

Construction and Application of an Intelligent Supervision System for Heavy-Duty Diesel Vehicle Emissions in Megacities: A Case Study in Shanghai

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Background

□ Heavy-Duty Diesel Vehicle Emissions Constrain the Improvement of Air Quality



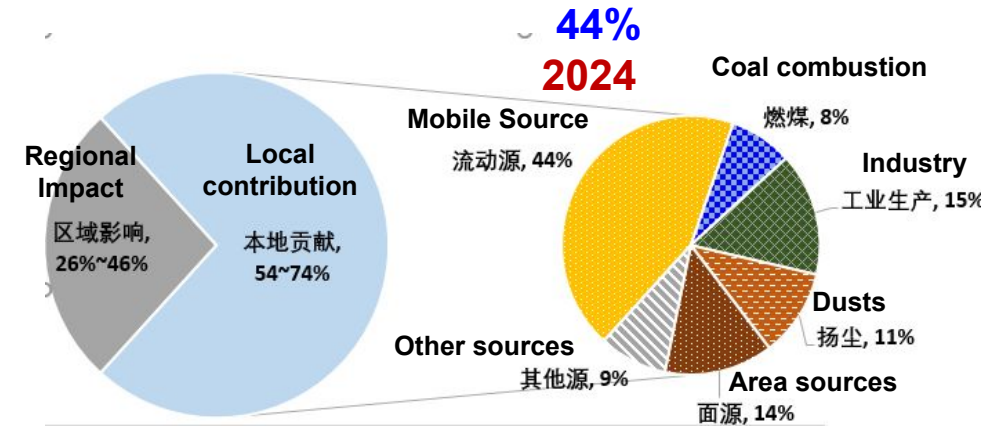
Mobile Sources as Primary Pollutants

Mobile sources are the most important sources of PM_{2.5} and NOx in Shanghai, contributing approximately **44%** and **84%** respectively, restricting the further improvement of air quality.

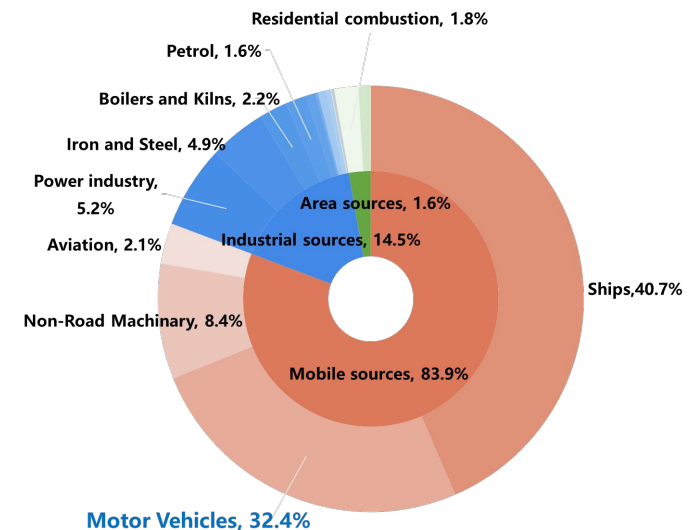


Heavy-Duty Diesel Vehicles (HDDV) Dominance

Motor vehicles contribute **32.4%** of the city's NOx emissions, with heavy-duty diesel vehicles accounting for approximately **67%** of motor vehicle emissions.



Shanghai PM_{2.5} source apportionment



NOx emission structure

Current Status and Challenges



Enormous Freight Pressure: Density Far Exceeds Beijing, Shenzhen

Heavy-duty truck density is 17.4/road-length, 3.5 times that of Shenzhen and 2.4 times that of Beijing.



Prominent Pollution on Freight Corridors: Extremely High NOx Concentration

NOx concentration at Outer Ring Road traffic points is 4.8 times higher than the city's average at national control points.



Significant Abnormal Emissions: High Exceedance Rate

Tampering with purification devices leads to a 4-5 fold increase in emissions; the excessive emission rates for National V/VI vehicles are 43%/32%.



Emission Structure Needs Improvement: Low National VI penetration,, Slow

Electrification

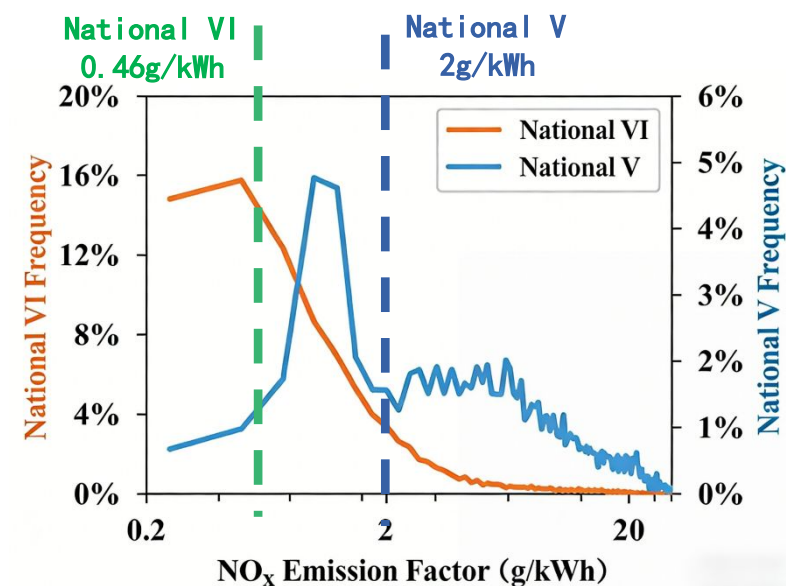
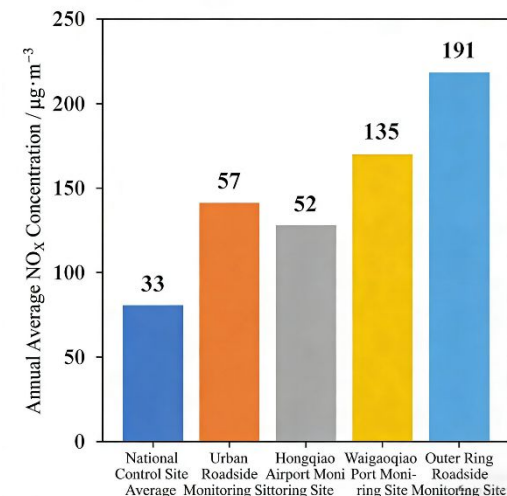
National VI diesel trucks account for only 18%; electric vehicle penetration rate is extremely low at only 0.9%.



Severe Emission Reduction Challenges: Emissions Not Decoupled from

Mileage

Increased mileage directly leads to higher pollution; NOx emissions in 2024 remain at 1.1 times the 2011 level.



Emission Distribution of National V and National VI Standard Vehicles in Shanghai (Based on Remote Monitoring Results)

Strategic Solution: Building an Intelligent Supervision System



Core Strategy: Building an Intelligent Supervision System for Heavy-Duty Diesel Vehicles

The effective way to break through the emission reduction bottleneck, integrating big data and AI technologies to achieve a leap from extensive management to refined and intelligent supervision.



Precise Identification & Positioning

Utilize big data and AI technologies to monitor vehicle operation status in real-time and accurately identify high-emission vehicles.



Dynamic Monitoring & Early Warning

Establish an emission monitoring network covering major freight corridors to provide real-time warnings for abnormal emission behaviors.



Closed-Loop Law Enforcement & Management

Link monitoring data with law enforcement systems to achieve closed-loop management from problem detection to law enforcement.



Data-Driven Decision Making

Provide a scientific basis for policy formulation and optimization through in-depth analysis of massive data.

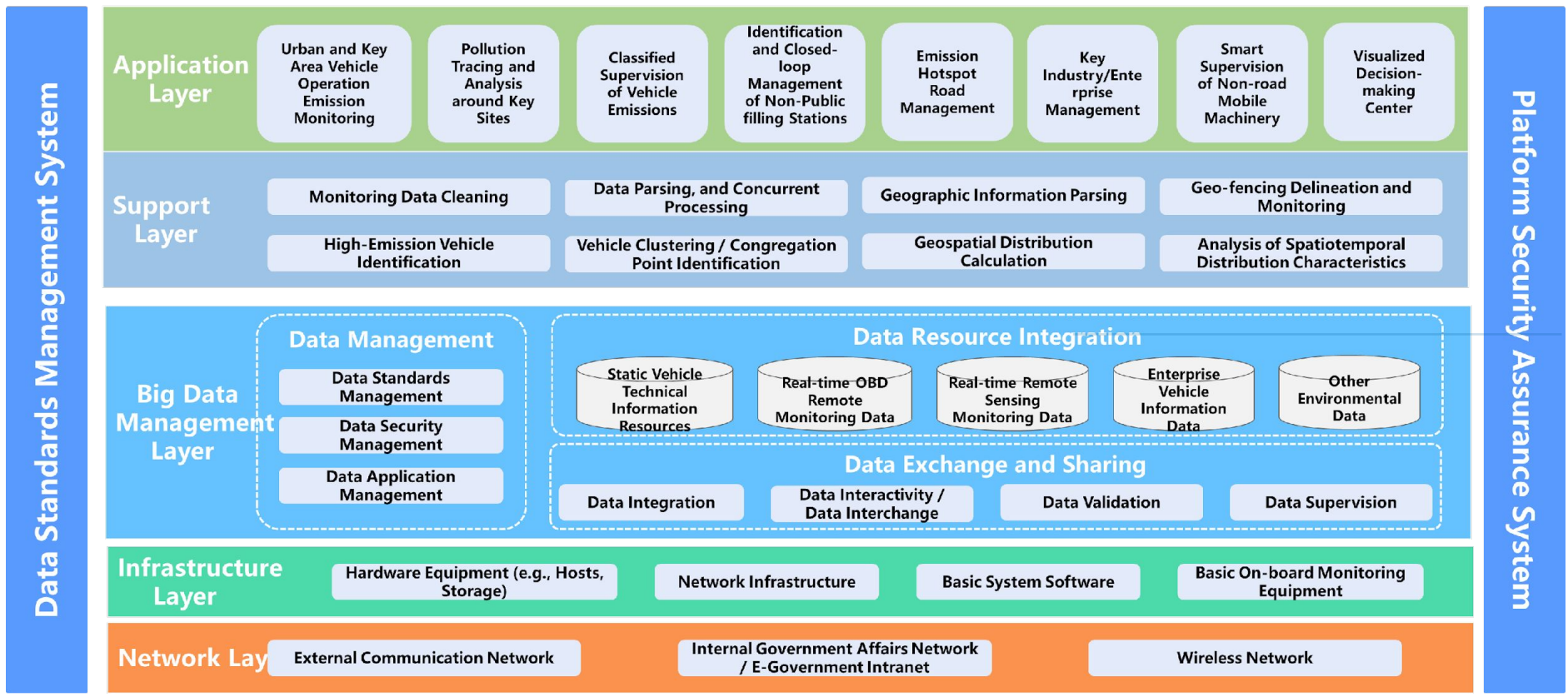


Expected Outcomes: Winning the Battle for Blue Skies

Achieve refined and normalized management of emissions, effectively curb abnormal emissions, promote the optimization of emission structure, and significantly reduce pollutants such as NOx.

Overall System Architecture

Shanghai Heavy-Duty Diesel Vehicle Remote Online Monitoring Platform



Core Capabilities

246GB Daily Data Flow
High operational throughput

High Scalability
ZooKeeper distributed architecture

High Concurrency
Kafka for real-time transmission

Real-time Computing
MapReduce parallel processing

Data Foundation

190,000 Heavy-duty Vehicles Remote monitoring (National V & VI)
250,000 Beidou Data Points Supplementary for National III & IV

Basic Vehicle Information
Comprehensive vehicle specs

Overall System Functions and Application Status



Vehicle: Individual Vehicle Emission Management

Establishing a comprehensive database for individual vehicle emissions, enabling real-time monitoring and compliance management to ensure environmental standards are met.



Oil: Refueling Point Identification

Identifying and tracking authorized refueling points to ensure the quality of fuel and reduce illegal refueling activities that contribute to pollution.



Road: Freight Corridor Monitoring

Implementing continuous monitoring along major freight corridors to analyze traffic flow and identify high-emission hotspots for targeted intervention.



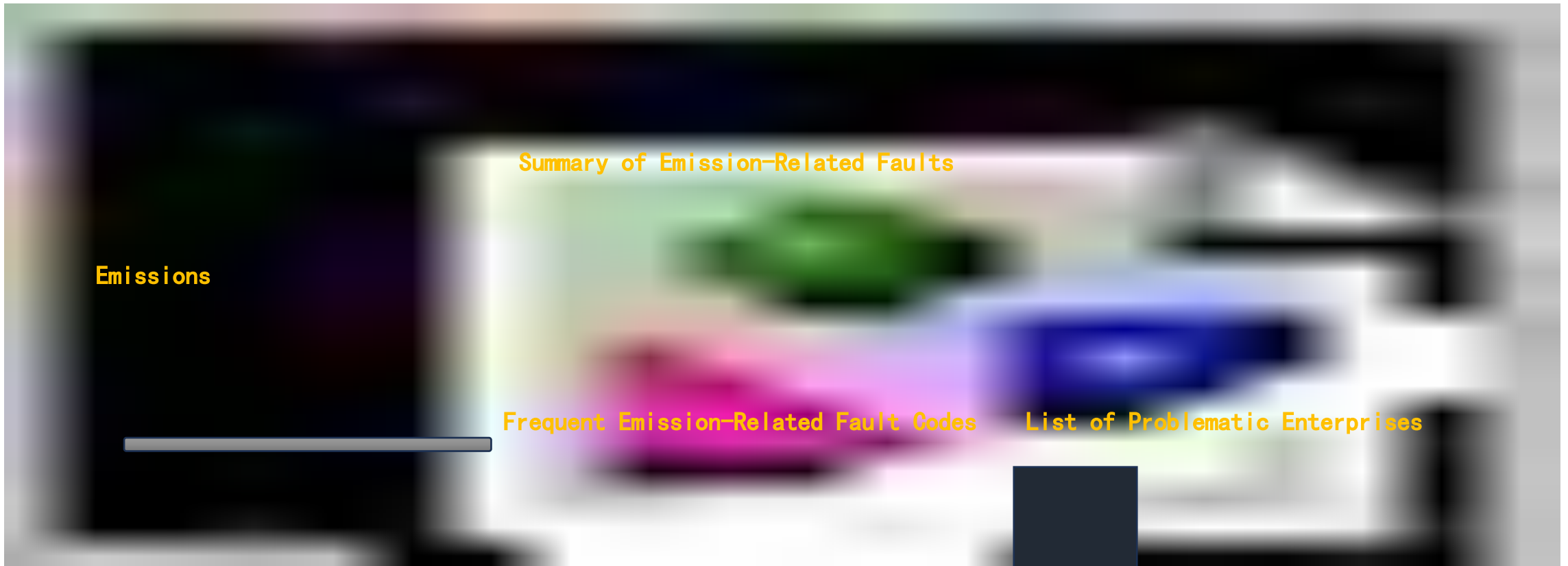
Enterprise: Key Vehicle User Management

Overseeing enterprises with large vehicle fleets to enforce emission reduction responsibilities and promote the adoption of cleaner technologies.

Vehicle, High-Emission Vehicle Monitoring & Problem Diagnosis

Core Monitoring Functions

- **Fleet Monitoring** Real-time tracking of NOx emissions categorized by "Industry-Vehicle Type-Manufacturer" for comprehensive oversight.
- **Fault Monitoring** Diagnosis of typical emission-related fault codes including aftertreatment devices, MIL lights, and urea additives.
- **Enterprise Monitoring** Identification of enterprises with a concentration of problematic vehicles, establishing a robust supervision mechanism.



Vehicle, Exemption from physical inspections for compliant clean vehicles

Policy Implementation Timeline

Announced Nov 2022, implemented Jan 2023. Established legal basis for remote monitoring-based exemption.

Data Flow & Process Linkage

Connected Heavy-Duty Monitoring, Emission Inspection, and Public Security Platforms for seamless joint operation.

Implementation Effectiveness

Issued 30+ exemption batches, significantly streamlining the inspection process for compliant vehicles.

67,000+ Benefited Vehicles (¥10M+ Savings)



Clean Vehicle Inspection Exemption



Monthly Publicity of Inspection-Exempt Vehicles

Oil, Supervision of Non-Public Filling Stations

Precise Positioning

Achieve precise positioning of non-public gas stations by combining parameters such as fuel tank level, identifying potential sources of substandard fuel.

Normalized Supervision Mechanism

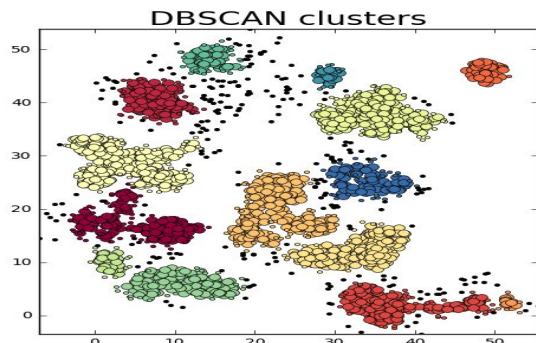
Established a normalized supervision mechanism for non-public gas stations, ensuring continuous oversight and compliance with environmental standards.

Regulatory Notice Issuance

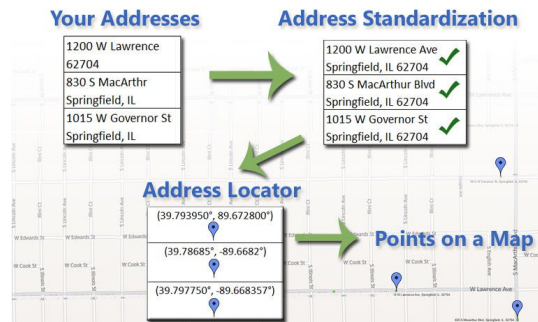
Issued official notices to strengthen supervision, requiring inspections based on clues pushed by the remote online monitoring system for heavy-duty diesel vehicles.

Monthly Clue Pushing

Since October 2021, the list of suspected non-public refueling points has been pushed to all districts monthly for targeted inspections.



Geographic Location Clustering Algorithm



Quick Search of Geographic Information Codes



on-site inspection

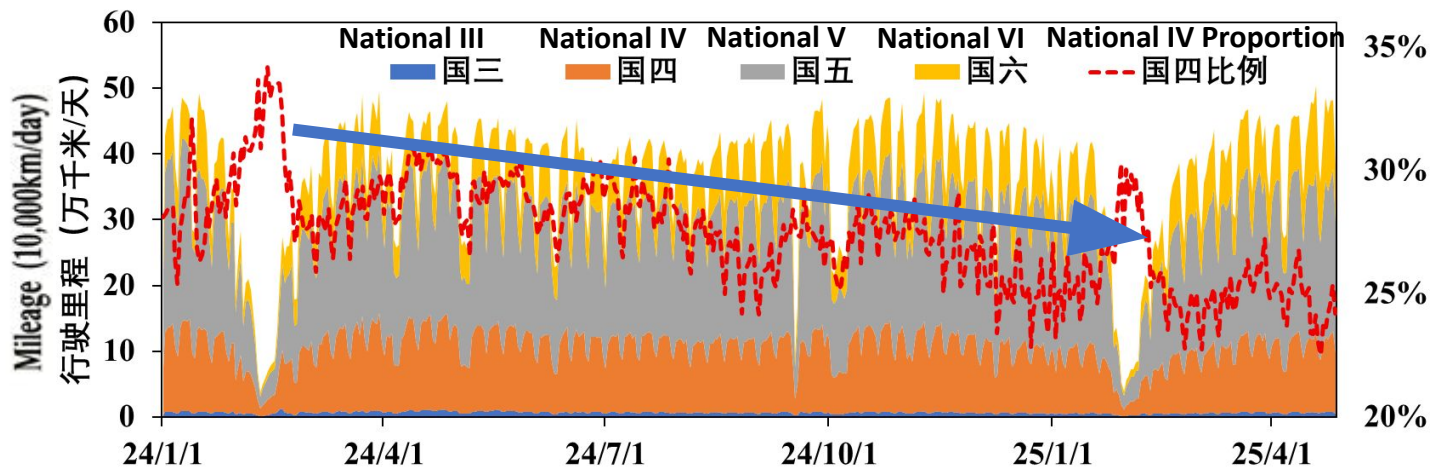
Road, monitoring of key areas and freight corridors

▲ Integrated Beidou Monitoring

Leveraging the full-scale Beidou operation monitoring data from the transportation department as the foundation, real-time awareness of the operational status of all heavy-duty vehicles within the city can be achieved. This enables differentiation based on various criteria such as region, vehicle type, place of registration, and emission level.

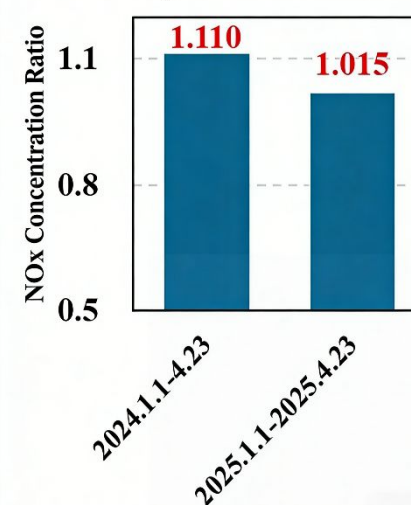
📷 Multi-dimensional Analysis

Electronic fences have been delineated for key transport locations and freight corridors, targeting areas such as port areas, key vehicle-using enterprises, construction sites, container yards, and logistics distribution centers.



Tracking and evaluation of the effects of restricting high-emission vehicles

Inside the Outer Ring/Outside the Outer Ring



Diesel Vehicles Reduction

↓ 5% drop within Outer Ring Road



NOx Concentration Drop

↓ 9.5% reduction in concentration

Enterprise, Transportation Cleanliness & Emission Management Assessment



Cleanliness Assessment

Research Scope & Methodology

- Sample: 313 key vehicle users in Shanghai
- Focus: Diesel usage & electrification readiness
- Goal: Identify intervention targets

Industry Findings

- High Vehicle Usage Intensity: Auto, Power, Steel, Petrochem
- Electrification Leaders: Steel & Construction sectors



Emission Management

Key Activity Hotspots


- Muck Truck Gathering Areas
- Logistics Distribution Centers
- Container Yards
- Other vehicle-related hotspots


Identification Methodology

- Logic: Vehicle type + trajectory analysis
- Goal: Enable targeted intervention






Future work plan

Technology & Platform

 **Platform Integration & Operation**
Strengthen docking with national platforms and enhance maintenance and operation management.

 **Functional Scenarios & Big Data**
Expand scenario development and explore the potential of monitoring big data applications.

Application & Regulation

-  Establish a closed-loop mechanism for high-emission vehicles.
-  Explore regulatory functions of the I/M (Inspection & Maintenance) system.
-  Establish dynamic compliance evaluation for in-use vehicles.
-  Track and evaluate freight structure adjustment effects.
-  Develop real-time monitoring of freight transportation carbon emissions.



**Thank you for
listening!**

Your comments and suggestions are welcome.