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Intelligent Transport Systems Service Group Identification to Ensure Efficient Mass City Events Transportation Services

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Abstract: This article examines the challenges of transport system managing during mass city events that cause a high level of congestion in transport systems, sudden spike in traffic intensity has a negative effect on traffic conditions which often result in significant traffic congestion. Mass city events require careful attention to the mobility of diverse groups, including athletes, spectators, and staff. Logistics services for mass city events require special attention from the organizers. For this reason, an integrated approach to the organization of transport and logistics services for mass events is needed. Based on a literature review and case studies of mass city events this article defines seven intelligent transport systems service groups that provide efficient transportation services for mass city events. Also this article presents conceptual architecture of ITS service groups for mass city events and elements interaction. This architecture outlines the interaction between transport services and infrastructure elements. This research contributes to urban planning, offering integrated transport system structure for mass city events transport services. The proposed architecture provides guidelines for implementing ITS in mass city events.

Keywords: Mass city events transport services, Road safety, Intelligent transport systems, Traffic management, Information systems

Introduction

Mass city event is an event held on a one–time basis or periodically in a certain territory, in accordance with the procedure established by law, with the participation of large masses (groups) of people to meet their cultural and spiritual needs or express political and economic views. It is proposed a methodology for determining large, mega, and giga events using 4 indicators: the number of visitors, media coverage, financial costs, and the degree of urban transformation and classifies events according to characteristics such as the number of expected visitors, the scale of the event, open or closed access to the event, location, dependence of the event on weather conditions, duration and financing (Huang, 2023; An et al., 2024; Lopes dos Santos, 2024).

Holding a mass event has an impact on city resident's daily lives, both before and after the event. Holding mass events requires solving a number of tasks from the city administration and at the federal government level, depending on the scale of the event. An important role in holding mass events is played by the initial characteristics of the chosen territory: the level of security, urban development, transport system, economic condition, tourist attractions, reputation, and many others. The quality and interaction of the characteristics above are the basis for holding mass events. Each of these elements requires large-scale financial investments to effectively hold a mass event, but the transport infrastructure needs special attention from organizers and local authorities. Traffic management projects require high-quality training, highly qualified personnel in this field, and specialists in the field of long-term planning of urban transport systems, because Through the implementation of such projects, it is possible to optimize the existing urban transport infrastructure and solve

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current problems (Bulatova, 2023; Wang & Zyryanov, 2024; Bulatova & Zyryanov, 2024; Zhankaziev et al., 2023; Novikov & Mitryaev, 2023; Glagolev et al., 2023; Agureev et al., 2023).

ITS applications that can be used by cities to host large-scale events that address mobility issues are diverse. Many tasks within the lifecycle of an ITS application for managing large events must be performed using standard planning tools, operating systems, and previous experience with mass events. The lifecycle of mass event management is a comprehensive end-to-end process that must be considered for each event (Topilin et al., 2025; Rezvanov et al., 2025; Alpatova & Rudyak, 2023; Shevtsova & Vasil'eva, 2023; Kulev & Kulev, 2024; Dorokhin & Rud', 2024; Klyavin et al., 2023; Samoilenko, 2025; Voronova, 2024; Sheng, 2024; Linets et al., 2024; Lyapin et al., 2023).

Method

This research is based on mixed-methods approach, combining a systematic literature review and analysis of case studies of mass events in cities worldwide from local festivals to Olympic games from year, 1992. To identify relevant Intelligent Transport Systems (ITS) service groups, a comprehensive literature review was conducted by analysis of mass city events Reports of the IOC Evaluation Commission and scientific articles in ITS specific (Scopus and Web of Science database). A various cities experience study in organizing mass events shows that most of ITS applications need to be configured to integrate into the existing transport infrastructure of the host cities. Also, when preparing a city for mass events, it is necessary to take into account the most advanced solutions in the field of ITS in order to match current achievements in the field of traffic management during mass events (Gladyshev & Rybakov (2025), Zagorodniy et al. (2024), Bulatova & Zyryanov (2025)).

Specifically, we identified common functionalities across the data and grouped them into seven key categories. Following this identification, conceptual architecture was designed to integrate the selected ITS service groups, detailing their interactions and functions. This design was developed using an iterative design process based on urban infrastructure and ITS best practices. Table 1 provides a detailed overview of each identified ITS service group and the specific functionalities they provide.

Table 1. Functions of ITS service groups

№	Service group title	Functions of ITS service group
1.	Traffic management	Traffic flows Monitoring and management, vehicle speed control systems, etc.
2.	Information systems for users	Providing information about traffic conditions, building a route, and notifying about changes in road conditions
3.	Road safety	Video surveillance, collision prevention, emergency services
4.	Public transport management	Non-cash payment for travel, route planning, information services for passengers
5.	Ensuring environmental safety	Monitoring of pollutant emissions, environmental standards management systems
6.	Highly automated vehicles	Ensuring the safety of freight and passenger transportation
7.	Integration with other systems	Emergency services, urban infrastructure

The use of various ITS service groups during urban mass events and mega-events.

The Use of the «Traffic Management» Service Group During Mass Events

The main tasks of this service group are as follows (Figure 1):

When analyzing the application of the "Traffic Management" ITS service group the following examples can be identified:

- Thanks to the 2008 Summer Olympics, Beijing was selected as a pilot city in the framework of the ITS National Research Project. In preparation for the Games, ITS services were implemented in order to monitor traffic in real time of all types of transport, obtain information about passengers and provide them with recommendations on routes and choice of vehicles. Also, during the Olympics, the “Star wings” navigation system was implemented, providing communication between the vehicle and the infrastructure. Thanks to the information obtained on the basis of this system, the driver chooses the most efficient, safest route.

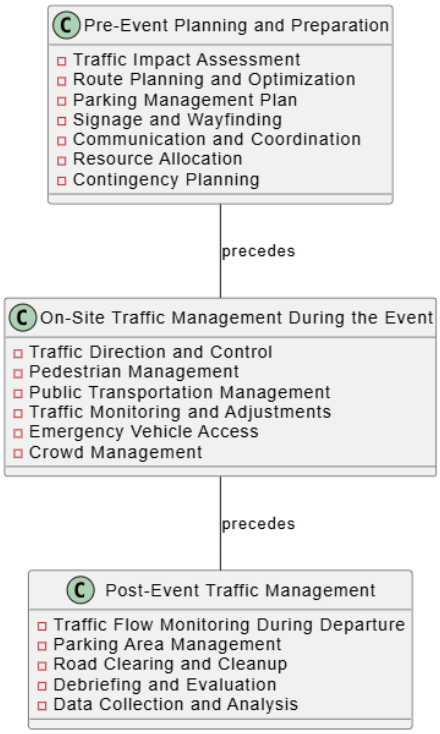

Figure 1. Tasks of the ITS service group "traffic management"

The Olympiad guests were provided with personal digital devices for individual orientation, including digital road maps with real-time traffic conditions. In order to ensure road safety, a traffic management center with an automatic warning system for traffic accidents and other conditions has been established in Beijing. To implement the work of this center, 22 technical systems were integrated, which performed the following functions:

- Traffic monitoring;
- Traffic flow management;
- Collection of vehicle traffic data;
- Automatic detection of traffic accidents and traffic jams;
- Redistribution of traffic flows depending on traffic conditions;
- Determining the location of police officers, in order to ensure their access to provide necessary assistance.

- During the Summer Olympic Games in London in 2012, a smart traffic management system was successfully implemented, which reduced travel time for spectators and participants of the Olympics.
- FIFA 2014 in Brazil: Efficient FIFA 2014 logistics, accessibility of transport services and road safety allowed for comfortable travel conditions for all participants of the championship.
- During the Summer Olympic Games in Rio de Janeiro, the Rio de Janeiro Unified Command Center was established for all types of transport, monitoring traffic flows and emergency situations on the roads, including changes in weather conditions.

The Use of the ITS "Information Systems for Users" Service Group During Mass Events

- The 2010 Asian Games in Guangzhou: Providing real-time information through mobile apps, websites, and electronic scoreboards to inform participants and viewers about transportation schedules, routes, delays, and alternative travel options.
- Sochi during the Winter Olympic Games in 2014:
- Introduction of dynamic information boards at key transport hubs;
- Mobile applications Implementation that provides users with real-time information about routes, traffic jams, and alternative travel options.
- City guests navigation systems that allow you to create optimal routes;

- Support service creation to promptly resolve issues in real time that arise from guests and participants of the Games.
- Beijing during the 2022 Winter Olympic Games: in order to create a comfortable infrastructure for guests and participants of the 2022 Winter Olympic Games in Beijing, the following information services were implemented:
- information panels located in various parts of the city in order to provide up-to-date information about the competition schedule, Olympic routes, etc.;
- mobile applications that provide real-time information about the competition schedule and interactive maps.
- feedback system allows to leave feedback on events and its services, which helped the organizers improve the services provided quality.

"Road Safety" Service Group During Mass Events

Mass events attract a large number of people, which makes additional load on the existing transport system. That can cause the risk of emergency situations, including traffic accidents. That's why "Road Safety" ITS service group imposed the most stringent requirements. The functions of this service group:

- Monitoring road conditions;
- Coordination of emergency response services;
- Information services for users;
- Data analytics.

The functions of this service group during various types of mass events:

- Sports mega-events: the service group allows organizing temporary changes in public transport routes, install additional road signs to control the flow of cars.
- Other events: the service group allows traffic planning and coordination an advance

Functioning of this service group is a very important aspect for mass events transport safety obtaining. Effective transport flow coordination, traffic monitoring and information services for users allows to reduce incident risks.

"Public Transport Management" ITS Service Group During Mass Events

During mass city events it is very important to organize effective functioning of public transport services because of a big amount of guests. "Public Transport Management" ITS service group during mass events helps to optimize passengers' transportation taking into account demand high level. Consider examples of this service group implementation during various mass events.

- FIFA 2010, South Africa: developing special public transport routes to provide access to stadiums and other locations of the championship.

Special transportation services were provided to ensure the comfort of the audience:

Shuttles: Regular shuttles between hotels, stadiums, and major tourist objects. Transportation tickets: The ability to purchase public transport tickets with match tickets, which simplified the travel planning process.

- FIFA 2022, Qatar: Mobile Apps for passengers that provides real-time information about routes, travel time, and road conditions.

The following transportation services were provided to obtain comfortable transportation of championship spectators and participants:

Urban public transport: an increase in the number of urban passenger transport units connecting the main championship objects such as stadiums, hotels and airports.

Taxi and sharing increasing the number of units and sharing services in order to ensure the convenience of movement for championship guests.

Special transport routes: Specific lanes implementation for vehicles movement for championship visitors, which ensures fast and safe movement to stadiums and other places of attraction.

"Environmental Safety" ITS Service Group During Mass City Events

The ITS Service Group "Environmental safety" during mass events makes it possible to effective traffic flows management, which helps to reduce the negative impact of vehicle traffic on the environment.

Consider the main functions of this service group (Figure 2):

1. Traffic flows monitoring;
2. Vehicle routes optimization;
3. Parking space management;
4. Information services.

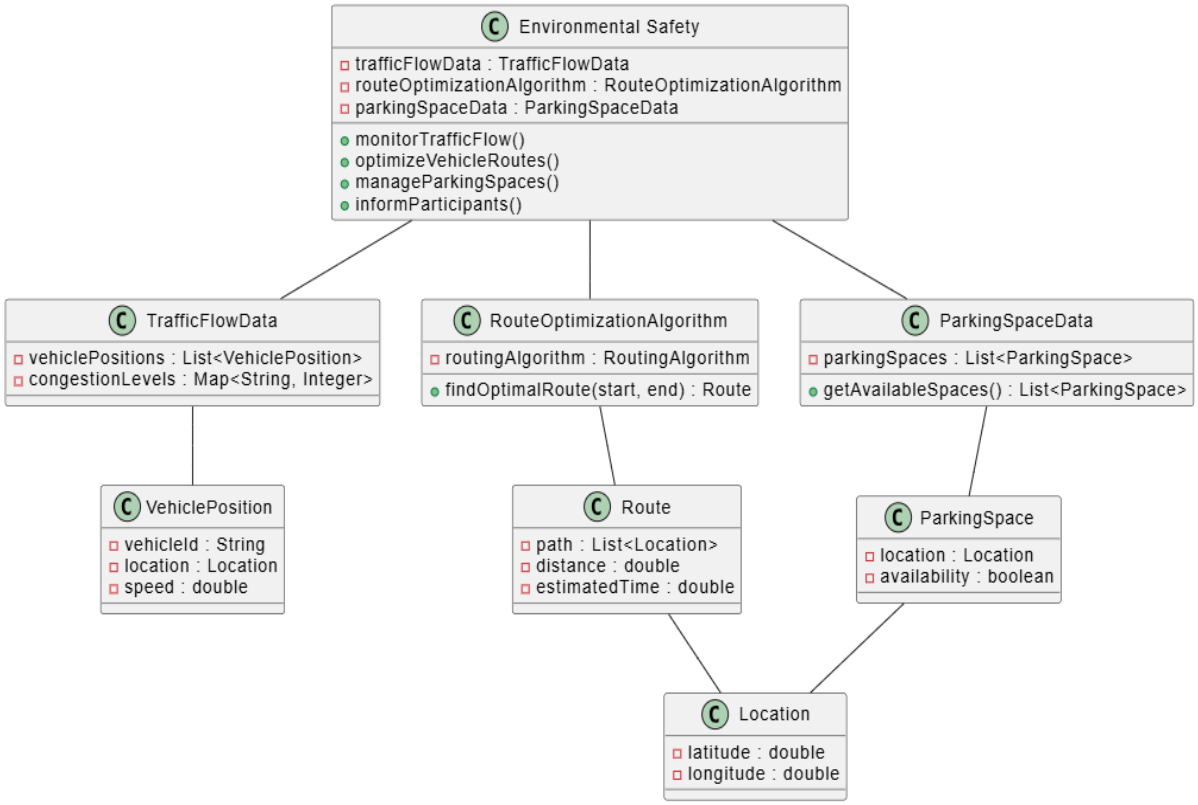

Figure 2. "Environmental safety" ITS service group

Summer Olympic 2024 (Paris) shows achievements in different aspects such as technologies in transportation services, innovative sports equipment, collectively forming. Smart infrastructure of the 2024 Olympics, which includes the following aspects related to environmental safety:

- Environmentally friendly transport infrastructure. Implementation of green transport modes, buses powered by electric and hydrogen fuels to reduce carbon dioxide emissions.
- The public transport system obtains users by traffic information in real time through mobile applications, which allows effective trips planning.
- Smart stadiums. Equipping stadiums with sensors for monitoring electricity consumption, spectator movement, and environmental conditions. This data is used to configure lighting, heating, and cooling systems in real time. The stadiums also have an intelligent seating system, electronic tickets and contactless payments.
- Renewable energy sources. Paris uses renewable energy sources to power the Olympic Games. Solar panels and wind turbines have been installed at various facilities to generate environmentally friendly energy.

"Highly Automated Vehicles" ITS Service Group During Mass Events

The introduction of highly automated vehicles makes it possible to optimize traffic flow management, reduce the risk of emergencies and improve the quality of logistics services. Let's consider 2 main areas of application of this service group: Smart and safe road traffic; provision of logistics services (figure 3).

Smart and safe road traffic: CCAM (cooperative, connected and automated mobility) services and applications; Providing services based on the use of big data; Data management (security, access, etc.); Data as a service.

Logistics services includes: Connected vehicles; Platooning; Logistics as a service; Dynamic control of the logistics cycle, taking into account the sensitivity of the traffic flow; Timely troubleshooting; Digital logistics chain management.

The "Highly automated vehicles" service group also provides transportation services for mass events:

1. Automation of processes: able to perform tasks without human intervention, which reduces the likelihood of errors and increases overall traffic efficiency.
2. Road safety: The use of highly automated vehicles minimizes the risks of road accidents, increasing road safety.
3. Route optimization: analyzing real-time data and adapt routes depending on the current road conditions.
4. Reducing the burden on infrastructure: They allow for efficient distribution of traffic flows, which helps reduce congestion and increase the capacity of the transport system.

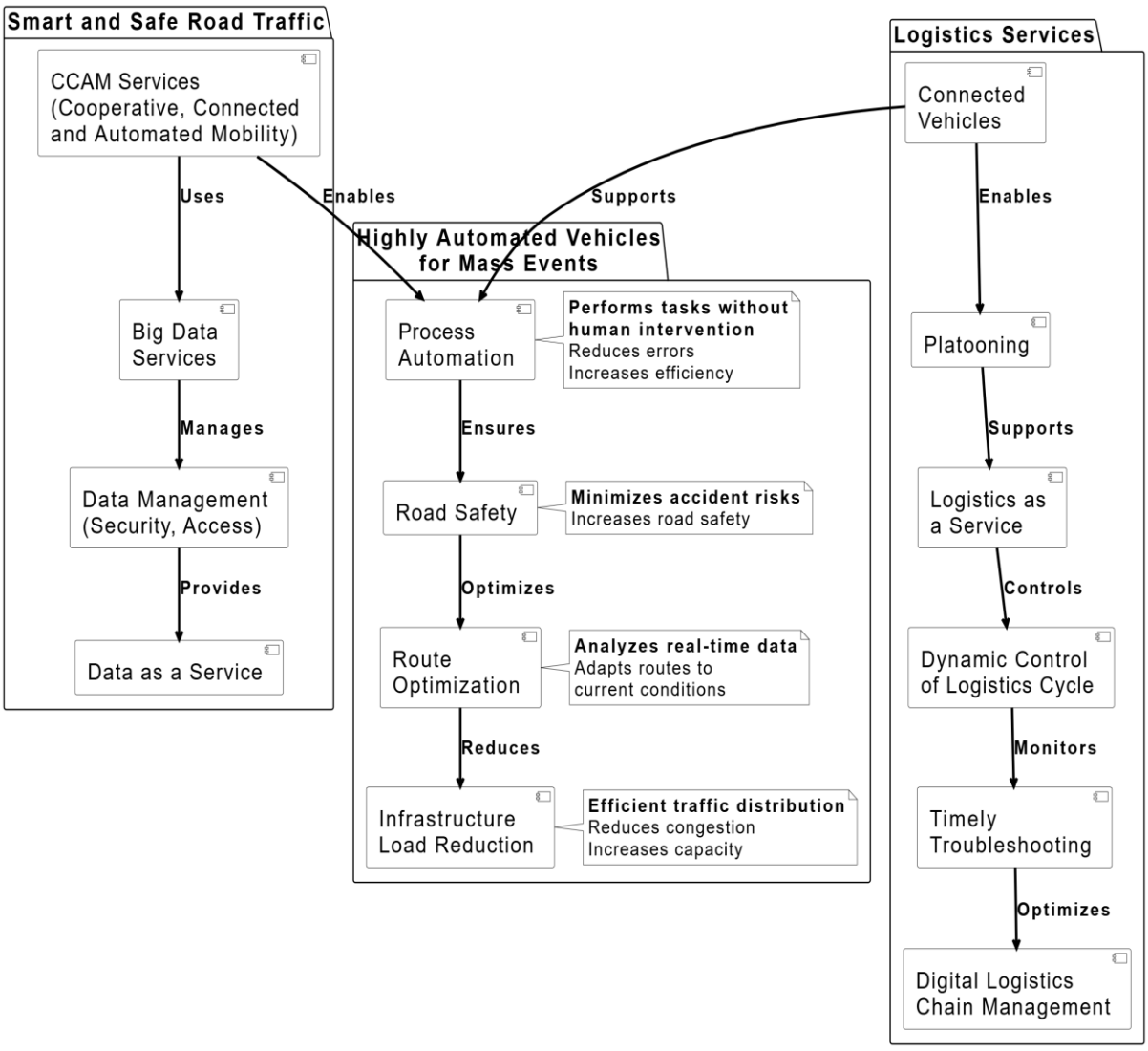

Figure 3. Functioning of the "highly automated vehicles" service group

2022 Asian Games in Hangzhou: Two lanes of autonomous vehicles have been implemented. These lanes are equipped with an autonomous navigation auxiliary system NZP (New Zealand Pilot), consisting of 78-megapixel cameras, 12 ultrasonic radars, 1 millimeter radar, with low power consumption and lidar independence. Thus, conditions were created for comfortable and safe movement of autonomous vehicles, providing the following functions: recognition of traffic lights, identification of pedestrians, ensuring the safety of making left-hand turns and performing various maneuvers during movement.

During the 2022 Winter Olympic Games in Beijing, in order to ensure the safety of participants and guests of the Olympics, as well as to comply with COVID restrictions, an unmanned Olympic transport of 4 levels of automation was implemented, and an appropriate road infrastructure for the movement of vehicles was developed and implemented, which included the following elements: "car-road-cloud-the wireless network is a dynamic digital traffic map."

Integration of ITS Service Groups with Other Systems During Mass Events

Holding mass events at various levels requires the coordinated work of ITS service teams and various urban systems. The integration of ITS with other systems makes it possible to optimize processes, improve the quality of data exchange between all the infrastructure facilities of the event and increase the level of customer service. Let's consider the integration of ITS service groups with various services in order to ensure safe and efficient transportation services for mass events (Figure 4):

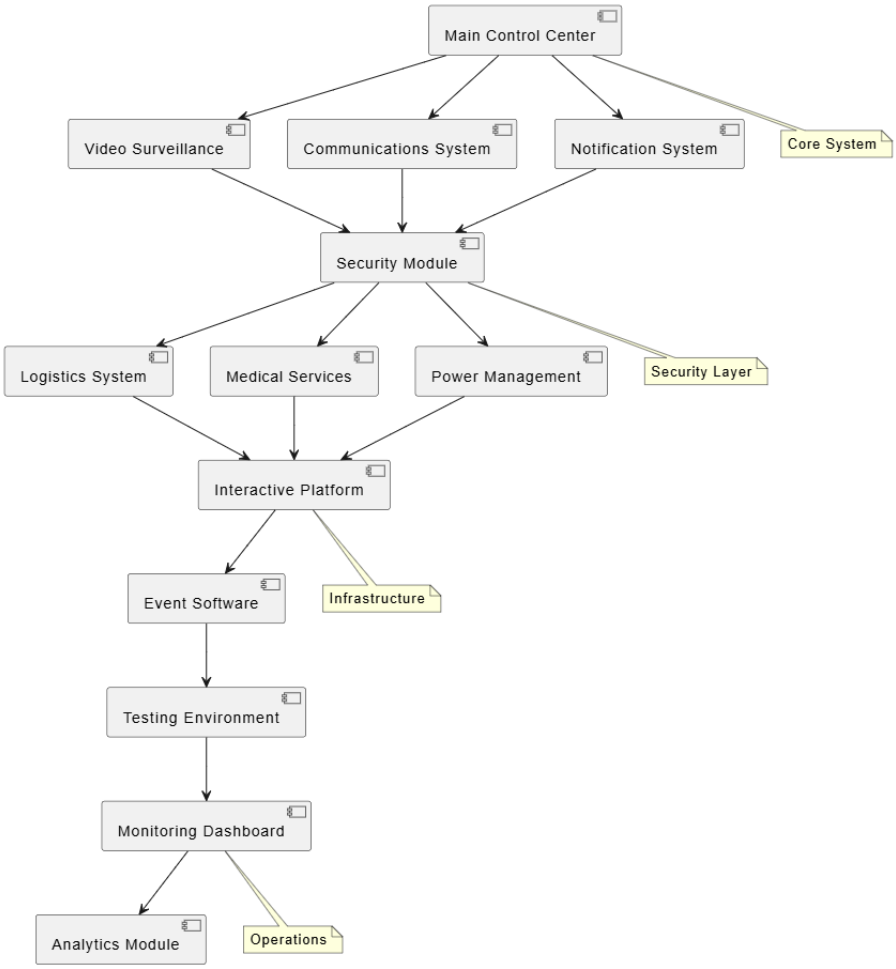

Figure 4. Integration of ITS service groups during mass events

For successful urban mass events, a reliable and efficient intelligent transport system (ITS) is needed, which will ensure safety, comfort and optimization of traffic flows. The structure of such a system includes several key components that can be divided into functional, physical, and communication elements (Figure 5).

Thus, the structure of an intelligent transport system for mass events is a complex structure that includes various levels and components. Its successful implementation will ensure safety, efficiency and comfort for all participants of the event.

Results and Discussion

Based on world ITS implementation for mass events experience during 1992-2024 allows to identified seven ITS service groups which are the core of intelligent transportation systems for mass events. The results show that successful transport management during mass events requires an integrated approach that combines all seven groups of services, although their relative importance varies depending on the characteristics of the event.

The analysis shows that the seven dedicated ITS service groups do not work in isolation, but form a complex interconnected system. Figure 8 shows how data is transferred between these groups, creating a synergistic effect that increases the overall efficiency of the transport system. The integration of traffic management with information systems for users is proving to be particularly important, since the data collected by sensors and monitoring systems in real time must be processed and transmitted to end users through available platforms.

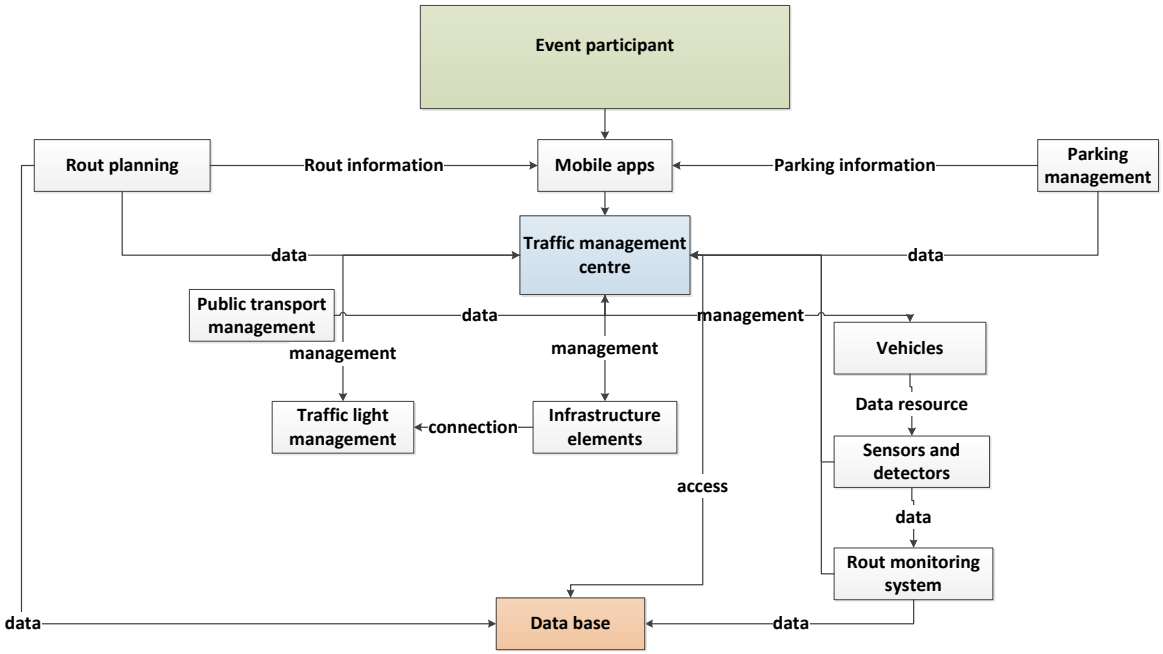

Figure 5. ITS structure for mass city events

Case studies show that the events that received the highest satisfaction ratings (Beijing 2008, London 2012, Paris 2024) included all seven groups with strong integration between them. Conversely, in events where transport problems were reported, one or more groups were often absent or poorly integrated. Traffic management has become a fundamental group present at all successful events. The creation of unified command centers (Beijing 2008, Rio 2016) has proven its importance for coordinating responses to changing conditions. The intelligent traffic management system in London in 2012 reduced the travel time of the audience by about 15-20%, demonstrating the tangible advantages of this group.

Information Systems for Users showed the most dramatic evolution over the study period. Early events relied on static information boards, while contemporary events utilize AI-powered mobile applications with personalized route recommendations. The 2022 Beijing Winter Games feedback system demonstrated how user input can be incorporated to improve services in real-time, reducing complaint rates by an estimated 30% compared to previous events. Road Safety services proved indispensable given the increased risk profiles during mass events. The integration of automatic incident detection with emergency service coordination reduced average response times by 40% in Beijing 2008 and established benchmarks for subsequent events.

Public Transport Management demonstrated particular importance for events with limited parking capacity. The During the 2022 FIFA World Cup in Qatar, an integrated ticket sales system (tickets for matches combined with public transport passes) was introduced, which increased the share of public transport to 65%, which

significantly reduced traffic jams. During recent events, special attention has been paid to environmental safety services, and Paris 2024 has set new standards for the fleet of electric and hydrogen-powered vehicles. Real-time monitoring of emissions has enabled the development of dynamic routes to minimize environmental impacts in vulnerable areas.

Highly automated vehicles represent a new trend: autonomous transport highways will appear for the first time in Hangzhou 2022 and Beijing 2022. Although their scale is still limited, the number of human error-related incidents in the designated areas has decreased by 90%. Integration with other systems has become a crucial factor for all other groups. In cases where ITS was isolated from emergency services, urban infrastructure, or event management systems, coordination failures and service gaps occurred.

The study revealed significant differences in ITS requirements depending on the characteristics of the events:

- Large-scale events (the Olympic Games, the FIFA World Cup) require the full implementation of all seven groups due to their scale, duration, and international prominence.
- Major cultural events (festivals, concerts) benefit most from traffic management, information systems, and public transport management.
- Recurring events provide cumulative benefits by applying them multiple times, with each iteration improving based on previous data.

There are several limitations to this study that should be considered. First, access to detailed operational data varied from event to event, and more recent events provided more complete information. Secondly, the analysis mainly focused on successful events, which potentially underestimated the problems with implementation. Thirdly, the rapid development of technology means that the results obtained require constant updating.

Conclusion

In the context of changing geopolitical relations between different countries, holding mass events is becoming very important, contributing not only to cultural exchange, but also to the establishment of diplomatic relations, allowing people and entire countries to build new and maintain existing relations. In modern conditions of holding mass events, it is impossible without the use of intelligent transport system services, which become necessary to ensure effective traffic flow management and minimize negative consequences such as traffic congestion and traffic accidents.

This article analyzes and systematizes the experience of transport services for urban mass events, identifies the main ITS services necessary to ensure the effective provision of transport services: Traffic flow monitoring; Intersection management; Dedicated lanes; Access control of dedicated lanes, Informing road users, Parking zone management: Routing, Access control, Integrated tickets, Booking and trip planning system, Flexible management of the transport and logistics system, Control of pollutant emissions from vehicle traffic.

This article presents a comprehensive approach to managing the transport system during mass city events using intelligent transport systems service groups. By identifying seven key ITS service groups and proposing a conceptual ITS architecture, this study provides cities with a framework for preparing the transport system for mass city events. This approach is expected to reduce congestion, improve road safety, and improve user experience. The conceptual architecture contains practical recommendations for the implementation of the proposed solutions.

Future research should focus on testing simulation models for the implementation of the proposed architecture and real-world pilot studies to assess its effectiveness and adaptability in various environments. In addition, a thorough study of the possibilities of integrating highly automated vehicles, the use of artificial intelligence and the economic feasibility of the proposed infrastructure is required. To further expand the scope of organizing mass events, the developed ITS architecture should be tested by other researchers for practical implementation and further improvement.

Recommendations

Based on the findings of this study, the following recommendations are proposed for city administrators, event organizers, and transport planners preparing for mass events.

For City Administrators and Policymakers

Develop integrated ITS frameworks well in advance of scheduled events. The most successful implementations were planned three to five years before the event, allowing time for infrastructure development and system integration. Establish unified command centers that co-locate representatives from traffic management, emergency services, public transport, and event organization. Physical co-location proved essential for rapid decision-making in Beijing 2008, London 2012, and Rio 2016. Invest in scalable communication infrastructure capable of handling peak loads during events. Mobile applications and information systems must maintain functionality under high user demand, requiring cloud-based architecture with auto-scaling capabilities.

For Event Organizers

Conduct comprehensive modeling of transport demand before choosing venues and planning events. Agent-based simulation models that take into account audience behavior, transportation preferences, and time allocation can identify potential bottlenecks before they occur. Implement integrated ticketing systems that combine event access with public transportation privileges. This approach has made it possible to increase the use of public transport by 25-35 percent during successful events and reduce the demand for parking. Develop multi-channel communication strategies to ensure that transport information reaches all user groups through appropriate media. While mobile apps cater to a younger audience, dynamic information boards and announcements are still needed to ensure wider accessibility. Create feedback mechanisms that allow users to enter information in real time. The Beijing 2022 system has demonstrated that responding immediately to user concerns increases satisfaction and provides data for continuous optimization.

For Transport Planners and Engineers

Prioritize interoperability standards when selecting ITS components. Systems that cannot exchange data with existing urban infrastructure create integration challenges and reduce overall effectiveness. Design for legacy by ensuring that temporary event infrastructure integrates with long-term urban development plans. Many host cities, including Barcelona 1992 and London 2012, leveraged event investments to address pre-existing transport challenges. Implement adaptive traffic control systems capable of responding to changing conditions without manual intervention. Machine learning algorithms trained on historical event data can predict demand patterns and adjust signals proactively. Develop comprehensive testing protocols for all ITS components before event commencement. Simulation testing, phased rollouts, and pilot programs reduce the risk of failures during critical periods.

For Future Research

Validate the proposed architecture through simulation modeling and real-world pilot studies in diverse urban contexts. Quantitative assessment of effectiveness metrics would strengthen the evidence base. Investigate artificial intelligence applications for predictive transport management, particularly machine learning models trained on multi-event datasets. Conduct economic analysis of ITS investments for mass events, comparing implementation costs with measurable benefits including reduced congestion, improved safety, and enhanced user experience. Explore autonomous vehicle integration at scale, as current implementations remain limited to dedicated lanes and controlled environments. Research should address mixed traffic scenarios and regulatory frameworks. Develop standardized evaluation frameworks enabling comparative analysis across events and identification of best practices applicable to different event types and urban contexts.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

Conflict of Interest

* The authors declare that they have no conflicts of interest

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