IQ Signal Analytics Overview

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Submitted by **INRIX**

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INRIX IQ Signal Analytics

INRIX IQ Signal Analytics is the first analytics platform for traffic signal management that does not rely on data from road sensors. Instead, the data is sourced from connected vehicles. The platform is scalable, easy-to-use, and cost-effective. It does not require special training, and there is no equipment to install or maintain. Users can easily access metrics to identify, rank, and prioritize intersection and corridors to achieve maximum impact on traffic flow. Signal Analytics allows users to view regional signals and corridors to easily conduct systemwide comparisons, corridor before and after studies, and review individual traffic signals performance measures.

The metrics provided by Signal Analytics allows for actively monitoring delays, percent arrivals on green, and turning movement ratios to help guide decision-making for improvement of signal operations. The most common use cases are system assessment (project prioritization), before/after studies, and quantifying improvements. As data is available in near real time, the same prioritization effort for signal retiming projects may also uncover faulty equipment, such as a malfunctioning detector.

The data in INRIX Signal Analytics is derived from INRIX Trips data, billions of observed, anonymized vehicle GPS waypoint data at road intersections. Sample sizes are provided for each individual intersection movement to ensure valid analysis. Data includes observed distribution of speeds (not just averages) to provide the clearest understanding of signal performance. The metrics are calculated for each movement independently and can be aggregated to the approach, intersection, and corridor level.

INRIX Signal Analytics can benefit agencies by reducing installation of hardware and/or removing the need for extensive fieldwork and associated data cleaning. Signal Analytics utilizes anonymous data from connected vehicles resulting in significant cost savings. The data used in Signal Analytics is superior to road sensor data because it utilizes the highest frequency GPS waypoints available, allowing for the analysis of individual vehicle paths through an intersection. Time savings is also significant because the data is immediately actionable - no pre-processing is required by the users of Signal Analytics. And, as the Signal Analytics platform is independent of the signal software, it can be used to assess actual system performance.

The biggest benefit of Signal Analytics is complete systemwide information. Most signal retiming projects occur on a scheduled basis, resulting in reactive interventions after signal performance issues are discovered. With Signal Analytics, systemwide daily performance reports enable proactive interventions before significant degradation of signal performance occurs.

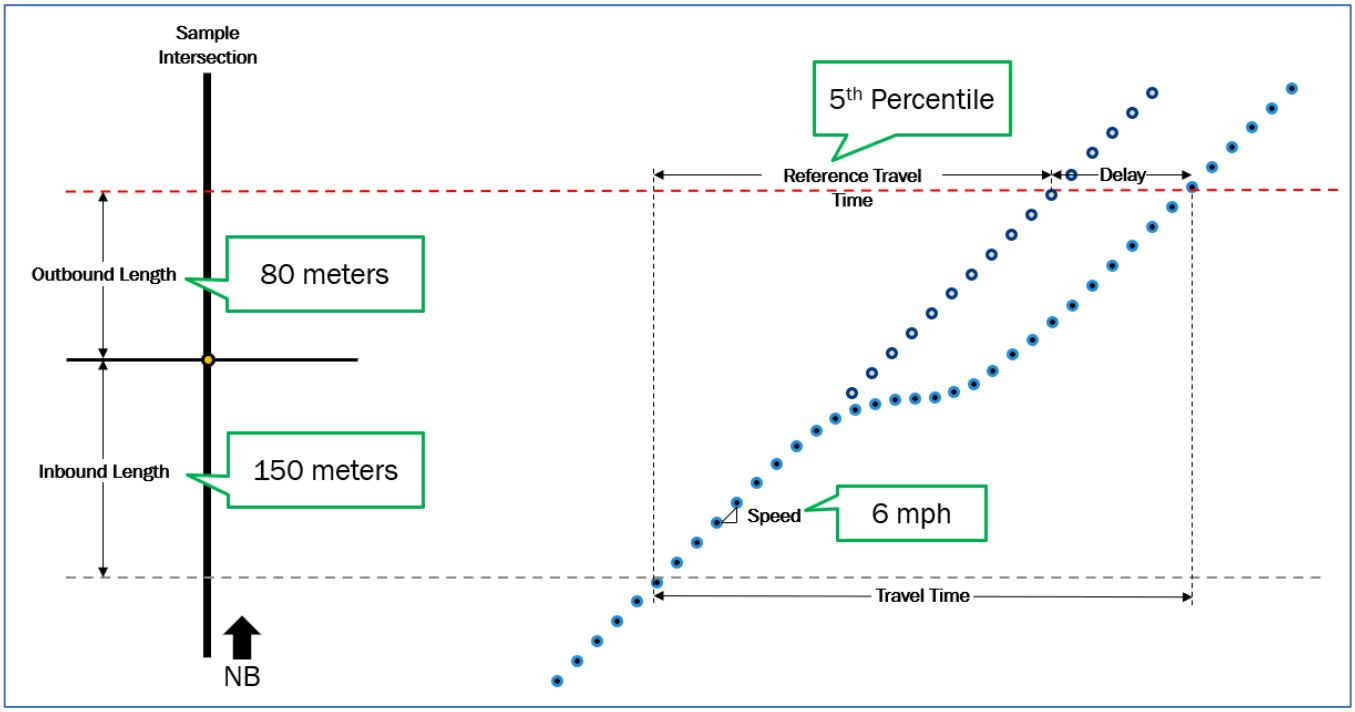
Common Use Cases

- Scalable and actionable performance measures - created with a few clicks of a mouse
- Identify and manage poorly timed signals
- Insights to guide prioritization of signal investments
- Quantify the impact of traffic signal management strategies
- A quick and accurate way to test new signal strategies
- Verifying the results of modeling software or simulation

Performance Metric Computation Process and Thresholds

Performance measures for each movement are based on an analysis zone placed around each signalized intersection. Measures are then computed for each vehicle that passes through the zone, as shown in the following figure. Plotting the movement of a sample vehicle through an intersection, the time/distance diagram shows a typical approach speed, travel time through the intersection, and two other measurements needed to calculate control delay — the reference travel time and the delay. Note that the slope of the dots represents the speed — a horizontal slope would indicate a full stop, and almost horizontal indicates a rolling stop while approaching the stop line.

The intersection analysis zone extends from a point that is 150 meters upstream of the stop line to a point 80 meters beyond it (along each of the departure paths). These 230-meter zones (one for each movement) are used to assign each sampled vehicle to a movement. They also determine travel times, control delays, and whether a vehicle is regarded as having stopped within the intersection.



The zone parameters are based on the Ground Truth Validations done against UTAH ATSPM.

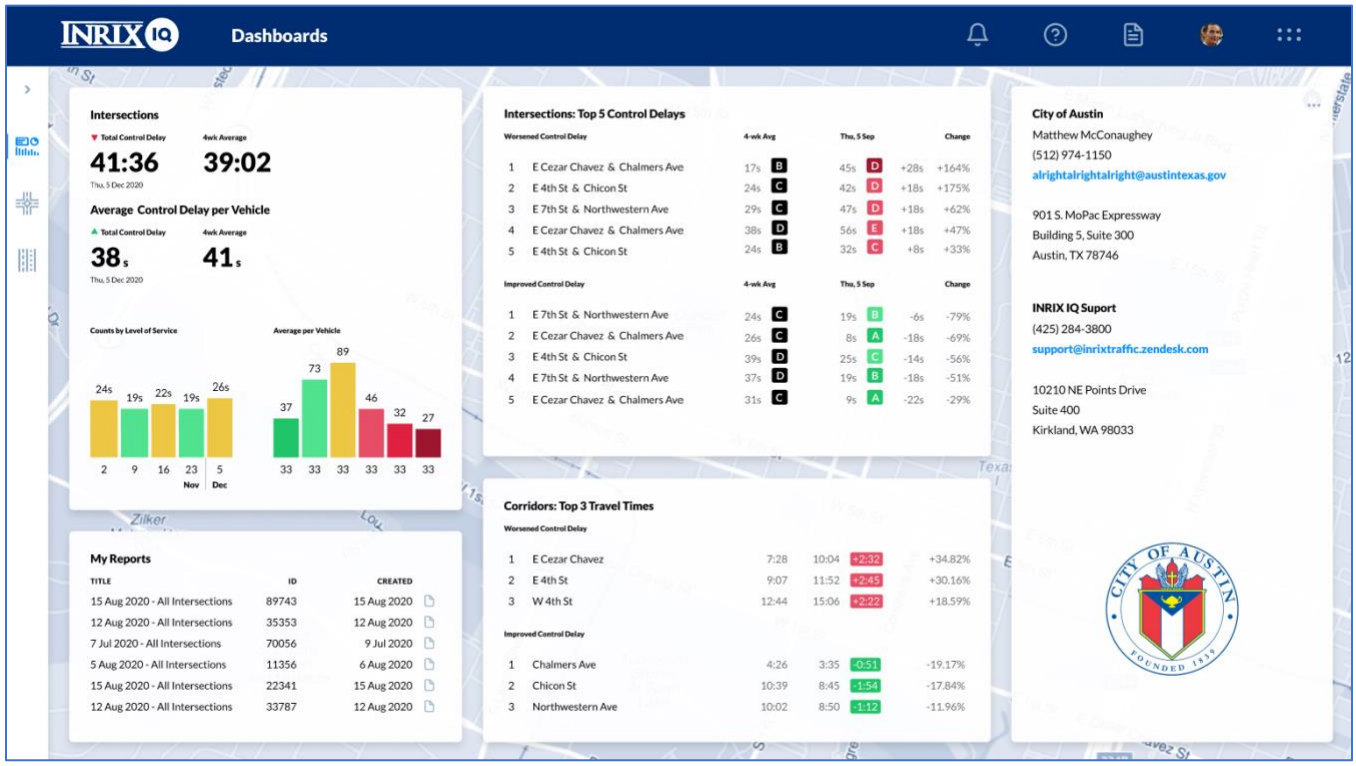
The following are the metric definitions used in Signal Analytics:

- **POG (percent arrival on green)**. Based on (a) the number of vehicles in a count that traversed a movement without stopping, divided by (b) the total vehicle count for that movement.
- **Travel Time (average and maximum)**. Computed based on the time it takes for a vehicle to travel the length of a movement, defined as 150 meters (500 feet) approaching the stop line and 80 meters (260 feet) beyond. For user-specified time periods, travel time averages and maximums are reported.
  Control Delay (average and maximum). The difference between the travel time a vehicle reports to traverse a movement and the reference travel time. The reference travel time is calculated as the 5th-fastest percentile of travel times for non-queued vehicle movements through a movement. For example, if a vehicle took 30 seconds to traverse a movement and the reference travel time was 10 seconds, the control delay for that movement would be 20 seconds. For user-specified time periods, control delay averages and maximums are reported.
- **Approach Speed (average and maximum).** Highest speed reported by a vehicle within the 150-meter approach zone. For user-specified time periods, approach speed averages and maximums are reported.
- **Vehicle Count.** The total number of sampled vehicles in the database for a specified movement and time period.
- **Stopped Vehicle Count**. Those vehicles in a count that stopped at least once in the approach zone of an intersection (a vehicle has "stopped" if it reported a speed of 10 kph (6 mph) or below).

The next sections of this document describe the two functional features of the INRIX Signal Analytics platform, Signal System Dashboards and the Intersection Analysis Tool powered by the Center for Advanced Transportation Technology Laboratory at the University of Maryland (CATT Lab). The Dashboards are based on daily reports indicating performance of all intersection in the system with comparative rankings and metrics of change from the previous 4 same-day-of-week metrics. The predefined reports provide daily metrics (24-hour) as well as values for agency specified peak time periods. The Intersection Analysis Tools provide capability for custom queries for any user specified date range and time period.

INRIX Signal Analytics Systemwide Dashboards

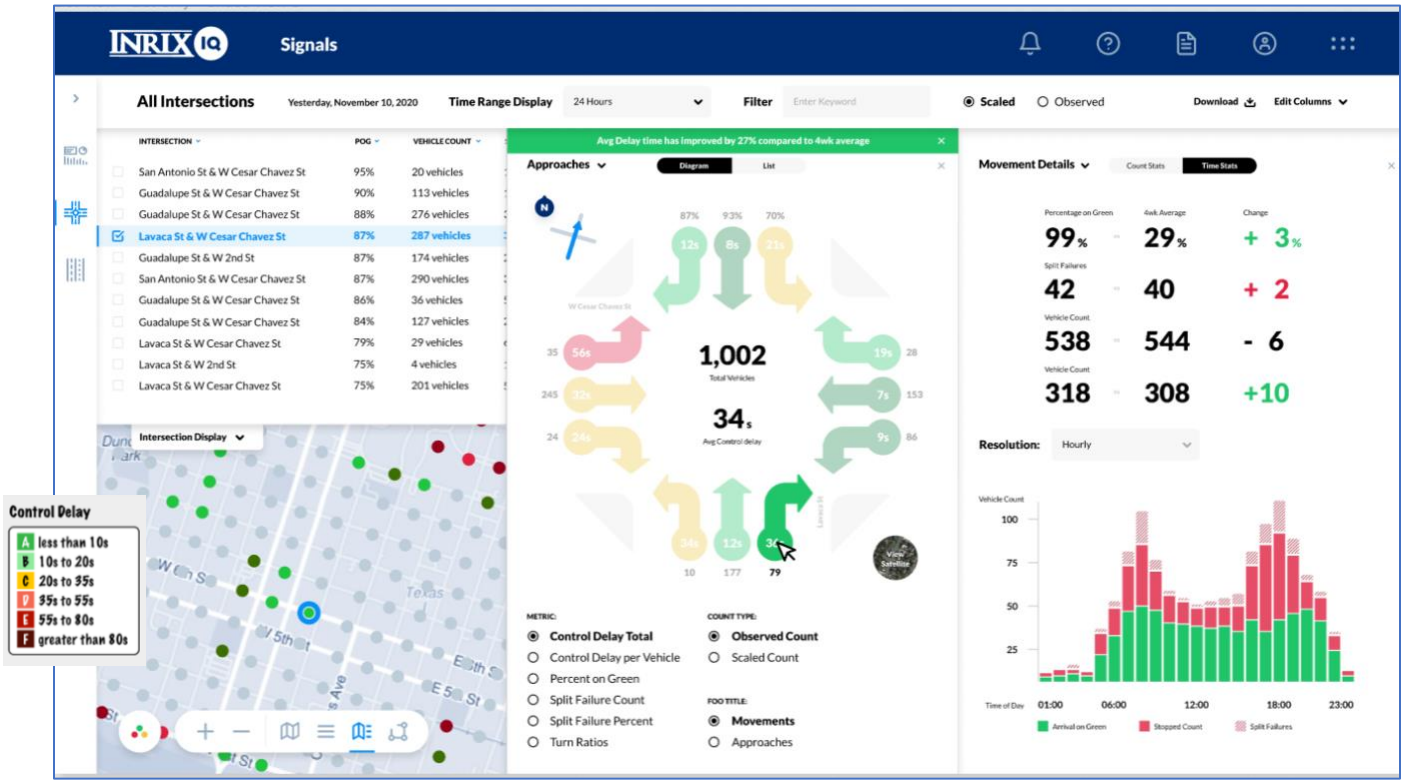
INRIX provides Signal Analytics Systemwide Dashboards in different customized formats. The following figures show two dashboards that could be created by the user. The daily metrics are compared to the four weeks of data for that day and time. The figure provides a summary of the total control delay for all intersections, average control delay per vehicle, counts by level of service, average per vehicle. In addition are the intersection top five control delay changes (worsened and improved) and the corridor top three travel time changes (worsened and improved).



Dashboard Example Displaying the Worst and Best Performing Intersections and Corridors

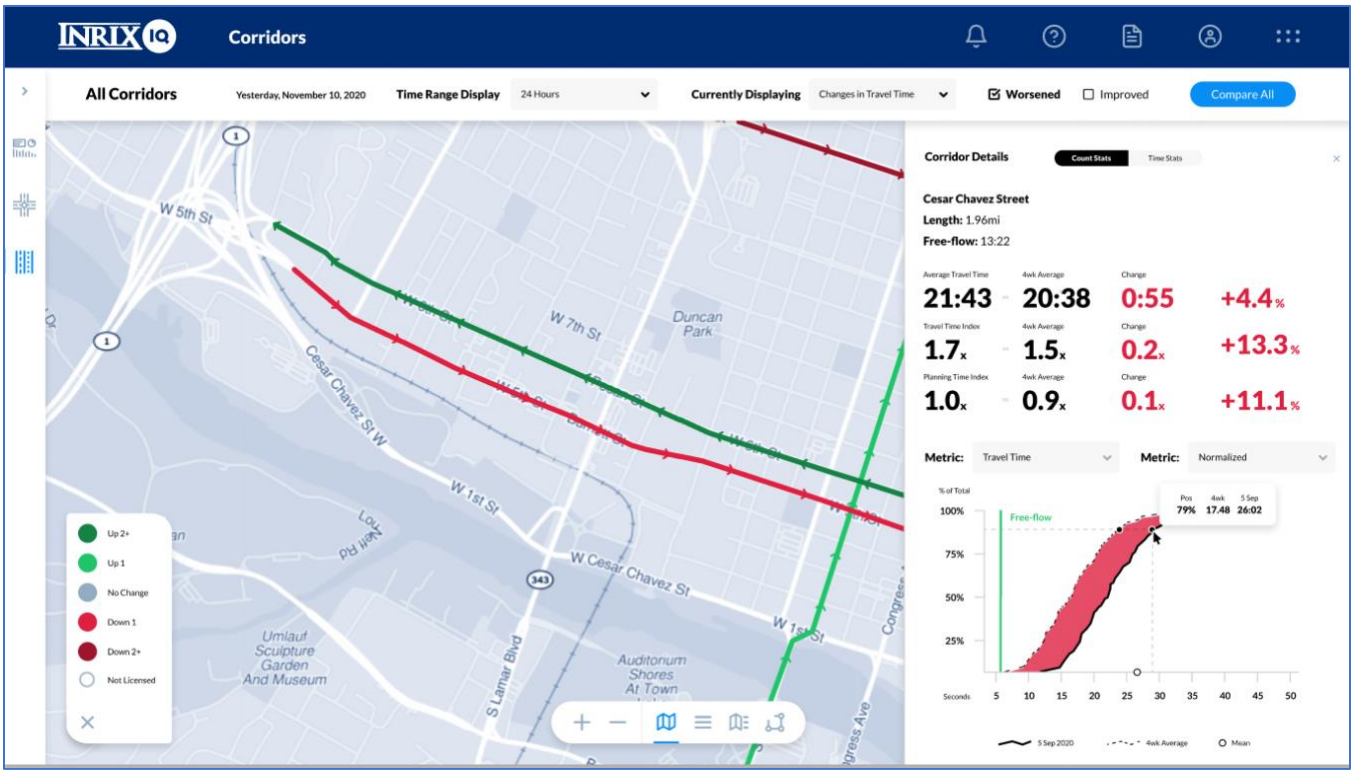
The System Dashboard includes the following information for easy review.

- List of worst performing intersections
- Map display showing intersection worsening and improving
- Display of the intersection movements colored by the control delay in seconds
- The difference metrics that can be displayed in the movement diagram including
  - Control Delay Total
  - Control Delay per vehicle
  - Percent on Green
  - Split Failure Count
  - Split Failure Percent
  - Turn Ratios



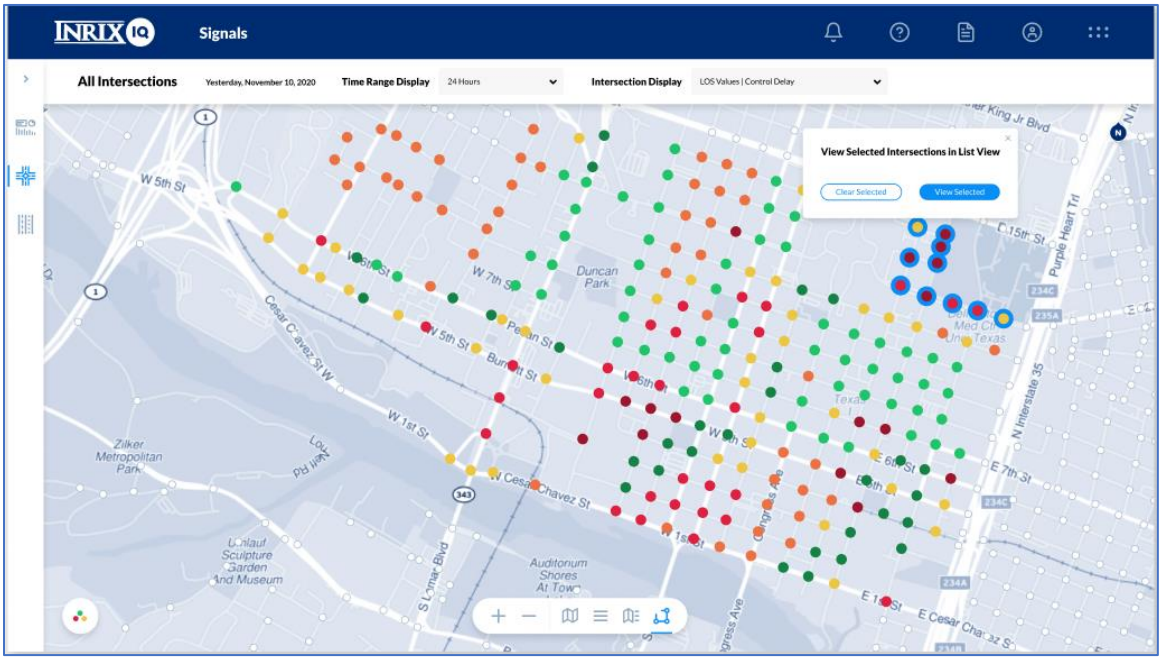
Dashboard Example for Overall Intersections Performance and a Specific Intersection

The agency can set up corridors to be monitored and evaluated. The figure below shows corridors created for evaluation. By simply clicking on the predefined corridor the user can pull up corridor details and performance metrics like average travel time, travel time index and planning time index and see how the measures compare to the average of the last four weeks. The bottom right quadrant displays CFD or normalized flow across the intersection. Daily corridor metrics for an intersection can be compared to historical daily metrics for corridor analysis.



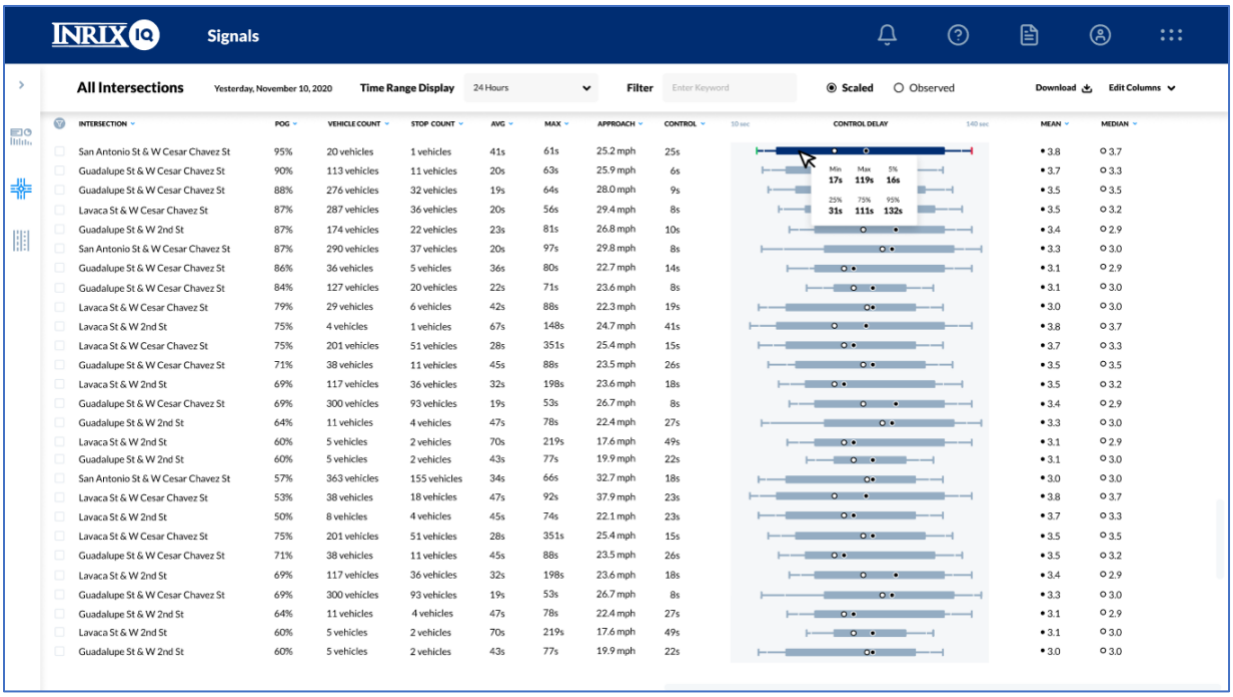
Dashboard Example for an Individual Corridor

A user can select a specified area to review the performance of those signals. The following figure is a screen shot of a selected area and the metrics that are provided for the signals in the specified polygon. For example, if the city wants to have metrics for all the signals in the region, a city could create a polyline around its borders to get the performance measures for only the city signals.

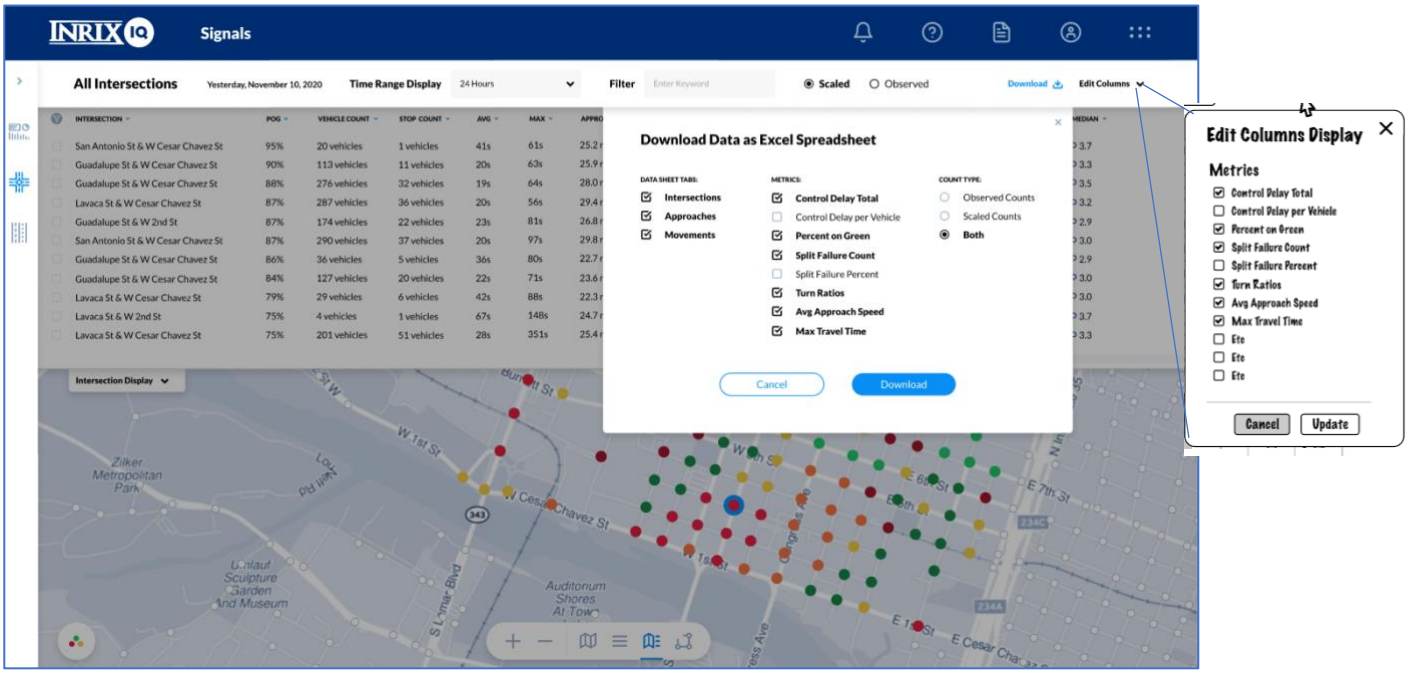


Dashboard Example for Selecting an Area for Evaluation

The control delays are shown in the figures below. The display can be edited for the user to focus on the key metrics of concern and can then be downloaded.



Dashboard Example for Intersection Control Delay



Dashboard Example for Control Delays for Intersections.

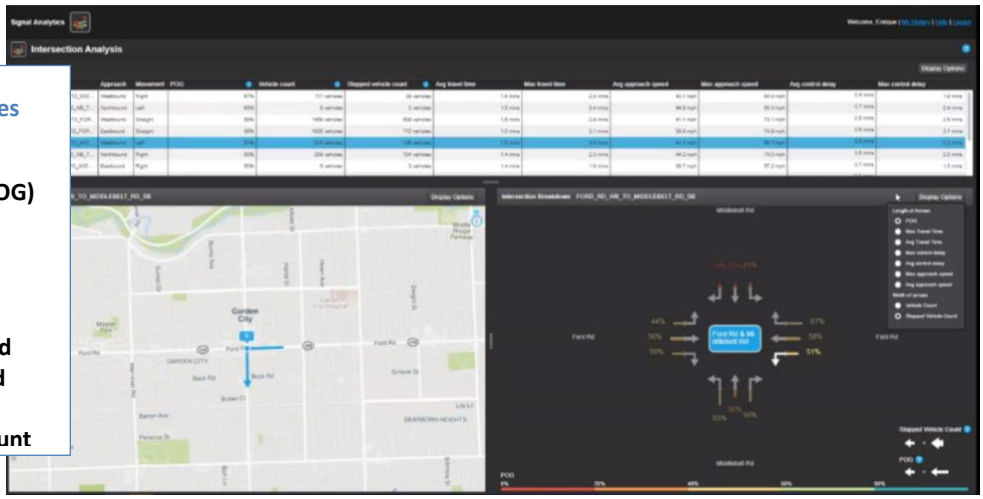
INRIX Signal Analytics Powered by the CATT Lab

Performance Measures for Intersection Movement

If a user wants to gather more detailed information, they can connect to the Signal Intersection Analysis tool powered by CATT Lab. Intersection Performance Measures are displayed based on the temporal and spatial filters selected by users as shown in the figure below. The figures show signals selected by road name and by zones.

Performance Measures Available Currently:

- **Arrival on Green (POG)**
- **Max Travel Time**
- **Ave Travel Time**
- **Max Control Delay**
- **Ave Control Delay**
- **Max approach speed**
- **Ave approach speed**
- **Vehicle Count**
- **Stopped Vehicle Count**



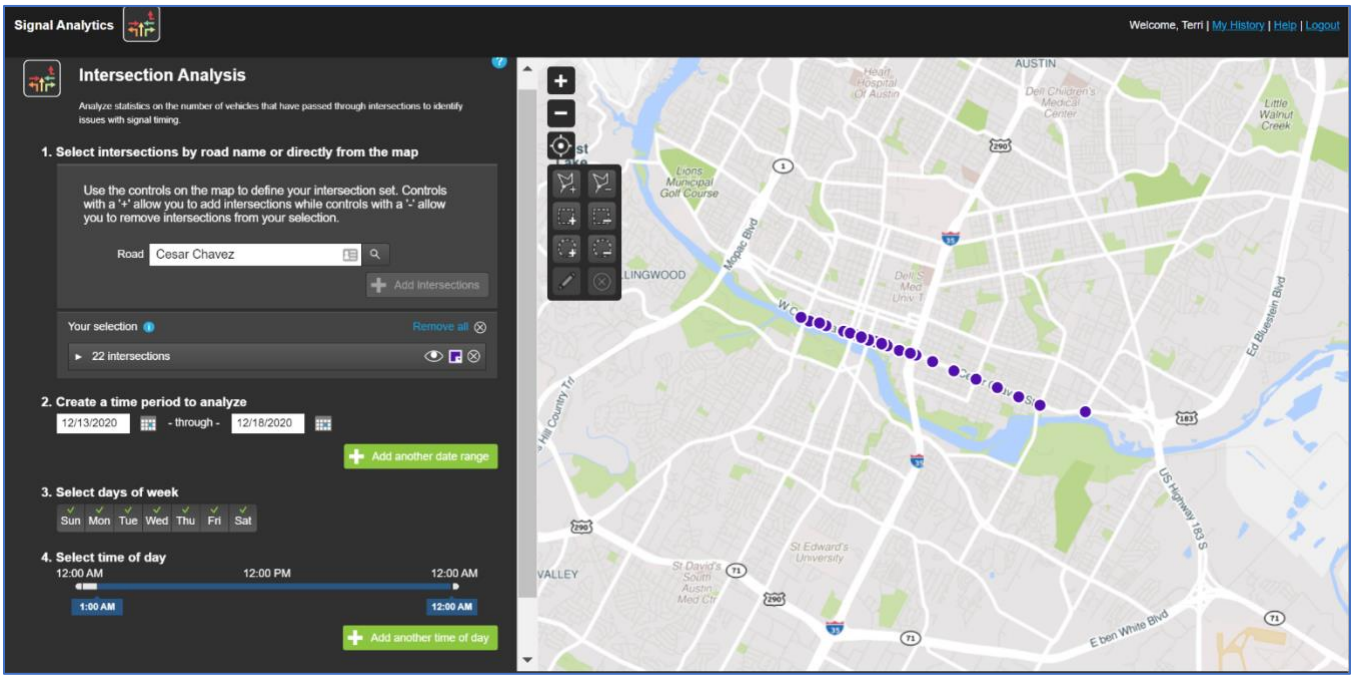
Currently available Performance Measures.

Creating a Study

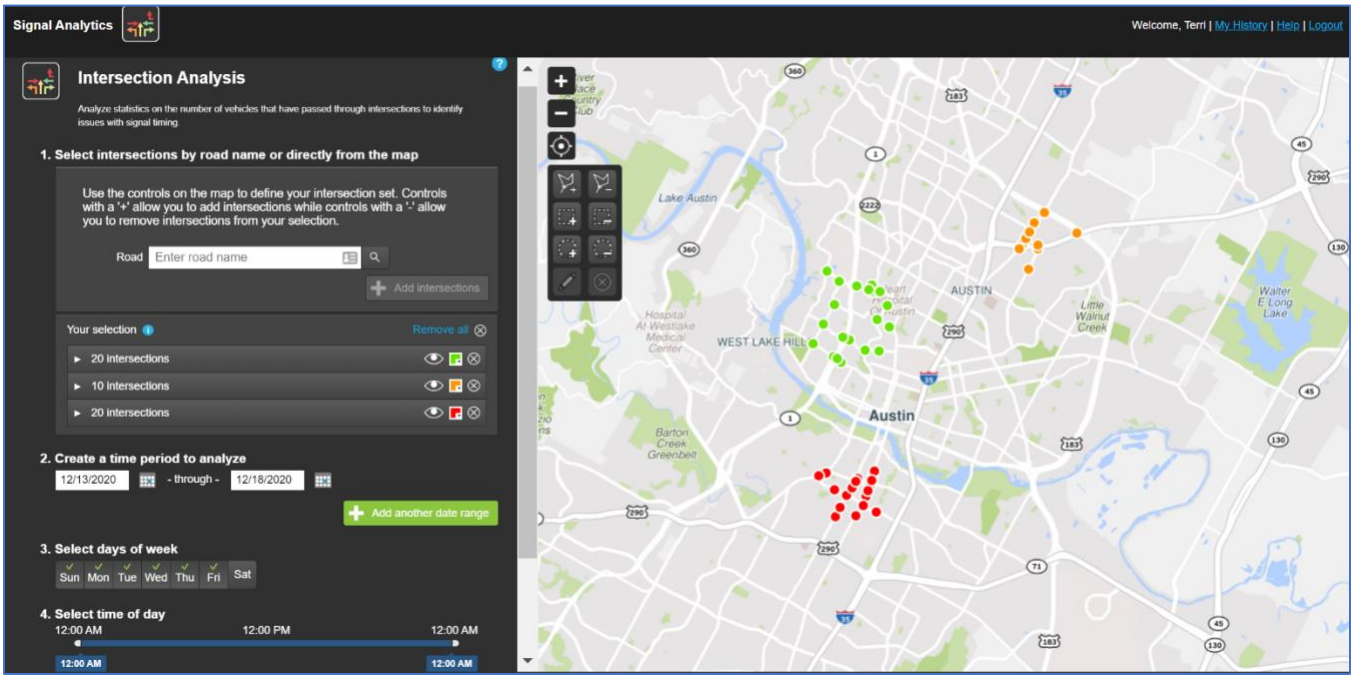
The process to initiate a custom intersection(s) study if very straight forward. The platform provides a simple interface to specify the desired intersection, or group of intersections, as well as the date range and time period of interest. The tool provides options to search the available intersections by the road name (Road Selection) or by free-drawing an area (Map Selection.

- **Road Selection.** Type the name or route number to produce a list of roads to select from; all signals on an entire road may be selected, or partial sections. (This process may be repeated multiple times to accumulate intersections for your analysis.)
- **Map Selection**. Use the "+" designated drawing tools at the top left corner of the map to outline the region of interest; all available intersections within the region will be highlighted for selection (if too many are identified, use the (-) designated tools to selectively remove those that are unwanted). Again, this may be repeated to add additional intersections.

  After identifying all intersections for analysis, finalize the list by click "Add intersections and select the date range that you would like analyzed. If desired, restrict your analysis to specific days of the week and times-of-day. *Note: you may select more than one time period; however, if you do the results will be merged into single output calculations.*



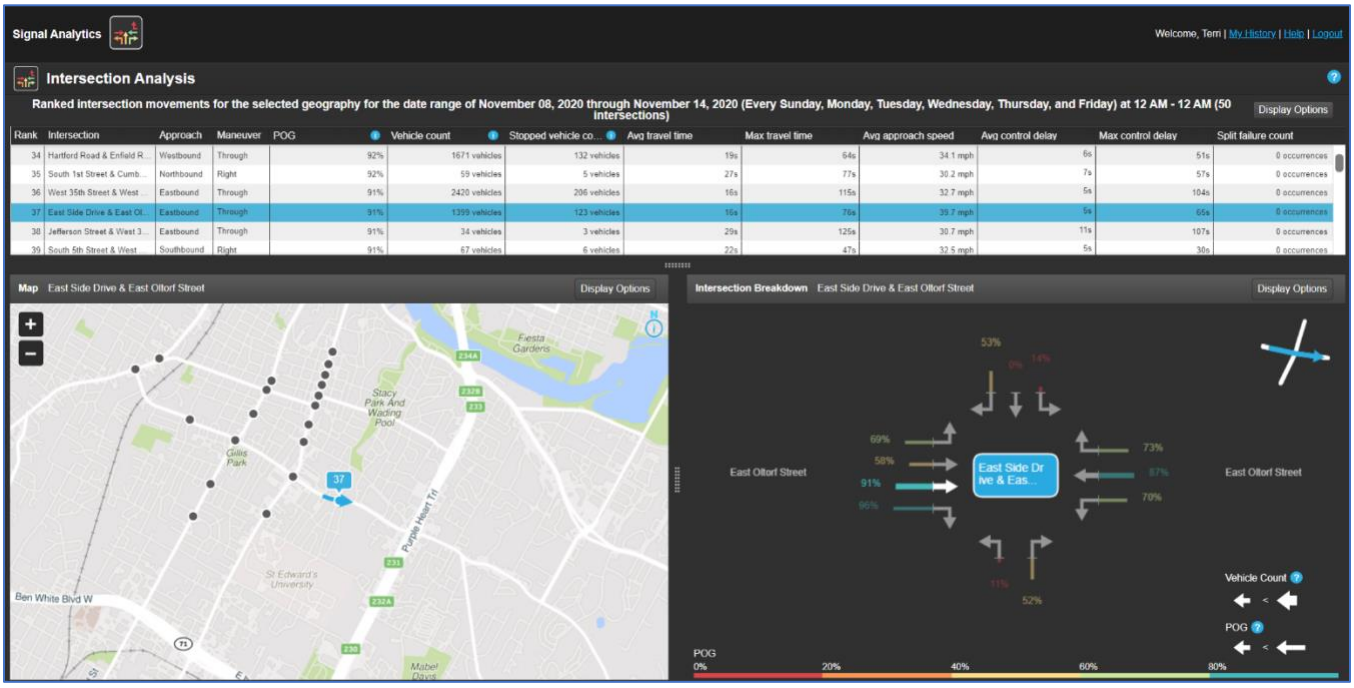
Selection by Road Name.



Selection by Zone.

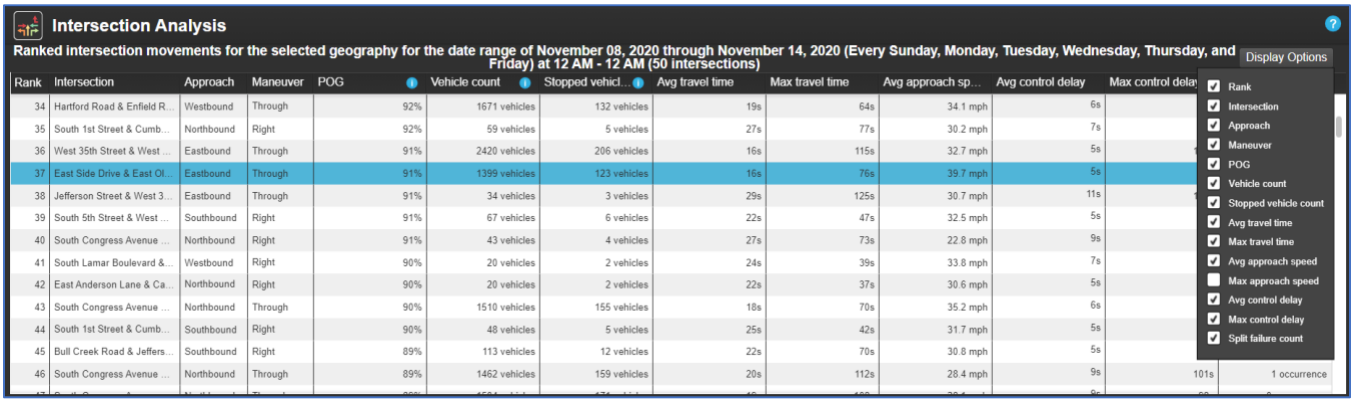
Interpreting the results. Results are loaded from an email link, or through 'My History' found at the top right of the screen (see 'My History' below). Results are returned in three interactive panels on one screen. The Ranking & Summary Table is found across the top; the Intersection Selection Map is at the lower left; and the Intersection

Data Display is at the lower right. Making selections in any of these panels will automatically be reflected, as appropriate, in the other two.



Ranking and Summary Table with Intersection Selection Map and Intersection Data Display

Ranking and Summary Table. Every movement of every intersection in the user's query — commonly 12 movements per intersection — has a row in this table. The ranking of the movements comes first. The user decides which metric is the basis for ranking by clicking the desired header to the right. The next three columns define the intersection, approach, and movement. The metrics farther right are displayed based on user preference, indicated by checking boxes in the "Display Options" menu at the top right. This table has several other interactive features. Clicking on the header of any metric will re-rank the table according to that metric. And clicking on any row will highlight that movement in the other two panels.



Ranking and Summary Table and illustration of the metrics.

Intersection Map. The map can be zoomed-out to see all the intersections in the analysis (black dots) or zoomed-in to focus on a single intersection. Clicking on any black dot will select that intersection, it will also highlight the associated movement for the intersection in the summary table above. Once a movement has been selected by the user (or by default), a blue arrow will appear that exactly illustrates the movement (note that while the lengths of the arrows will vary widely, no information is conveyed by that length).

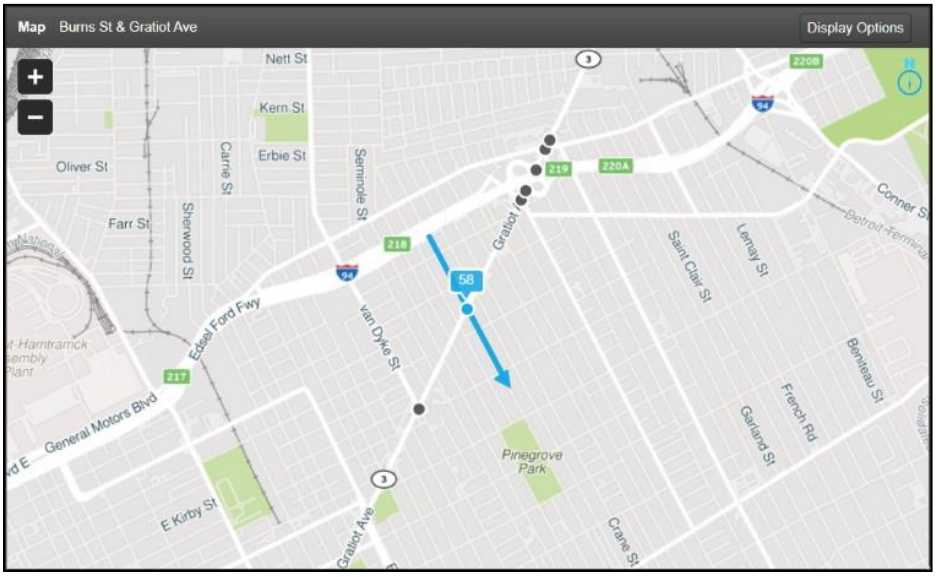


Illustration of selecting an intersection and visualization of the flow metrics

Intersection Data Display. This visualization graphic allows the user to focus on one movement at a time, while providing the larger view of all approaches. First, because this is a schematic that does not rotate, "northbound" can be confused with "westbound", for example, when an intersection is not cleanly aligned to N-S-E-W. To provide certainty, a thumbnail sketch of the active movement is provided in the upper right corner of this panel; the blue arrow there mirrors the arrow in Panel Two and corresponds with the highlighted approach arrowhead in the graphic.

Whichever metric is chosen, the length of each arrow shaft corresponds to the numerical value of that metric — a larger number or percentage produces a longer shaft, and vice versa. (Note that for metrics where larger values are normally regarded as "worse", e.g., travel times, the shafts will be longer. However, where larger numbers mean "better", i.e., travel time or POG, long shafts have the opposite meaning.) The color of the arrow provides further detail, based on the scale shown across the bottom.

Regarding the width of the shafts, wider shafts are used to represent higher sample vehicle counts (and stopped vehicle counts). Note also that the user can hover the cursor over any movement to see the corresponding sample count. Like the other panels, interactivity is built into this panel. Clicking on any movement arrowhead will highlight that movement in the other two panels

The flow metrics for this intersection are displayed one at a time. The user chooses the metric using the "Display Options" menu in the corner of the panel, as shown below:

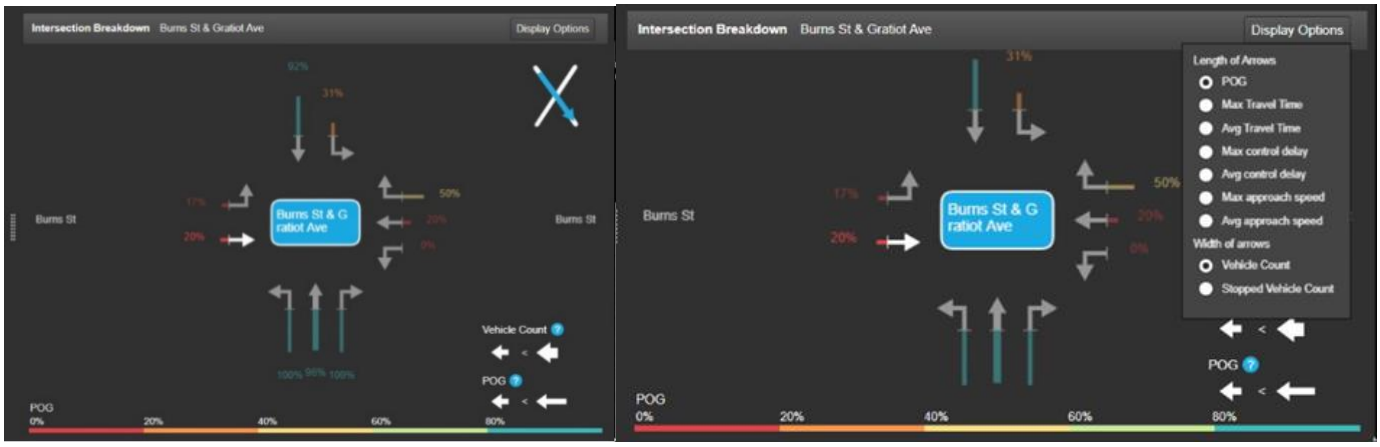
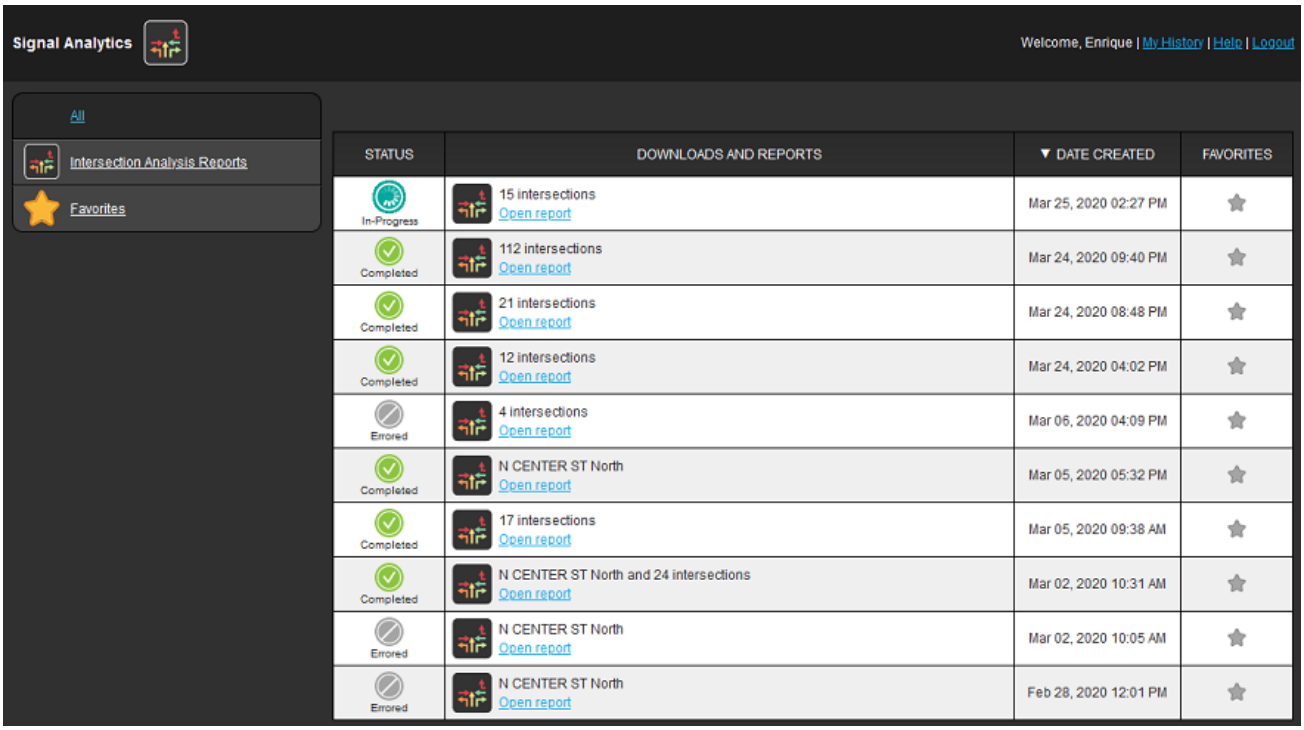


Illustration of the flow metrics for a specific intersection.

My History. The "My History" tool lets agencies access the results of any of your past reports from one location.



My History Dashboard.

Service Fees (updated March 2021)

The cost of INRIX Signal Analytics is simply a function of the number of intersections being monitored and the time period of data being licensed, using the formulas noted below.

For any projects licensed in 2021, we have revised our fee model to reflect the following:

1. Waive the start-up fee
2. Reduced the minimum project fee to $25,000 (from $50,000)
3. Modified the pricing table (see below)

The annual license fee is calculated using a sliding scale as shown in Table 12, reflecting economies of scale of larger regions. Fees include all components and expenses necessary to operate and maintain a fully-functional system for 12-months including but not limited to: data fees, cloud-service fees, system development fees, etc.

These fees are a discount to list price.

Intersection Count Category	Annual Ongoing Licensing Fee ($/intersection)
First 50	**$500**
51 - 200	**$300**
201 – 1,000	**$240**
1,001 – 3,000	**$180**
3,001 - 5,000	**$150**
>5,000	**$120**

Table Above:
Signal Analytics Ongoing Annual Fee Per Intersection Fees via The Eastern Transportation Coalition Vehicle Probe Project (TETC VPP)

Summary of Foundational Research

Waddell, J., S.M. Remias, J.N. Kirsch, S.E. Young, "Scalable and Actionable Performance Measures for Traffic Signal Systems Using Probe Vehicle Trajectory Data," Transportation Research Record, 2020. DOI: 10.1177/0361198120941847

Waddell, J., S.M. Remias, J.N. Kirsch, M. Kamyab, "Replicating Advanced Detection Using Low Ping Frequency Probe Vehicle Trajectory Data to Optimize Signal Progression," Transportation Research Record, 2020. DOI: 10.1177/0361198120923654

Waddell, J.M., S.M. Remias, J. Kirsch, "Characterizing Traffic Signal Performance and Corridor Reliability Using Crowd Sourced Floating Car Trajectories," ASCE Journal of Transportation Engineering, Jan. 2020. DOI: 10.1061/JTEPBS.0000378

Waddell, J.M., S.M. Remias, J. Kirsch, T. Trepanier, "Utilizing low ping frequency vehicle trajectory data to characterize delay at traffic signals," ASCE Journal of Transportation Engineering, Jan. 2020. DOI: 10.1061/JTEPBS.0000382

Remias, S.M., C.M. Day, J.M. Waddell, J.N. Kirsch, T. Trepanier, "Evaluating the Performance of Coordinated Signal Timing: A Comparison of Common Data Types with Connected Vehicle Data," Transportation Research Record. 2018. DOI: 10.1177/0361198118794546

Day, C. M., Li, H., Richardson, L. M., Howard, J., Platte, T., Sturdevant, J. R., & Bullock, D. M. , “Detector-Free Optimization of Traffic Signal Offsets with Connected Vehicle Data,” Transportation Research Record, 2620(1), 54–68. 2017. DOI: 10.3141/2620-06

Day, C.M, S.M. Remias, H. Li, M.M. Mekker, M.L. McNamara, D.M., “Performance Ranking of Arterial Corridors Using Travel Time and Travel Time Reliability Metrics,” Transportation Research Record: Journal of the Transportation Research Board, No. 2487, pp. 44-54, 2015. DOI: 10.3131/2487-04

Remias, S.M., A.M. Hainen, C.M. Day, T.M. Brennan, H. Li, E. Rivera-Hernandez, J. Sturdevant, S.E. Young, and D.M. Bullock, “Performance Characterization of Arterial Traffic Flow with Probe Vehicle Data,” Transportation Research Record: Journal of the Transportation Research Board, No. 2380, pp. 10-21, 2013. DOI: 10.3141/2380-02

INRIX Special Terms

These INRIX Special Terms address the unique nature of the licensed INRIX traffic-related products (the "INRIX Products") to be provided pursuant to a purchase order ("PO") or contract to be mutually negotiated after acceptance of a request for proposal ("RFP"). In submitting these Special Terms, INRIX expressly reserves the right to further negotiate the terms of a contract between you and INRIX. In the event of conflict or ambiguity between these Special Terms and other terms incorporated into any RFP, contract or PO involving INRIX, these Special Terms will govern:

1. As INRIX develops the INRIX Products for a variety of companies, INRIX retains all intellectual property and other rights with respect to the INRIX Products and all related and derivative technology, except for technology that INRIX specifically develops for you pursuant to a mutually agreeable contract or PO that expressly identifies you as the owner or joint owner of such technology. Unless expressly stated otherwise in a mutually signed agreement, the INRIX Products are licensed, and not sold.
2. The INRIX Products license granted to you will be for used for your internal purposes or solely by your customers in the territory encompassed by this proposal, will be nonexclusive, nontransferable and nonsublicensable (except to such customers). The license granted is limited to the term of the applicable contract or PO, except that if you are a public sector agency, INRIX will grant you a perpetual license to the underlying INRIX data to the INRIX Products ("INRIX Data") that is provided by INRIX during the term of the applicable contract or PO. All presentations of the INRIX Products will contain proprietary notices and logos and/or website links of INRIX and/or the INRIX suppliers in a form reasonably provided by INRIX from time to time.
3. Except as otherwise expressly provided in a follow-on contract, all INRIX Products will be provided "as is" and without warranty or obligation of any kind, and to the maximum extent permitted by law, any and all representations, warranties and conditions of any kind whatsoever (including implied or other warranties of merchantability, fitness for a particular purpose and the like) are expressly excluded. No acceptance procedures will apply to such products.
4. The INRIX Products will be the designated products that INRIX customarily provides its other customers in the territory encompassed by this proposal, which is subject to modification from time-to-time. The INRIX Products will not be merged or combined with any other traffic data not provided by INRIX. INRIX will provide all data-related services from its existing USA servers. INRIX reserves the right, at its sole discretion, to use third parties to provide services or data hereunder, including government agencies, and such parties will not be deemed to be subcontractors.
5. If INRIX receives data from you, INRIX will not be provided with any personally identifiable (or personal) information in relation to that data, and you must comply with all applicable laws. All of your security guidelines will apply to confidential information marked as such by you, and the parties will hereafter agree upon which of those guidelines should apply to INRIX, and how to properly implement those guidelines.
6. Neither party (nor its direct or indirect suppliers) will be liable to the other or its customers or any other third parties for consequential, incidental, special, punitive or any indirect damages (including lost profits) related to the INRIX Products, or for any damages relating to any malfunctions, data delays, loss of data or interruption of service.
7. INRIX's suppliers will not have any liability in relation to the use of the INRIX Products hereunder. INRIX and its suppliers will not be liable for any claim, loss or penalty resulting from use or timeliness of the INRIX Products by your customers, and you agree to use reasonable efforts to ensure such limited liability in your end user license agreements with those customers. INRIX will maintain only the insurance policies and limits currently in force as of the date of this proposal.
8. Under no circumstances will INRIX's aggregate liability for all claims, acts and/or omissions arising out of related to any resulting contract or PO, regardless of whether any claim or action is based on contract, tort or otherwise, exceed the total amount paid by you to INRIX under the applicable contract or PO during the 12-month period prior to the date on which the claim arose. Nor will INRIX be liable for any circumstances beyond its control.
9. There will be no financial retention, withholding or offsets with respect to compensation due to INRIX. Invoicing may be conducted by the use of signed PDF's via email. Neither party will have any right to terminate the contract (or any part thereof) for convenience. All permitted terminations will be for the contract as a whole, not individual PO's or other portions. INRIX will provide no bonds or performance guarantees.
10. Except as required by public agency laws/regulations, the contract or PO will be governed by Washington law, excluding conflict of law provisions. Each party may seek equitable relief where necessary. Except for such relief, all claims and/or disputes relating to any contract or PO for the INRIX Products will be finally and exclusively settled by binding arbitration in the capital city in the corresponding state to the governing law in accordance with the then-existing rules of the American Arbitration Association. The arbitral tribunal will consist of ONE (1) arbitrator and will be appointed in accordance with the rules of such institute. This proposal is confidential and proprietary to INRIX, and subject to the formal signing of a mutually-agreeable written contract between the parties.
11. These Special Terms will supersede all inconsistent terms in any business form supplied by either party.