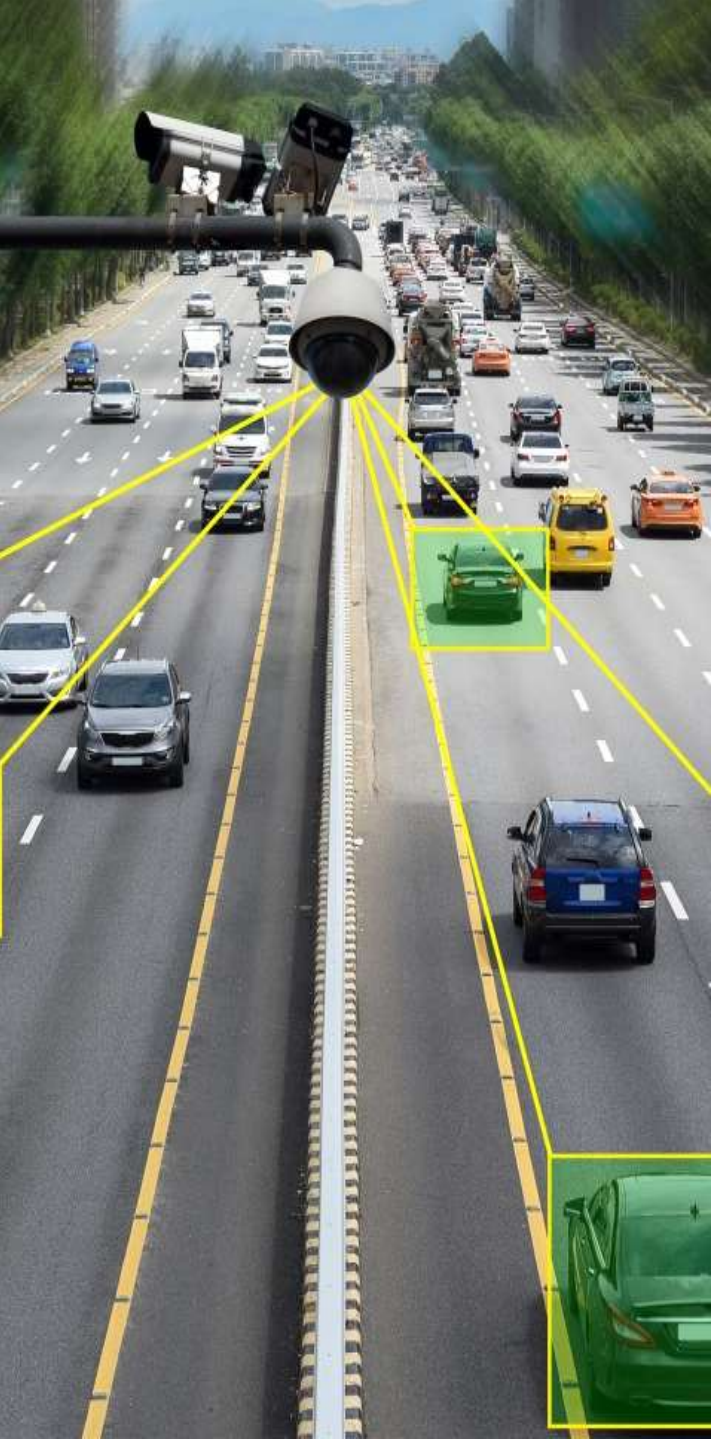

Strengthening Sustainable and Digital Trade Routes and Logistics Concepts Between Eastern Partnership Countries and with the EU

Autumn Academy in Ukraine

Towards smart enforcement: control authority tools and enabling technologies

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TRANSPORT INNOVATION ASSOCIATION

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EasTnT Eastern Partnership for Trade and Transport

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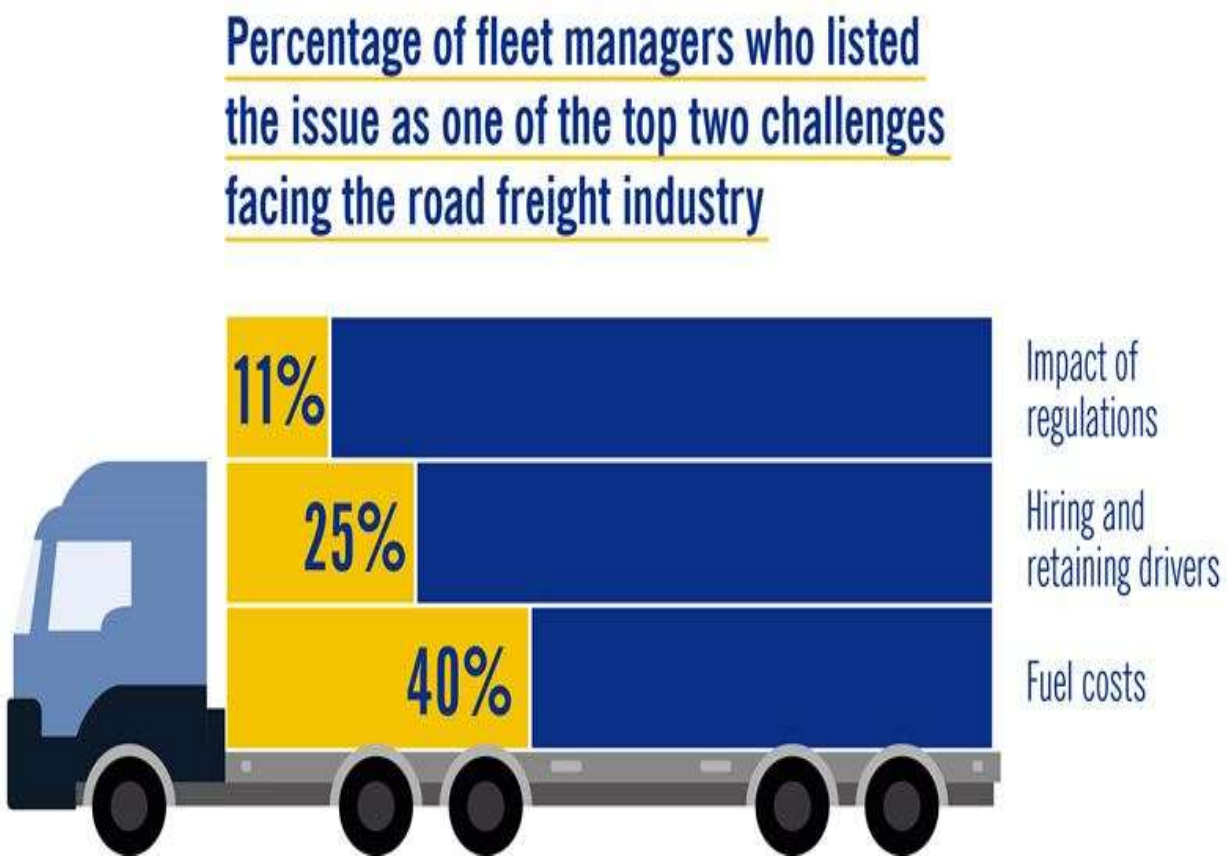
Road transport sector regulatory complexity

- The **road transport sector** is a backbone of most of countries economies and plays a pivotal role in facilitating the movement of goods and people across borders.
- It is central to the EU internal market, ensuring connectivity among Member States and linking peripheral regions to economic hubs.
- The sector accounts for approximately **5% of the EU's Gross Domestic Product (GDP)** and more than **11 million people** are employed across Member States.
- Freight transport by road represents the largest share of inland transport modes, contributing over 75% of total freight activity (measured in tonne-kilometres).
- More than **450.000 companies** are active in road freight transport within the EU, with about **90%** of them being **micro** or **small enterprises** operating fewer than 10 vehicles.

The Scale of the Problem

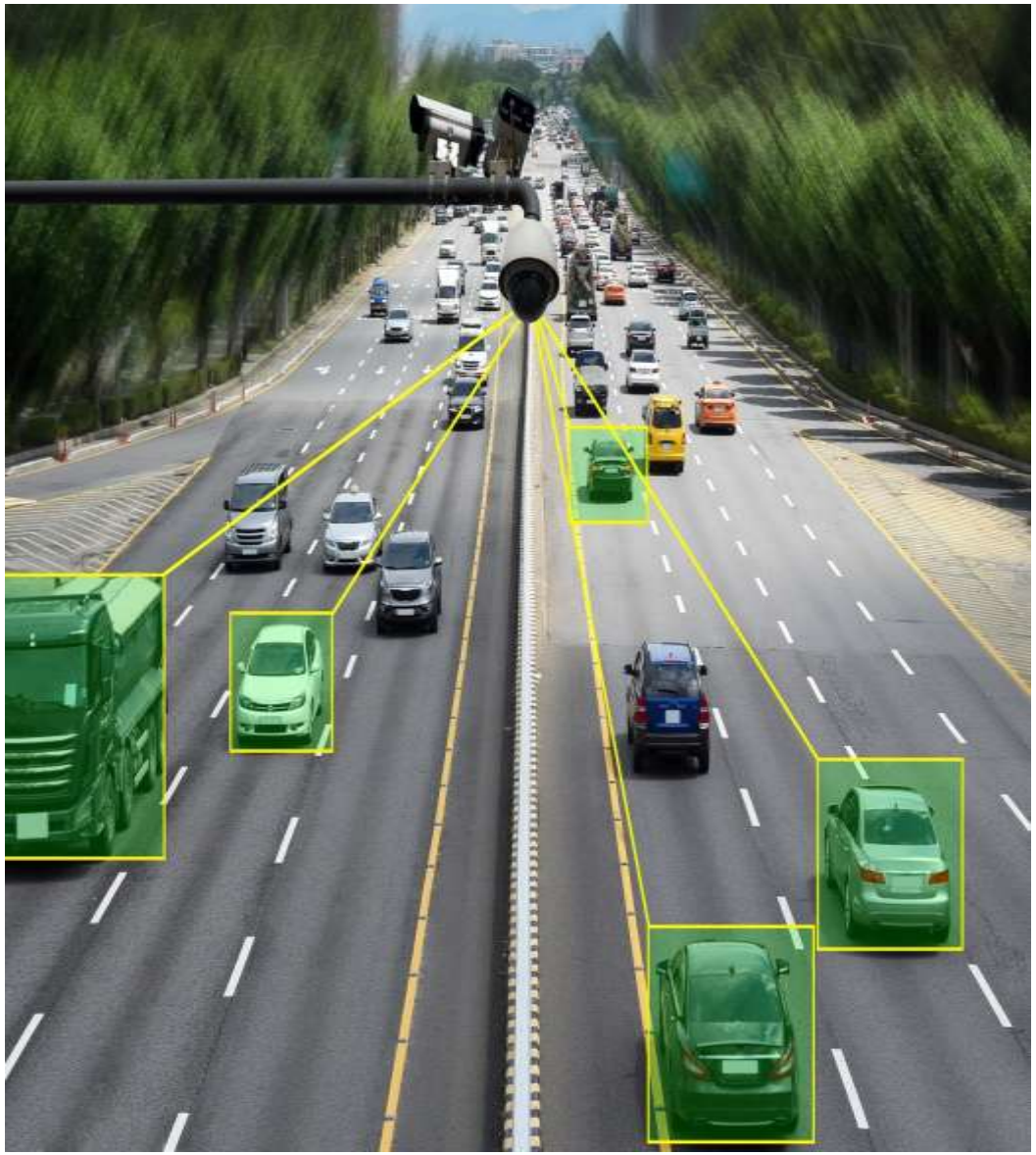
- **Lack of enforcement harmonization:** road enforcement processes vary significantly across countries, resulting in a fragmented and inconsistent approach.
- **Data management challenges**: legal restrictions on information sharing, combined with a continued reliance on paper-based or analogue formats, create structural barriers to effective enforcement.
- **Legislation complexity**: both operators and enforcement authorities must navigate a complex web of rules and requirements. Enforcing regulations – such as those related to posting of drivers or cabotage – is especially difficult without integrated digital tools that combine multiple data points.
- **Limitation of existing digital solutions**: enforcement data is dispersed across various IT systems, leading to inefficiencies and delays in decision-making. The current digital ecosystem lacks a robust, real-time data exchange framework and fully implemented risk-based enforcement systems, resulting in suboptimal resource allocation and unnecessary inspections.



What is Smart Enforcement?

Smart transport enforcement represents a paradigm shift from traditional, manual, and reactive methods to a modern, automated, data-driven, and proactive system:

- **Traditional Enforcement:**
  - Relies on physical officer presence (patrols, checkpoints).
  - Largely reactive (responding to incidents or visible violations).
  - Resource-intensive and limited in scale.
  - Data is often siloed and manually processed.
- **Smart Enforcement:**
  - Uses technology to monitor compliance 24/7.
  - Proactive and predictive, identifying high-risk areas or behaviors.
  - Automates detection, verification, and penalty processes.
  - Data-driven, providing insights for policy and resource allocation.



The core goals of smart enforcement

- Enhanced **driver welfare** through guaranteed rest periods and wage parity;
- Improved **road safety** by reducing fatigue and enforcing better vehicle maintenance;
- More **uniform rules** for performing transport operations across borders.

Challenges and information needs in road transport enforcement

Effective enforcement requires access to reliable and up-to-date data.

It also necessitates the seamless integration of information systems to facilitate cooperation among various bodies at both national and cross-border levels.

Inconsistent enforcement in the EU road transport is a result of multiple **challenges** that **enforcement authorities are facing:**

- Limited digitalisation
- Lack of resources for enforcement authorities
- Insufficient harmonisation and interoperability
- Absence of a smart system for targeted road enforcement

Limited digitalisation

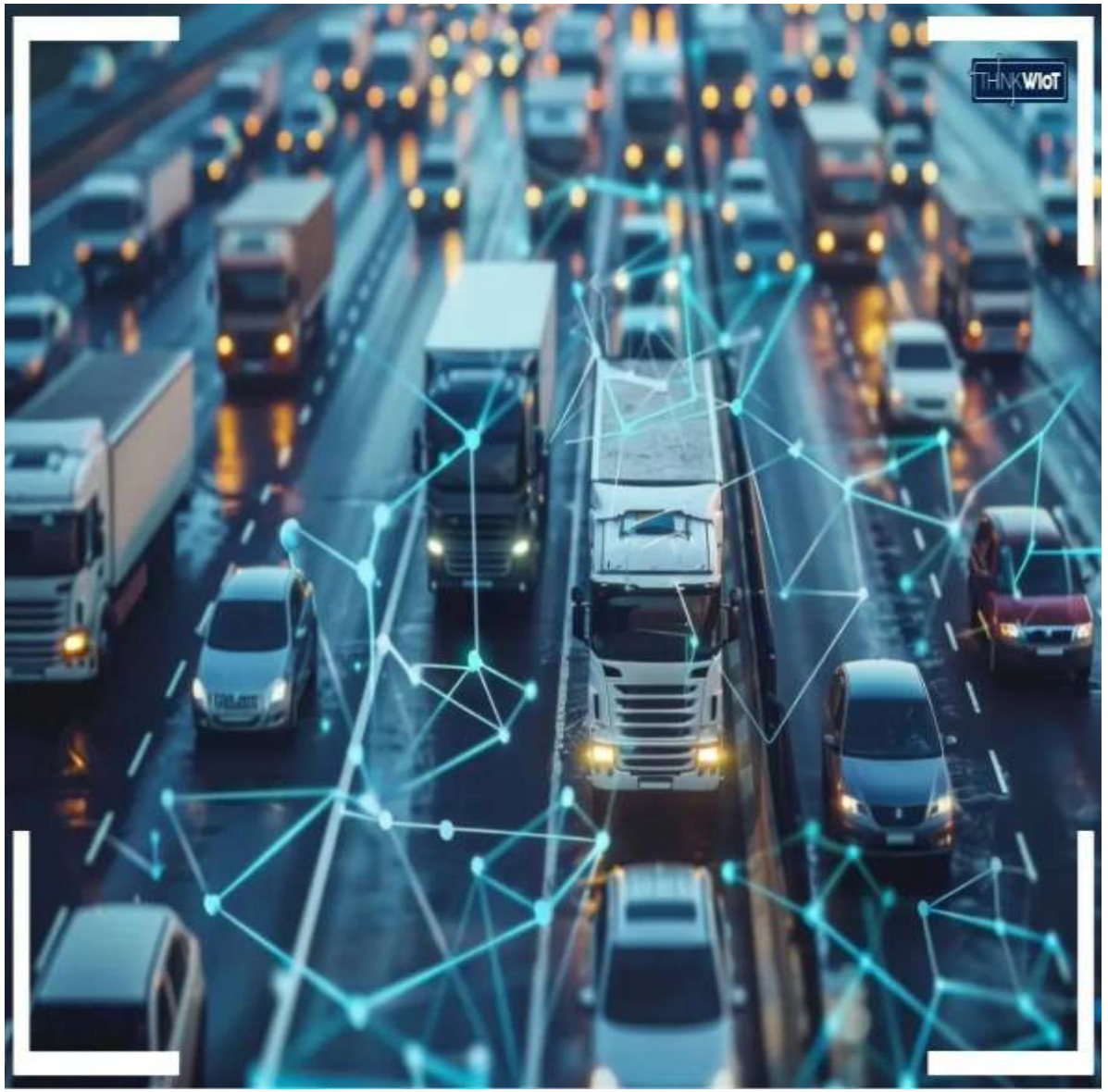
- **Data sharing challenges:** information sharing, especially in cross-border scenarios remains very challenging due to data protection regulations and their restrictive influence on information exchange. Individual authorities employ different tools and procedures. As a result, the exchange of the information is limited even if this is not explicitly mandated by legislation.
- **Limited access to digital information on transport operators, drivers and vehicles:** physical documents such as driving license or registration certificate are often the main source of information. Prompt access and up-to-date digital data is crucial for the authorities as the **authenticity of paper documentation** is difficult to assess. Another difficulty lies in ensuring if presented physical documents are valid and have not been revoked (for example due to loss of privileges).
- **Limitations of cross border enforcement:** authorities in utilise advanced tools and software to access digital information regarding drivers, transport operators, and vehicles. However, these tools primarily allow access to information on domestic operators, resulting in a significant gap in the enforcement processes towards domestic and foreign operators.

Lack of resources for enforcement authorities

- The **increasing number of operators and vehicles** in road transport, coupled with **shrinking enforcement resources**, presents significant difficulties.
- The **lack of human, financial, and technical resources** is another challenge for enforcement authorities.
- While detection rates at both roadside and premises have improved, the **efficiency of checks conducted at premises** remains significantly **higher** than that of **roadside inspections**.
- Another challenge is the lack of specific competences: the number of **trained officers analysing digital tachograph data** has **declined**.
- Additionally, the number of units available for analysing tachograph data has decreased.

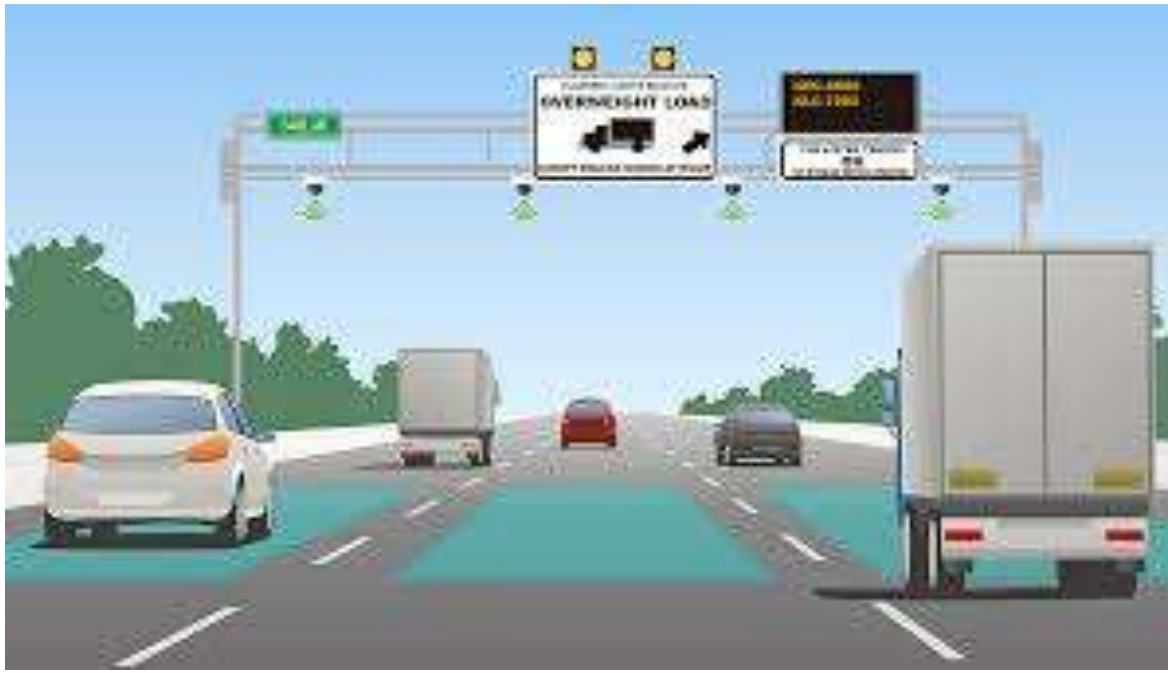
Insufficient harmonisation and interoperability

- In recent years, numerous tools and databases have been developed, often independently, leading to **fragmented structures** for collecting and **exchanging information** related to drivers, vehicles, transport operations, and carriers.
- This **fragmentation** poses considerable **operational difficulties** for **enforcement bodies**, which must gather and process information across **multiple unconnected systems**. Consequently, inspections related to tachographs or vehicle dimensions, for instance, must be conducted through different information platforms, significantly increasing the time and costs associated with each inspection activity.
- The situation is further complicated by the **division of control responsibilities** among various authorities, each utilising different tools and procedures, which hinders efficient data exchange and cooperation.
- One of the **challenges** is **obtaining additional information** about **drivers, transport companies, transport violations, etc**.
- A potential solution to this issue is the enhanced integration of existing systems and tools, enabling the consolidation of data collected from various sources for use by authorities in diverse scenarios.



Absence of a smart system for targeted road enforcement

- One of the key limitations of the current enforcement models is the **absence** of an **intelligent, automated system** that enables **selective and data-driven targeting** of enforcement activities.
- Currently, the majority of inspections are conducted randomly, without prior utilisation of **risk indicators**, **violation histories**, or other data that could identify entities most susceptible to non-compliance. The lack of integration of analytical tools and insufficient levels of **digitalisation** often compel enforcement authorities to act based on **incomplete or non-accurate information**.
- As a result, inspections are not only **time-consuming** and **costly** but also **ineffective** for both public administration and carriers. Compliant operators are unnecessarily stopped, disrupting their business operations and generating **additional operational costs**, while high-risk carriers may evade detection.
- Furthermore, there is **inadequate utilisation** of available **data-exchange mechanisms** and **registries** which, despite their potential, operate in a **fragmented manner** without ensuring **interoperability** and comprehensive **real-time data exchange**.
- The magnitude of the problem is intensified by the large majority on **paper documentation**. This hinders the ability to conduct **automated risk assessments** and properly assign the risk scores to transport operators.



Players and technologies

The Key Players: Control Authorities

"Smart enforcement" empowers a range of public and private bodies responsible for overseeing transport networks:

- **National & Local Police:** Responsible for traffic law enforcement (speeding, distracted driving, DUI).
- **Transport Ministries & Departments (DOTs):** Manage road infrastructure, traffic flow, and safety regulations.
- **Commercial Vehicle Enforcement (CVE):** Specialized agencies that monitor heavy goods vehicles (HGVs) for weight, driver hours, vehicle safety, and credential compliance.
- **Municipal Authorities:** Manage urban transport, including parking, bus lanes, and Low Emission Zones (LEZs).
- **Highway & Toll Operators:** Enforce toll collection and manage safety on specific corridors.

The Core Toolkit: Enabling Technologies (1)

These are the foundational technologies that make "smart" enforcement possible. They can be broken into three categories:

1. Data Capture (The "Eyes and Ears")

- **ANPR/LPR (Automatic Number Plate Recognition):** High-speed cameras that read license plates, forming the backbone of most automated systems.
- **Radar & LiDAR:** Detect vehicle speed, position, and proximity. LiDAR can also classify vehicle types and detect illegal maneuvers (e.g., U-turns).
- **Weigh-in-Motion (WIM) Sensors:** Sensors embedded in or on the road surface to weigh vehicles as they travel at speed.
- **Acoustic Sensors:** Microphones used to detect excessive vehicle noise (e.g., modified exhausts).
- **On-Board Units (OBUs) & GPS:** Mandated in commercial vehicles (like digital tachographs) or used for road user charging.

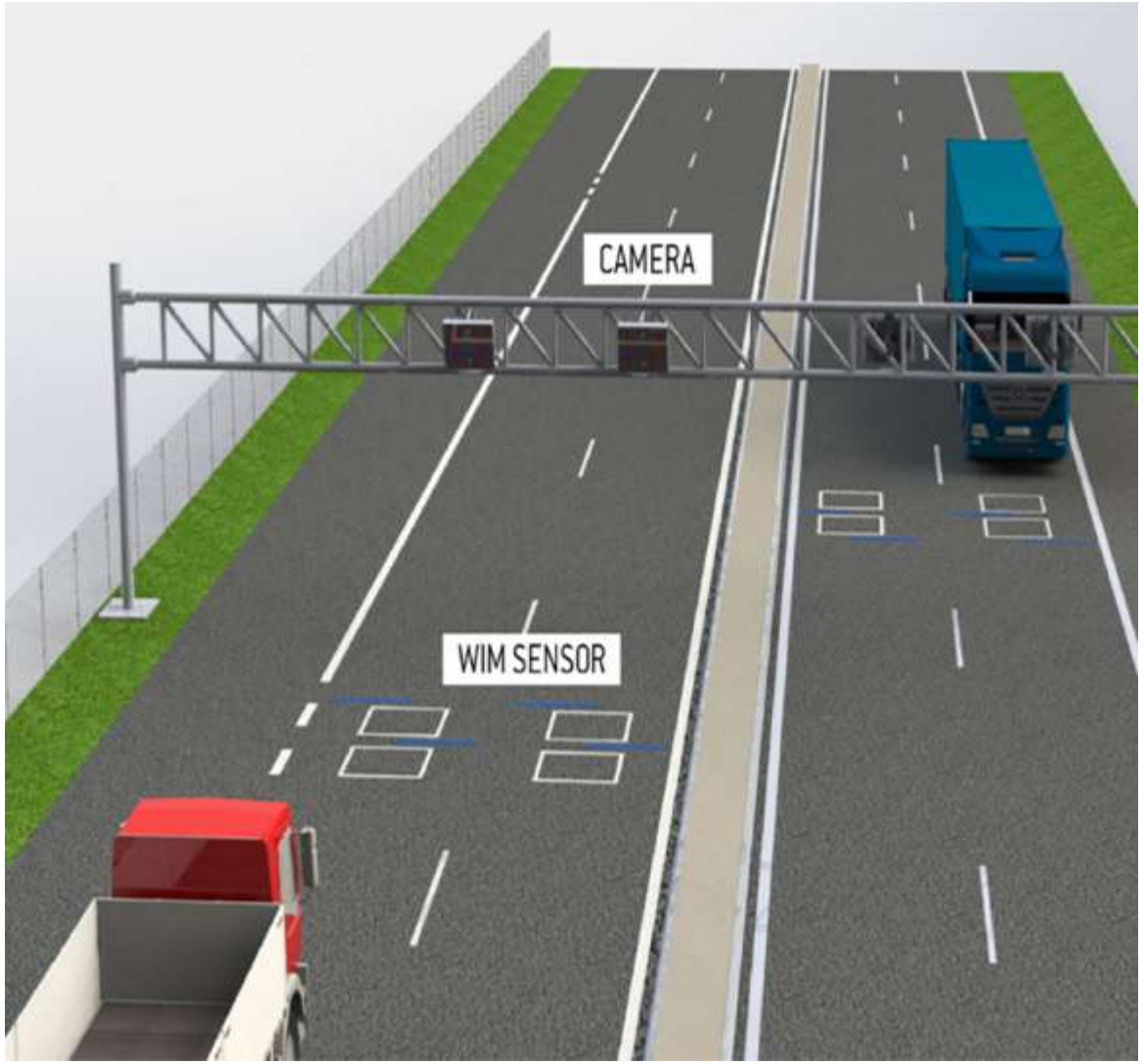
The Core Toolkit: Enabling Technologies (2)

2. Connectivity:

- **5G & IoT:** Provide high-speed, low-latency communication for real-time data transmission from sensors to processing centers.
- **V2X (Vehicle-to-Everything):** Allows vehicles to communicate directly with infrastructure (V2I) and enforcement systems. A vehicle could, for example, self-report its speed or credential status.

3. Data Processing:

- **AI & Machine Learning (ML):** The most critical element. AI models analyze video and sensor data to:
  - Detect complex violations (e.g., mobile phone use, seatbelt non-compliance).
  - Verify ANPR reads and reduce false positives.
  - Predict high-risk "hotspots" for accidents or congestion.
- **Big Data Analytics:** Ingesting and analyzing massive datasets (traffic flow, weather, violation history) to identify trends and inform policy.
- **Cloud & Edge Computing:** Cloud provides centralized processing power, while Edge Computing allows for initial processing (like violation detection) to happen directly at the sensor, reducing data backhaul.

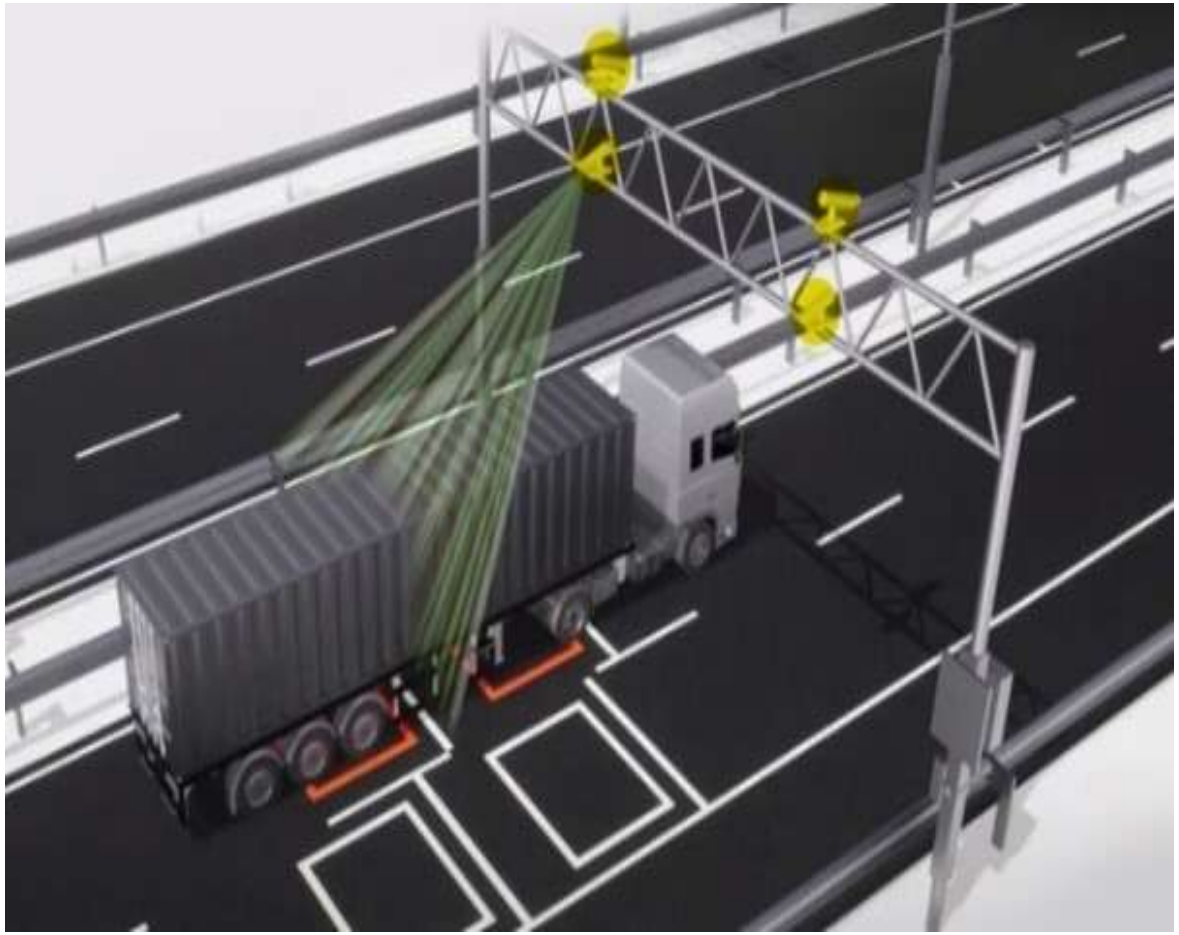


Use cases

Key Tools for Control Authorities

These are the operational systems that authorities use, built from the enabling technologies.

- **Automated Violation Detection Systems:** Fixed or mobile units for speed, red-light, and bus lane enforcement.
- **Digital Enforcement Platforms:** Centralized software that manages the entire workflow: from violation capture to data verification, owner identification (database lookup), and penalty issuance.
- **Real-time Traffic Management Centers (TMCs):** A central hub where authorities monitor network health using CCTV, ANPR, and sensor data. They can dispatch patrols, change digital signage (e.g., variable speed limits), or manage incidents.
- **Predictive Policing & Deployment Dashboards:** AI-powered tools that show officers *where* and *when* to patrol for maximum impact, based on predictive analytics.
- **Virtual Weigh Stations / Electronic Screening:** Systems that "pre-screen" commercial vehicles at highway speeds, allowing compliant trucks to bypass physical inspections.



Use Case 1: Smart Commercial Vehicle Enforcement (CVE)

Objective: Improve safety and protect infrastructure by targeting high-risk, non-compliant trucks (overweight, unsafe, non-compliant driver hours).

Technologies: WIM sensors, ANPR, vehicle credential databases, AI risk-scoring.

How it Works (Virtual Weigh Station):

1. A truck approaches an inspection "pre-screening" gantry on the highway, miles before a physical weigh station.
2. **WIM sensors** in the road record its axle and gross weight.
3. **ANPR cameras** capture its license plate.
4. The system instantly checks the plate against databases for:
   - Safety rating (e.g., CSA score in the US)
   - Tax and insurance status
   - Electronic logging device (ELD) / driver hours flags
5. An **AI model** combines all data (weight, credentials, history) to generate a real-time "risk score."
6. **Low-risk, compliant trucks** receive a "bypass" signal (via an in-cab transponder or digital sign) and continue at highway speed.
7. **High-risk trucks** (overweight, poor safety record) are automatically signaled to "pull in" for a full inspection.

Benefits: Dramatically increases efficiency, reduces congestion at weigh stations, and allows officers to focus time on the 10-20% of vehicles that pose the greatest risk.

Use Case 2: European Digital Identity and Business Wallets

Objective: Digital Wallets support the following objectives: paperlessness and reduced time of controls:

Paperlessness: Digital wallets fundamentally transform document handling by storing and sharing pre-verified, cryptographically secured credentials that replace traditional paper documents and physical cards. Benefits depend on type of users:

- **For natural persons**, digital wallets provide unified document management through a single, secure platform that works seamlessly across all EU member states.
- **Businesses and authorities benefit** from streamlined credential management capabilities that allow issuing authorities to digitally manage the entire credential lifecycle, including real-time revocation when credentials are compromised or expired.

Reduced time of controls: Time savings are expected from credential digitalisation transforming multiple aspects of control process:

- **Advanced verification capabilities** represent a fundamental improvement over traditional document checking methods. Digital credentials use standardized formats that eliminate language barriers in cross-border enforcement, enabling consistent verification regardless of document origin.
- The creation of a **unified enforcement environment** enables authorities to develop standardized skills and procedures. This standardization improves efficiency while reducing training requirements for enforcement personnel, as officers need to master only one verification system rather than multiple country-specific approaches.
- Digitalisation also enables **digital trail for chain of operations and traceability of operations** performed. Every transaction and verification creates a permanent, cryptographically secured records that support comprehensive policy monitoring and compliance tracking.

Benefits: The Digital Wallets system delivers interoperability and standardization benefits that extend far beyond immediate operational improvements.

Use Case 3: Automated Speed & Distracted Driving

Objective: Reduce accidents by enforcing speed limits and cracking down on mobile phone use.

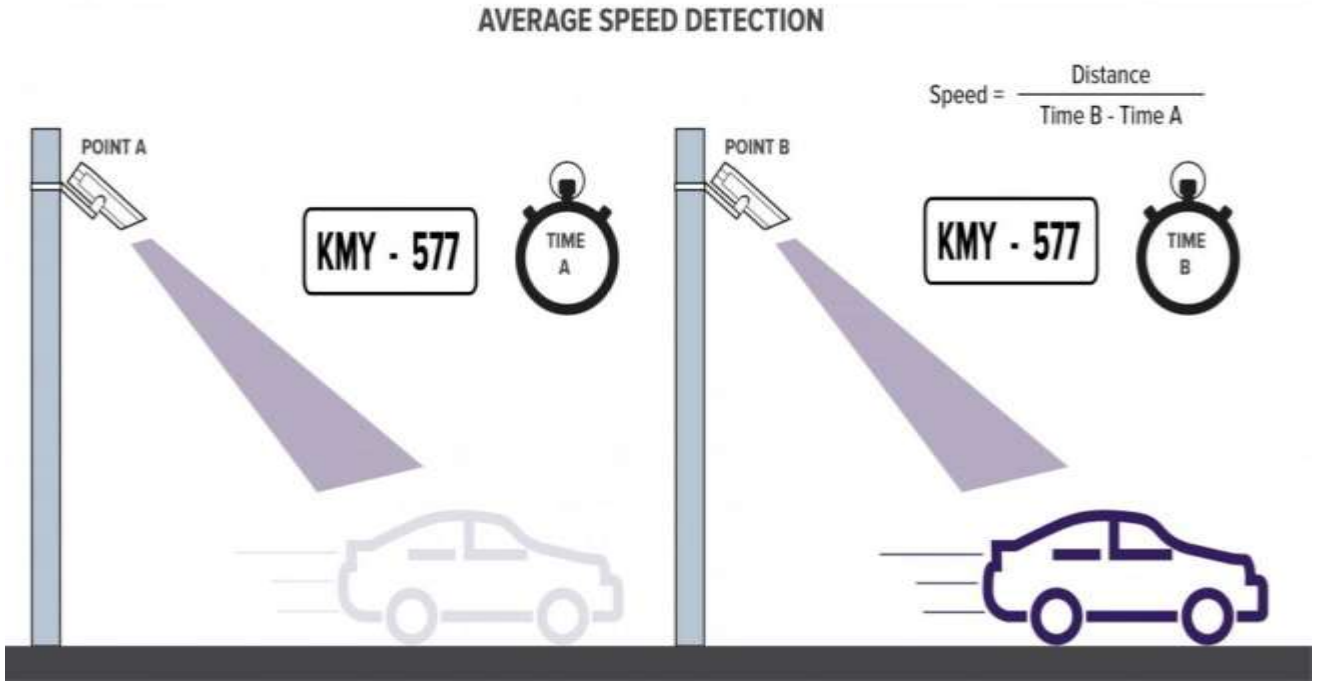
Technologies:

- **Speed:** Point-to-point (average speed) ANPR systems or fixed-point radar/LiDAR.
- **Distracted Driving:** Roadside cameras with specialized AI models trained to identify the posture and object (a phone) characteristic of a driver using a mobile device.

How it Works:

1. A camera system (often mobile) captures high-resolution images of every vehicle.
2. An AI model analyzes the images from multiple angles (driver and windscreen).
3. Potential violations (phone to ear, texting) are flagged.
4. Flagged images are sent to a human operator for final verification.
5. If verified, the ANPR data is used to issue a penalty.

Example: Transport for NSW in Australia has deployed mobile phone detection cameras, which have proven highly effective.



Use Case 4: Urban Access & Low Emission Zones (LEZs)

Objective: Improve urban air quality and reduce congestion by restricting access for polluting or unauthorized vehicles.

Technologies: ANPR cameras, vehicle registration databases (with emission standards).

How it Works:

1. A network of ANPR cameras is installed at the perimeter of the restricted zone (e.g., London's ULEZ, Stockholm's Congestion Charge zone).
2. As a vehicle crosses the boundary, its plate is captured.
3. The system checks the plate against a national vehicle database to determine its characteristics (e.g., Euro 6 emission standard, vehicle type, disabled permit).
4. Based on pre-set rules (time of day, emission standard), the system automatically determines if a charge or penalty is due.
5. The entire process is automated, from detection to billing.

Benefits: Enforces complex environmental policies at a city-wide scale with minimal human intervention.

Use Case 5: Real-time traffic management systems

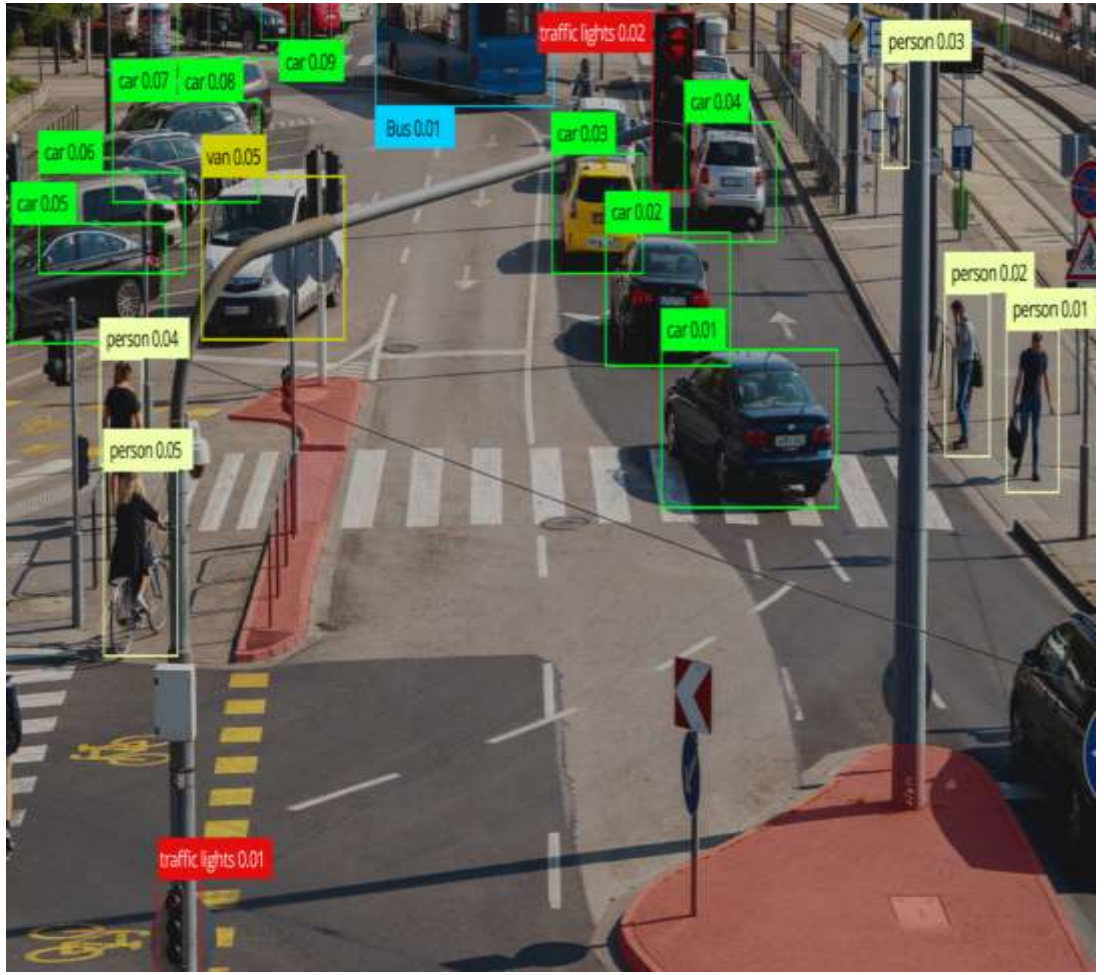
Using AI algorithm, AI vision-based real-time traffic flow monitoring systems detects and tracks vehicles at intersections.

This advanced system effectively extracts diverse types of traffic flow information, including directions, duration, total and categorical counting of vehicles, even under challenging circumstances such as rainy or snowy weather conditions, camera shaking, day/nighttime, partial or full occlusion, and various illusion occurrence cases.

Effective Traffic Monitoring
Real-time traffic management systems utilize advanced technology to monitor traffic flow effectively, ensuring efficient movement on roads.

Timely Driver Information
These systems provide real-time information to drivers, allowing them to make informed decisions to avoid congestion.

Reducing Traffic Congestion
By managing traffic flow effectively, these systems help to reduce congestion and improve overall traffic conditions in urban areas.



Challenges

Challenges and Ethical Considerations

- **Data Privacy & Surveillance:** The 24/7 collection of location and behavioral data (ANPR, video) raises major "Big Brother" concerns. Strong data protection (like GDPR) and clear public policy are essential.
- **Accuracy & Bias:**
  - **False Positives:** An incorrectly read license plate or a flawed AI judgment (e.g., mistaking a coffee cup for a phone) can lead to citizens being wrongly fined.
  - **Algorithmic Bias:** Predictive policing models can be biased if trained on historically skewed data, potentially leading to over-enforcement in certain neighborhoods.
- **Cost & Complexity:** The initial investment in sensors, connectivity, and data platforms is extremely high.
- **Data Security:** A centralized system is a high-value target for hackers. A breach could expose citizen data or cripple enforcement operations.
- **Public Acceptance:** Citizens may resist what they see as impersonal, "cash-cow" enforcement. Transparency and focusing on safety (not just revenue) are key.

The Future: Integrated & Connected Enforcement

The next generation of smart enforcement will be fully integrated:

- **Connected Vehicles (C-V2X):** Vehicles will broadcast their status (speed, weight, "hard-braking" events) directly to infrastructure (V2I) and enforcement platforms. This could enable "self-reporting" systems.
- **Digital Twins:** Control authorities will use real-time digital replicas of their transport networks to simulate the impact of new enforcement strategies *before* deploying them in the real world.
- **Automated Incident Detection (AID):** AI will monitor all camera feeds not just for violations, but for accidents, stopped vehicles, debris, or pedestrians, allowing for instant incident response.
- **Unified Enforcement Platforms:** A single agency (e.g., a DOT) will be able to manage *all* enforcement types—speed, weight, emissions, tolls, and incident response—from one integrated platform.

CONCLUSIONS

Key Takeaways

- **It's a Revolution, Not Evolution:** Smart enforcement fundamentally changes the *how, where,* and *when* of transport control, moving it from reactive to predictive.
- **Tech is the Enabler:** AI, ANPR, WIM, and 5G are the building blocks that automate detection and processing.
- **Data is the Asset:** The primary output is not just fines, but a rich dataset that allows authorities to understand network behavior and make roads safer and more efficient.
- **Major Benefits, Major Hurdles:** The gains in safety and efficiency are undeniable, but they must be carefully balanced against significant challenges in privacy, cost, and public trust.

THANK YOU!

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