles of the running average, helping to separate one-off incidents from real trends that require attention.



## Identifying Progression and Coordination Issues

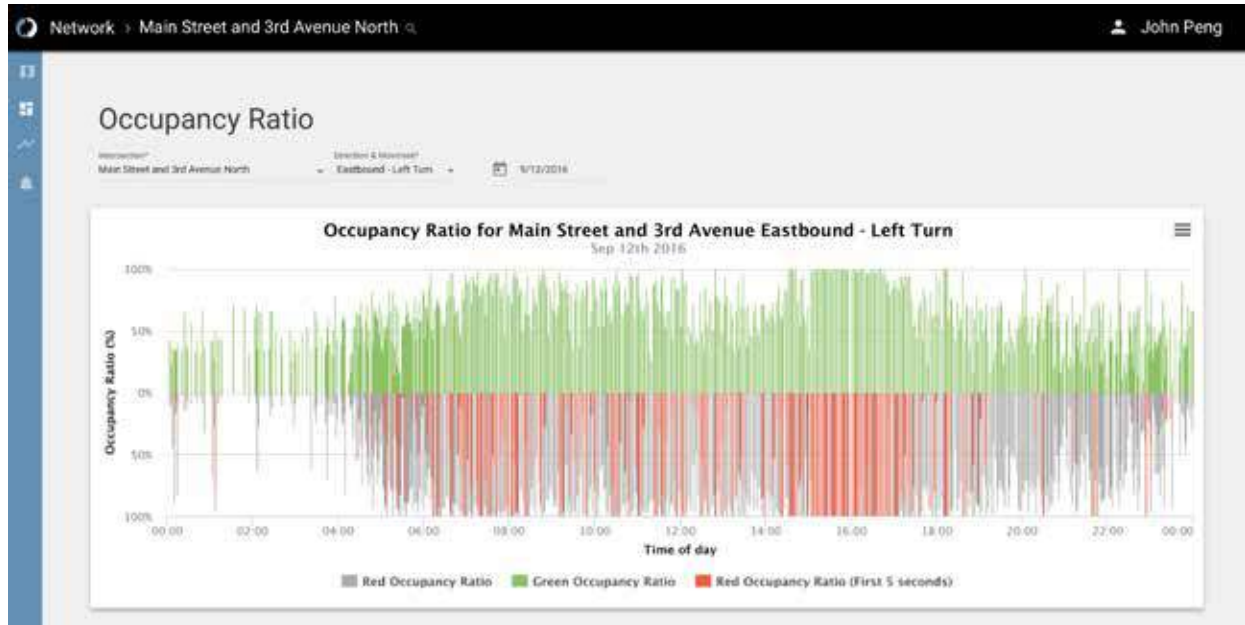
By evaluating travel time trends in a corridor, it is possible to highlight a problem, like a change in traffic patterns, which warrants further investigation. One of the contributing factors could be out-dated coordination parameters.

By looking at arrivals on red for the sequence of intersections along a corridor, it is possible to identify the root cause of the deteriorating traffic flow. In the example it can be seen that arrivals at the first intersection are fairly evenly distributed between red and green. As platoons are established, progression is effective through the second intersection. However, at the third intersection, the arrivals are predominantly on red. This is an indication of sub-optimal coordination that could have been caused by something as simple as controller clock drift, a lack of sufficient main street green time, or a change in inflowing traffic patterns between intersections.



## Optimizing Intersection Green Allocation

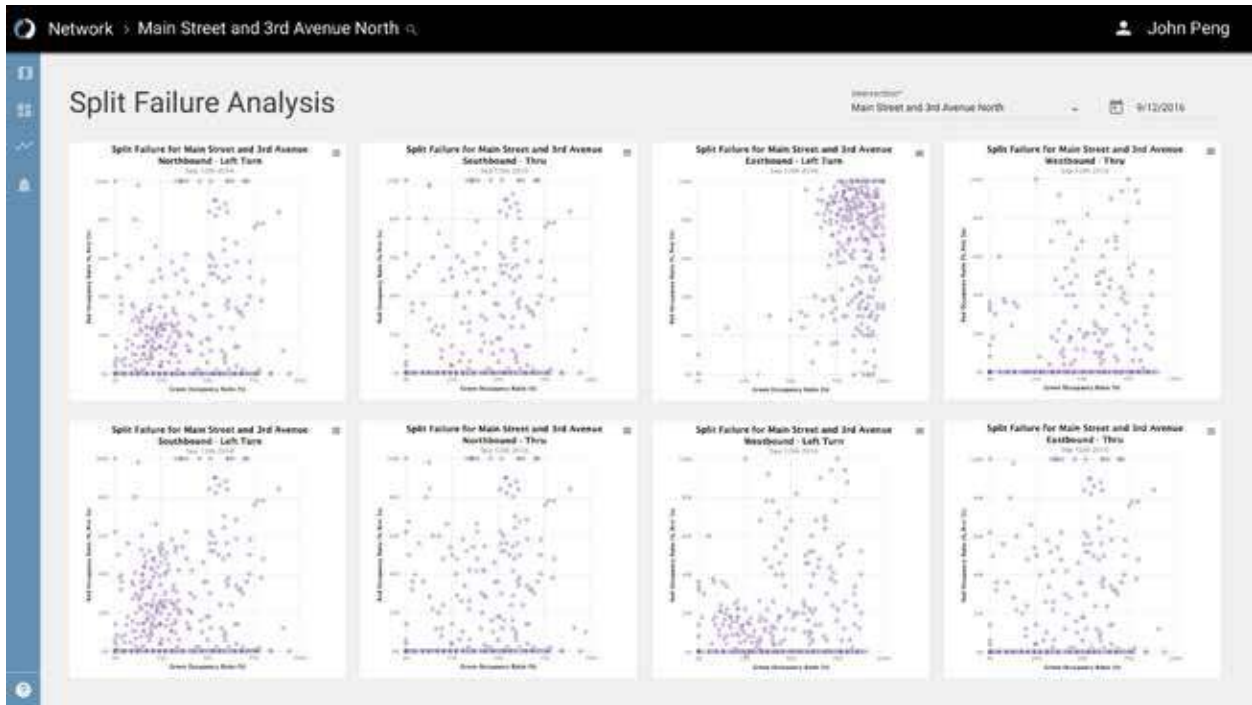
A citizen complains about being stuck at a left turn for three consecutive cycles. They are unable to provide the day or exact time. Using detector occupancy data, a traffic operator can look through a series of occupancy ratio graphs for the movement and over the days in question. Sure enough, a problem is observed on the left turn between 3:00PM and 5:00PM.



With further cycle time chart analysis and observing a consistent green time during the period in question, it is possible to confirm that this is a split allocation problem (vs. a gap-out setting issue).



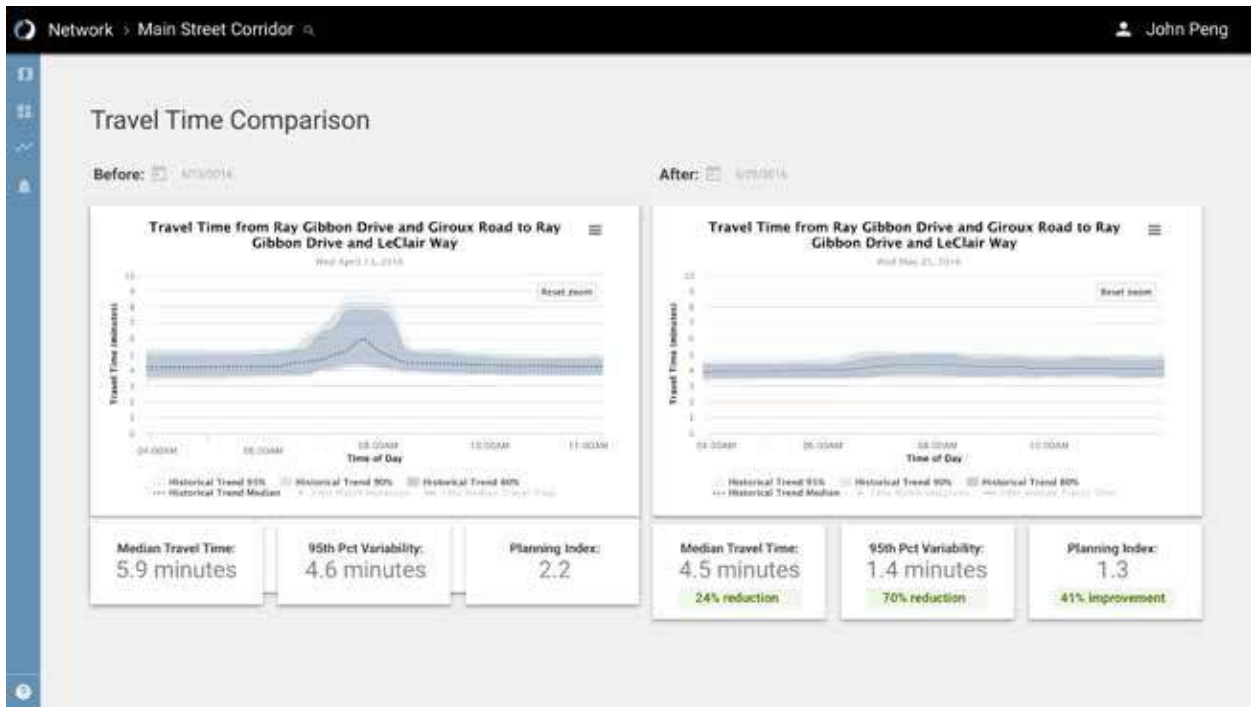
A split failure analysis at the intersection shows that there is spare capacity on the in the Southbound Left Turn (bottom left chart). This is illustrated by many dots being in the bottom left quadrant of the split failure chart – meaning there is low Green Occupancy (i.e. the green light is being under utilized) and low RoR5 (i.e. there is no residual demand after green).



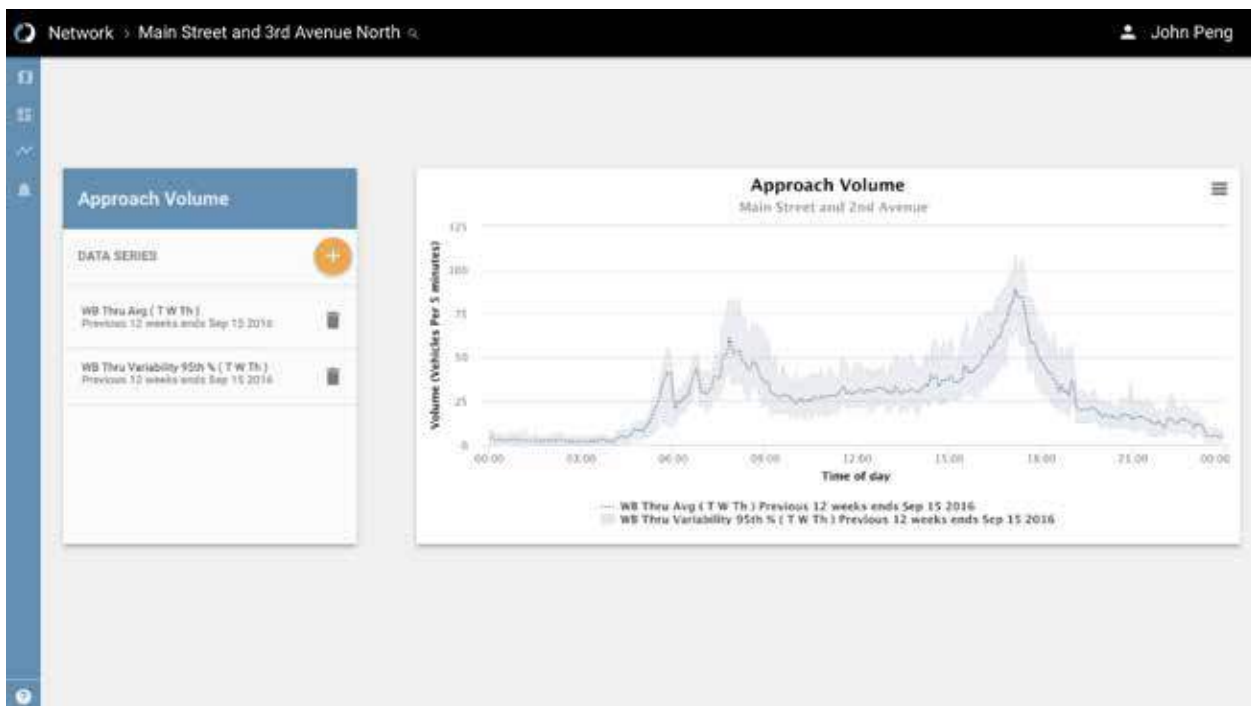
## Calculating Impact and Return-On-Investment

Ubiquitous data collection is not only able to identify areas of the traffic network that require attention, but also validate the results and quantify the impact of the investments that have been made in a ‘smart’ traffic system.

In the following example, a signal retiming of the morning peak results in an improvement to both travel time and travel time reliability. In this example there is a moderate improvement in the median travel time, but a much greater improvement in the reliability, a key indicator of user satisfaction.



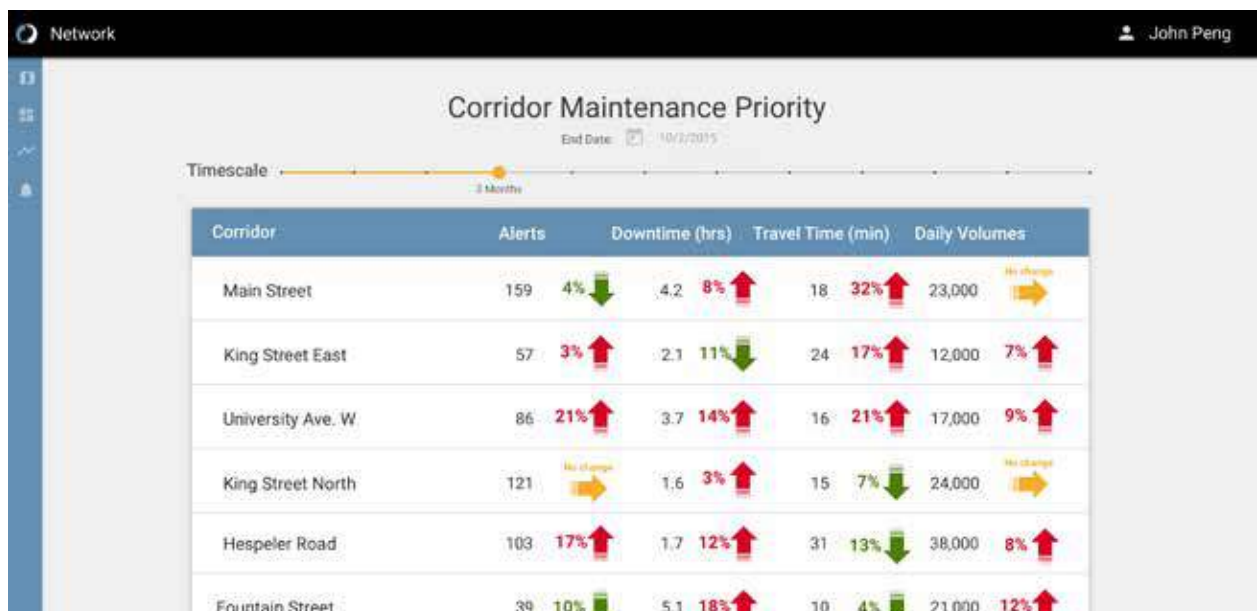
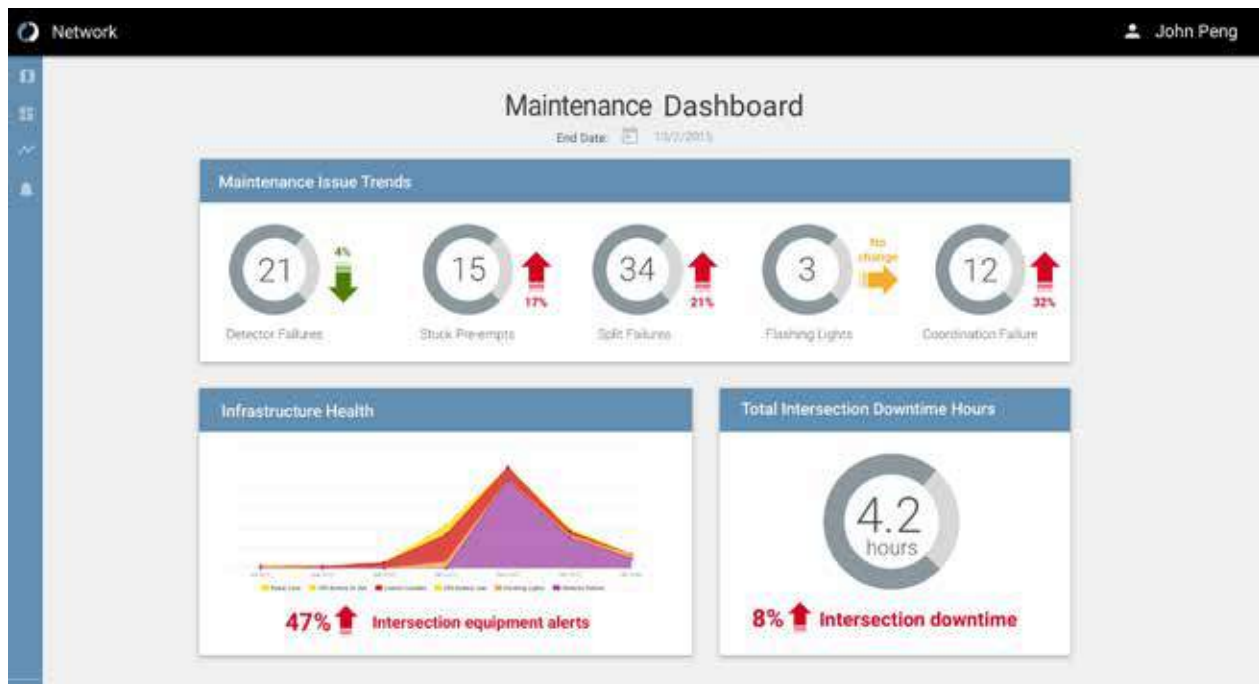
Combining this data with volume information at a key intersection in the corridor, it is possible to calculate a total saving of approximately 800 vehicle delay-hours per month during the two peak weekday morning hours shown.



## Managing Maintenance Services

Agencies that utilize external contractors for maintenance and field operation tasks often have an expected level of service for the contractor, but struggle to quantify whether those performance levels are being met.

The Traffic Insights maintenance dashboard allows investigation of key trends in maintenance resolution time, uptime, and call volume. This information can be segregated between multiple zones in a city, allowing comparison between multiple groups of technicians.





# GETTING STARTED WITH TRAFFIC INSIGHTS

Spectrum allows cities to move towards data-driven practices in an easy, incremental, and affordable manner.

To discuss how your agency can utilize Spectrum to better analyze and understand the traffic network, please contact your Miovision account representative, or email [sales@miovision.com](mailto:sales@miovision.com).

