MassDOT Roadway Safety Request for Information and Ideas: Speed Safety Cameras

COMMBUYS “Bid Number”: BD-24-1030-CPO1-CPO1-97530

March 28, 2024

PREPARED FOR:

Massachusetts Department of Transportation

CONTACT:

Tara Pham
Chief Executive Officer
inquiries@numina.co

To: Michael Woods
10 Park Plaza
BOSTON, MA 02116
michael.p.woods@dot.state.ma.us

March 28, 2024

Dear Mr. Woods,

I am pleased to submit the enclosed informational package in response to MassDOT's Roadway Safety Request for Information and Ideas. Our company, Numina, makes a mobility sensor and data platform dedicated to measuring the public realm (streets, parks, and other shared spaces), with special focus on vulnerable road users and safety behaviors. Unlike many other solutions on the market, we focus on *street-level behaviors* and do so with the utmost care and commitment to protecting citizen privacy. From Day 1, we have sought to provide *Intelligence without Surveillance*.

Local to the Northeastern US (headquartered in New York, manufacturing in New Jersey), and having deployed in more than 50 cities around the world, we are proud to have worked in a variety of roadways environments, ranging from urban (including with City of Boston in your state), to suburban and rural. I was excited to see the opportunity to submit our information to MassDOT, with a focus on testing the technology without automated fines. Because Numina does not collect Personally Identifiable Information, as a platform we have not served enforcement applications and instead want to help transportation agencies design, build, and maintain the roadways for *everyone* (not just cars) with a focus on safety first, not on punitive approaches. That said, our technology can help determine the best allocation of police officer enforcement, as needed.

I hope that the enclosed information provides valuable insight into the value of technologies like Numina's, toward MassDOT's safety goals. We would be thrilled to answer any additional questions and support Massachusetts' vision for safer roadways, together.

Thank you for your consideration,

Tara Pham
Chief Executive Officer and Founder
Numina | 370 Jay St., 7th Floor, Brooklyn, NY 11216
tara@numina.co

Table of Contents

Company Overview

Numina's mission: Empower cities with data to become more responsive, so they are safer, healthier, and more equitable for the people who live in them.

Numina provides real-time, ground-level intelligence — without surveillance — to help urban planners and facilities managers design better streets and shared places. Numina's standalone sensor and data platform uses computer vision to measure how people and objects move through the public right of way. Specifically, we detect and differentiate travelers and objects by mode, measuring their paths of travel in the public realm and deriving metrics such as volumes, dwell times, density, relative speeds, and more. By doing all image processing on the device itself, Numina does not need to save or stream video elsewhere and transmits only the critical, anonymous count and location data over GSM cell phone network. Numina only collects occasional random samples of imagery for purposes of accuracy validation and algorithm improvement. At every step of the way, Numina implements best practices in data security, minimization, aggregation, and visualization to prevent re-identifiability. By design, Numina uses the camera as a sensor to provide Intelligence without Surveillance.

Numina's data privacy and security approach is a key differentiator from its competitors. Numina data is anonymous by design. During normal operation, only anonymous data is transmitted from the sensor. Every aspect of data collection, transmission, validation, analysis, delivery, and visualization is intentionally built to uphold the principles of 'Privacy by Design.' Numina collects occasional random image samples for accuracy validation and algorithm improvement, ensuring the system is used purely as a sensor and never as a recording device. These sample images are automatically de-identified and then deleted after 30 days. Numina's current privacy policy is always viewable at https://numina.co/privacy, and our privacy philosophy is explained at https://numina.co/our-privacy-principles.

Numina is aligned with the Massachusetts Department of Transportation's commitment to improving roadway safety. As stated in the Strategic Highway Safety Plan, a safe system is needed now. Due to its automated data minimization strategy and prevention of collecting any Personally Identifiable Information, Numina cannot support automated ticketing and enforcement, but it can be an extremely powerful and efficient tool to help determine the best locations, times, and practices for deploying police officer enforcement. Simultaneously, it can provide unprecedented insight into improving street design to engineer for safety first.

Numina's Product Experience

Numina is founded on principles of **Privacy by Design** and **Intelligence without Surveillance**. That is, while harnessing the power of camera-based data collection, the platform can gather incredibly detailed behavioral information while never collecting Personally Identifiable Information (PII), not even accidentally. Numina minimizes data at every possible step in its architecture, preventing the overcollection of data such as images, identifiers like license plate numbers, or any other PII. You can read more about this philosophy at https://numina.co/our-privacy-principles/ and can always view Numina's current Privacy Policy at https://numina.co/privacy.

The Numina Sensor

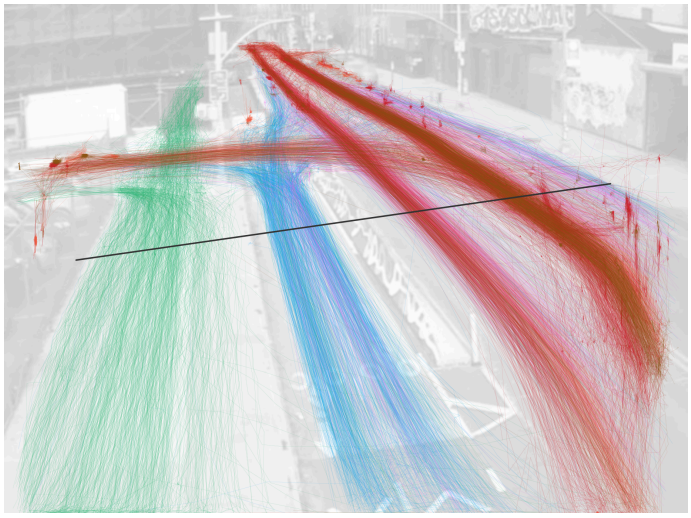
Numina's data collection happens through its patented, proprietary, standalone sensor, which is designed to capture and process how people and objects move through the public right of way, using **computer vision** processing on-board the unit ("at the edge"). Please see Attachment B for Numina's sensor technical specifications, and Numina's Installation Guide is viewable at numina.co/install.

Numina's sensor is designed to strap to light poles using the same steel straps that a street sign uses, take variable input power, and send data over GSM cellphone network, using best-in-class security practices and encryption.

Numina Data

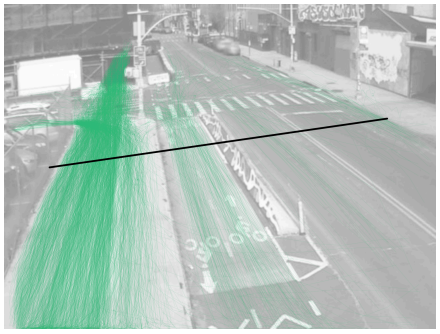
Numina's computer vision algorithms detect and differentiate travelers and objects by mode, measuring their paths of travel in the public realm and deriving metrics such as volumes, trajectories, dwell times, density, and more. Numina customers have access to traffic volumes, commonly traveled paths, and additional safety insights using a self-serve **dashboard**, a queryable GraphQL **API**, and automated **reporting**.

Numina data includes complete volume and path detection of: pedestrians, bicycles, motorbikes, cars, buses, trucks (freight), and newer, more experimental object classes like dogs, trashbags, scooters, and delivery vans.

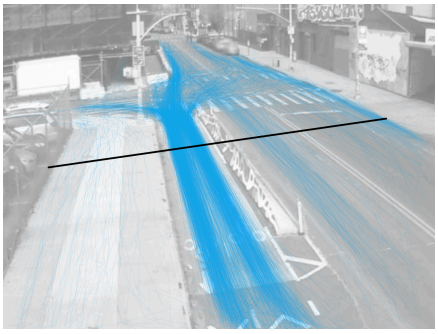


The sensor detects and visualizes street traveler paths, differentiated by mode (coded by color).

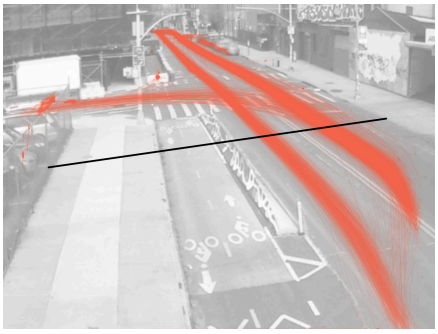
You may filter all visualizations by mode:



Pedestrians

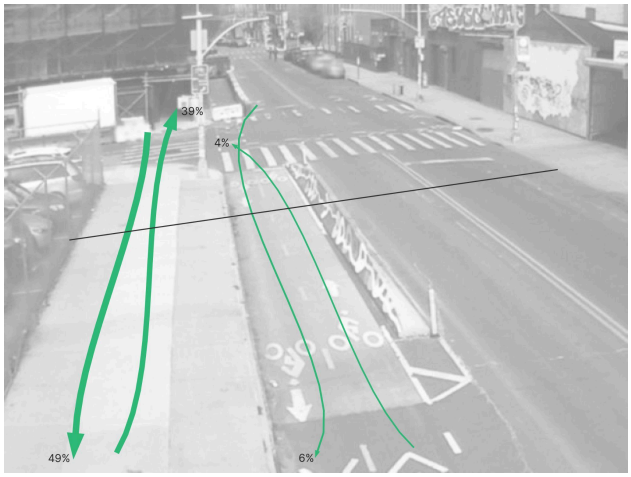


Bicyclists

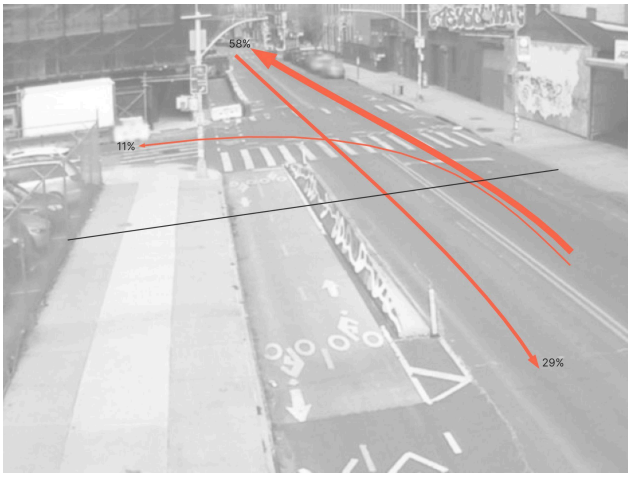


Cars

Numina further processes these object “tracks” (or traced paths) for additional insights. For example, we cluster them to understand common traveler routes and turning movements:



Pedestrians



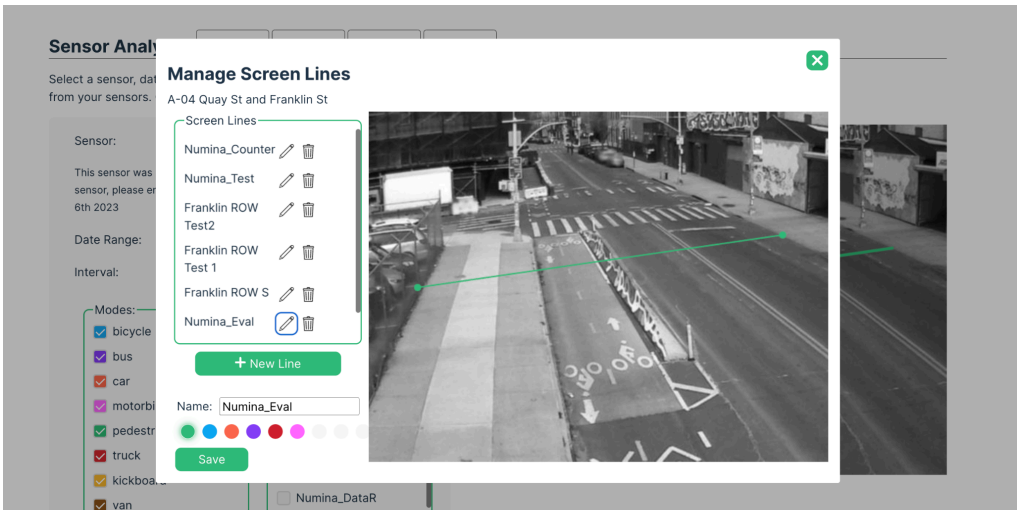
Cars

Numina Dashboard & Analytics

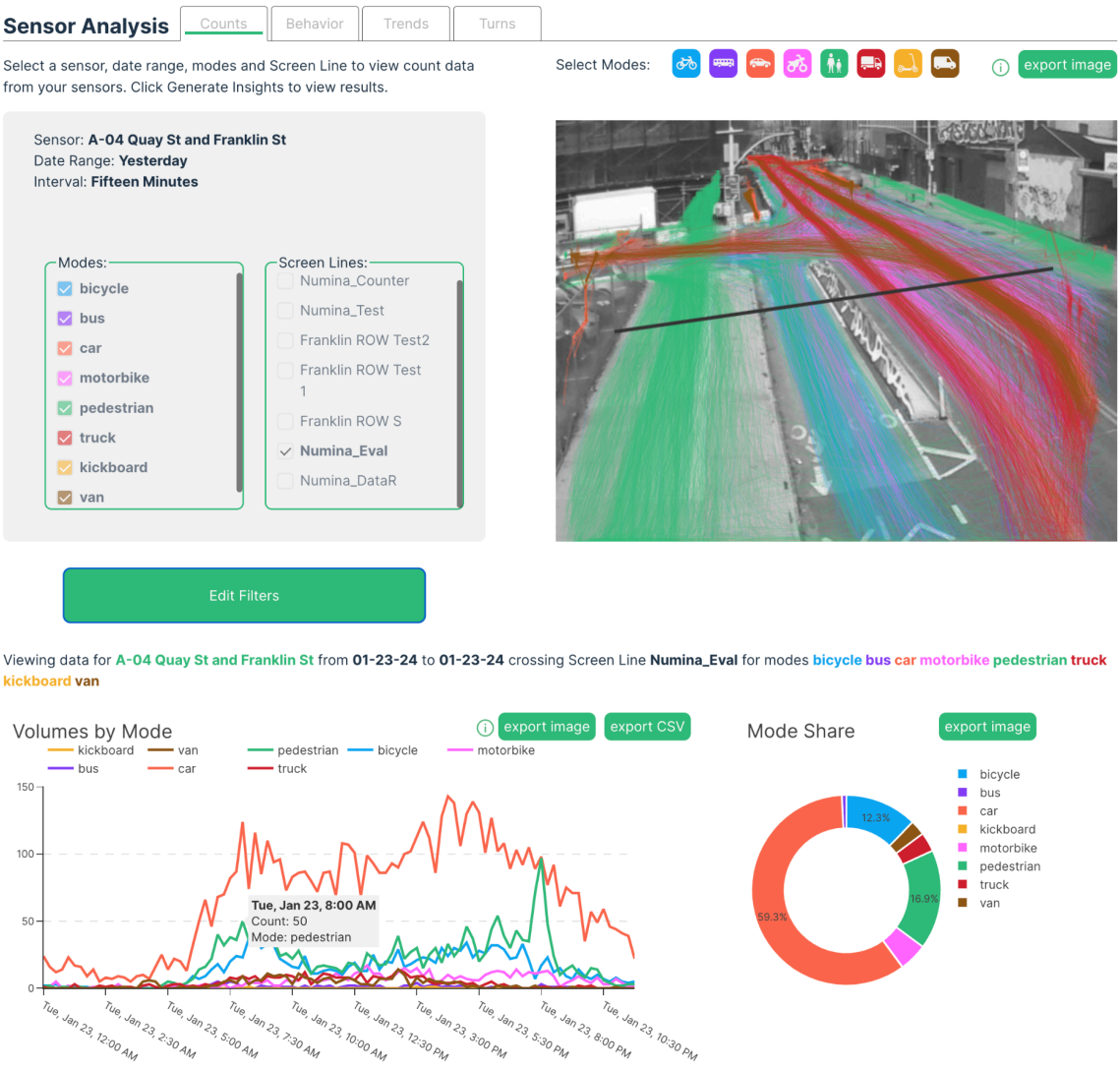
Numina provides a web dashboard for users to access the data, generate reports, and perform analysis. There, users can draw their own Screen Lines (virtual trip wires) and Behavior Zones (polygons) onto each Sensor's View, then view or export the following charts for each:

- Desire lines by mode
- Heat maps by mode
- Volumes by mode in a line chart
- Activity by time of day chart
- Mode share (%) in pie chart form

For example, to view Desire Lines and Counts, draw a Screen Line onto the Sensor View (here called "Numina_Eval"):



When you click "Generate Insights," you can see Desire Lines by mode and Counts data for the selected Screen Line:



All counts are totally portable out of the Numina platform, by clicking the “export CSV” button.

Numina API

Numina API can be used to integrate Numina data with other systems and applications, such as traffic management systems, urban planning tools, and mobility apps. Developer documentation is at https://developer.numina.co.

RFI Questions

1. **Where else has your technology been implemented? Or, to the best of your knowledge, would we be the first place to try it?**

   Numina technology has been implemented in over 50 cities throughout the world, where our machine learning models have been trained and tested across a diverse variety of urban, suburban, and rural environments. In Massachusetts, Numina has worked with the City of Boston, who installed Numina sensors to understand the impacts of temporary street-level changes that were part of the Healthy Streets initiative. Details on the initial pilot can be seen in detail at https://boston.gov/numina.

2. **Have any of your deployments faced challenges based on racial equity or equity concerns? If so, how did you work with partners to address these concerns?**

   From its inception, Numina has deployed in service of transportation equity. By specifically giving visibility to bicyclists and pedestrians, it seeks to include those populations who rely on non-motorized and public transportation in planning processes where they were previously "invisible" and unaccounted for. This work is particularly important to advance racial and socioeconomic equity, as research shows that low-income and minority populations suffer disproportionately high cycling fatality rates and less access to biking infrastructure.[1] For example, Black Americans are killed by cars at more than twice the rate of White Americans while walking, and at more than four times the rate while biking.[2]

   One of the larger concerns when deploying in underserved areas is residents' privacy rights and surveillance, especially as it is well-documented that marginalized communities are overburdened by surveillance and feel the compounding negative effects of surveillance technologies such as facial recognition and other AI.[3] Numina specifically communicates its Privacy-by-Design philosophy and architecture through municipally conducted Privacy Impact Assessments, its own public signage and online resources, and through community engagement activities like local workshops.

---

[1] Braun, L. M., D. A. Rodriguez, and P. Gordon-Larsen. Social (in)Equity in Access to Cycling Infrastructure: Cross-Sectional Associations between Bike Lanes and Area-Level Sociodemographic Characteristics in 22 Large U.S. Cities. Journal of Transport Geography, Vol. 80, 2019, p. 102544. https://doi.org/10.1016/j.jtrangeo.2019.102544.

[2] Matthew A. Raifman, Ernani F. Choma, Disparities in Activity and Traffic Fatalities by Race/Ethnicity. American Journal of Preventive Medicine 63, 2, 160-167 (2022).

[3] Lee, N. & Chin, C., 2022. Police surveillance and facial recognition: Why data privacy is imperative for communities of color, Brookings Institution. United States of America. Retrieved from https://policycommons.net/artifacts/4141776/police-surveillance-and-facial-recognition/4950424/ on 28 Mar 2024. CID: 20.500.12592/g36hgs.

In one example of such a workshop, facilitated scoping and workshops with the Long Beach Collaboratory (LB Co-Lab), a program that engages community members in an immersive and collaborative technology deployment and training process to design a technology solution that works for them. LB Co-Lab participants identify neighborhood needs in a series of collaborative brainstorming sessions, and then design an accessible technology solution to address an agreed-upon "challenge." The technology implemented through this program will ensure the City invests in technology enhancements based on community-identified needs. While designing and deploying technology infrastructure solutions in their neighborhoods, LB Co-Lab participants are also taught professional skills in technology. They receive career guidance for navigating the tech world and earn a credentialed technology certificate to support their professional development goals. Through this program, the Willmore neighborhood in Long Beach selected Numina to identify opportunities for improved bicycle and pedestrian safety, and Numina's CEO Tara Pham facilitated conversations about the technology and ways to scope infrastructure projects at the community level. For this project, Numina has taken community input to design signage and notification systems that allow passersby to learn about the sensor project and road safety issues, as well as access reports published in multiple languages, monthly.

Given our privacy philosophy and value of tech-literacy, we've listed our technology and projects with Digital Trust for Places and Routines. DTPR is an open-source communications platform that increases transparency, legibility, and accountability of digital technology in the built environment (DTPR website). Additionally, Numina offers signage to be posted near sensors installed on the street so that street users can gather information about the purpose of the project and use of this technology (pictured).

3. **Do you have staff or a company footprint in New England?**

Numina is based in New York City and manufactures its equipment in New Jersey.

4. **Does your hardware solution require a power source? Can it be solar/battery powered? Does it need network connectivity?**

   The Numina sensor transmits data over cellphone network and thus does not need to be tethered to WiFi, Fiber, or Ethernet, or other backhaul communications infrastructure such as gateways. Each sensor can be deployed on its own and added to the Numina platform, no meshing necessary. Furthermore, Numina can install where other systems cannot, such as at mid-block locations, non-signalized intersections, and in more natural environments. This flexibility is critical because only 16% of pedestrian fatalities happen at intersections, with 75% (and 62.0% of bicyclist fatalities) occuring at non-intersections; yet practically all other platforms in the market focus solely on intersections.[4]

   Each device requires a consistent (but not necessarily 24/7) power source. Typically, the sensor is hardwired to a light pole. There are currently two models: one with a small internal backup battery meant to sustain the sensor through momentary power outages or "brown-outs," and the other with a 16+-hour internal battery to charge from an electrified streetlight overnight and power the sensor throughout daylight hours (in cases where, for example, a light pole may be photocell-controlled or on a timer to turn off during daylight hours). Both models weigh less than 10 pounds, are simply and non-damaging to install or remove, take in 12VDC power, and are deployed with a power supply that can take in variable 90VAC-260VAC power. Even in high-activity areas, the sensor typically consumes less than 8 kWh per month.

   Some customers have deployed Numina with solar kits. It is generally not recommended or feasible in urban environments, as it requires a large panel (at least 160W panel with 100Ah battery). Any alternative power configurations are at the discretion, and responsibility, of the customer.

5. **Describe the operational approach your company would take to validate the accuracy of your cameras.**

   Numina continually works to validate our data and update our accuracy metrics. We are able to roll out improvements to existing sensors in the field via over-the-air software updates. As our accuracy continues to improve, we will re-publish accuracy numbers for our customers and make all improvements available via the Numina Data Platform. The process for how sensors sample random, de-identified imagery for accuracy validation and algorithm training is thoroughly described in the Numina Privacy Policy (https://numina.co/privacy).

[4] National Highway Traffic and Safety Administration, Traffic Safety Facts : 2021 Data (2023). NHTSA's National Center for Statistics and Analysis. Retrieved from https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813458.

Notably:

- In normal **Operation Mode,** sensors collect Sample Images once per hour, at a random time within each 1-hour interval (a sample rate approximately 0.003% of the total images collected and processed onboard the sensors). These images are relatively low-resolution, only viewed by humans after *de-identified* (blurred of any identifiable information), and used by Numina only to evaluate how its models are performing and make adjustments to improve their accuracy.
- For the first two weeks of every deployment, the sensors are configured into a **Calibration Mode**. While the sensor is in Calibration Mode, the standard data sampling and retention policies are modified. There is an increase in image sampling, with up to 5 random images sampled per hour (approximately 0.02% of the total images collected), and video collection (in the form of a sequence of images with an 8 frame-per-second sample rate) of up to 1 minute per hour (approximately 1.7% of the total images collected) sampled at a random time per hour. Data collected while in Calibration Mode is not deleted. This calibration data enables us to continually improve our machine learning algorithms, and is used as a ground truth for benchmarking accuracy of Numina algorithms and to create more accurate models which are periodically pushed out to all sensors. If desired for further performance improvements, Calibration Mode may be extended or re-engaged later, only with explicit, advanced authorization from the customer. Customers may also opt out of Calibration Mode periods but must request such before sensor installation, in order to avoid the default calibration settings.

Numina's platform maintains industry-leading accuracy for multimodal transportation data. In the second half of 2023, Numina conducted a comprehensive accuracy validation exercise for its current computer vision model. This exercise used customer-approved data samples from over 25 sensors, of which all but a few were located in NYC. In the analysis of 1,127 sequences that included over 12,396 unique object detections, Numina demonstrated best-in-class multimodal accuracy, with pedestrians, bicyclists, and cars all reported with over 90% confidence (i.e. <10% deviation from verified counts). Numina also exceeds the "acceptable" accuracy outlined in the *Making Bikes Count* white paper by the National Association of City Transportation Officials (NACTO). A detailed white paper on this accuracy study and general computer vision evaluation methodologies is available upon request.

6. **What is the minimum resolution needed for your software to accurately determine (or 'read') a license plate?**

The sensor technology detects objects anonymously by design, and the software will not read a license plate or keep identifiable images of objects.

7. **How does your technology handle inclement weather? License plate covers? Night-time and direct sunlight?**

   Numina can operate in reasonable lighting situations, most weather conditions, and generally lower-speed (<60mph, non-highway) environments without loss of accuracy.

   Instances where we might not produce reliable results include:

   - Darkness. We suggest deploying on light poles and buildings that offer adequate lighting. While our sensors continue to operate at night and can detect objects in the illuminated area, we anticipate loss of accuracy at night, especially on smaller objects such as people and bicycles.
   - Fog, snow, and heavy rain may also impact accuracy during extreme weather events where a human would also struggle to see objects.

   Additionally, all Numina sensors are equipped with an internal battery that provides at least 4 hours of on-board power (larger models have 16+ hours of battery back-up). If a sensor gets disconnected, it will alert the Numina team and continue operation as normal until the battery is fully expended (or, ideally, a physical intervention restores power). Any data that does not successfully transmit is stored onboard and transmitted once the sensor is online again.

8. **If you provide physical infrastructure as part of your solution, is it mobile or fixed equipment? If mobile, how long does calibration take in a new location? Describe any relevant criteria for the use of one over the other if you offer both.**

   Numina sensors are designed to be easy to install using the same steel straps any street sign uses. Due to the challenge of securing power sources in streets, the sensors are usually deployed as fixed equipment in a long-term data collection program. That said, some customers maintain a fleet of Numina sensors, which they relocate as needed. It usually takes Numina 1-2 business days to fully onboard a newly installed sensor into its platform, and we recommend a 2-week calibration period in case of a rare error in site detections. For example, if the sensor is deployed in a public plaza with a statue of a person, that statue may be detected as a pedestrian until “trained” not to do so.

9. **Please describe the requirements for any space or physical assets needed for installation of equipment.**

   Numina provides the sensors, installation kits, and its Installation Guide. We work with the customer agency to scope locations which meet the following requirements:

- A mounting height of 15-25 feet (approximately 5-8 meters), with clear line of sight to the study area, free of obstructions like foliage, scaffolding, or street signs
- Access to electrical power
- Permission to attach to pole infrastructure

In addition to auxiliary equipment that Numina provides with its sensor, the installation process may require basic off-the-shelf tools, such as:

- Safety equipment and gear, such as hard hats, safety vests, and traffic cones
- 12' step ladder or bucket truck
- 4 waterproof wire nuts
- Drill + 3/8" drill bit
- "3/8" outdoor EPDM push-in grommet
- 1.5mm and 3mm hex key

10. Please describe any criteria for heights and distances to ensure accuracy of the data collected.

The sensor installs at 15-25 feet (approximately 5-8 meters) high, with some flexibility in its view and range. The horizontal viewing angle is 89º, and the distance can be configured physically and digitally at sensor installation and onboarding, reaching a radius of ~30-150 feet from the sensor.

11. Do you offer a turnkey service? If so, what is included in that service and what is the minimum scale needed to implement?

Numina will support the Customer with guidance on site selection, permitting, and other project planning. The Customer is responsible for installation, for which Numina will provide remote live support. On a cost-plus pricing basis, Numina can include third party installer services in its project scope.

12. Does your company provide data processing, violation review and mailing services? If yes, please describe the general approach for how these services would be delivered. Please pay particular attention to the note above that we are not issuing tickets, fines, or fees in response to the observed violation.

Not applicable.

13. What integration would you need to have with the Registry of Motor Vehicles in order to mail safety messages to drivers who are observed violating the speed limit?

Not applicable.

14. **How long would it take you to implement your solution, from signed contract to solution go-live? In other implementations, what tends to slow down the path to deployment?**

    From the time of complete contract or Purchase Order, Numina can be implemented in as little as 2 weeks. Once the contract is signed, sensors are shipped within a week and can be installed on the scheduled installation date. Within about 48 hours of installation, the sensors are onboarded into the web-accessible platform, for access via the Numina User Dashboard and API.

    The most common factors that slow down implementation include municipal permitting processes and scheduling the electrician for installations.

15. **Describe the smallest high-fidelity implementation scenario you can imagine. Please include information like minimum size of a deployment, minimum suggested duration, what types of costs (not actuals) are included in your business model (e.g., installation, on-going service, mailing, deinstallation).**

    The smallest high-fidelity implementation would include one sensor, for a minimum of one year. Numina's pricing scales with major volume breaks based on the project size, but it generally does not engage in pilots less than $15,000.00 in contract size.

    Every Numina project includes:

    - One-time equipment fees, for sensor and installation kits
    - Data services subscription (usually per sensor per year)
    - Recommended project management and data analysis support, on an hourly basis
    - Other costs: Shipping & Handling, Installation

16. **What is your approach and delivery of staff training as it relates to your proposed solution?**

    The Numina team will host meetings with the Customer and Installer to create and review an installation plan. Once the sensors are installed and some data collection has happened, Numina will perform a data review and Dashboard training with the Customer. The Numina team is available to assist with any requests or issues as needed.

17. **Is your company currently providing services to the Commonwealth of Massachusetts? If so, what kind?**

    We are not currently providing services to the Commonwealth of Massachusetts. From a previous project with the City of Boston, some Numina data is openly available on Analyze Boston.

Data Collection Questions

18. **Personally Identifiable Information (PII) is any information about an individual that can be used to determine an individual's identity, including an individual's name, social security number, date of birth, medical or educational records, geolocation data, photographic images, or other information that is linked to any of the above. If your technology collects data, does your proposed data collection tool involve the collection of PII?**

    Numina's software does not involve the collection of Personally Identifiable Information (PII). Numina software processes images captured by sensors to extract object data in real-time. Those images are not stored or sent to any other server. The software collects de-identified images, and does not collect any PII such as names, social security numbers, or medical records.

19. **Provide a brief (yes/no) answer to the following questions**

    a. Would MassDOT own the raw data collected?

    Yes

    b. Would the raw data be anonymized?

    Yes

    c. Would the data be deleted periodically? If so, how often?

    No

    d. Would any third parties have access to the raw data collected?

    No

20. **Provide a brief table that outlines the lifecycle of the data collected. Please indicate the following:**

Where will the data be stored and processed?	All of our data is stored in Amazon Web Services (AWS), is encrypted at rest, and access is restricted to current Numina employees and trained contractors using AWS best practices for limited identity and access management. Only authorized devices can communicate with sensors. This requirement removes pathways for data interception or sensor access by unauthorized third parties. Numina's current privacy policy and practices are described at https://numina.co/privacy.
Who will own and have access to the data?	Numina and the partner will own the data. The authorized Dashboard users and the Numina team will have access to the data. Data is fungible, so all parties should be aware that data may be retained indefinitely by any person or party who has access to the data.
How will data security be maintained?	Numina adheres to best-in-class security practices and may provide more information through a confidential cyber review.
Whether the data will contain PII; whether and how any such PII will be anonymized?	The sensor processes raw Detection Image data onboard and immediately discards them after they are processed. In normal Operation Mode, sensors collect Sample Images once per hour, at a random time within each 1-hour interval (a sample rate approximately 0.003% of the total images collected and processed onboard the sensors). These images are relatively low-resolution, only viewed by humans after de-identified (blurred of any identifiable information), and used by Numina only to evaluate how its models are performing and make adjustments to improve their accuracy. When trained staff review Sample Images for accuracy and training purposes, they only access de-identified versions which have any automatically

	detected objects pre-blurred beyond recognition.
How will the data be disposed of, destroyed, sent elsewhere, or made public?	The anonymous mobility data (object detections and tracks) are not disposed of. They are only served in aggregate analytic form to users and, in that format, may be made public on an open-data portal.
In your previous deployments, how long the data will need to be stored before deletion, if applicable.	Not applicable

21. **What risks or vulnerabilities are associated with the data collection you require to perform that tasks stated by your offering?**

    Not applicable

22. **How have you ensured safe and limited access to motor vehicle registration data and systems in your previous deployments?**

    Not applicable

Civic Research Questions

1. **What sustainability metrics (like fuel consumption) are you able to provide insight into that could also correlate to safety improvements?**

   Numina is an enabling technology that brings unprecedented visibility to vulnerable road users and important road uses like commercial freight. By differentiating bicyclists, pedestrians, and different types of vehicles, planners can design better street experiences for *everyone* (not just cars) and optimize for goals to shift more travel to low- and no-emissions modes. Safety countermeasures are a critical climate change mitigation strategy because pedestrian fatalities have increased 70% since 2010, and society cannot ask people to drive less if the alternative is exposing themselves to regular life-threatening roadway conditions.[5]

[5] National Center for Statistics and Analysis. (2023, June). Pedestrians: 2021 data (Traffic Safety Facts. Report No. DOT HS 813 458). National Highway Traffic Safety Administration.

In New York City, for example, Numina works with New York City Transit's bus planning team (NYCMTA), with the hopes of optimizing routes and improving rider experiences. By improving the rider experience, the NYCMTA can attract more customers, converting more drivers to riders. A single commuter opting to use public transportation, instead of driving, results in a reduction of up to 20 pounds of carbon dioxide emissions per day.[6]

In this study, Numina also captured curb-level behaviors of multiple street user types, including e-bicyclists on sidewalks, double-parked cars, trucks loading, sitting buses, and other frequently idling vehicles. The City can create major efficiencies and mitigate air quality concerns by unblocking the right of way and identifying opportunities for new types of loading zones and e-micromobility lanes.

2. **Show us something unique about your work that would provide new actionable insight for MassDOT in helping us prioritize resources.**

   Because MassDOT cannot issue tickets, fees, or fines for moving violations without a police officer present, Numina may be a powerful option to acquire comprehensive intelligence about street-level safety behaviors and, in a very cost-efficient way, understand how to best allocate police officer resources to where and when violations are most common.

   You may see a deck of case studies, in Numina's vehicular violations detection work, here: https://hubs.ly/Q02r6RHt0

3. **How could your tool be leveraged to support the work of cities and towns in making their roadways safer through annual construction project planning?**

   Numina's granular street-level insights help to comprehensively quantify the usage of, and demand for, infrastructure — not just for vehicles in car lanes, but for all users across the right of way. This more accurate demand intelligence can inform smarter regional planning.

   Numina data will further empower MassDOT to:
   - know what activity matches normal patterns and what is anomalous.
   - identify travel demand peaks, as an opportunity to improve efficiencies and also facilitate modeshift, and

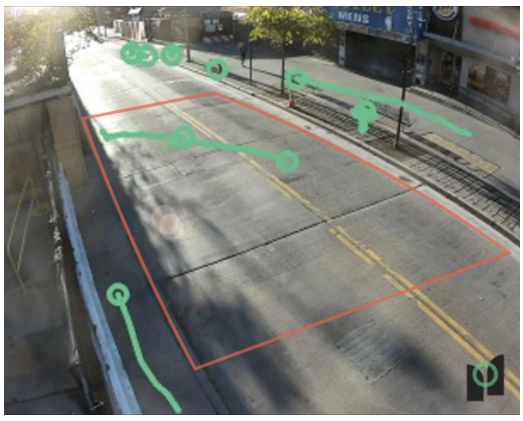
[6] Report. *Public Transportation Reduces Greenhouse Gases and Conserves Energy*, American Public Transportation Association, 2008. *American Public Transportation Association*, 2008, https://www.apta.com/wp-content/uploads/Resources/resources/reportsandpublications/Documents/greenhouse_brochure.pdf. PDF download.

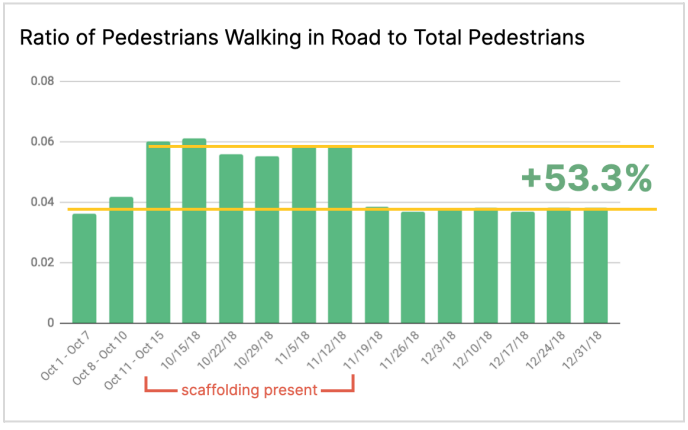
- identify traffic lows, as opportunities to perform maintenance, construction, or other interventions while minimizing potential traffic interference.

Numina also helps state and local governments understand when and where to target more cost-intensive programming, outreach, surveying, etc. For example, should MassDOT need to conduct in-person surveys to understand qualitative information or gather otherwise non-automated data, then they can deploy such resources to areas, and at times, where travelers will likely be. Furthermore, the data collected in those brief periods can be mapped and correlated to the actual traffic patterns of the area, so extrapolations to longer periods, larger populations, etc., can be more realistic and more grounded in real, detailed data.

Numina provides additional insight around active construction, as well, to understand safety, better navigation around phased construction, and more. During construction periods, Numina's sensors track pedestrian movements, highlighting areas where sidewalk closures force pedestrians onto roadways. This data enables agencies to identify high-risk zones and implement temporary pedestrian refuges or mid-block crosswalks to enhance safety. This data can inform decisions and policies about pedestrian safety in construction zones, which may point to the need for better signage, temporary pedestrian infrastructure, or additional motor vehicle traffic enforcement during construction periods. In two examples:

Fulton Mall for Downtown Brooklyn Partnership (Brooklyn, NY)
Numina measured the impacts of construction and scaffolding on pedestrian safety for Downtown Brooklyn Partnership. With over 300 miles of sidewalk sheds erected in New York City on any given day, scaffolding poses safety concerns for pedestrians and disrupts the flow of traffic across multiple modes of transportation.





For Downtown Brooklyn Partnership and Newlab's Circular City Lab, Numina deployed along Fulton Mall, a corridor primarily for pedestrians and MTA buses. Numina measured multimodal behaviors and found stunning conclusions, such as the average

dwell times and most frequent locations of illegal freight loading; which roads were the primary feeders of illegal private car traffic into the pedestrian mall; and regular drops in traffic on Sundays and during snowy weather.

During this study, there was a month-long construction project on the Fulton Mall. Numina compared pedestrian activity during the construction period, to that before and after. By applying spatial analysis techniques to our pedestrian movement data (represented by green circles and desire lines in the left image), we were able to analyze how many more pedestrians walked on the street (through the Behavior Zone shown in red), when the sidewalk was obstructed by construction. The data showed **that pedestrians were 53.3% more likely to walk into the road while sidewalk sheds were erected** in the streetscape. Read more about this project on our blog.

Subway platforms for the New York MTA

For MTA Construction & Development (MTACD), Numina performs passenger counting on subway platforms, to evaluate egress for building code compliance. Over two months of data collection on the W. 42nd Street at the Northbound and Southbound F platforms, sensors counted over 20,000 passengers daily. The first visualization shows the percentage of total users traveling in either direction (up or down). The second visualization provides an hourly average number of passengers going in each direction. The chart includes minimum and maximum volumes observed in each direction. These data points help MTACD understand how many stairwells they can close for construction while still allowing adequate egress.