



## **INTELLIGENT TRANSPORT SYSTEMS AND THEIR IMPACT ON URBAN MOBILITY**

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### **ABSTRACT**

**Purpose:** This research investigated the influence of technology on intelligent transportation systems (ITS). The objectives are to determine the impact of these technologies on urban mobility and to assess the factors influencing traffic congestion and safety.

**Design/Methodology/Approach:** This article is an original study that combines a systematic review of relevant research with an analysis of secondary data. This research uses a combination of system and economic analysis, mathematical modelling, and applied transport analytics. Urban transportation data, driver time-loss profiles, traffic density, and results from adaptive traffic management systems were used to evaluate the efficiency of the ITS systems. An integral of total mobility loss was used to evaluate efficiency, and time-series models and machine learning algorithms were used to make predictions. Results were grouped by the characteristics of the city under study and the type of traffic control method utilised.

**Research Limitation:** The research has limitations because it focuses only on two urban networks and on the traffic data collected during the study. The results may not be generalizable to other cities with different infrastructure or local mobility patterns.

**Findings:** The multi-level ITS showed significant improvements in traffic efficiency compared with single-level ITS systems. The use of adaptive algorithms combined with predictive analytics significantly reduced delays and improved trip predictability while decreasing traffic flow randomness. The system performance was positively correlated to the quality of the technical components of the ITS. The ITS also had a positive impact on traffic safety and environmental outcomes.

**Practical Implication:** The findings of this study will assist urban planners in designing ITS strategies that utilise predictive analytics and adaptive traffic management to maximise urban mobility.

**Social Implication:** Improving ITS can help reduce travel times, decrease travel-related stress, and lower emissions, which will contribute to a higher quality of life for citizens in urban areas.



**Originality/Value:** The original contribution of this work is the evolution of present processes. The article develops an extrapolated strategy for a fully integrated ITS technology combined with a holistic model of urban mobility systems.

**Keywords:** *Artificial intelligence. information technology. intelligent transport systems. road transport. traffic management*

## INTRODUCTION

Intensive urbanisation is actually on the decline due to heavy traffic. Trips are growing faster than the supply of street and road space. This creates persistent traffic jams. These result in long delays and decreasing traffic safety. Injurious emissions are not receding. Mobility in cities is increasingly a facet of economic and social immobility (Papageorgiou et al., 2024). Traditional traffic management techniques are grounded in static policies. Their basis is fixed signal timing plans. It's a clunky series of solutions to bring supply and demand into balance. They are non-random and 'stiff'. The transport system has not lived up to its potential even with modern infrastructure.

Urban activity in the digital age paves the way for paradigm shifts towards smart mobility management. Sensor networks, data processing platforms and AI algorithms are used for real-time traffic analysis. We can now forecast congestion. Management choices are inherently flexible. This is the reverse of transport policy. However, several problems arise in the implementation of intelligent transport systems (Kotenko, 2023). There is no standard for evaluating a case. The exposure effect is typically assessed piecemeal. Design mechanisms and procedures from control mechanisms. The practical usefulness of a study is also eroded.

The point is that a systematic analysis of the impact of intelligent transport systems (hereinafter, ITS) on urban traffic characteristics has been lacking to date. It would travel both upstream and downstream from the technological process itself to measured outcomes. One should work out a fully analytical model. This is the basis for the current research.

## LITERATURE REVIEW

The studies by Algherbal and Ratrout (2025) and Richter et al. (2022) explore how ITS are integrated into smart cities and communicate with automated vehicles. The authors also claim a reduction in traffic jams and an improvement in traffic safety. But applying current solutions to cities with different spatial arrangements still lacks practical approaches. Cities have varying levels of resources and capacity. The results of this review are in favour of studying the universal mechanisms of interaction between ITS deployment and urban mobility.



The works of Alotaibi et al. (2025), Kumar & Verma (2025), and Puzio et al. (2025) recommend real smartphone technologies, supported by evidence. The reduction in travel time and the flow equilibrium are illustrated by the authors. However, it is uncertain whether these effects can be maintained. It is expensive to maintain good data. Cities, too, have a technical cross to bear: the costs of operations. Nonetheless, the research provides methods for measuring the benefits of ITS.

Known works, such as Gheorghe and Soica (2025), Imran (2025), and Bastia (2024), have studied the application of IoT, big data analytics, and predictive models for adaptive traffic management. The authors indicate that using an Artificial Intelligence algorithm improves management decisions by leveraging a sensor network. But there are issues of information security and technical synchronisation. Technical standards remain inconsistent. Cybersecurity systems have limitations. The results confirm the holistic ITS analytical approach.

Similarly, Avci and Koca (2024) and Bellam et al. (2025) state the technical and organisational barriers to ITS implementation. The authors attribute this to a shortage of properly trained personnel, difficulties with trans-agency cooperation and unmanageable integration costs. The studies don't propose formal models to quantify how these factors affect mobility. This is an operational limitation of the observations.

For example, Hafiz et al. (2025), Konečný (2025), and Hu et al. (2025) investigate the impact of autonomous driving and intelligent transport management systems on traffic characteristics. They note gains in safety and network capacity. But the dynamic between regular cars and self-driving cars may pose some difficulty. There should be better oversight. It is methodologically difficult to simulate the behaviour of traffic participants.

Nikolova (2025), Sami & Sara (2023), United Nations Economic Commission for Europe (2024) and Zhao & Chen (2025) have also confirmed the importance of ITS that align with strategic needs for sustainable urban mobility development. However, the authors note that there is currently no systematic approach for evaluating implementation effectiveness. This has led to the need to analyse the technical feasibility of ITS in different urban scenarios.

The purpose of the article is to examine the technological process and to determine the empirical impact of ITS implementation on urban mobility development.

## **MATERIALS AND METHODS**

### **Research Design**

This article presents original research. It combines a systematic review of relevant studies with an analysis of secondary data.

ISSN: 2408-7920

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## Sampling Method

The primary research materials consisted of selected industry publications indexed in leading scientific databases (Web of Science, Scopus) and statistics from official sources. The sampling period is 2022–2025. The inclusion and exclusion criteria for publications were the spatiotemporal scope and the reliability of the information. The criteria for assessing the quality of sources were the publication's relevance and objectivity, the comprehensiveness of its topic coverage, and the source's authority.

## Sample size

The appropriateness of the sample size was determined by the adequacy of the data's statistical power. The search for literature sources was conducted in the Google Scholar, JSTOR, ScienceDirect, and Wiley databases, using a predefined list of keywords derived from categories identified through grounded theory analysis of the preliminary sample of sources.

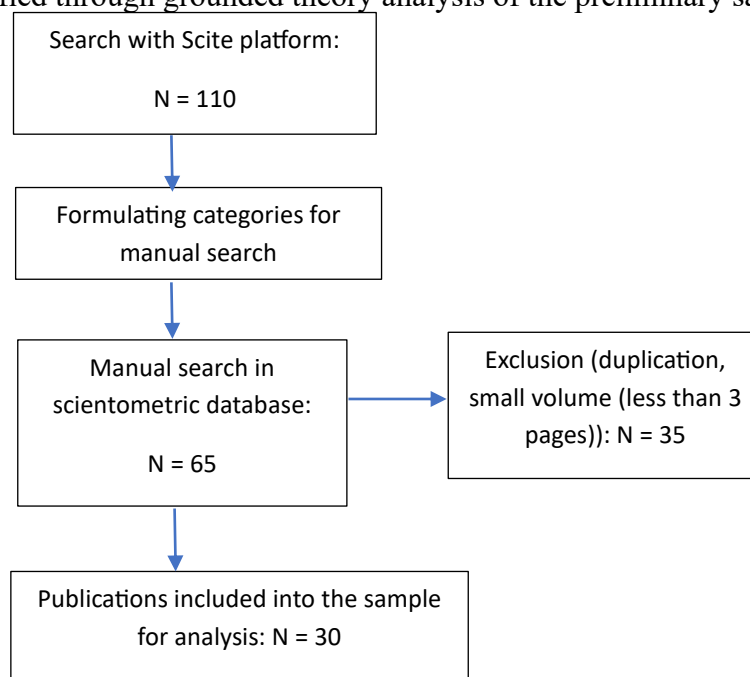


*Figure 1. Scheme of searching the sources for analysis\**

*\*Source: Developed by the authors*

## Data sources and materials

The empirical analysis was based on joint data from urban transport networks and statistical data on traffic delays and travel time losses. Official reports on ITS application results and analytical documents from authoritative international organisations were also analysed. Also,



the effects of flow intensity, density, and variability on the technical parameters of traffic lights were studied.

#### *Data Analysis*

System analysis, economic and mathematical modelling, and applied analytics are a methodological basis of the approach. Transportation processes were described using the vector closure of traffic states and the calculation of integral indicators of the degree of mobility loss. The performance of ITS was compared across baseline and controlled networks in terms of travel time, delay level, and traffic flow stability.

The impacts were forecast using time-series modelling and machine-learning approaches to project congestion and demand dynamics. Adaptive traffic light control and flow routing were investigated using mathematical optimisation techniques. The findings were presented as a comparative analysis and an analytical interpretation of the acquired data.

## **RESULTS AND DISCUSSION**

### **Conceptualisation of the Implementation of Intelligent Transport Systems in The Practice of Ensuring Urban Mobility**

Urban mobility is to be conceived as a governed flow system, not as an accumulation of trips. The first change was how transport is managed. It is all about data, algorithms, and management procedures. These, in turn, dictate a city's adaptive capacity to fluctuating demand, events, and spatial mismatches. Its science forms the basis for the shift from regulatory control to adaptive management.

Conventional transportation systems are based on static traffic plans, schedules and signal timings. They are not driven by the dynamics of the urban setting (Arora et al., 2025). Intelligent systems work differently. According to the INRIX global report for 2023, only one city exceeded this threshold of 'over 100 hours of time lost per driver'; in 2024, four such cities already appeared. Altogether, the average time lost, 78.7 hours for the 20 most congested cities, climbed to 84.25, showing that gridlock is not a local problem but rather one with evidence-backed widespread causes. The figure shows not only the absolute growth in congestion, but also an enlargement of the set of cities with very high losses (INRIX, 2025).



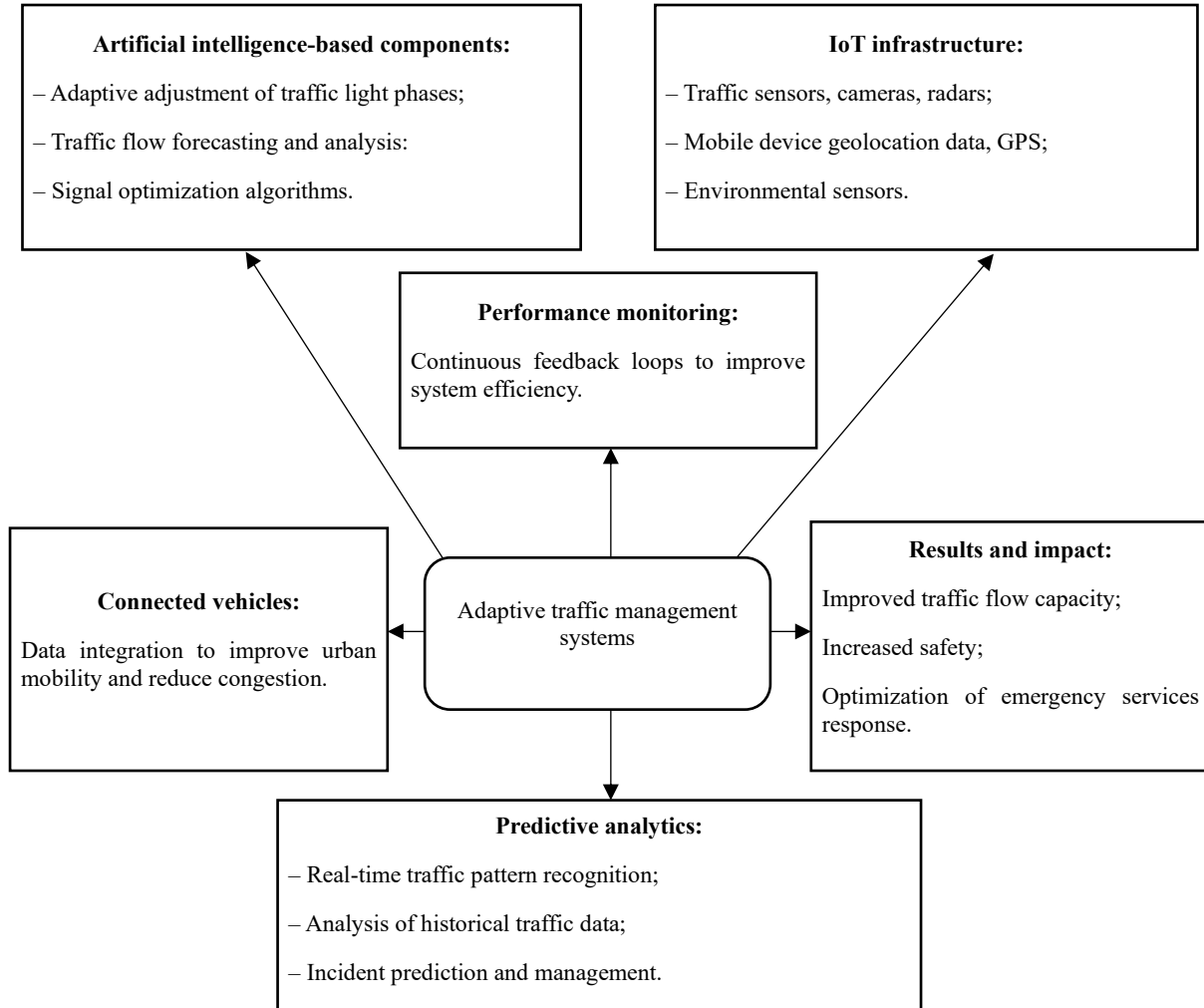


*Figure 3: Architecture of adaptive intelligent traffic management systems in urban transport networks*

*Source: Developed based on Cordoş et al. (2025), Makedon et al. (2025), Tryhuba and Kotenko (2023)*

The organisational aspect of the deployment of ITS is equally important or even more so than the technology itself. If you have a Ferrari in the garage but no asphalt to drive on, then the Ferrari will sit there as an expensive static object. City management has historically broken down the transportation area into silos with different areas overseeing different parts of the process: one may oversee the building of roads while another may operate public transportation systems, and yet another may focus on keeping the drivers safe. A city traffic control centre is



the ultimate authority (Zhai, 2024) and is where the city's traffic management decisions are made.

It is hard to coordinate parts, lacking common tech standards. The infrastructure idea has to be tailored for the given data types and open interfaces. Data Organization is a figment of its own imagination in the organisation. Mobility data is an operational and management asset. Forms a basis for day-to-day traffic control and tactical planning. The integration of technology and organisation is relevant in the context of road haulage as well. Intelligent systems also orchestrate buses on the streets, as well as trams and subways. This model is only applicable if transport operators and road services planning are integrated (Algherbal & Ratrout, 2025).

Incident management is given special attention in the conceptualisation. Accidents, road works, and weather events have a significant impact on urban mobility. Intelligent systems quickly detect such events and adjust all routes (Table 1).

*Table 1: Conceptual characteristics of urban ITS use*

| <b>ITS component</b>                | <b>Level of implementation</b> | <b>Management function</b>      | <b>Institutional challenge</b> | <b>Expected effect on mobility</b>   | <b>Strategic horizon</b> |
|-------------------------------------|--------------------------------|---------------------------------|--------------------------------|--------------------------------------|--------------------------|
| Traffic management systems          | Urban                          | Flow coordination               | Interoperability               | Reduction of delays                  | Short-term               |
| Data exchange platforms             | Interagency                    | Analytical support              | Data standards                 | Improving the soundness of decisions | Medium term              |
| Integration with spatial planning   | Territorial                    | Coordination of development     | Institutional fragmentation    | Balanced accessibility               | Long-term                |
| Environmentally oriented algorithms | Political                      | Implementation of climate goals | Policy coordination            | Emissions reduction                  | Long-term                |
| Autonomous management modules       | Technological                  | Decision automation             | Responsibility management      | Improved security                    | Medium-term              |



|                                       |                |                           |                        |                       |            |
|---------------------------------------|----------------|---------------------------|------------------------|-----------------------|------------|
| Cyber defence contours                | Infrastructure | System protection         | Cyber risks            | Functional resilience | Continuous |
| Institutional coordination mechanisms | Management     | Synchronisation of actors | Distribution of powers | Management stability  | Long-term  |

*Source: (Algherbal & Ratrout, 2025; Makedon et al., 2019; Saigal, 2025)*

The technical concept also covers issues of system reliability and resilience. Urban mobility is a critical function of a city. Failure of the intelligent system could lead to transport collapse. Therefore, the design provides for backup control scenarios and redundancy of key components.

### **Technological Mechanisms of Influence of Intelligent Transport Systems on Urban Mobility Parameters**

Modern intelligent transportation systems use the multi-layered combination of Internet of Things (IoT) sensors, data collection, Artificial Intelligence (AI), and Big Data Analytics to form a closed-loop system that controls urban mobility (Bastia, 2024). In this loop, there is an ongoing process of observing and analysing traffic conditions, predicting future conditions, and regulating traffic flow (Tykha et al., 2025).

At the lowest level of the architecture are physical devices that collect traffic-related information, such as traffic speed, traffic density, road surface conditions, and the behaviour of drivers and vehicles in traffic. The flow of the initial data collected at time  $t$  is represented as a vector:

$$D_t = \{q_t, v_t, k_t, t, t\},$$

where:

$q_t$  – traffic flow intensity;

$v_t$  – average speed;  $k_t$  – traffic density;

$t$  – direction of traffic;

$t$  – stochastic disturbances related to behavioural and external factors.

This is a level that underpins the whole system with information (written or otherwise). The efficiency and frequency with which data are collected directly influence ITS's ability to accurately communicate the status of the transportation network and respond appropriately when changes develop. Aggregating, cleaning and synchronising are done by the intermediate layer of the architecture. Here, the streams of information in different modalities are converted



into an analytically processable form (Thopate et al., 2025). The data preprocessing operation is defined as an operator:

$$\tilde{D}_t = F(D_t, \Omega),,$$

where:

$\tilde{D}_t$  is a cleaned and normalized data set;

$F()$  – preprocessing operator;

$\Omega$  – set of filtering, calibration, and synchronization parameters.

The stability of follow-up management decisions depends on the rigour at this level. Aggregation errors or time delays result in the accumulation of global errors and a decrease in adaptive control performance.

The top layer of the structure consists of a set of analytical and managerial modules that employ artificial intelligence algorithms to support instantaneous decision-making. At this point, we move from descriptive analytics to predictive and prescriptive decision management. The problem boils down to minimising the sum of losses in urban mobility, formally denoted as an integral functional (Kumar & Verma, 2025):

$$J = \int_0^T (\alpha \cdot d(t) + \beta \cdot \sigma_q(t) + \gamma \cdot e(t)) dt,$$

where:

$d(t)$  – average traffic delay;

$\sigma_q(t)$  – dispersion of traffic flow intensity;

$e(t)$  – environmental losses;

$\alpha, \beta, \gamma$  – weighting coefficients reflecting the priorities of urban transport policy.

Adaptive traffic control is the central mechanism for implementing this functionality. Unlike fixed control schemes, adaptive systems change signaling parameters, lane priorities, and routing logic based on current and predicted data. The control signal is formed as a function of the system state:

$$u_t = \pi(\tilde{D}_t),,$$

where  $\pi$  is the control strategy implemented through optimisation algorithms, rules, or reinforcement learning methods.



Delay reduction is achieved by synchronising traffic light phases and balancing the load between alternative routes (Anthony Jnr, 2025). The unevenness of traffic flows is quantitatively described by the coefficient of variation:

$$CV_q = \frac{\sigma_q}{\bar{q}},$$

where:

$\sigma_q$  – standard deviation of intensity;

$\bar{q}$  – average flow intensity.

A decrease in the value of CVq indicates a more even distribution of traffic and a reduced risk of local congestion in the network.

Predictive modules play a decisive role in the transition from reactive to proactive mobility management. The general form of the traffic flow intensity forecast can be presented as:

$$\hat{q}_{t+h} = f(q_t, q_{t-1}, \dots, q_{t-n}, X_t),$$

where:

$\hat{q}_{t+h}$  – intensity forecast for time horizon  $h$ ;

$X_t$  – vector of exogenous variables, including weather and event factors;

$f()$  – trained prediction model.

The accuracy of forecasts determines the effectiveness of advance redistribution of flows and prevention of congestion before it actually occurs. Machine learning algorithms are also used to optimise public transport routes and manage demand (Nwaigbo et al., 2025). The usefulness of a route for a user can be formalised as:

$$Ui = -\delta_1 Ti - \delta_2 Ci - \delta_3 Ri,$$

where:

Ti – travel time;

Ci – monetary costs;

Ri – route reliability index;

i – user sensitivity coefficients.

Optimisation of urban mobility consists of maximising total utility under conditions of limited transport network capacity (Figure 4).



At the vehicle level, ITS technological mechanisms are implemented through control support systems and autonomous modules. The design task is to ensure course and dynamic stability, which directly affects the safety and capacity of the network.

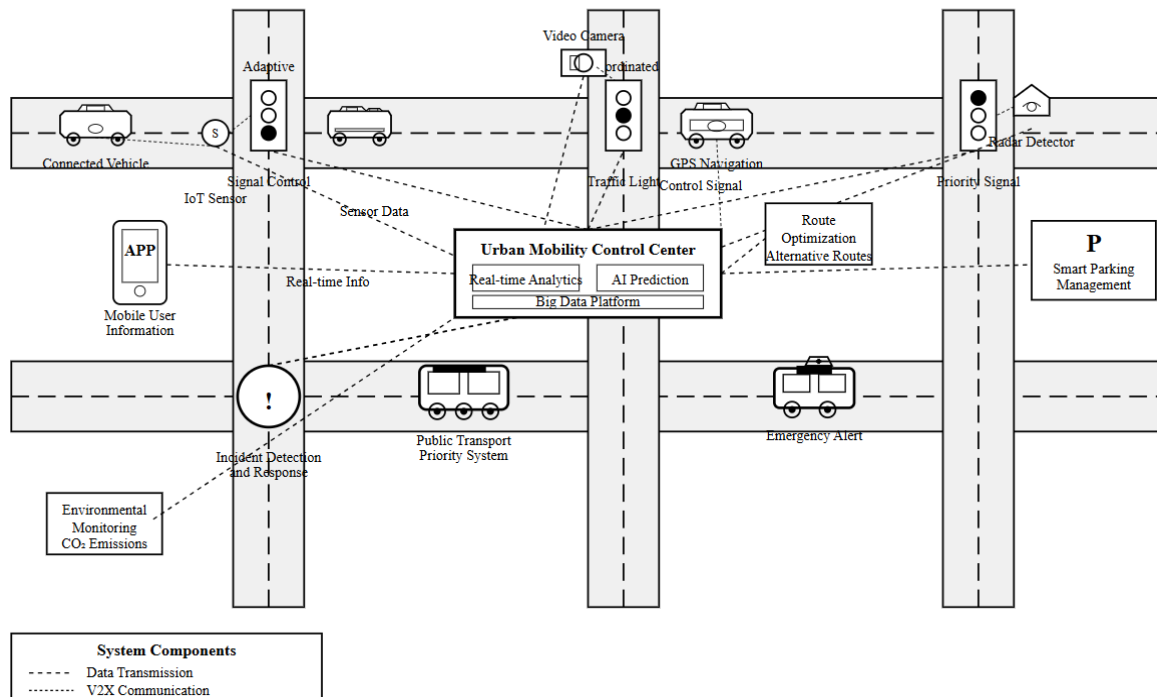


*Figure 4: Multi-level architecture of ITS in urban traffic flow management*

*Source: Built in the Adobe Firefly software environment*

Course dynamics can be described by the equation:

$$I_z r = M_z,$$

where:

$I_z$  – moment of inertia relative to the vertical axis;

$r$  – angular velocity;

$M_z$  – total control moment.

The deviation from the desired trajectory is estimated as a course error indicator:

$$e_r = r - r_{ref} ,$$



where  $r_{ref}$ — reference value of angular velocity.

Minimising  $r_{ref}$  in combination with lateral acceleration control reduces the likelihood of accidents and has a systemic effect on the entire transport network. To summarise the technological mechanisms by which ITS influence urban mobility parameters, it is advisable to systematise them in Table 2 (Sikdar, 2025).

*Table 2: ITS technological mechanisms and their impact on urban mobility parameters*

| <b>Level of implementation</b> | <b>Leading technology</b> | <b>Main controlled parameter</b> | <b>Analytical tool</b>  | <b>Effect on mobility</b>           |
|--------------------------------|---------------------------|----------------------------------|-------------------------|-------------------------------------|
| Touch                          | IoT devices               | Traffic intensity                | Signal filtering        | Reducing uncertainty                |
| Analytical                     | Big Data platforms        | Flow density                     | Statistical aggregation | Improving the accuracy of estimates |
| Management                     | Adaptive algorithms       | Traffic delay                    | Optimization models     | Reducing travel time                |
| Predictive                     | Machine learning          | Future congestion                | Neural networks         | Congestion prevention               |
| Routing                        | Path selection algorithms | Demand distribution              | Utility functions       | Flow balancing                      |
| Transportation                 | Control support systems   | Course stability                 | Dynamic equations       | Improved safety                     |
| Autonomous                     | Intelligent controllers   | Trajectory                       | MPC control             | Network stability                   |
| Integration                    | Interaction platforms     | Level synchronization            | System analysis         | Sustainable mobility                |

*Source: Developed by the authors*

Interactions among ITS architecture levels create a multiplier effect for urban mobility. Improved vehicle-level controllability increases the predictability of traffic flows and simplifies the operation of adaptive control systems. At the same time, accurate forecasts and



correct control signals reduce the load on autonomous modules and the need for sharp trajectory corrections. This ensures the systemic stability of urban transport.

### **Empirical Effects of ITS Implementation for Urban Mobility and Directions for Further Development**

The basic parameter of urban mobility is travel time. To correctly measure the effect of ITS, it is necessary to consider not individual routes, but the entire sample of trips in the transport network. Let  $T_i$  be the travel time of the  $i$ -th user; then the average travel time is defined as:

$$\bar{T} = \frac{1}{N} \sum_{i=1}^N T_i,$$

where  $N$  is the number of trips during the observation period.

The introduction of ITS changes not only the value of  $T$ , but also the distribution of  $T_i$ . To capture this effect, it is advisable to use the standard deviation:

$$\sigma_T = \sqrt{\frac{1}{N} \sum_{i=1}^N (T_i - \bar{T})^2},$$

A decrease in  $T$  after the implementation of adaptive control indicates increased predictability of mobility, which has independent practical significance. The level of delays is determined as the difference between the actual and the conditionally free travel time (Avcı & Koca, 2024). For a route of length  $L_j$ , the delay will be as follows:

$$D_j = T_j - \frac{L_j}{v_f},$$

where  $v_f$  is the free-flow speed. The average delay across the network is:

$$\bar{D} = \frac{1}{M} \sum_{j=1}^M D_j,$$

where  $M$  is the number of routes analysed.

The empirical effect of ITS is to reduce  $D$  by synchronising traffic lights, balancing flows, and redirecting traffic. A valuable indicator is the stability of delays, which is described by the variance:



$$Var(D) = \frac{1}{M} \sum_{j=1}^M (D_j - \bar{D})^2$$

A decrease in VarD reduces the risk of extreme congestion, even with constant demand. Road safety is an indirect but critical effect of ITS implementation (Puzio et al., 2025). The accident rate is used for quantitative assessment:

$$R = \frac{A}{Q \cdot L},$$

where:

A – number of road accidents during the period;

Q – average daily traffic intensity;

L – network length.

ITS affects  $R$  by reducing fluctuations in speed and acceleration. The dynamic traffic mode is characterised by the root mean square acceleration:

$$a_{rms} = \sqrt{\frac{1}{T} \int_0^T a(t)^2 dt}.$$

Empirical data show a correlation between arms and accident rates. A decrease in arms after the introduction of ITS means an increase in dynamic safety. The environmental effects of ITS are related to changes in the time structure of traffic. The emissions of a single vehicle over a period  $T$  are described by the integral dependence:

$$E = \int_0^T \phi(v(t), a(t)) dt,$$

where  $\phi()$  is the specific emission function.

At the network level, total emissions are:

$$E_{tot} = \sum_{k=1}^K E_k,$$

where  $K$  is the number of vehicles.



ITS reduces  $E_{tot}$  by eliminating stop-start modes and reducing downtime, even without reducing the total mileage of motor vehicles.

The quality of urban mobility is not limited to physical traffic parameters. It is shaped by a combination of time, reliability, safety, and information support (Nikolova, 2025). For an integrated assessment, a mobility quality index is proposed:

$$Qm = w_1 \left( \frac{\bar{T}}{T_o} \right)^{-1} + w_2 \left( \frac{Var(D)}{Var_0} \right)^{-1} + w_3 R^{-1} + w_4 I,$$

where:

$T_o$ ,  $Var_0$  – baseline values prior to ITS implementation;

$I$  – information accessibility index;

$w_i$  – weighting coefficients.

The information accessibility index is defined as:

$$I = p \cdot (1 - \varepsilon),$$

where:

$p$  – proportion of users receiving up-to-date information;

$\varepsilon$  – average relative error of arrival time prediction.

When  $\varepsilon$  decreases, trust in transport services increases, which affects users' behaviour to drive more along rational routes. Future prospects for ITS as an integrated approach. The next generation of intelligent transport systems should be viewed in terms of multi-criteria optimisation (Konečný, 2025). The overall losses of urban arterials are represented by the following function:

$$J = \int_0^T [\alpha \bar{T}(t) + \beta Var(D(t)) + \gamma E_{tot}(t) + \delta R(t)] dt,$$

where the coefficients  $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $\delta$  reflect urban policy priorities.

The primary objective of ITS is to reduce  $J$  subject to capacity, budget, and demand constraints. This allows for an elastic adjustment of the system, depending on strategic purposes regarding urban development. Based on this approach, we will develop suggestions for next steps in the development of ITS, focusing on key issues related to urban transport infrastructure (Table 3).

ISSN: 2408-7920

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*Table 3: Proposals for ITS development to improve the efficiency of urban mobility*

| City type                            | Key problem                  | ITS tool                            | Organisational solution                             | Technical solution                                          | Expected effect           |
|--------------------------------------|------------------------------|-------------------------------------|-----------------------------------------------------|-------------------------------------------------------------|---------------------------|
| Megapolis                            | Chronic traffic jams         | Adaptive traffic corridors          | Centralised management of main corridors            | Real-time traffic light coordination                        | Reduction of delays       |
| Agglomeration                        | Peak congestion              | Transport demand forecasting        | Inter-municipal mobility coordination               | Analytical platforms for load forecasting                   | Traffic stabilization     |
| Compact city                         | Traffic unevenness           | Intersection coordination           | Single control centre                               | Synchronised traffic light control                          | Predictability of trips   |
| City with developed public transport | Low transport reliability    | Priority for public transport       | Coordination between OT operators and road services | Intelligent prioritisation at intersections                 | Increased user confidence |
| Industrial city                      | High environmental impact    | Environmentally oriented algorithms | Integration of transport and environmental policies | Optimisation of traffic modes taking emissions into account | CO <sub>2</sub> reduction |
| Tourist city                         | Congestion in central areas  | Dynamic navigation                  | Seasonal mobility management                        | Information services for redirecting flows                  | Flow balancing            |
| Small city                           | Limited management resources | Centralized management              | Consolidation of transport functions                | Single traffic management platform                          | Cost optimization         |
| Polycentric city                     | Network fragmentation        | ITS integration platforms           | Interagency coordination of decisions               | Integration of data and services from different areas       | Improved safety           |



## **Discussion**

The results of this study are consistent with those obtained by Gheorghe and Soica (2025) and Imran (2025). The authors demonstrate that for urban traffic management, IoT infrastructure coupled with big data analytics and AI algorithms can be beneficial. The smaller time loss and lower variability in traffic flow observed in the study corroborate the pattern noted by Puzio et al. (2025). The authors note the damping influence of urban adaptive control systems on traffic flows. The quantitative fundamental conclusions of the ITS modelled in this article are consistent with international data today.

This study demonstrates the work of Alotaibi et al. (2025) and Kumar and Verma (2025). In this scenario, the authors also assess smart mobile intermediary solutions using federated performance metrics. The discussion in the paper will provide evidence that it is not digitalisation as such, but the design of a multi-level ITS architecture that makes sense. The system's functioning depends on how well it integrates the three levels: perception, analysis, and management. That might help explain why the same technologies can produce such varied returns in cities with similar attributes. This issue has not been addressed before now.

This brings up a discussion when compared with the findings of Avcı and Koca (2024) and Bellam et al. (2025). The latter noted safety constraints and integration complexity as the primary barriers to TS effectiveness. These arguments are not refuted by the results of this paper. Despite all those limits, the research demonstrates that well-engineered feedback loops and predictive modules neutralise these negative effects. What I'm trying to convey here is that when we discuss technical risks, they should be evaluated with respect to architectural answers, not in isolation.

Nikolova (2025) and Sami and Sara (2023) analysed the effects of ITS from a more abstract, theoretical perspective. The paper is used to analyse traffic time, network, and environmental parameters.

The contribution of the research to capability in ITS derives from the explanation for multi-level ITS architecture. This is an institutional issue with lead-time performance. The practical value lies in the application of the method as a basis for the rationalisation of urban transport control. The method is feasible for identifying investment priorities and for scaling up intelligent traffic management systems.

## **CONCLUSION**

It is stressed that, with the spatial concentration of transport demand, managing urban mobility becomes increasingly difficult. The hollowness of the approaches to urban regulation offered



by traditional traffic regulation models is demonstrated. A system mismatch is observed between the actual load on transport and the tools used to regulate it.

ITS is seen as the infrastructure which will form the transition to dynamic and data-driven mobility management models. It is known that the effectiveness of urban transport systems depends not only on the amount of capital investment. The potential of ITS for real-time data processing, analysis, and application is inexhaustible, creating new demands for the organisation of motor transport.

Technological effects of ITS on the main parameters of urban mobility are disclosed. An architecture for multi-level ITS is also proposed, and the specific functions of the sensory, analytical, and management levels are defined. The dependence between the quality of primary information and the reliability of management decisions is proved. The importance of artificial intelligence algorithms in reducing traffic delays and smoothing traffic flow is demonstrated. Dependence between the effectiveness of network management and the dynamics of streams is found.

Several studies have shown that the application of ITS in urban areas may yield positive effects, including reduced travel time losses, improved traffic predictability, and enhanced safety and environmental protection. It also happens that the efficiency of measures varies with the city's typology and the structural characteristics of the transport network. Strategic orientations for the future development of ITS as an integrated urban policy instrument are suggested. The original contribution of this work is the evolution of present processes. The article develops an extrapolated strategy for a fully integrated ITS technology combined with a holistic model of urban mobility scenarios.

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