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## Traffic Control System for the Opening and Closing Ceremonies of Major Sports Events

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**Abstract:** The highly concentrated pedestrian and vehicular flow volume during the opening and closing ceremonies of major sports events that are intensely covered by news median demand a high level of service and security. Based on the experiences of several major sports events on pre-event preparation of traffic control for the opening and closing ceremonies, this paper analyzes the characteristics and challenges of travel demands, transportation control strategies, plan assessment and command system. The paper points out that traffic control system for the opening and closing ceremonies should consider ceremony proceedings, security policies, origin and destination of attendees, travel time and service mode. The traffic flow under different scenarios during peak hours are assessed by using traffic simulation model, which can identify risks. Consequently, a planning method framework and procedure for the opening and closing ceremonies is proposed. The paper concludes that effective transportation control strategies, systematic plan assessment and improvement, efficient command system, teamwork and collaboration are important for successfully hosting the opening and closing ceremonies of major sports events. **DOI:** 10.13813/j.cn11-5141/u.2021.0035-en

**Keywords:** major sports events; opening and closing ceremonies; traffic connection and evacuation; high passenger flow management; transportation service; command system

### 0 Introduction

It is widely recognized that the success of the opening and closing ceremonies marks half of the success of large-scale sports events. The traffic organization of the opening and closing ceremonies is unique for event traffic organization. In addition to serving the same stakeholders as the event, it will also serve dignitaries, special guests, actors and ceremony personnel, etc. Therefore, the traffic service level and orderly operation have higher priority in the traffic organization of the opening and closing ceremonies. At the same time, due to the high media and social attention to the opening and closing ceremonies, its transport organization aims to make no mistakes.

It is very important to summarize the characteristics and main challenges of the opening and closing ceremonies of large-scale sports events at home and abroad, as well as the planning and evaluation methods for the successful provision of transport services for the opening and closing ceremonies. Therefore, the organizers of various large-scale sports events have always paid special attention to the traffic organization and implementation of the opening and closing ceremonies.

However, In the past, the summary of traffic operation strategies is mainly for each specific opening and closing ceremonies<sup>[1-5]</sup>. Based on the practice of opening and closing ceremonies transport planning, evaluation and optimization as well as on-site participation experience, this paper attempts to systematically summarize the challenges and strategies of transport organization planning for the opening and closing ceremonies of large-scale sports events, as well as the evaluation and optimization methods, in hope to systemize the methodology of transport organization planning for the opening and closing ceremonies.

### 1 Demand characteristics and challenges

Large scale sport events include Olympic Games and Paralympic Games, the Asian Games, the Youth Olympic Games, the World Military Games, the World University Games, the national games and various championship games, etc. Although the organizers are different, the traffic demand characteristics and traffic organization challenges of the opening and closing ceremonies have high similarities<sup>[6]</sup>.

Based on years of practical experience and investigation,

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the traffic demand, service characteristics and challenges of the opening and closing ceremonies include:

1) The opening and closing ceremony venue gather large crowds and vehicles, especially during the evacuation period.

The total flow of people for the opening ceremony of the 2008 Beijing Olympics was about 160,000, and about 6,000 vehicles were collected and distributed, including more than 5,000 vehicles for the various stakeholder groups and 800 buses<sup>[7]</sup>.

The passenger flow of the opening and closing ceremonies was concentrated around the National Stadium, causing a large number of people and vehicles to gather and evacuate. When the opening and closing ceremonies are dismissed, almost all stakeholder groups depart (Fig. 1). The peak of exit traffic usually occurs 1 hour after the dismissal, which brings the risk of stampede and vehicle congestion to the evacuation traffic organization<sup>[7]</sup>.

2) Need satisfy multiple service objects, with high service standards, and high security requirements.

The opening and closing ceremonies transport serves a wide variety of stakeholders, in addition to the main stakeholder groups such as athletes and team officials, various media (TV and paper), domestic and foreign technical officials, ceremony guides, anti-doping agency, marketing partners, actor, also includes domestic and international dignitaries, invited guests, etc., which brings huge pressure to security needs and transport service capacity, including roadway, load zones, parking and pedestrian spaces<sup>[8]</sup>.

The service clients could be divided into fleet service groups and public transport service groups. Fleet service groups include dignitaries (international and domestic), host VIPs and guests (such as the Olympic family, the International Military Sports Federation), athletes and team officials, various media (broadcast and press), domestic and foreign technical officials, and ceremony guides, anti-doping organizations, market partners, actors, etc. Public transport service groups include organized spectators, ticketed spectators, staff and volunteers, etc.

The service standards of each stakeholder groups are different, which requires a close connection between the traffic organization planning and security policies of the opening and closing ceremonies, and tailor-made high-level traffic service plans for each group. The opening and closing ceremonies are concentrated from the periphery to the venue, resulting in an hourglass effect. The entry paths of each stakeholder group need to be effectively separated to avoid path crossing as well as people and vehicles congestion<sup>[9]</sup>.

3) The opening and closing ceremonies and its traffic organization attract much attention from the media and organizers.

The evacuation time of the opening and closing ceremonies is often used as a specific indicator to assess the success of the transport organization of the opening and closing ceremonies, and the host city may have to make a commitment.

4) There is possible inter-zonal travel

Due to reasons such as conditions for skiing, making usage of existing venues or the promotion of more cities in the region, many large-scale sports events are held in different cities. Athletes, technical officials and media live in different competition zones, resulting in inter-zonal transport needs during opening and closing ceremonies. For example, the 2022 Winter Olympics will be held in two cities and three competition zones in Beijing City, Beijing Yanqing District, and Zhangjiakou zone in Hebei Province. The opening and closing ceremonies will involve inter-zonal traffic organization. The 2018 Pyeongchang Winter Olympics was divided into mountain (snow sports) and coastal (ice sports) clusters, while the 2021 Xi'an National Games and the 2022 Hangzhou Asian Games will be held in multiple cities in the corresponding provinces.

5) The weather brings special service demands and traffic risks.

Due to the hot weather in summer, the opening and closing ceremonies need to consider the risks of extreme heat and thunderstorms; for winter Olympics, the opening and closing



a 2019 Military World Games in Wuhan



b 2008 Olympic Games in Beijing

**Fig. 1** Audiences leaving the opening and closing ceremonies of major sports events

ceremonies need to minimize the outdoors time of participants and strengthen the heat preservation facilities of each stakeholder group, and deal with risks caused by snow and ice weather (see Fig. 2).



**Fig. 2** Audiences leaving the closing ceremony of the 2018 Pyeong Chang Winter Paralympic Games under snowy weather

6) Uncertainty exists in the traffic organization plan for the opening and closing ceremonies.

Due to the high degree of confidentiality of the stakeholder groups involved in the opening and closing ceremonies, some stakeholder and ticketing information may be delayed or changed, which brings uncertainty to the transport organization, which in turn leads to the uncertainty of the transport plan, and increases the possibility of urgent revision in the final stage plan and the flexible demand of the program.

## 2 Transport organization goals and strategies

### 2.1 Traffic organization goals

The traffic organization of the opening and closing ceremonies aims to ensure safe and orderly traffic operation and reach the service level of each stakeholder group. The transport service goal is to provide satisfactory traffic service for each stakeholder group in an orderly manner, and to avoid the path crossing of stakeholders as far as possible. The departure traffic service should evacuate the people and vehicles in an orderly and efficient manner to avoid the risk of traffic and crowd congestion. For some events, the opening and closing ceremonies venue cluster need to be evacuated within the promised time.

### 2.2 Core strategies of transport organization

Based on the characteristics of the traffic demand for the opening and closing ceremonies, the preparation of the traffic organization plan usually adopts different strategies compared to the competition time in order to achieve the traffic service goals.

1) Accurate service strategy.

Precisely serving each stakeholder group is the core

strategy for the successful opening and closing ceremonies of the traffic organization. First, communicate closely with the opening and closing ceremony planning team, understand the opening and closing ceremony program, the number of various personnel and their accommodation location, as well as the requirements and impact of the ceremony arrangements on the use of the entrance and exit of the venue, and grasp the key information including the ticketing information and various personnel seating arrangement in the venue, which is an effective way to ensure the implementation of the opening and closing ceremonies transport plan. At the same time, as the security requirements for the opening and closing ceremonies are higher than those during the competition, the traffic paths and the arrangements for picking up and dropping off passengers should be coordinated with security measures in order to ensure the plan feasibility.

2) Compact travel strategy.

Based on the concept of public transport priority, staff and volunteers should try their best to use green transport such as subways, buses, and shuttles. This will not only reduce the traffic and parking pressure around the venues, but also reduce the burden of government vehicle cost, and embodies the principle of environmental protection. Accredited groups should arrive at the venue by minibus or bus if possible.

3) Remote assembly and security check strategy.

In order to reduce the traffic pressure around the venue, the opening and closing ceremonies usually adopt remote assembly and security check approach for accredited groups. Even VIP stakeholder groups are also security-checked at the remote assembly place and transfer to a minibus or bus to enter the venue area without inspection to minimize the pressure of car travel and security check at the venue, while also reflecting the principle of green and high-capacity transportation.

4) Spatial-temporal separation strategy.

In order to ensure the orderliness of arrival and evacuation, according to the service priority of each stakeholder group and the time required to arrive, try to allocate their arrival and departure time and path appropriately in order to make full use of timing difference, exchange time for space, and ensure the orderliness of arrival and departure. For example, staff and volunteers arrive the earliest, followed by the media and actors. In order to prevent the audience from intensively arriving before the starting time, staging performance has become a common measure to even out the audience's arrival time. At the end of the ceremony, the fireworks display time is normally used to allow some VIPs to leave the stadium first, and some domestic events even staging spectators' departure to avoid large crowds. Accredited groups and ticket-holders often use different sides of the venue in their seating arrangements, which spatially separate stakeholders and avoid path crossing.

5) Traffic demand management and detailed analysis strategy.

Using traffic assessment methods, the traffic demand management and traffic control scenarios and traffic operation scenarios around the venue and at the city or even regional level are evaluated, selected and optimized to ensure the safety and effectiveness of the traffic organization. For example, the traffic load of the main related roads around the venue is usually used to evaluate the traffic demand management plan on the opening and closing ceremonies (such as odd and even tag numbers, added holidays, workday shorting, etc.). Road traffic simulation and flow analysis around the venues are usually used for scenarios comparison and selection and the development of traffic management measures. The crowd simulation method is usually used for the formulation, comparison and optimization of the crowd evacuation plan.

6) Efficient command system and reliable communication strategy.

The traffic command of the opening and closing ceremonies involves many agencies, and requires efficient on-site decision-making and command. Usually, a command system with clear hierarchy, clear command relationship and all relevant operating departments will be established. At the same time, reliable and interference-free means of communication are needed to ensure the timely on-site command and the implementation of emergency measures. In general, the independent channel mobile station is used as a guarantee of communication.

7) Adequate rehearsals and emergency plan strategies.

Although the opening and closing ceremonies only happen once, only through multiple desktop exercises and comprehensive exercises, testing the command system and traffic plan, discovering problems, adjusting the plan, re-drilling, and training the team can the final implementation be perfect. Therefore, rehearsals and emergency plans are also the core strategies of transport organizations.

### 3 Overall planning method

In view of the importance and complexity of the opening and closing ceremonies, the transport organization plan should be planned as early as possible, and multiple rounds of dialogue and feedback should be carried out with various stakeholder groups. The traffic organization planning of the opening and closing ceremonies generally requires 3 stages:

In the first stage, the overall transport plan for the opening and closing ceremonies is prepared, the traffic organization principles and traffic service modes of each stakeholder group are determined, the roads and traffic control measures around the opening and closing ceremonies are comprehensively evaluated, and the plan is reported to various authorities at all levels, the organizing committee, the executive committee and even higher decision-making levels for approval.

In the second stage, the implementation plan of transport services for each stakeholder group is prepared and implemented in the aspects of operation plan, vehicle allocation, post allocation and logistics support.

In the third stage, traffic service personnel of the opening and closing ceremonies need to attend training and rehearsals, and the plan is further adjusted through the rehearsal to form the final traffic implementation plan.

The traffic organization planning method and steps of the opening and closing ceremonies are shown in Fig. 3.

### 4 Critical tasks of the overall plan

#### 4.1 Understand the program and ticketing policies of the opening and closing ceremonies

The primary task of the transport planning team is to

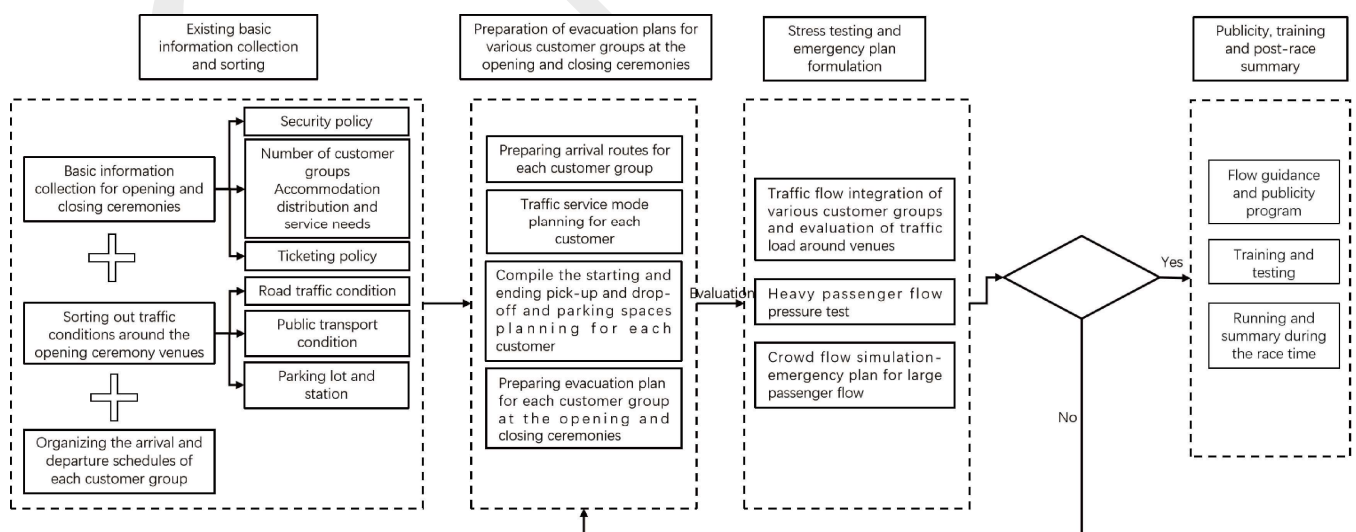


Fig. 3 Procedure of traffic control for the opening and closing ceremonies of major sports events



communicate with the organizing committee of the games, especially the planning team of the opening and closing ceremonies, about the key information of the opening and closing ceremonies, such as the content and time arrangement of the opening and closing ceremonies, the number of each type of stakeholders participating in the opening and closing ceremonies, their accommodation locations and seating arrangement in the venues. This information will be updated continuously with the planning progress of the opening and closing ceremonies.

#### 4.2 Develop preliminary plans for each stakeholder group of their corresponding responsible party and vehicle provider

The responsibility matrix of each stakeholder group was established considering the high complexity and great difference of the traffic service stakeholders of opening and

closing ceremonies. That is to say, to reach an agreement with relevant departments on the main responsible agency of each stakeholder group, the source of the vehicle, and which transport department is responsible for the transport service. Under normal circumstances, when the responsibilities in the early stage of planning are not clear, a preliminary form could be formulated, and as the preparation work progresses, the division of responsibilities becomes even clear, in order for each agency to perform its own duties. When it is difficult to determine the responsibility allocation, the superior decision-making department will make decision on it. Table 1 introduces the main agency responsible for each stakeholder group of the opening ceremony of the 2008 Beijing Olympic Games, the agency responsible for vehicle procurement and services, as well as the main units responsible for travel routes, pick-up and drop-off zones and parking on the opening ceremony day.

**Table 1** User groups and institutions of the opening ceremony of the 2008 Beijing Olympic Games

Stakeholder Categories	Stakeholder Type	Stakeholder Group	No. of persons	No. of Veh.	Stakeholder Responsible Agency	Veh. Procurement Responsible Agency	Collection and distribution lines, drop-off and parking responsible unit	
Special car stakeholder group (About 76,000 people)	VIP	Super VIP	722	30 mini buses, 70 cars	Security Bureau	Security Bureau, BOCOG Transport Department	Security Bureau, Beijing Municipal Transport Administration	
		Registered VIP	8 000	150 mini buses, 220 buses	BOCOG Transport Department	BOCOG Transport Department	Beijing Municipal Transport Administration, BOCOG Transport Department	
		Invited VIP	2 000	80 buses				
	Performers	Pre-show performers	3 000	75 buses	Opening and Closing Ceremony Department	Opening and Closing Ceremony Department	Beijing Municipal Transport Administration, Opening and Closing Ceremony Department	
		Ceremony performers	17 000	425 buses	Opening and Closing Ceremony Department	Opening and Closing Ceremony Department	Beijing Municipal Transport Administration, Opening and Closing Ceremony Department	
	Ceremony staff	ceremony athletes	12 000	240 buses	International Liaison Department of Olympic Village Operation Team	BOCOG Transport Department	Beijing Municipal Transport Administration, BOCOG Transport Department	
		Ceremony guide, etc.	2 522	65 buses	Opening and Closing Ceremony Department	Opening and Closing Ceremony Department	Beijing Municipal Transport Administration, Opening and Closing Ceremony Department	
	Media	TV reporter	2 500	100 buses	Media Operations Department	BOCOG Transport Department	Beijing Municipal Transport Administration, BOCOG Transport Department	
		Text, photojournalist	2 550					
	Sponsors	Sponsors	15 000	350 buses	Ministry of Transport, MPCP Department	Ministry of Transport, Market Development Department	Beijing Municipal Transport Administration, BOCOG Transport Department, Market Development Department	
	Other accredited stakeholders	Athletes watching the ceremony	1 000	30 buses	International Liaison Department of Olympic Village Operation Team	BOCOG Transport Department	Beijing Municipal Transport Administration, BOCOG Transport Department	
		Organized audience	10 064	150 mini buses, 170 buses				
	Public transport stakeholder group (about 83,000 people)	Audience	Casual ticket audience	32 936	Bus, Subway	Beijing Municipal Transport Bureau	Beijing Municipal Transport Bureau	Beijing Municipal Transport Administration, Beijing Municipal Transport Bureau
		Staff	Staff, Volunteers	50 000				

Note: The Ministry of Transportation, Market Development, and Opening and Closing Ceremony Departments mentioned in the table all refer to the internal departments of the Beijing Olympic Organizing Committee in 2008.

### 4.3 Lay out arrival and departure schedules for each stakeholder group

According to the program of opening and closing ceremonies and with reference to the arrival and departure rules of each stakeholder group in previous ones, the quantity distribution of each stakeholder group arriving and leaving the venue in each period was initially compiled. Fig. 4 clearly shows the overall arrival and departure peak of each stakeholder group at the opening ceremony and the service time for each stakeholder group, which also provides an important basis for the traffic load analysis of roads around the venue, the analysis of people and traffic flow, and the demand analysis of various facilities such as vehicles and security check at each time period.

### 4.4 Inventory of the traffic facilities around the opening and closing ceremonies venue

The security measure, traffic management measures, traffic facilities layout, carrying capacity, service level, background traffic volume and traffic load of the opening and closing ceremonies venue area needs to be analyzed<sup>[5]</sup>, laying a quantitative foundation for the transport operation plans of each stakeholder group in the next step. The key points of current situation analysis include: 1) Preliminary plan of security and traffic management measures for the opening and closing ceremonies; 2) Road class, traffic capacity, clearing height surrounding the venues, and important roads crossing competition zones; 3) Carrying capacity and traffic load of key intersections and overpasses; 4) Carrying capacity of metro stations and lines, road traffic volume and load during peak hours of the opening and closing ceremonies, operation time of metro lines, etc.; 5) Surrounding public transit lines, stations and service coverage areas of the lines, daily operation hours, night bus service time; 6) The area of parking lots (permanent and temporary) around the venue, the available location and quantity of parking lots for the

opening and closing ceremonies, and the surrounding road space for temporary parking.

### 4.5 Formulate traffic organization principles and preliminary plans

Combining the status quo analysis report and the characteristics of the opening and closing ceremonies, drawing on past experience, formulating traffic organization principles and the traffic organization mode of each stakeholder group. For example, there are two modes of transport organization for the staff and volunteers. One is to reach the Stadium by public transit. The other is to assemble at the selected staging area and take the shuttle bus to the Stadium (Fig. 5). On this basis, the preliminary plan of important transport gathering points, traffic flow lines, entrances and exits from the accommodation to the venue will be prepared, and the responsible parties of each stakeholder group of the Opening and Closing Ceremonies Department (preparation group), the Organizing Committee (Executive Committee), security, traffic management and other relevant departments will be connected to lay a foundation for quantitative analysis.

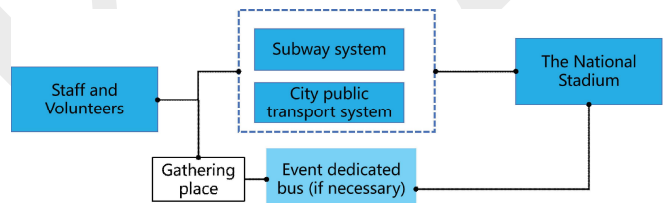


Fig. 5 Traffic control of city buses or dedicated buses

### 4.6 Develop plans for stakeholder groups served by car from accommodation to their venue seats

During the opening and closing ceremonies, the service priority of registered groups is significantly higher than that of ticket holders, staff and volunteers. The main considerations for plan preparation include:

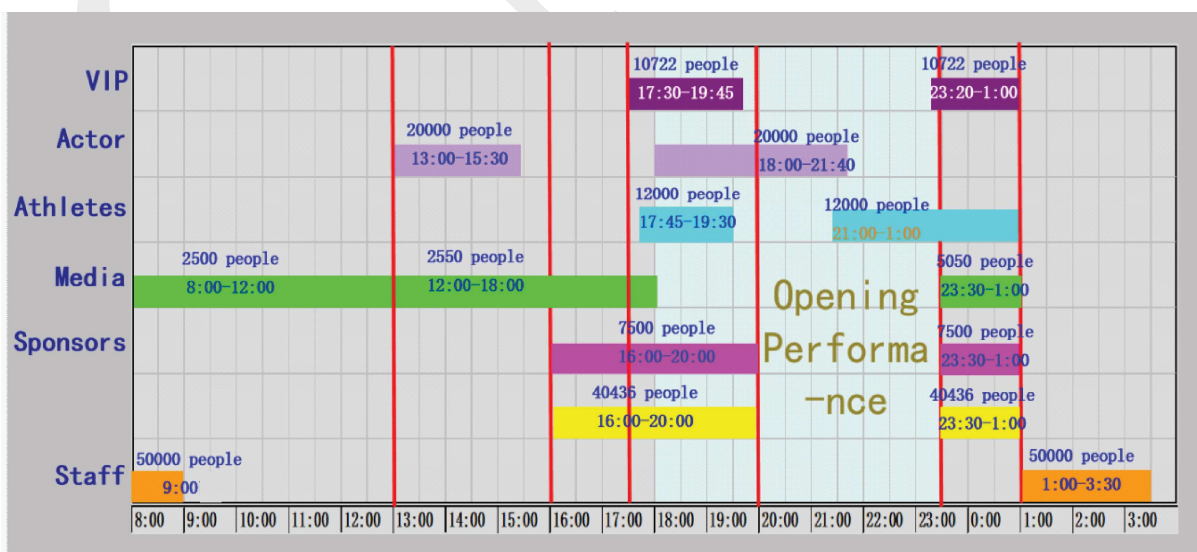


Fig. 4 Schedule of user arriving and departing of the opening ceremony

1) Transport service standards for various stakeholder groups: Compared with the transport service standards during the competition, the opening and closing ceremonies are more intensive in vehicle use and traffic organization arrangements. For example, groups served by cars, such as T1, T2, and T3 during the competition, often use remote assembly during the opening and closing ceremonies, and use minibuses or even bus services to minimize the pressure on roads, security checkpoints and parking at the opening and closing ceremonies.

2) Convenient service: On the basis of intensive service, make it as convenient and friendly as possible. For example, as far as possible, the remote assembly point selects locations where the stakeholder groups are more concentrated: VIP hotels, media villages, media centers, athletes' villages, or squares and hubs that are close to VIPs, with convenient transport services, and sufficient parking spaces.

3) Safe and orderly: the assembly time, entrance and exit should try to meet the characteristics of the stakeholder group, and the time and space should be staggered to ensure an orderly arrival. In general, the registered groups will gather and arrive in batches, and inform the relevant stakeholder groups in advance. For example, athletes generally adopt the scheme of gathering different sports teams in batches.

4) Punctual delivery: Compile a transport route map for the opening and closing ceremonies to ensure that vehicles use dedicated roads(lanes), or temporary traffic management measures as much as possible to ensure that registered groups arrive on time as planned.

5) Compliance with security requirements: the use of remote security inspections for remote assembly or venue-side security inspections requires close consideration, negotiation and optimization of transport and security inspection departments.

#### **4.7 Prepare the opening and closing ceremony plan for public transport service groups (ticket holders, staff and volunteers)<sup>[4]</sup>**

In view of the large number of these groups, private car parking spaces are generally not provided for them at the opening and closing ceremonies venue. Taxi dropping is also not available at nearby location. In addition, these groups generally live relatively scattered, and the existing public transport system (subway, bus) services of the city should be used as much as possible. To encourage the use of public transportation, free public transport for ticket holders is commonly used. However, if the urban public transport coverage is insufficient, the capacity of the bus system around the opening and closing ceremonies is insufficient or not convenient, or the staff and volunteers' accommodation are concentrated, the dedicated buses for the audience or staff (volunteers) can provide direct services and to improve service level. The pros and cons of the scenarios should be compared and determined in consultation with staff, volunteers and urban public transport operators.

How to serve these groups should also be closely coordinated with the security department, and comprehensively evaluate the safety, order, convenience, feasibility of land use, number of vehicles used and related costs of different scenarios based on security policies, security line allocation and the possibility of remote security inspection. On the bases of meeting the security inspection requirements and giving priority to the registered groups, provide spectators, staff and volunteers with as compact, green and convenient services as possible.

At the same time, it is common to extend the operating hours of subways and buses on the day of the opening and closing ceremonies, as the ceremonies may end later than the usual service hours of public transport systems, especially for staff and volunteers.

#### **4.8 Prepare evacuation plan for the opening and closing ceremonies**

The biggest traffic load and pressure of the opening and closing ceremonies occur at the departure time after the ceremony. Because almost all stakeholders evacuate at the same time when the ceremony is over, crowds and vehicle flow crossing are inevitable. And because of the concentration of people and traffic flow, crowds trample, traffic congestion, especially insufficient vehicles, insufficient loading zones, stakeholders having difficulty finding their vehicles, could all cause the evacuation time delay.

Therefore, the evacuation plan must be comprehensively evaluated for space and vehicle needs of stakeholder group overlapping, comprehensive comparison and selection, to ensure the safety, order and speed of the evacuation. The determination of the evacuation plan requires qualitative and quantitative comparison, and the use of scientific evaluation tools.

There is usually a promised evacuation time for large sports events for all stakeholders except for the staff, and this time has become one of the focus of media attention. If the evacuation time is too long, it could have a negative impact on the athletes who have competition the next day and the service satisfaction of stakeholder groups. Therefore, the main points of transport organization include:

1) Try to disperse different stakeholder groups and guide them to different directions.

2) According to the needs of different stakeholder groups and security requirements, as far as possible to provide adequate and convenient loading zone and vehicles; Vips and athletes, in particular, are the two groups with the highest service level requirements and the largest number of registered people for evacuation, so detailed evacuation routes, guidance and boarding strategies, as well as dedicated driving routes should be formulated respectively.

3) Provide clear guidance services for registered stakeholder groups. From the venue seats to the boarding location, it is necessary to arrange the corresponding entrances and exits, walking paths, and clear guide signs in detail, all the



way to dedicated vehicle boarding area. At the same time, the traffic control measures on the roads outside the venues should be implemented to guide the vehicle flow to leave the venue area in an orderly manner (Fig. 6). It is particularly important to note that since most of the opening and closing ceremonies are held at night, clear guidance signs and guidance personnel are important conditions for ensuring the orderly evacuation of registered personnel.

4) The spectator is the largest-numbered stakeholder group, and has the highest risk of congestion and the longest evacuation time (Fig. 7). The spectator at the opening and closing ceremonies of large-scale sports events generally reach 30,000 to 60,000. The spectator evacuation plan needs to be planned and evaluated systematically from inside to outside the venue, and it should be seamlessly connected

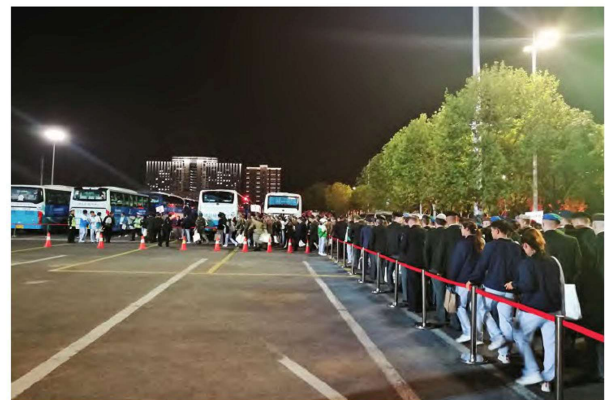
from leaving the seat to taking the public transport system and finally arriving at home. The plan generally includes three parts: the stadium evacuation plan, the public area evacuation plan, and the peripheral public transport system operation plan.

#### 4.9 Optimize the preliminary plan for each stakeholder group

As the surrounding area of the opening and closing ceremonies is the destination of all stakeholders and the area with the most concentrated traffic pressure, the traffic flow and path of each stakeholder group need to be described for different periods (Fig. 8), in order to achieve time and space separation as far as possible and reduce path-crossing in each



a Electric guiding board



b Barrier precautions

**Fig. 6** Traffic control on registered users leaving the 2019 Wuhan Military World Games



**Fig. 7** Spectators remained in the sunken square of subway when leaving the opening ceremony of the 2008 Beijing Olympic Games



**17:30-20:00 (Peak admission, and preview performers exit)**

17:30-19:00 Registered VIPs and invited guests:10000

17:45-19:30 Admission of athletes:12000

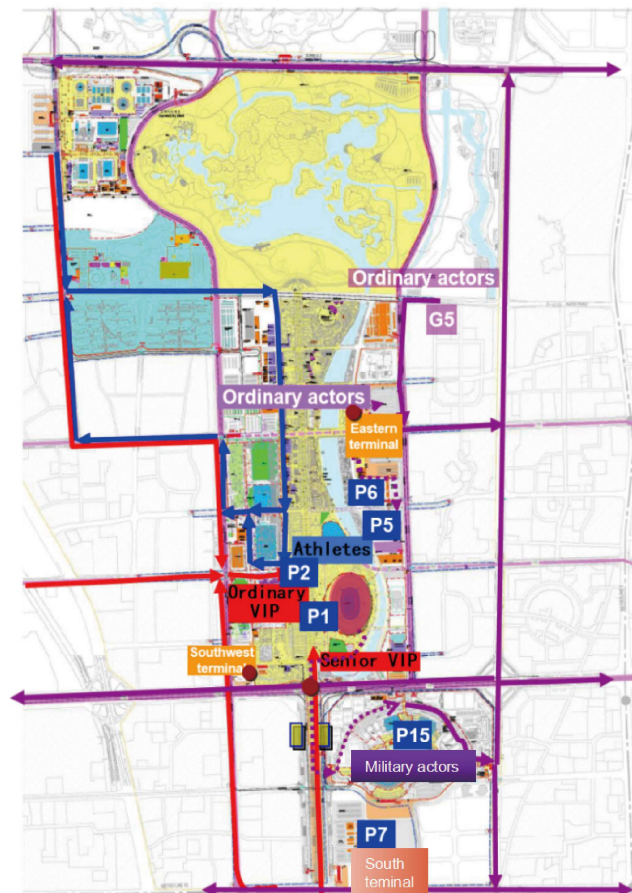
19:00-19:45 VIP admission:722

18:30-21:40 Actors leave:20000,

16:00-20:00 Admission for ordinary ticket holders:40436,

15:30-20:00 Sponsors admission:7500

- VIP vehicles are separated from other vehicles and people at the same time



**Fig. 8** Streamline analysis of the arriving time period at the evening peak during the opening ceremony of the 2018 Beijing Olympic Games

period, especially in the peak hours of entry and evacuation. If severe routes crossing is identified for different stakeholder groups that interfere with each other in a certain period of time, or violate security conditions, it is necessary to coordinate the relevant stakeholder service team and the organizing committee to adjust the arrival and departure time or route for certain stakeholder groups.

#### 4.10 Assessment of traffic load around the core area and recommendations for temporary traffic management measures

According to the above assembly and evacuation traffic plan, the traffic flow of each stakeholder during each time period, especially the peak hours of entry and evacuation, is loaded on top of the background traffic volume, and the evaluation method of road capacity calculation or traffic model simulation is used to assess the traffic load of surrounding roads. The evaluation not only provides the basis for the city-level traffic management strategies of the opening and closing ceremonies, but also provides technical support for traffic management measures and temporary traffic guidance measures during the opening and closing ceremonies.

At the city level, traffic management measures could

include additional holiday, vehicle travel restriction by tag number, flexible working system, and temporary traffic control measures to ensure the smooth operation of roads on the opening and closing ceremonies<sup>[10]</sup>; at the venue surrounding area, traffic control measures by different zones could be adopted. For example, around the National Stadium, the opening and closing ceremonies of the 2008 Beijing Olympic Games divided the area around the venue into 3 zones from the inside to the outside to take traffic control measures.

1) Traffic diversion area: In accordance with the instructions of the Olympic Security Command Center, measures such as traffic diversion, persuasion, and vehicle type screening was implemented to reduce the amount of background traffic leading to the core venue area;

2) Traffic control area: In order to further reduce the background traffic volume, set up vehicle restriction signs, arrange checkpoints, and conduct traffic diversion, detour, restriction and other traffic control measures in time according to the situation;

3) Traffic control zone: only ceremony permitted vehicles and dedicated buses was allowed to enter. Vehicles without permits are not allowed to enter; it was in effect at 11:30 on August 8, and the tunnel under Datun Road will be closed at the same time, background vehicles and buses bypass.

## 5 Key points for preparing the implementation plan

Since each stakeholder group of the opening and closing ceremonies is ultimately responsible for the corresponding transport service team, each transport service team needs to prepare a practical implementation plan based on the characteristics of each stakeholder group on the basis of the overall transport plan. The main points of the preparation of the implementation plan should include the specific pick-up and drop-off points and routes of each stakeholder group, the fleet scheduling plan, the allocation of drivers and passengers, the locations of guides and service volunteers, etc., and the implementation plan should be refined through training and rehearsal. The implementation plan generally includes the following 7 categories according to the priority of the service object.

1) Transport implementation plan for state guests and special guests: combined with security, provide adequate fleet and boarding and unloading space guarantees, high-quality guidance services and driving priority guarantees.

2) Traffic implementation plan for ceremonial athletes and team officials: When assembled, the team usually gathers in batches; specify the detailed locations for pick-up and drop-off and the team's batch transport plan; when leaving the stadium, it is necessary to park enough vehicles in advance. Generally, the vehicle will leave as soon as the vehicle is full and return as soon as possible. If the distance is close, walking is an option for returning trip after the ceremony.

3) VIP and Olympic family traffic implementation plan: When entering the venue, try to use remote security checks and assembly to reduce on-site pressure and ensure service levels; when evacuation, basically return by boarding the original vehicle, requiring guidance and full volunteer service.

4) Media traffic implementation plan: When entering the venue, it is generally used to gather at a remote location and depart regularly; at the evacuation period, the media bus will depart by schedule, and an appropriate amount of dedicated taxis can be supplemented to provide transport services for media that cannot take the shuttle on time.

5) Performers and ceremonial personnel: When entering the venue, the method of remote assembly is generally adopted; when the ceremony ends, if the program arrange the performers to complete their performance in batches, it is appropriate to leave immediately after each stage of performance to reduce the pressure of the final concentrated dispersal.

6) Spectator public transport plan: mobilize sufficient public transport vehicles and subway trains, deploy sufficient on-site dispatch commanders and volunteers, and do a good job in video tracking, route guidance throughout the process to ensure orderly and fast evacuation. Do a good job in spectator guidance and crowds management by responsibility district<sup>[11-12]</sup>.

7) Transport plan for staff and volunteers: As these two groups arrive early and return late with longest working hours, it is necessary to extend the public transport service time or provide night-shift special buses on the basis of the spectator transport plan to ensure that they return home safely.

## 6 Program evaluation process and key points

Due to the high pressure of people and traffic at the opening and closing ceremonies, repeated and thorough program research, integration and evaluation are important measures and tools for discovering risks and comparing the advantages and disadvantages of the programs. Program evaluation uses a combination of quantitative and qualitative evaluation methods.

### 6.1 Quantitative evaluation

#### 1) Macro-level evaluation

The four-step travel demand model is usually used to evaluate the urban area and guaranteed roads (Fig. 9). The main evaluation indicators include traffic load, running time, etc.



**Fig. 9** Assessment on the level of service of connecting roadways around stadium using the four-stage model

#### 2) Micro simulation evaluation

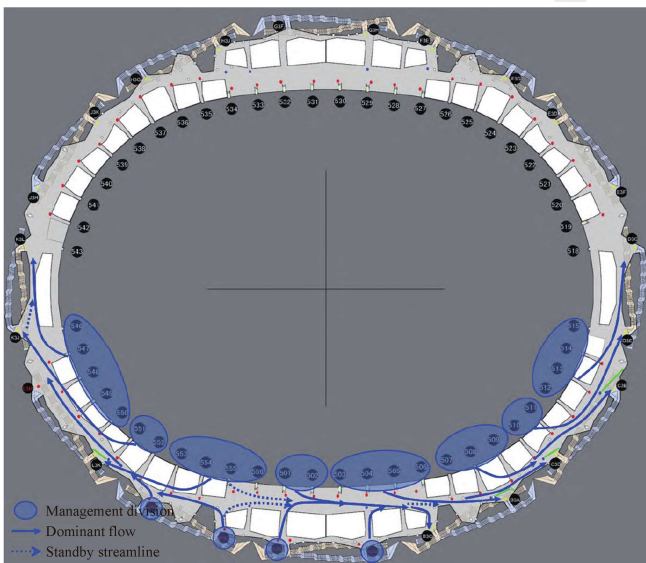
The micro-traffic simulation model is used to evaluate the surrounding and internal roads of the stadium (Fig. 10). The main indicators include the road traffic load, running speed, delay time and queue length during peak hours.



**Fig. 10** Assessment on the level of service of roadways surrounding and within the stadium area using microscopic simulation

### 3) People flow simulation evaluation

The simulation model is used to evaluate the crowd distribution. The main indicators are the crowd load of venues, public areas, entrances and exits, and security facilities. Risk points are found and assisted in formulating evacuation plans<sup>[13-14]</sup> (Fig. 11).



**Fig. 11** Optimized stadium evacuation plan using passenger flow simulation

## 6.2 Qualitative assessment

Considering the traffic flow and the feasibility of the plan, the end-to-end flow of each stakeholder group from the accommodation to the venue is evaluated. The main points include: whether the pick-up and drop-off points of each stakeholder group, especially VIPs, are too far away from the venue; whether there is a path-crossing problem between the spectator and the registered groups; whether there are bridges and tunnels in the shuttle route that do not support the clear

height of the bus; whether the organization of the stakeholder group shuttle bus flow is reasonable, etc.

## 6.3 Program integration and key points of exercise

Opening and closing ceremonies transport option requires multiple desktop exercise, service team site visits, fleet route trial run, the emergency plan exercise, as well as several tests and comprehensive rehearsal. These exercises and tests are helpful for operating the command system, getting familiar with operation routes and operating procedures, testing technology and communication equipment, training operation teams, revising and verifying traffic service assumptions, refining plans, and improving emergency response levels, etc.

## 7 Conclusion

The transport organization service for the opening and closing ceremonies is very important and complex, and the organizers of large-scale sports events should carry out scientific and detailed overall plan planning, implementation plan preparation and transport plan evaluation. The development of the overall transport plan for the opening and closing ceremonies of the traffic organization requires multiple rounds of dialog and feedback with various stakeholder groups, and it should be planned as early as possible. The implementation plan should be prepared on the basis of the overall traffic plan according to the characteristics of each stakeholder group. The main points of the preparation of the implementation plan should include the specific pick-up and drop-off points and routes for each stakeholder group, the fleet scheduling plan, the allocation of drivers and passengers, and the locations of guides and service volunteers. The evaluation of the traffic plan should be qualitatively and quantitatively combined and coordinated with multiple rehearsals for further implementation. Drawing lessons from historical experience, systematic and scientific planning, evaluation, testing, and the establishment of an efficient traffic command system are the guarantee for the traffic organization at the opening ceremony of large-scale sports events.

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