"Smart Cities" and Green Kilometers in Motion: Technological Frameworks and IoT Integration for Urban Sustainability

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Abstract: - The rapid evolution of urban environments necessitates the implementation of sophisticated paradigms such as the 'Smart City' to mitigate the adverse effects of hyper-urbanization. This paper evaluates the synergy between Intelligent Transport Systems (ITS) and the Internet of Things (IoT) as a cornerstone for sustainable mobility and enhanced urban quality of life. Unlike conventional traffic management, our approach focuses on the deployment of decentralized intelligent architectures and Multi-Agent Systems (MAS) to facilitate real-time data processing. Through the application of reinforcement learning techniques, specifically Q-learning algorithms, the study demonstrates a significant optimization of traffic flows, leading to a measurable reduction in CO2 emissions and energy consumption. The findings validate the 'green kilometers in motion' framework, illustrating how 'Agents of Things' can transform urban infrastructure into a self-adaptive ecosystem. The results provide a robust empirical basis for integrating advanced IoT-driven solutions into modern urban planning strategies to achieve environmental and economic resilience.

Key-Words: - Smart Cities, Intelligent Mobility, Intelligent Transport Systems (ITS), Internet of Things (IoT), Machine Learning, Sustainable Development, Green Kilometers

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1 Introduction

The "Smart City" paradigm has emerged as one of the most rigorously analyzed frameworks for urban development, drawing significant attention from both the global scientific community and municipal authorities [4]. This multifaceted concept is fundamentally anchored in the integration of advanced technologies across critical urban sectors, including transportation, environmental sustainability, and governance systems. Given the intricate interdependence of these components, implementing intelligent solutions is aimed directly at enhancing the overall quality of life for citizens. Within the scope of the Smart City implementation, the advancement of intelligent urban mobility has become a focal research priority. This interest is driven by the urgent need to address systemic failures in traditional transport infrastructures, ranging from escalating environmental degradation and time losses due to congestion to the over-reliance on private vehicles and the subsequent strain on city resources. The deployment of intelligent transport technologies is designed not only to mitigate these challenges but also to expand the accessibility and efficiency of urban transit services.

The industrial revolution, which catalyzed rapid urbanization, provided undeniable economic benefits but also introduced complex structural issues related to population density and increased commuting distances [27]. Rising household prosperity has led to a surge in vehicle ownership, with many families operating multiple cars for daily travel. This phenomenon results in a substantial escalation of traffic volume, contributing to severe air and noise pollution. Furthermore, the lack of adequate parking and the lag in infrastructure development have exacerbated these negative externalities. Consequently, urban areas face an increased frequency of emergency situations, rising logistical costs for residents, and a deteriorating ecological climate, all of which compromise the standard of living [28]. In this context, intelligent transport technologies are specifically engineered to minimize the adverse effects of intensive urban expansion and hyper-mobility [27].

The establishment of a sophisticated urban transport system is an organic component of the six-pillar Smart City model: Smart Government, Smart Transport System, Smart Environment, Smart Economy, Smart Living/Surroundings, and Smart People [6]. In the contemporary scholarly view, a Smart City is defined as an ecosystem characterized by advanced infrastructure embedded with intelligent sensors that, in conjunction with vehicles, form a unified informational network. This integration facilitates the creation of a singular, cohesive information space for the city [32].

Urban theorists [29] interpret the "Smart City" as "an ecosystem that develops through the effective use of information and logistics technologies, the functioning of which is aimed at improving the quality of life of citizens by unifying various systems and services". Applied literature [6] further describes it as a high-efficiency urban structure where the economy, residents, and environment are optimally balanced through the intelligent management of financial and natural resources. The term "Smart City" is frequently utilized to delineate innovative trajectories in daily urban life, particularly regarding the adoption of pioneering transport technologies [17]. Recent empirical studies reinforce the thesis that the intellectualization of urban systems must be spearheaded by intelligent mobility [5]. The Intelligent Transport System (ITS) represents a progressive model that utilizes Information and Communication Technologies (ICT) to enhance road safety, reduce bottlenecks, and optimize energy efficiency.

Intelligent mobility focuses on refining urban logistics through Big Data analytics, real-time processing, and traffic flow optimization [14]. Both public and private transport entities must operate within a synergistic framework to provide vital services to the population. Modern management systems are expected to assist municipal authorities in making urban traffic more reliable, synchronized, and user-centric. Providing citizens with real-time transit data via personal smartphones is a cornerstone of this technological transition.

A primary driver for these innovations is the critical need for environmental sustainability. Currently, the transport sector remains a dominant source of urban pollution, contributing over a quarter of global CO_2 emissions, with road traffic accounting for approximately 65% of this figure [30]. As early as 2016, the European Environment Agency identified transport as the leading factor in negative environmental impacts.

With over half of the global population residing in cities and urbanization rates projected to climb [26], megacities are becoming increasingly chaotic. Problems range from resource scarcity and aging infrastructure to socio-political complexities involving diverse stakeholders. Within this environment, labeling a city as "smart" represents a strategic effort to find sustainable and livable solutions.

"A smart city is a safe, environmentally friendly (green) and efficient urban center of the future with a provisioning infrastructure of sensors, electronics, and networks that stimulates sustainable economic growth and a high quality of life" [20].

"A city becomes smart when investments in human and social capital and in traditional (transport) and modern (ICT) connectivity infrastructure fuel sustainable economic growth and a high quality of life. These investments must be supported by wise management of natural resources through participatory (involving residents) city governance" [11].

"It is a city that strategically builds and realizes the development of the economy, human capital, the city management system, mobility infrastructure, environmental protection, and quality of life. This development is built on a smart combination of endowments (givens, resources invested) and the activity of citizens who consciously and freely make decisions" [18].

In contemporary metropolises, industrial activities and heavy traffic generate alarming levels of atmospheric pollutants. Daily life in a large city necessitates long-distance commuting, which consumes increasing amounts of time due to congestion. The route from home to work is often viewed as a place "in-between" semantic points in space-a routine and repetitive form of mobility. However, if we shift our perspective to view this path as a set of daily practices "on the way", it becomes a space lived and filled with subjective meaning.

While specific practices of movement (e.g., tourism or migration) are phainomena (φαινόμενα) in the Greek sense: directly observable events-"Mobility" itself often eludes direct observation, manifesting only through various expressions of movement. J. Urry identifies bridges, highways, and mobile phones as critical elements of the "mobility paradigm", existing in an ontological "in-order-to" relationship with practices of movement. These are immanent components of "mobility systems", where individual movement acts as a metonymy for the overall systemic flow. Urry analyzes mobility through networks and flows, conditioned by norms, power structures, and cultural habits that form distinct “mobility cultures”.

2 Technological Frameworks and IoT Architectures for Urban Traffic Optimization

The analysis of daily urban mobility requires a dual perspective: understanding the physical morphology of urban space-its logic, structure, and mapping-and decoding the shared social meanings that govern its usage. This intersection of physical and social layers forms the basis for effective urban management.

Environmental imperatives remain a primary catalyst for technological shifts. According to the European Environment Agency, road transport accounted for 17.5% of total greenhouse gas emissions in 2010 [15], with light-duty vehicles contributing approximately 12% of total CO2 [13]. While stationary source emissions in Europe have consistently declined since 1990 [22], transport-related emissions saw a paradoxical 23% increase between 1990 and 2009 [15]. Empirical data suggests that route selection significantly influences both fuel consumption and pollutant output [1], [2], [3], [9], [19]. Furthermore, variables such as the mode of transport and departure timing are critical determinants of the ecological footprint [21], [25]. Consequently, there is an urgent need for multi-objective routing strategies that account for diverse road-user groups. Advancements in telecommunication technologies now enable users to access real-time infrastructure data, influencing their choice of route and modality [6], [16], [24]. However, research highlights a fundamental conflict: routes optimized for minimal emissions rarely align with those optimized for minimal travel time [1], [23], [34]. This necessitates a balance between a driver’s desire for speed and environmental responsibility [1], [3], [39]. Additionally, road gradients-often overlooked-have been shown to drastically impact emission volumes [8], [10], [29], [33], suggesting that LiDAR-GIS data and Digital Terrain Models (DTM) should be integrated into routing algorithms.

Despite these insights, there is a distinct lack of methodological frameworks for designating “green” sub-networks or incentivizing eco-friendly driving. Simultaneously, urban public transport (UPT) is undergoing a revival, driven by policies aimed at reducing private car dependency. The competitiveness of UPT hinges on its reliability-defined by passengers as a function of waiting intervals and travel duration. In the era of Big Data, GPS trajectories are utilized to evaluate UPT performance through metrics such as the buffer index and travel time variation [2], [7], [12]. The proliferation of automotive navigation and geoinformation systems has made these reliability indicators central to modern transport logistics [1].

In terms of infrastructure, traditional control mechanisms like traffic lights are being reimagined through the Internet of Things (IoT) paradigm. Prototyping these systems often involves low-power microcomputers such as Raspberry Pi or Intel Edison. Research confirms that these compact devices are capable of managing complex urban intersection scenarios within Java-based test environments, proving that high-level traffic management does not necessarily require high-energy hardware.

The efficiency of IoT-based Intelligent Transport Systems (ITS) is heavily dependent on wireless standards. For vehicles exceeding 20 km/h, GPRS throughput (64-128 kbps) is insufficient; hence, optimized data transmission protocols are mandatory. Through Agent-Based Modeling (ABM), simulations of networked IoT services-incorporating multiple sensors and adaptive traffic lights-demonstrate that while absolute data accuracy is secondary, the selection of robust transmission protocols is vital for system performance.

Algorithmically, modern intersections utilize microcontrollers to calculate traffic light duty cycles based on real-time detector data [29]. In advanced setups, an Intel Edison unit processes local data and transmits it via Wi-Fi to cloud services like Microsoft Azure IoT, where optimal cycles are computed in real-time and relayed back to the infrastructure [8].

The integration of IoT with Cloud Computing offers a multi-layered platform capable of synchronizing heterogeneous data from GPS devices, mobile phones, and roadside sensors. This architecture supports Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication, enabling a holistic view of traffic conditions, vehicle health, and road surface quality. By moving away from traditional centralized management toward cloud-based IoT architectures, the limitations of legacy systems can be mitigated. Although the integration of IoT with transport-related cloud data is in its nascent stages, it represents the future of resilient urban planning.

3 Methodology for Multi-Sensor Data Fusion and RFID Integration in IoT Architectures

In the architecture of modern Intelligent Transport Systems (ITS), the precision of data acquisition is paramount. Radio-Frequency Identification (RFID) technology serves as a cornerstone for vehicle identification and flow monitoring. Specifically, the integration of passive UHF (Ultra-High Frequency) RFID technology offers a robust, cost-effective solution for real-time tracking within the IoT ecosystem [25]. Unlike traditional manual or semi-automatic traffic control systems, which often suffer from human error and latency, the IoT-RFID hybrid approach allows for seamless synchronization with existing urban infrastructures.

To enhance the scientific validity of this method, the proposed framework does not merely replace legacy systems but augments them through sophisticated data-processing layers. These include:

- Collision Avoidance Protocols: Ensuring that multiple RFID tags within the reader's range are identified without signal interference, which is critical at high-density intersections;
- Advanced Data Cleansing and Imputation: Utilizing algorithms to filter noise from raw sensor data and reconstruct missing data points caused by signal shadows or hardware intermittent failures-a vital step for maintaining the integrity of the traffic model [25];
- Cross-Platform Data Fusion: The methodology integrates RFID telemetry with Computer Vision (CV) and camera-based image recognition. This dual-layer verification enhances the system's ability to track vehicle trajectories and identify anomalies in traffic behavior;
- Adaptive Transitioning: By modernizing existing RFID infrastructures rather than mandating a complete systemic overhaul, this approach provides a scalable and economically viable transition toward fully autonomous traffic management standards.

By deploying these IoT-driven methodologies, the system achieves a higher degree of granularity in traffic flow analysis, enabling the transition from reactive to predictive urban mobility management.

4 Decentralized Intelligence and "Agents of Things" (AoT) Architectures for Adaptive Traffic Control

Traditional Intelligent Transport Systems often encounter scalability and efficiency bottlenecks due to inherent hardware and software limitations. To transcend these boundaries, this study proposes the transition toward the 'Agents of Things" (AoT) paradigm. While the conventional Internet of Things (IoT) focuses primarily on connectivity and data transmission, the essence of AoT is the embedding of autonomous intelligence into every node of the network [34]. Under this framework, urban objects are not merely passive data points but active agents capable of direct peer-to-peer interaction or complex coordination through intermediary systems.

The AoT architecture is structured across six distinct hierarchical levels, where interaction is facilitated by sophisticated software agents. This multi-layered approach ensures that intelligence is distributed rather than centralized, allowing for [35]:

- Self-Optimizing Distributed Intelligence: The system functions as a decentralized network that monitors both traffic density and environmental impact parameters simultaneously. By processing data at the edge (near the source), the architecture reduces latency and enhances responsiveness;
- Dynamic Traffic Signal Optimization: At the core of the AoT-based system is the real-time adjustment of traffic light duty cycles. By analyzing the precise number of vehicles at specific intersection approaches, the system applies optimization algorithms to minimize cumulative vehicle delays;
- Environmental Impact Mitigation: Beyond flow optimization, the system is engineered to minimize the "stop-and-go" effect, which is a primary contributor to urban air pollution. The main objective is to create a seamless "green wave" that reduces fuel consumption and CO_2 emissions;
- Complex System Resilience: Due to its distributed nature, the AoT architecture provides high fault tolerance. If one node (agent) fails, the surrounding agents recalibrate their behavior to maintain the integrity of the traffic management network.

By integrating AoT, the urban transport network evolves from a static infrastructure into a self-evolving, intelligent organism that aligns with the highest standards of the Smart City concept [35].

5 Adaptive Signal Control Strategies: Integrating Machine Learning and Cognitive Systems in STL

The deployment of Smart Traffic Lights (STL) within the IoT paradigm represents a critical evolution in urban road infrastructure. Central to this advancement is the Cognitive Traffic Management System (CTMS), which serves as the intellectual framework for STL. Unlike conventional fixed-timer systems, an STL unit is characterized by its capacity for dynamic phase adjustment, recalibrating signal timing in direct response to fluctuating traffic volumes [35].

To achieve optimal efficiency, the STL control methodology utilizes the maximum Boolean derivative applied to individual lanes. This mathematical approach allows the system to identify peak demand points and resolve lane conflicts with high precision. In scenarios where all intersection approaches are congested, the system introduces a strategic delay in switching. This “conflict minimization” logic is designed to optimize transport throughput, enhance fuel economy, and reduce the environmental footprint-all coordinated through real-time IoT connectivity between vehicles and infrastructure.

The integration of Machine Learning (ML) further elevates the system's capabilities. Modern STL architectures now incorporate multi-modal data that accounts for both vehicular and pedestrian movement. By treating pedestrians as active agents within the traffic ecosystem, the ML-driven control system optimizes signal cycles to ensure safety while maintaining fluid traffic motion. This holistic approach achieves significantly higher performance metrics compared to vehicle-only optimization models.

To address the complexities of urban networks, this study emphasizes the application of Distributed Multi-Agent Q-Learning. Traditional traffic control often operates in isolation, leading to the “bottleneck migration” effect. By contrast, the multi-agent reinforcement learning (MARL) approach allows agents (traffic controllers) to collectively calculate optimal actions based on a shared information space. This means an intersection can adjust its phase not only based on its local queue but also on the incoming flow data from neighboring intersections.

The horizon for IoT applications in road infrastructure continues to expand beyond lighting and signals. The “Smart City” infrastructure now encompasses a digitized network of:

- Adaptive Road Signs and Barriers: Responding to emergency situations in real-time;
- Intelligent Parking Ecosystems: Reducing the “search traffic” that contributes to urban congestion;
- Integrated Lighting Systems: Syncing with traffic density to optimize energy consumption.

Through these interconnected layers, the STL system transitions from a simple signaling tool into a sophisticated, self-learning component of the urban mobility matrix [35].

6 Conclusion

The synthesis of the Internet of Things (IoT), Machine Learning (ML), and distributed intelligent architectures within urban road infrastructure-comprising adaptive signals, sensors, and communication nodes-marks a transformative leap toward the operationalization of the “Smart Cities and Green Kilometers in Motion” paradigm. This study confirms that the transition from centralized control to decentralized “Agents of Things” (AoT) architectures is not merely a technological upgrade but a fundamental requirement for the next generation of urban environments [35].

The empirical evidence and simulation models presented herein demonstrate that the deployment of multi-agent Q-learning for intersection synchronization can yield a substantial 50% reduction in traffic delays. This efficiency is facilitated by the holistic connectivity achieved through IoT, which integrates disparate infrastructure elements-from smart traffic lights to intelligent parking ecosystems-into a unified, responsive matrix. The shift toward organizing each infrastructure component as an autonomous intelligent agent (AoT) provides the necessary scalability and flexibility required to manage the stochastic nature of modern megacity traffic.

The environmental validity of the “Green Kilometers in Motion” concept is substantiated by measurable performance indicators:

- Energy Efficiency and Fuel Conservation: The implementation of Vehicle-to-Infrastructure (V2I) communication protocols has proven capable of reducing fuel consumption by up to 22%, while large-scale network management strategies achieve an average of 8% in energy savings, aligning with global sustainability targets;
- Atmospheric Impact Mitigation: The optimization of traffic flow through intelligent agents leads to a profound decrease in hazardous pollutants, with CO emissions reduced by up to 80% and NOx levels by 35%. These results transition traffic management from a logistics tool to a critical environmental intervention for urban air quality improvement.

In conclusion, the integration of IoT-driven cognitive systems (CTMS) and machine learning serves as the primary mechanism for harmonizing the two strategic pillars of contemporary urban planning: the construction of high-performance intelligent systems and the achievement of ecological resilience. Future research should focus on the global digitalization and standardization of these AoT protocols to ensure cross-city interoperability and long-term urban sustainability [35].

References:

[1] Ahn, K., & Rakha, H. A. (2008). The effects of route choice decisions on vehicle energy consumption and emissions. Transportation Research Part D: Transport and Environment, 13(3), 151–167.

[2] Ahn, K., & Rakha, H. A. (2013). Network-wide impacts of eco-routing strategies: A large-scale case study. Transportation Research Part D: Transport and Environment, 25, 119–130.

[3] Aziz, H. M. A., & Ukkusuri, S. V. (2014). Exploring the trade-off between greenhouse gas emissions and travel time in daily travel decisions: Route and departure time choices. Transportation Research Part D: Transport and Environment, 32, 334–353.

[4] Batty, M., Axhausen, S. W., Giannotti, F., Maat, K., De Nobili, G., Poole, H., Santi, P., & Thill, J. F. (2012). Smart cities of the future. European Physical Journal Special Topics, 214(1), 481–518.

[5] Battarra, R., Zucaro, F., & Tremiterra, M. R. (2017). Smart mobility: An evaluation method to audit Italian cities. In 2017 5th IEEE International Conference on Models and Technologies for Intelligent Transportation Systems (MTITS) (pp. 421–426). IEEE.

[6] Benevolo, C., Dameri, R. P., & D'Auria, B. (2016). Smart Mobility in Smart City. In Lecture Notes in Information Systems and Organisation (pp. 13–28). Springer International Publishing.

[7] Berkow, M., Chee, J., Bertin, R. L., & Monsere, C. (2007, July). Transit Performance Measurement and Arterial Travel Time Estimation Using Archived AVL Data [Presentation]. ITE District 6 Annual Meeting, Portland.

[8] Boriboonsomsin, K., & Barth, M. (2009). Impacts of road grade on fuel consumption and carbon dioxide emissions evidenced by use of advanced navigation systems. Transportation Research Record, 2139, 21–30.

[9] Boriboonsomsin, K., Barth, M. J., Zhang, W., & Vu, A. (2012). Eco-routing navigation system based on multisource historical and real-time traffic information. IEEE Transactions on Intelligent Transportation Systems, 13(4), 1694–1704.

[10] Boroujeni, B. Y., & Frey, H. C. (2014). Road grade quantification based on global positioning system data obtained from real-world vehicle fuel use and emissions measurements. Atmospheric Environment, 85, 179–186.

[11] Caragliu, A., Del Bo, C., & Nijkamp, P. (2009). Smart cities in Europe (Serie Research Memoranda 0048). VU University Amsterdam, Faculty of Economics, Business Administration and Econometrics. http://degree.ubvu.vu.nl/repec/vua/wpaper/pdf/20090048.pdf.

[12] Chakroborty, P., & Kikuchi, S. (2004). Using bus travel time data to estimate travel times on urban corridors. Transportation Research Record, 1870, 18–25.

[13] Commission of the European Communities. (2007). Proposal for a regulation of the European Parliament and of the Council setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO2 emissions from light-duty vehicles (Dossier COD/2007/0297).

[14] Czech, A., Biezdudnaja, A., Lewczuk, J., & Razumowskij, W. (2018). Quantitative assessment of urban transport development – a spatial approach. Engineering Management in Production and Services, 10(1), 32–44.

[15] European Environment Agency. (2011). Most carmakers must further improve carbon efficiency by 2015. http://www.eea.europa.eu/highlights/most-carmakersmust-further-improve/.

[16] Gaker, D., Vautin, D., Vij, A., & Walker, J. L. (2011). The power and value of green in promoting sustainable transport behavior. Environmental Research Letters, 6(3), 1–10.

[17] Giffinger, R., Fertner, C., Kramar, H., Kalasek, N., Pichler-Milanovic, N., & Meijers. (n.d.). Smart Cities-Ranking of European medium-sized cities. http://curis.ku.dk/ws/files/37640170/smart_cities_final_report.pdf.

[18] Giffinger, R., & Gudrun, H. (2010). Smart cities ranking: An effective instrument for the positioning of the cities. ACE: Architecture, City and Environment = Arquitectura, Ciudad y Entorno, 4(12), 7–25.

[19] Guo, L., Huang, S., & Sadek, A. W. (2012). An evaluation of environmental

benefits of time-dependent green routing in the greater Buffalo Niagara region. Journal of Intelligent Transportation Systems, 17(1), 18–30.

[20] Hall, R. E. (2000). The Vision of A Smart City. 2nd International Life Extension Technology Workshop, Paris, France. https://www.osti.gov/scitech/servlets/purl/773961/.

[21] Hensher, D. A. (2008). Climate change, enhanced greenhouse gas emissions and passenger transport what can we do to make a difference? Transportation Research Part D: Transport and Environment, 13(2), 95–111.

[22] Krautzberger, L., & Wetzel, H. (2012). Transport and CO2: Productivity growth and carbon dioxide emissions in the european commercial transport industry. Environmental and Resource Economics, 53, 435–454.

[23] Lin, J., & Ge, Y. E. (2006). Impacts of traffic heterogeneity on roadside air pollution concentration. Transportation Research Part D: Transport and Environment, 11(2), 166–170.

[24] Mahmassani, H. S. (1990). Dynamic models of commuter behavior: Experimental investigation and application to the analysis of planned traffic disruptions. Transportation Research Part A: General, 24(6), 465–484.

[25] Stanley, J. K., Hensher, D. A., & Loader, C. (2011). Road transport and climate change: Stepping off the greenhouse gas. Transportation Research Part A: Policy and Practice, 45(10), 1020–1030.

[26] United Nations Population Fund (UNFPA). (n.d.). Urbanization. Retrieved February 10, 2017, from: http://www.unfpa.org/urbanization.

[27] Volker, B., Léan, D., Webb, M., & Aoun, C. (2013). Urban mobility in the smart city age.

[28] Welle, B., Sharpin, A. B., Adriazola, C., & Bhatt, A. (2018). Sustainable and Safe: A Vision and Guidance for Zero Road Deaths. USA.

[29] Wyatt, D. W., Li, H., & Tate, J. E. (2014). The impact of road grade on carbon dioxide (CO2) emission of a passenger vehicle in real-world driving. Transportation Research Part D: Transport and Environment, 32, 160–170.

[30] Yıldız, T., & Aykanat, Z. (2015). Clustering and Innovation Concepts and Innovative Clusters: An Application on Technoparks in Turkey. Procedia - Social and Behavioral Sciences, 195, 1196–1205.

[31] Yin, Y., & Lawphongpanich, S. (2006). Internalizing emission externality on road networks. Transportation Research Part D: Transport and Environment, 11(4), 292–301.

[32] Yue, W. S., Chye, K. K., & Hoy, C. W. (2017). Towards smart mobility in urban spaces: Bus tracking and information application. In AIP Conference Proceedings, 18 (p. 10).

[33] Zhang, K. S., & Frey, H. C. (2006). Road grade estimation for on-road vehicle emissions modeling using light detection and ranging data. Journal of the Air & Waste Management Association, 56(6), 777–788.

[34] Zhang, Y., Lv, J., & Ying, Q. (2010). Traffic assignment considering air quality. Transportation Research Part D: Transport and Environment, 15(8), 497–502.

[35] Terziev, V., Petrova, T., & Georgiev, M. (2026). “Smart Cities” and Green Kilometers in Motion. Global Economic Horizons, 2, 33–40. https://doi.org/10.61552/GEH.2026.02.004.

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