# The Future of Urban Traffic Management: Integrating AI and LiDAR for Smarter Cities

White Paper

How advanced technologies are revolutionizing traffic systems for safer, smarter urban environments

2024

## Introduction

Urban traffic management is at a critical juncture. With the rapid expansion of cities, the increasing complexity of road networks, and the growing need to ensure the safety of all road users, traditional traffic management systems are struggling to keep pace. Congestion is worsening, pedestrian safety remains a significant concern, and the limitations of existing technologies, such as inductive loops, are becoming more apparent.

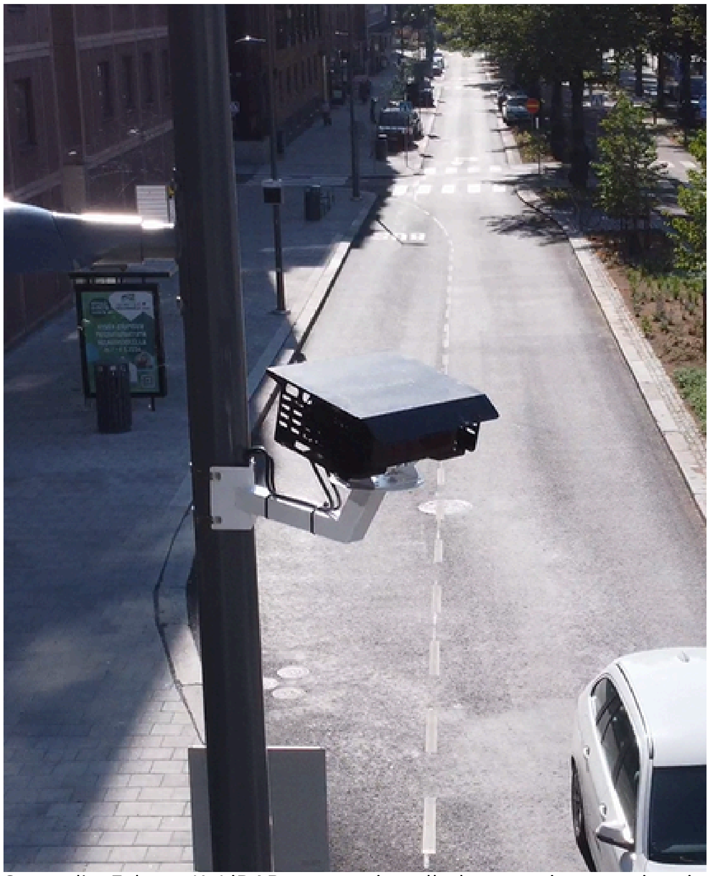
As urban centers become more densely populated, the demand for innovative solutions to manage traffic flow, reduce accidents, and enhance the overall efficiency of city infrastructure has never been greater. This is where advanced technologies like Artificial Intelligence (AI) and Light Detection and Ranging (LiDAR) come into play.

AI has already begun to transform numerous industries by providing real-time data analysis, predictive capabilities, and automation. In traffic management, AI offers the potential to revolutionize how cities monitor and respond to traffic conditions, optimize signal timings, and ensure smoother flow on busy streets.

Meanwhile, LiDAR technology, known for its high-precision mapping capabilities, is emerging as a game-changer in traffic detection. Unlike traditional methods, LiDAR can detect and classify a wide range of road users—including vehicles, pedestrians, and cyclists—with unparalleled accuracy, even in challenging environments.

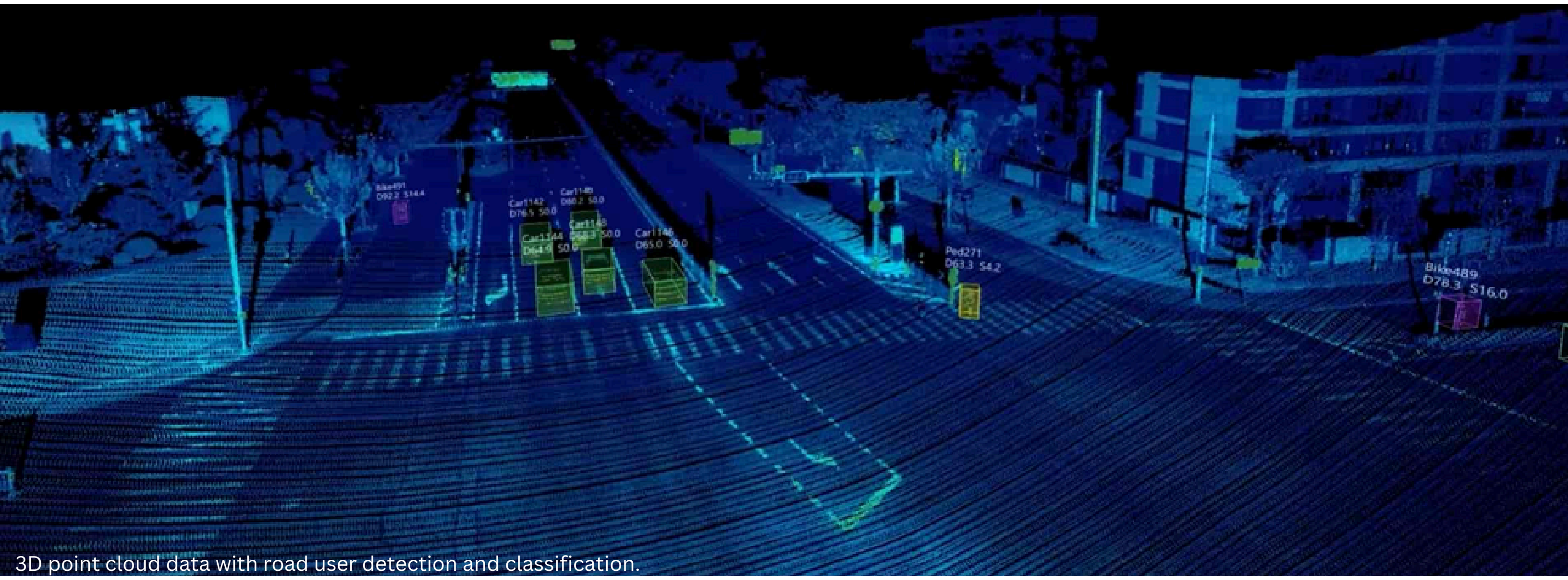
Together, AI and LiDAR represent the future of urban traffic management. By integrating these technologies, cities can develop smarter, more adaptive traffic systems that not only improve the efficiency of road networks but also significantly enhance safety for all.

This white paper explores the transformative potential of AI and LiDAR in urban traffic management. It delves into the benefits of these technologies, the practical considerations for their implementation, and the opportunities they present for cities and city contractors. As cities around the world look to build smarter, safer urban environments, understanding and leveraging AI and LiDAR will be key to staying ahead of the curve.



Seyond's Falcon K LiDAR sensor installed at an intersection in Finland.

## LiDAR Technology: Revolutionizing Traffic Detection



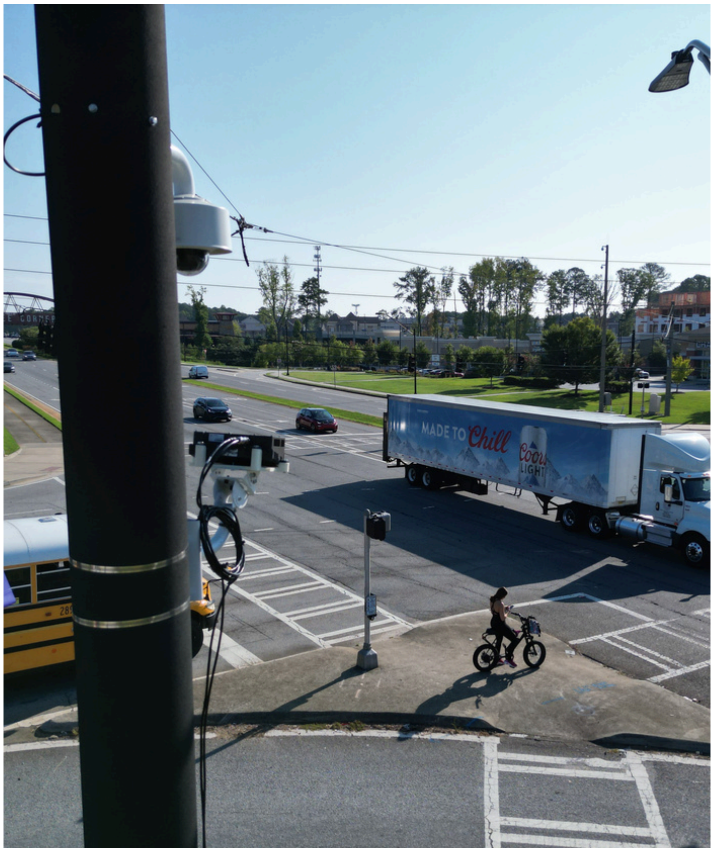
3D point cloud data with road user detection and classification.

As urban centers continue to expand and evolve, the need for accurate, reliable, and versatile traffic detection systems has become more critical than ever. Enter LiDAR technology—an advanced sensing method that is reshaping how cities monitor and manage traffic flow.

LiDAR is a remote sensing technology that uses laser pulses to measure distances and generate detailed, three-dimensional information about the surrounding environment. Originally developed for applications like topographical mapping and autonomous vehicles, LiDAR has found a powerful new role in traffic management.

In the context of traffic detection, LiDAR sensors are typically mounted on poles or other elevated positions at intersections or along roadways. These sensors emit thousands of laser pulses per second, which bounce off objects—such as vehicles, pedestrians, and cyclists—and return to the sensor.

By measuring the time it takes for the pulses to return, LiDAR can create an accurate, real-time map of the area, detecting the position, speed, and movement of all road users.




Seyond's Falcon K LiDAR sensor installed at an intersection in Georgia, USA.

## Advantages of LiDAR Over Traditional Methods:

LiDAR technology offers several significant advantages over traditional traffic detection methods, such as inductive loops and cameras:

- **High Accuracy:** LiDAR can detect objects with remarkable precision, even in challenging conditions such as low light, fog, or rain. This high level of accuracy makes it ideal for monitoring busy intersections and ensuring that all road users are accurately detected and tracked. Seyond's Falcon LiDARs can accurately detect vehicles up to 100m behind the stop bar and pedestrians up to 50 m away from the intersection.

Seyond's Falcon K LiDAR sensor.

- **Detailed Object Classification**: LiDAR can differentiate between various types of road users, such as vehicles, pedestrians, and cyclists. This ability to classify objects is vital for implementing advanced traffic management strategies that prioritize safety and efficiency for all road users.
- **Real-Time Data Collection**: LiDAR provides real-time data on traffic flow, allowing cities to respond quickly to changing conditions. This capability is crucial for optimizing traffic signals, managing congestion, and enhancing road safety.
- **Reliable in All Weather and Lighting Conditions**: Unlike cameras that need good weather and external lighting, LiDAR uses its own light source, making it effective even in rain, fog, and snow.
- **Non-Intrusive Installation:** LiDAR sensors can be installed without disrupting the roadway, unlike inductive loops that require cutting into the pavement. This non-intrusive installation process reduces costs and minimizes the impact on traffic during deployment.
- **Low Cost of Maintenance:** In most cases, only two LiDAR sensors would be required to cover an entire intersection, making this system less expensive to maintain than other solutions that require more sensors to provide full coverage.
- **Privacy-Friendly:** LiDAR sensors do not capture or use any personal information like biometrics, unlike traffic cameras.

## The Role of AI in Traffic Management

AAt its core, Artificial Intelligence (AI) in traffic management involves the use of machine learning algorithms, neural networks, and other advanced computing techniques to classify road users, analyze multimodal traffic data, identity patterns, and automate decision-making processes. Unlike traditional systems, which rely on pre-set rules and manual inputs, AI-driven systems continuously learn from the data they collect.

### Benefits of AI Integration

- **Optimized Traffic Flow:** AI can dynamically adjust traffic signal timings for vehicles and other users such as pedestrians and cyclists, based on real-time traffic conditions, reducing congestion and minimizing delays.
- **Improved Safety:** By being able to adjust traffic signals based on real-time traffic conditions, an AI system can enhance road safety for the most vulnerable users. In addition, AI can detect potential hazards and alert drivers or pedestrians in real-time. For example, AI-driven systems can identify when a pedestrian is about to cross the street outside of a designated crosswalk and automatically adjust traffic signals or warn drivers.
- **Cost Efficiency:** AI systems can reduce the need for manual traffic monitoring and intervention, lowering operational costs for cities. Additionally, by optimizing traffic flow and reducing congestion, AI can decrease fuel consumption and emissions, contributing to environmental sustainability.
- **Scalability and Flexibility:** AI-driven traffic management systems are highly scalable and can be tailored to the specific needs of different urban environments.

### Challenges and Considerations

While the benefits of AI are substantial, there are also challenges and considerations that cities and contractors must address:

- **Data Quality and Privacy:** AI systems rely heavily on high-quality, accurate data to function effectively. Additionally, cities must navigate concerns around data privacy, particularly when using AI systems that involve video surveillance or other sensitive data. Using LiDAR as the primary source of data ensures both data quality and privacy.
- **Integration with Existing Systems:** Implementing AI often requires integration with existing systems, such as traffic lights controllers. Ensuring compatibility and smooth integration can be complex and may require upgrades to current systems.
- **·Skill Requirements:** The deployment and maintenance of AI-driven traffic systems require specialized knowledge and expertise. It is important to choose a solution from a vendor that offers training and on-going support.

## Integrating AI and LiDAR for a Smarter Urban Traffic System

While LiDAR provides detailed, high-resolution data about the physical environment, AI processes this data to identify and classify different road users, analyze the presence, speed and trajectory of the road users and make real-time decisions.

Together, these technologies enable a traffic management system that can understand and respond to the complexities of urban traffic with unparalleled precision.

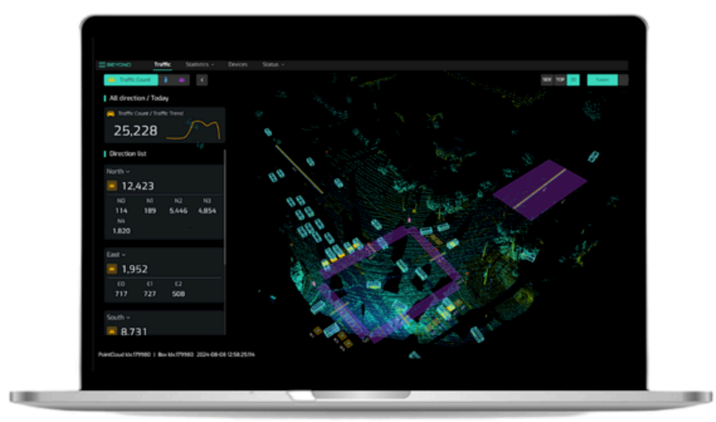
- **Real-Time Decision Making:** LiDAR continuously generates vast amounts of data, capturing details of the traffic environment. A perception software using AI algorithms can fusion the point cloud data from multiple LiDAR sensor into a comprehensive view of the intersection and detect and classify all road users, tracking their trajectories and providing detailed traffic data in real-time.

- **Dynamic Signal Control:** The real-time data can be shared with traffic light controllers to dynamically adjust traffic signals based on current conditions and optimize traffic flow.

- **V2X Applications**: Real-time data from a LiDAR-based solution can be shared with other connected infrastructure and vehicles to improve mobility and increase safety.

- **Adaptive Traffic Systems:** By continuously learning from traffic patterns and outcomes, AI can refine its algorithms over time, making the traffic management system more adaptive and effective. This continuous improvement ensures that the system remains responsive to the evolving needs of the city.

- **Automated Safety Measures:** With AI, the traffic management system can automatically implement safety measures based on the detected presence of pedestrians and cyclists. For example, the system can temporarily halt vehicle traffic at an intersection when it detects a pedestrian crossing, or it can issue warnings to approaching vehicles about cyclists in their path.




Real-time 3D point cloud data with virtual loops set up to detect and count vehicles and vulnerable road users. The software provides real-time traffic data.

## Practical Considerations for Cities and City Contractors

While these advanced technologies offer the potential to revolutionize urban traffic management, their successful deployment requires careful planning, technical expertise, and a clear understanding of the unique demands of each urban environment. This section outlines the key practical considerations that cities and city contractors should keep in mind when working with AI and LiDAR systems.

Seyond's LiDAR sensor being installed at an intersection.

### Installation and Integration

- **Site Assessment and Planning:** Before installation, a site assessment should be done to determine the optimal placement of LiDAR sensors and other components. Factors such as traffic patterns, environmental conditions, and the presence of existing infrastructure must be taken into account to ensure the sensors provide accurate and reliable data.

- **System Compatibility**: To ensure a seamless integration, it is important to choose a LiDAR systems that is compatible with existing hardware and software, or plan for necessary upgrades.

- **Infrastructure Modifications**: In some cases, the installation of AI and LiDAR systems may require modifications to existing infrastructure, such as the installation of new poles, power supplies, or communication networks. Contractors should be prepared to manage these modifications efficiently, minimizing disruptions to traffic and ensuring compliance with local regulations.

### Maintenance and Support

- **Routine Calibration and Testing:** LiDAR sensors and AI algorithms require periodic calibration and testing to maintain their accuracy and effectiveness. The vendor or the contractors should establish a regular maintenance schedule that includes updating software, and testing system functionality under different conditions.

- **Troubleshooting and Repairs:** Despite their advanced capabilities, AI and LiDAR systems can experience technical issues that require prompt resolution. Establishing a clear communication and support protocol between all parties involved will help ensure that any issues are addressed quickly and efficiently.

### Cost-Benefit Analysis

- **Upfront Costs vs. Long-Term Savings**: While some AI and LiDAR systems can be expensive, these costs are often lower than traditional traffic management systems like inductive loops. Plus, the upfront cost is offset by long-term savings in maintenance, operational efficiency, and improved traffic management. Potential return on investment (ROI) also includes reduced congestion, lower accident rates, and decreased fuel consumption.

- **Scalability**: One of the advantages of AI and LiDAR systems is their scalability. This technology can be expanded or adapted as the city's needs evolve. This scalability makes the initial investment more attractive, as the system can grow alongside the city without requiring a complete overhaul.

- **Funding and Incentives**: In some region, funding sources and incentives are available for cities adopting smart traffic technologies. This includes grants, government programs, or partnerships with private sector companies.


Seyond's Falcon K LiDAR sensor installed at an intersection in Georgia, USA.

## Case Study - Columbia County, Florida

In Columbia County, FL, Seyond performed and accuracy test comparing LiDAR detection against inductive loop detection.

**Technology**

Two Falcon Prime LiDAR sensors running on FW4464 were installed on a cement pole at the corner of the intersection along with a POC edge box running our perception software (v1.3). This set up was specifically tailored to address the unique conditions of the location.

Due to the difficulties in accessing suitable wiring to power the LiDAR sensor at another cement pole, both sensors were mounted on the same pole. This arrangement offered a comprehensive view of the intersection, although it also increased the risk of occlusion.

This testing was done from 2024-04-22 to 2024-04-23, involving 2 hours 50 minutes of recording analyzing two inductive loops, which is the equivalent of 5 hours 40 minutes of loop analysis.

**A 99% accuracy rate**

In total, 909 events were detected during the test through a visual manual count, acting as ground truth.

The total count accuracy of the LiDAR solution was 99% and Seyond's solution proved to be more accurate than the inductive loop (85%).

The inductive loop missed 135 cars due to the cars being too close together in the inductive loop area. It also counted a vehicle with an attached-trailer as 3 box ID and caught 38 events where a vehicle coming from the west side doing a wide turn to go north and counted them as an approaching vehicle.

Seyond Intersection Management Platform (SIMPL) missed 2 events where one of the approaching car changed lane at the last moment. There were also two occurrences where the system counted the same vehicle twice due to occlusion. In both cases, a solution was found to resolve these issues.

For more information and all the data:
simpl.seyond.com/accuracy-report/columbia-county-florida

## Case Study - Tampere, Finland


In the heart of Tampere, Finland, Seyond recently put its Intersection Management Platform (SIMPL) to the test, aiming to validate the accuracy of its vehicle count data against the existing inductive loop system.

The test was conducted across five lanes over a span of four days, between June and July 2024.

Seyond's team compared the vehicle count data from SIMPL with that of the traditional inductive loop system.

### The Results

After 4 full days of data, SIMPL's data closely matched that of the inductive loops, with only minimal deviations noted for four of the five lanes.

| Time Slot | Lane | Vehicle Count Number of Inductive Loop Detection | Vehicle Count Number of SIMPL Detection | Deviation |
|---|---|---|---|---|
| July 29, 00:00:00 to July 30, 00:00:00 | B-0-1 | 2630 | 2576 | 2.05% |
| | B-0-2 | 1176 | 1157 | 1.62% |
| | **D-1** | **1107** | **1655** | **-49.50%** |
| | A0 | 1679 | 1624 | 3.28% |
| | E-1 | 443 | 444 | 0.23% |

Data from July 29

However, when the team examined the data from lane D-1, they encountered a significant discrepancy. SIMPL's counts differed from the inductive loop data by 39 to 49% depending on the days.

To understand the cause, the team downloaded 24 hours to data and performed a manual visual count, revealing a major problem with the loop's accuracy.

| Vehicle Count Number of Inductive Loop Detection | Vehicle Count Number of SIMPL Detection | Manual Visual Count | Inductive Loop Deviation | SIMPL Deviation |
|---|---|---|---|---|
| 89 | 134 | 137 | 35.04% | 2.18% |

This discovery highlighted a critical issue with the inductive loop in lane D-1 that would require further investigation. Meanwhile, it served as a testament to the accuracy and reliability of Seyond's SIMPL technology.

Not only did SIMPL closely match the manual count, but it also outperformed the traditional inductive loop system in terms of precision.

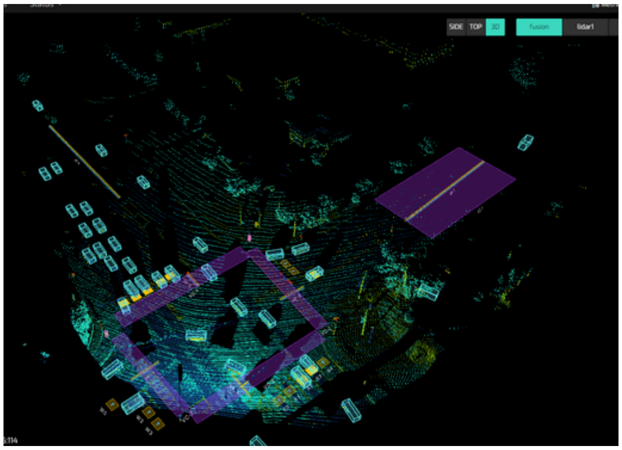
For more information: simpl.seyond.com/accuracy-report/tampere-finland

## Case Study - Peachtree Corners, Georgia


**Incovering Critical Insights into Pedestrian Safety at Mid-Block Crossings**

In response to growing concerns about pedestrian accidents occurring mid-block, away from designated crosswalks, Seyond installed its cutting-edge Intersection Management Platform (SIMPL) at a busy city intersection in Peachtree Corners, Georgia.

The primary goal: to detect and analyze the behavior of all road users, including vulnerable pedestrians. To address these concerns, Seyond's team created pedestrian detection zones using their perception and detection software.



3D point cloud data with virtual detection zones for approaching vehicles and pedestrians crossing the street.

These virtual loops are designed to accurately detect and count the number of pedestrians crossing mid-block to gather data where incidents had been reported.

The data collected revealed a distinct pattern: the west side of the intersection was overwhelming utilized for mid-block crossing compared to the other 3 approaches and pedestrians were most likely to cross mid-block during lunchtime. This discovery pointed to a clear reason behind the risky behavior—on one side of the street is a parking lot, while directly across is a shopping area. Shoppers, eager to reach their destination, often chose to take the shortest route, crossing mid-block rather than walking to the nearest crosswalk.

With these insights, the city is actively exploring various strategies to improve pedestrian safety. Potential measures include reducing vehicle speeds in this area, installing signage or signals to alert drivers to pedestrian activity, and encouraging the use of crosswalks through physical design changes.

# Conclusion

The future of urban traffic management is at a transformative crossroads, driven by the integration of advanced technologies like Artificial Intelligence (AI) and LiDAR.

**For Cities**

Cities around the world stand to gain immensely from the implementation of AI and LiDAR in their traffic management systems. These technologies provide cities with the data and intelligence needed to make informed decisions, reduce congestion, and protect vulnerable road users. By investing in AI and LiDAR, cities can move beyond reactive traffic management to a proactive approach that anticipates and addresses traffic issues before they escalate. This not only improves the daily lives of citizens but also supports broader goals of sustainability and economic growth.


**For Contractors**

For contractors, the adoption of AI and LiDAR represents a significant opportunity. By embracing these cutting-edge tools, contractors can position themselves at the forefront of the industry, offering cities the solutions they need to meet the complex demands of modern traffic management. The ability to install, integrate, and maintain AI and LiDAR systems will set contractors apart as leaders in smart infrastructure, opening doors to new projects and long-term partnerships with forward-thinking municipalities.

As cities continue to grow and evolve, the demand for intelligent traffic management systems will only increase. Contractors who seize this opportunity to innovate and lead in the integration of AI and LiDAR will find themselves at the heart of a rapidly expanding market, with the chance to shape the future of urban mobility.

**About Seyond**

Seyond™ is a leading global provider of image-grade LiDAR technology, powering a safer, smarter and more mobile world across the automotive, intelligent transportation, traffic management, robotics and industrial automation sectors.

simpl.seyond.com

SEYOND