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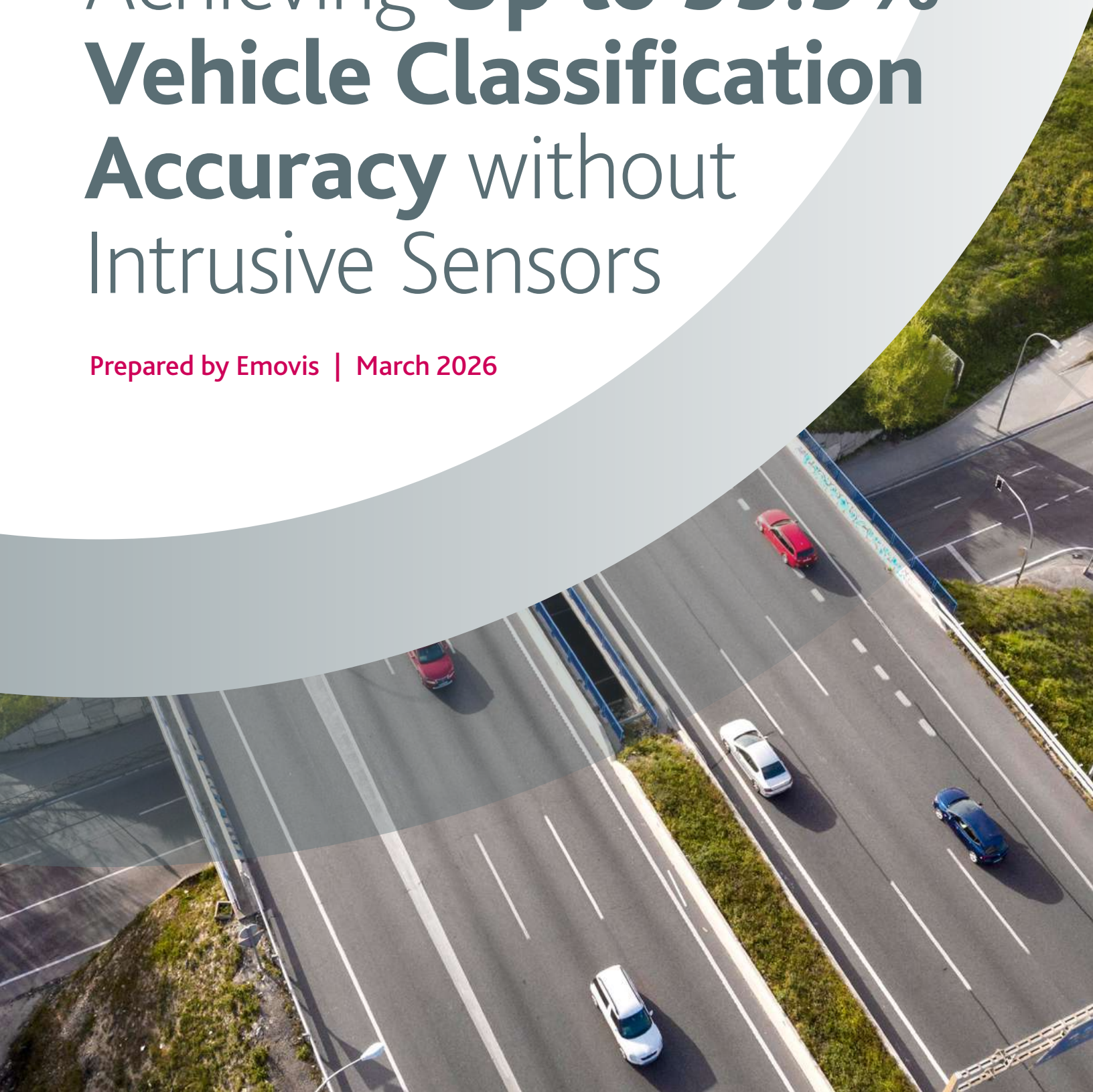
Achieving **Up to 99.9% Vehicle Classification Accuracy** without Intrusive Sensors

Prepared by Emovis | March 2026



Executive **Summary**

For decades, vehicle classification in U.S. tolling has been closely tied to pavement-embedded roadside infrastructure. In earlier electronic toll collection environments, intrusive sensors were the industry standard because they offered reliable performance for tolling authorities. However, as tolling operations have scaled and modernized over the years, these classification systems are no longer sustainable and present several challenges ranging from costly installation and maintenance fees, to frequent repairs that necessitate lane closures. Additionally, sensor accuracy is subject to wear and tear over time as hardware deteriorates from heavy traffic loads and inclement weather conditions.[1]

When intrusive sensors fail, tolling errors and customer disputes increase, and manual review teams become overwhelmed which can create inefficiencies across the entire back-office ecosystem.

To meet today's expectations for accuracy and operational resilience, tolling agencies are leaning more on the AI-driven capabilities of their back offices and embracing non-intrusive classification technologies that lower maintenance burdens and do not require cutting into the pavement.

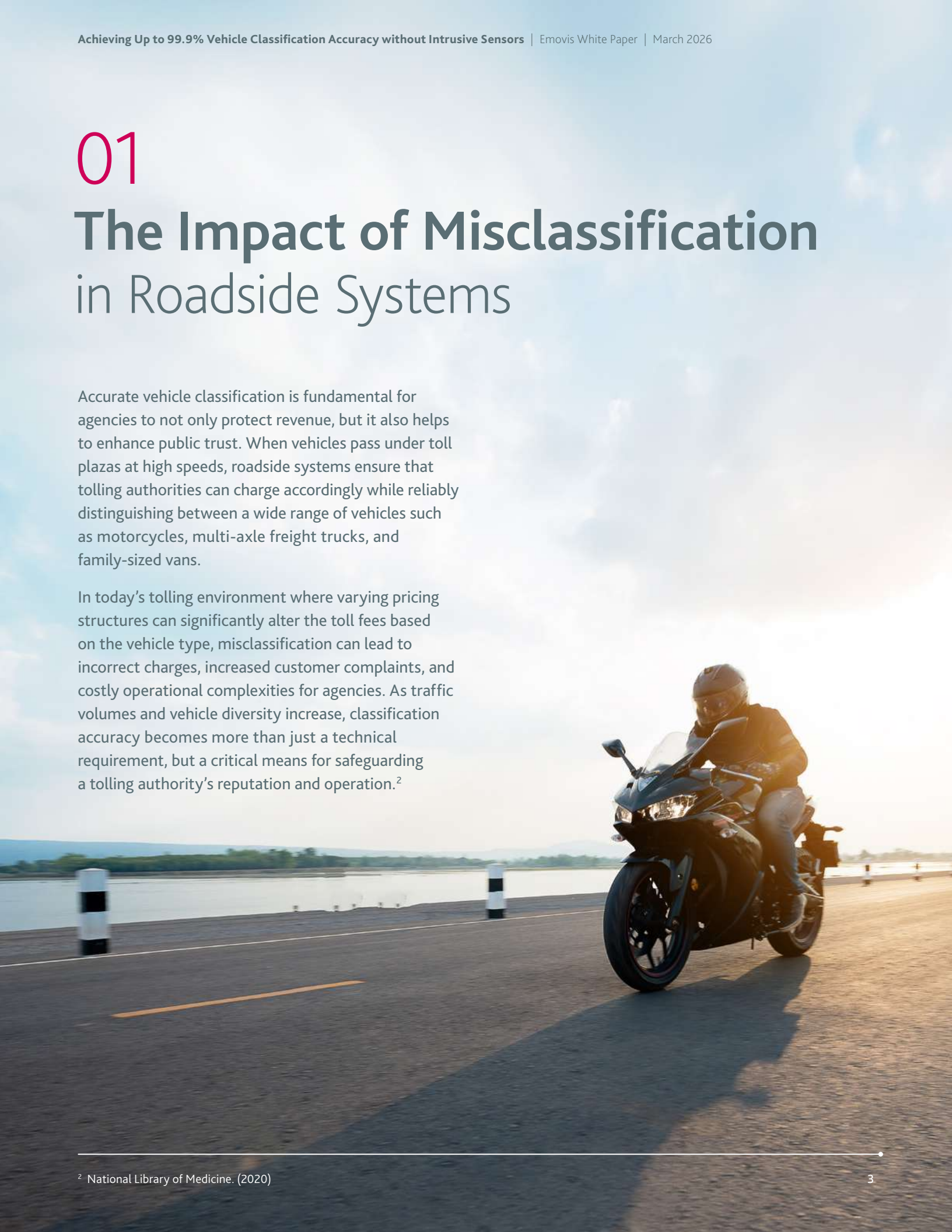
These advanced solutions have made accuracy independent of physical infrastructure, and help agencies strengthen revenue assurance while offering a future-proof path towards more efficient tolling operations.

[1] National Academies, Sciences, Engineering, and Medicine. (2022)

01
The Impact of Misclassification in Roadside Systems

Accurate vehicle classification is fundamental for agencies to not only protect revenue, but it also helps to enhance public trust. When vehicles pass under toll plazas at high speeds, roadside systems ensure that tolling authorities can charge accordingly while reliably distinguishing between a wide range of vehicles such as motorcycles, multi-axle freight trucks, and family-sized vans.

In today's tolling environment where varying pricing structures can significantly alter the toll fees based on the vehicle type, misclassification can lead to incorrect charges, increased customer complaints, and costly operational complexities for agencies. As traffic volumes and vehicle diversity increase, classification accuracy becomes more than just a technical requirement, but a critical means for safeguarding a tolling authority's reputation and operation.[2]



[2] National Library of Medicine. (2020)

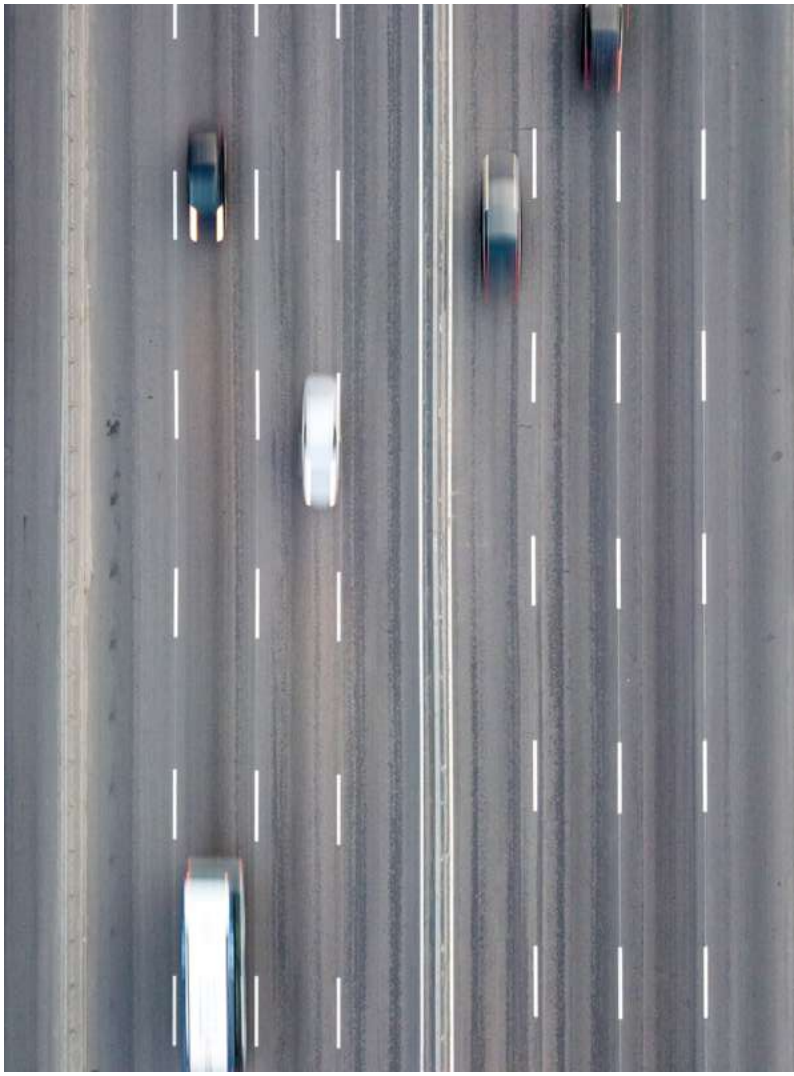
02

How Intrusive Sensors **Became the Default for Classification Accuracy**

In the early days of electronic toll collection, fixed, roadside-based sensors represented the most effective path to accuracy. Traffic volumes were lower, lanes were controlled, and tolling agencies prioritized classification at the exact point of transaction. Traffic-intrusive approaches such as inductive loops and piezoelectric sensors were the standard method of classification due to their familiarity among engineering teams and efficiency in controlled environments.

However, as tolling transitioned to a more free-flow state where multi-lane configurations and high-speed traffic made classification more complex, the limitations of these legacy systems became more apparent.[3]

The frequent need for pavement cutting, traffic control requirements, and maintenance challenges introduced operational friction that intrusive sensors were simply never designed to sustain.[4]



[3] Federal Highway Administration. (2023)
[4] Federal Highway Administration. Chapter 4. (2014)

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MODERNIZING TRADITIONAL TOLL LANES WITH NON-INTRUSIVE VEHICLE CLASSIFICATION

To address these barriers, agencies have begun adopting non-intrusive classification methods such as infrared, acoustic, microwave, and video-based technologies. These solutions reduce the burden of maintenance demands by eliminating the need for pavement-embedded hardware.[4]

Emovis Identify, an advanced video-based tolling solution, is a prime example of this shift. The over-roadway classification technology, which is deployed on gantries that oversee the highways, is designed to capture high-resolution imagery from multiple angles, and simplifies the roadside setup, enabling more compact, lighter, and lower-maintenance designs while applying advanced analytics to determine vehicle size and axle count in real time.

This approach offers agencies the ability to cover multiple lanes while accurately classifying and registering a transaction for every vehicle passage without a need for roadway disruptions to traffic flow.

[4] Federal Highway Administration. Chapter 4. (2014)

03

The Hidden Operational Costs of **Intrusive Roadside Sensors**

Despite their historical role in tolling accuracy, in-pavement sensors are prone to fail over time; a vulnerability that stems from a variety of environmental factors, exposure to physical damage, and costly errors made during installation and maintenance.[5]

When sensor accuracy is compromised, the integrity of even the most reliable tolling systems is called into question and authorities are left to face public scrutiny, damaged trust with road users, and significant revenue loss as a result. These operational risks include but are not limited to the following:

→ INCREASED NEED FOR MAINTENANCE AND DOWNTIME

Sensor repairs often cause a need for full or partial road closures, lane reductions, or shoulder closures to protect workers and drivers alike. Although transportation agencies try to minimize the effects of these disruptions through traffic alerts and public service announcements, this type of maintenance inevitably impacts revenue and decreases customer satisfaction.

→ INCLEMENT WEATHER CONDITIONS IMPACT ON SENSOR PERFORMANCE

Ice, rain, and even fog can severely impact sensor performance by obstructing sensor surfaces or housings, potentially making them inoperable until they are cleared.[6]

→ FAULTY INSTALLATION ERRORS

With in-pavement sensors, improperly applied sealant can compromise the sensor's long-term durability and allow water and other substances to seep through the installation area. When system wiring is wet, the sensor could malfunction and fail to properly detect vehicles, which results in substantial financial losses over time.[7]

When intrusive sensors deteriorate, manual image review workloads are prone to spike, requiring additional staff hours and expenses. Consequently, agencies need more sustainable classification methods that can be maintained without the need for physical road interventions.

[5] University Transportation Research Center. (2013)
[6] Federal Highway Administration. Chapter 3. (2014)
[7] Federal Highway Administration. (2006)

04
Vehicle Classification **Beyond the Roadside**

Advances in artificial intelligence along with back-office processing capabilities are reshaping the long-standing models of tolling. This shift has created an opportunity for tolling authorities to fundamentally redefine how vehicle classification is performed.

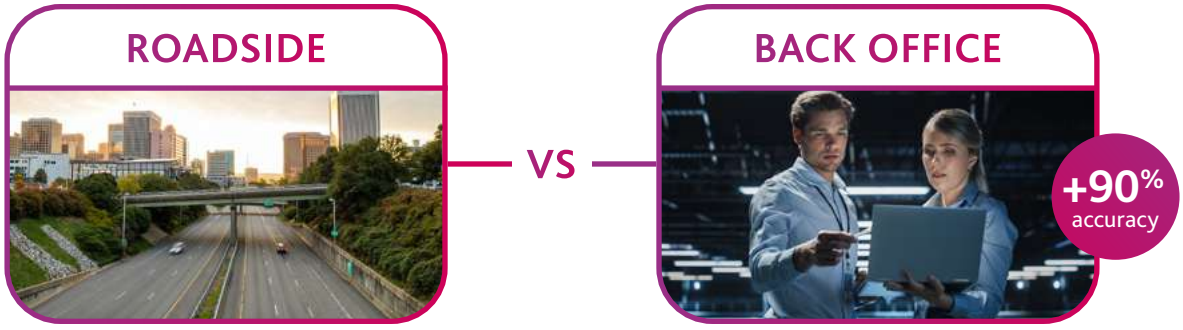
While vision-based classification solutions like Emovis Identify can achieve an accuracy rate higher than 90%, AI-driven video analysis in Emovis Qualify now allows agencies to perform classification entirely within the tolling back office using images already generated from existing systems. This transition moves classification into a software-based environment that is easier to maintain, update, and scale when needed.[8]

Emovis Qualify represents this next evolution in tolling operations as its AI video-based classification module operates within the back office. This eliminates the need for intrusive sensor maintenance demands while providing agencies with greater flexibility as roadside technologies continue to evolve.

VEHICLE CLASSIFICATION IN THE BACK OFFICE: SIMPLIFYING ROADSIDE EQUIPMENT

Shifting classification to the back office allows agencies to simplify the design of roadside equipment by deploying smaller, lighter, and easier-to-maintain roadside systems without the need for intrusive sensors, and save dollars on both capital and operating expenditures. This type of software-based classification module ensures that no vehicle goes misclassified while also providing a much more flexible and scalable deployment configuration.[8]

One of the most strategic advantages of AI-based back-office classification is its interoperability. Emovis Qualify, for example, can integrate with any tolling infrastructure that transmits transaction images to the back office.



[8] Cheung, S.Y.; Varaiya, P. (2007)

05

The Future of Tolling Is **Non-Intrusive and Powered by AI Solutions**

Accurate vehicle classification remains a top priority for tolling authorities, but the methods used to achieve it are modernizing at a rapid pace.

Gone are the days when intrusive sensors were the primary means to classify road users. As vehicle mix, traffic volumes, and technology ecosystems evolve, classification models built around pavement-embedded sensors are proving time and time again to be increasingly misaligned with the operational reality of toll authorities.

Instead, a new wave of vehicle classification approaches offer a more resilient path forward.[9] These systems help to bridge operational gaps, and allow agencies to achieve an accuracy of up to 99.9% in classifying motorists, all without the burden of intrusive sensors and high-maintenance roadside hardware.

For more information about Emovis Qualify or the Emovis Identify solution, contact an expert today or visit us online at:

emovis.com/products/

[9] M. Won. (2020)

REFERENCES

Cheung, S.Y.; Varaiya, P. *Traffic Surveillance by Wireless Sensor Networks: Final Report*; Technical Report UCB-ITS-PRR-2007-4; California Path Program, Institute of Transportation Studies, University of California: Berkeley, CA, USA, 2007. https://escholarship.org/uc/item/4pn0m283

Federal Highway Administration. (2006). Traffic Detector Handbook, Third Edition—Volume II. Publication No. FHWA-HRT-06-139. https://www.fhwa.dot.gov/publications/research/operations/its/06139/06139.pdf

Federal Highway Administration. (2014). *Chapter 3—Overview of vehicle detection and surveillance technologies*. U.S. Department of Transportation. https://www.fhwa.dot.gov/policyinformation/pubs/vdstits2007/03.cfm

Federal Highway Administration. (2014). *Chapter 4—Traffic Data Collection Equipment for High-Volume Locations*. U.S. Department of Transportation. https://www.fhwa.dot.gov/policyinformation/hpms/volumeroutes/ch4.cfm

Federal Highway Administration. (2023). *Technologies That Enable Congestion Pricing. U.S. Department of Transportation*. https://www.ibtta.org/sites/default/files/Technologies%20that%20Enable%20Congestion%20Pricing.pdf

M. Won. (2020). *Intelligent Traffic Monitoring Systems for Vehicle Classification: A Survey. IEEE Access*, vol. 8, pp. 73340-73358, 2020, doi: 10.1109/ACCESS.2020.2987634. https://ieeexplore.ieee.org/document/9064724

National Academies, Sciences, Engineering, and Medicine. (2022). *Tolling agency infrastructure and maintenance research*. https://rip.trb.org/View/1948960#:~:text=Most%20of%20the%20tolling%20agencies,in%20wires%2C%20and%20sealant%20failure

National Library of Medicine. (2020). *Sensors (Basel)*. https://pmc.ncbi.nlm.nih.gov/articles/PMC7309154/

University Transportation Research Center. (2013) *Vehicle Classification Using Mobile Sensors*. https://www.utrc2.org/sites/default/files/pubs/Vechile-Classification-Final.pdf