An integrated scheme for Olympic Village traffic and parking arrangements

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Abstract: The present study deals with the development of an integrated transportation scheme serving the needs of guests at an Olympic Village during the 2004 Athens Olympics. The Olympic Village was located at the port of Piraeus docks (within the Athens Greater Area), and was designed to accommodate 13.500 guests. This integrated scheme comprised vehicle and pedestrian traffic arrangements as well as bus and passenger car parking arrangements. Based on the various transport and security needs of the Olympic guests, the related transportation parameters were estimated, leading thus to the design of the infrastructure and operation provisions of the various transportation sub-systems, including secured areas and control entrance and exit gates. The final implementation of the proposed integrated scheme together with the special transportation management measures resulted in a high level of service offered to the Olympic guests during the Athens 2004 Olympics, a success case to be used as example in other similar cases.

Keywords: Traffic management, Olympic Village, Parking facilities, Safety, Security, Integrated design

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1. Introduction

1.1. Background

Transportation issues have become a major component of the organisational success of the Olympic Games, and special attention is given to construct an efficient design integrating the different elements of the transportation system. As the design and implementation of such a system is now a prerequisite for the success of the games (IOC, 2001), such events offer the chance for a “fast track” urban regeneration (Chalkley and Essex, 1999).

In August 2004, Athens hosted the “2004 Olympic Games”, an event that was anticipated to attract masses of people both from inside and outside Greece. Athens had not hosted before an event of such magnitude, and special attention had to be given in various aspects of the Games, including the increased transportation needs and the increased security measures. The Athens Bidding Committee (1996) noted that quality transport services should be provided corresponding to the distinct needs of the different categories of people involved. To prepare for the significant number of guests arriving for the 2004 Olympic Games in Athens, the city had to undergo renovation of existing and design of new infrastructure involving stadiums and accommodation as well as interventions in the city infrastructure and operations.

A direct consequence of the above was the need for an updated design of the transportation system due to new transportation related parameters and new traffic demand generation poles. The difference in both the number and the type of urban trips taking place during the Olympic Games is a fact triggering extensive congestion (Bovy, 2006; Shusen, 2006); a 54% increase of the use of public transport was observed during the Olympic Games in Atlanta (Barry-Cross, 1992). As planned special events can significantly affect travel safety, mobility, and travel time reliability (Latoski *et al.*, 2003), lack of provision of satisfactory transportation services can damage the smooth running of the Olympic Games (Bovy, 1999). Previous experience has indicated that planning and management of transport especially for the Olympic Games is a complex and diverse task (ORTA, 2001), as the pressures on a city's transport system are enormous (Hensher and Brewer, 2002).

The present study involves the design of an integrated transportation scheme serving efficiently the needs of the Olympic guests of an Olympic Village. The examined Olympic Village was located in the area of the Central Port of Piraeus (within the Athens greater area) and guests were accommodated on cruise-ships permanently berthed alongside the southern quays of the port (Rogan Associates S.A., 2002a). The design scenario estimated a maximum number of 13.430 guests along with the 6.715 cruise ship personnel, who would be accommodated at a maximum of 11 cruise ships (Rogan Associates S.A., 2002b). The southern quays of the Central Port of Piraeus are used all year long, but for the specific period of the Athens 2004 Olympic Games the 11 cruise ships were permanently berthed and the port area was heavily secured.

1.2. Objectives and Structure of the Study

To design an efficient scheme several parameters had to be considered; and the core axis on which the scheme was constructed is illustrated in Figure1.

**** Figure 1 to be inserted here****

First, the transportation demand for both pedestrian and vehicle movements had to be estimated, according to which the elements of the scheme would be designed. It must be pointed out that the demand used for the planning of the transportation scheme could only be a rough estimation of the actual generated demand for the Olympic Village during the Olympic Games. Hence, the design of the scheme was proven to be a rather challenging task. Several assumptions and alternative scenarios were used, as proposed by the Athens Organising Committee, on the basis of past experience gained from previous Summer Olympics.

One of the main objectives of the design was to provide efficient transportation services meeting the needs of both the Olympic Village guests and the related supporting personnel by achieving high level operational performance for the transportation services concerned. Furthermore, emphasis had to be given to ensure optimum safety and, due to the nature of the event, high security level. The two elements of the investigated scheme were the pedestrian and vehicle movements performed within the area. Movement design in a safely manner, avoidance of delays and traffic disruption, minimisation of waiting times and queues were targeted. Finally, the issue of security should also be taken into account when designing such big events, where large crowds are involved, and optimal security needed to be implemented within the infrastructure design according to the related Olympic Games rigorous standards. Hence, the security control strategies comprised additional parameters for planning the investigated arrangements of the Olympic Village.

One important prerequisite was the integration of the different operations and transportation services provided in the Olympic village, as well as their integration with the corresponding transportation system of the nearby area and the overall Olympic transportation system. To achieve this, an inter-modal approach was adopted and travel demand management (traffic and parking) strategies in combination with security control strategies were utilised. The comprehensive operation of all transportation and security services was an additional prerequisite.

Two constraints had to be taken into account into designing the transportation scheme; the available space and the existing infrastructure in terms of land use in the port area and transport infrastructure and services in the neighbouring areas. It was desirable to make the optimum use of the existing infrastructure and avoid any unnecessary constructions and demolitions, hence ensuring minimisation of the implementation cost and sustainability of the design, which were two additional prerequisites set during the design process.

2. Principal Design Elements

2.1 Segregation of the Olympic Village into different areas

The approach adopted for the design of the provided operations in the Olympic Village is illustrated in Figure2.

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The initial input for the design of the operations was the number of ships berthing at the port as well as the number of the accommodated guests, based on which three elements of the system were estimated – namely, the required personnel, services to cater for the needs of the guests (non-transport related) and travel demand. The travel demand defined the transport alternatives to be offered to the guests also having taken into account the transport system of the neighbouring area. A rough estimation of the security operations was also designed. Based on the above, the different operations that needed to be designed were established and the subsequent segregation of the Olympic Village into distinct areas of different characteristics and sub-zones was made. The segregation into distinct areas and sub-zones is required especially in cases where the nature of the different operations is such that they should be clearly segregated location-wise or the examined area is quite vast. Hence, in the examined case, the Olympic Village consisted of three distinct areas:

- the waterfront area (mainly the apron zone),
- the parking area, and
- the transport mall area.

The latter two were divided into five sub-zones. A rough illustration of the three areas and the respective five sub-zones of the Olympic Village is presented in Figure 3.

**** Figure 3 to be inserted here****

The area close to the cruise ships should be a totally secured area, and hence in the waterfront port area guest movements were performed either by dedicated buses or on foot. Special service vehicles were also allowed to enter after having passed successfully the necessary security checks. The entrance to this area was only allowed to the accredited guests, who had already passed successfully from the security checks at the passenger terminals and also to the cruise-ship, emergency services and the Organising Committee personnel. In addition, areas offering parking facilities had to be incorporated in the plan and subsequently two areas: the parking area and the transport mall area were designed. The parking area accommodated for long-term parking facilities for vehicles transporting Olympic guests from the Olympic Village to other destinations, whereas the transport mall area offered short-term parking facilities. As the parking and transport mall areas were rather vast, their division into five – identical in terms of operation – sub-zones was desirable. Hence, each of these sub-zones consisted of parking and transport mall areas, and parking and transport mall gates. Provision had to be made for connectors between the three different areas, that should also operate as areas in which accreditation and security checks would be conducted. Passenger terminals served as the pedestrian connectors, which ensured the pedestrian movement between the waterfront area and the transport mall area. Emergency vehicle gates were the vehicle connectors linking the waterfront area with transport mall areas, in each sub-zone. The parking gates linked the parking area to the transport mall areas and the transport mall gates linked the transport mall areas with the Piraeus road network.

These connectors should also operate as areas in which security and accreditation checks were conducted. Hence, vehicles and pedestrians would enter the Olympic Village from the Piraeus road network through the transport mall gates where accreditation checks were conducted. All passengers would also disembark the vehicles at the transport mall areas. Vehicles would then continue to either the transport mall areas for short-term parking or to the parking areas through the parking gates, where security checks were conducted for long-term parking. The entrance to the waterfront area is only allowed to pedestrians who would have to pass through security checks at the passenger terminals.

The five defined sub-zones in the parking and transport mall areas were: the Kanellou, the Lion, the Central, the Customs and the Telecom sub-zone; and had been defined taking into account the locations of the cruise-ships at the waterfront, their capacity and the category of guests that would dwell in them, as well as the topology of the area. The characteristics of the sub-zones are presented in Table 1.

**** Table 1 to be inserted here****

Three types of secure fences were decided for the Olympic Village: one to segregate the waterfront area from the transport mall area, one to segregate the parking area from the transport mall area, and one to segregate the Olympic Village from the city of Piraeus (see also Figure 3).

2.2 Modal Split

An important parameter for the design of the transportation scheme was the modal split of trips that originated from and destined for the Olympic Village. The definition of several parameter values was made taking into account the experience gained through the Sydney 2000 Olympic Games and the further adjustments to accommodate the prevailing conditions were set by the Transport Department of ATHENS 2004. The Organising Committee provided estimations for the modal split of the trips connecting the Olympic Village to destinations outside the village, which also depended on the different guest categories (sponsors, spectators, journalists) taking into account the following assumptions:

- The departure of the guests is completed within at least 3 hours and their arrival within at least 5 hours. These two periods are identified as the morning and afternoon peak periods. The whole design should cater for the highest demand which is anticipated to be during the 3 hour morning peak period.
- 5% of the guests are anticipated to use the metro network for their transportation, irrespectively of whether buses or passenger cars have been allocated for their transfers.
- 10% of the guests will enter and exit the Olympic Village on foot, and will choose taxis or other transport modes to complete their journey. These guests will not use the dedicated bus services, passenger cars or the metro network.

The alternative transport modes for trips linking the Olympic Village with outside destinations were buses, passenger cars, foot and metro; and the modal split of those trips for the morning peak is presented in Table 2.

**** Table 2 to be inserted here****

3. Design of the waterfront Area

3.1 Pedestrian infrastructure

As noted in Section 2.2, the waterfront Area was only accessible for the accredited guests and the personnel of the Organising Committee who had first passed successfully accreditation checks at transport mall gates and the security check at the passenger terminals. Pedestrian movement was allowed within this area, and specific attention had to be provided for pedestrians to be able to make all necessary movements in a safely way. Hence, a pedestrian footpath was designed alongside the waterfront, providing pedestrians with full accessibility to their accommodation (cruise-ships) and also to their exit from the area (passenger terminals).

3.2 Vehicle infrastructure and services

3.2.1 Internal Ring Road

Delivery vehicles, internal bus services, emergency service vehicles and vehicles of the Organising Committee were the only vehicles allowed to enter and move within the waterfront area and an internal ring road had to be designed to cater for the transportation needs within the waterfront Area.

The internal ring road followed a loop design, starting at the southwest end of the port (Kanellos sub-zone) and ending at its southeast (OTE sub-zone), where transfer to public transport was provided. The ring road was a two-way road, of 7.5 m width, with one lane per direction. The width of the designed road allowed for the movement of wide vehicles such as buses, heavy goods vehicles for delivering goods or fire brigade and first-aid vehicles.

The ring road passed close to the five Passenger Terminals, where specially designed bus-stations were foreseen. Such stations were foreseen also in front of the cruise-ships that were not close to the Passenger Terminal.

Additionally to the ring road, close to the passenger terminals of the Kanellos and Lion sub-zones a small number (34) of parking spaces was allocated in the likelihood of parking needs for emergency service vehicles and vehicles of the Organising Committee. Specially designed gates – the emergency vehicle gates – were located along the ring road close to each of the sub-zones, for the entrance and exit of these vehicles from the waterfront area to the transport mall areas.

3.2.2 Delivery vehicles

Providing accommodation for a large number of guests required services provided by delivery and garbage collection vehicles. These vehicles would also be using the internal ring road, but would not use emergency vehicle gates for their entrance and exit from the waterfront Area. The reason for this is that extra security was required for those vehicles while there was no need for them to pass through the transport mall areas before entering the waterfront Area, as no embarkation or disembarkation of passengers was involved. Generally, these vehicles provide completely different services from the emergency service vehicles and vehicles of the Organising Committee and were from different providers, hence their separation in terms of exit and entrance points and security checks was required. For this reason, one gate for entrance and exit was designed at the southwest side of the port, close to the Kanellos sub-zone, linking the internal ring road directly to the road network of Piraeus. Within the gate, a small area (20 x 10 m) was designed for the security checks of the vehicles.

3.2.3 Internal Bus Service

The provision of a means to transfer guests between locations within the waterfront area had to be made, and an internal bus service was planned. The internal bus operated only inside the waterfront area, using the internal ring road, and the bus-stops were located at passenger terminals and next to the cruise-ships, which are not close to passenger terminals. Guests could use it for their transfers between cruise-ships or between cruise-ships and passenger terminals, from which they could continue using other transport modes (i.e. taxis, shuttle bus rail service, parked passenger cars etc). Hence, the transfers that would be made using the internal bus service during the morning peak period comprised guest trips and trips made by the cruise-ship personnel. In general, the trips inside the waterfront area were made either by the dedicated bus service or on foot, and the following assumptions were made:

- 5% of the guests shall be using the internal bus service for transfers between cruise-ships.
- The cruise-ship personnel should not use the internal bus service during the morning and afternoon peak periods, and their working schedule shall be organised accordingly. However, 10% of the personnel are assumed to be using the internal bus service during peak periods.

The demand for the use of the internal bus service had to be estimated. Hence, based on the modal split (Section 2.2) and the aforementioned assumptions, the distribution of trips between the internal bus service and foot inside the waterfront area for each transport mode linking the Olympic Village to outside locations is presented in Table 3, and the estimated number of guests using the internal bus routes during the morning peak period is illustrated in Table 4.

**** Table 3 to be inserted here****

**** Table 4 to be inserted here****

The demand for the internal bus service was estimated to be 1.995 users per hour during this peak period. As a next step the characteristics of the internal bus service operation, including bus capacity, fleet size and service frequency had to be estimated. The time of one complete bus route was first calculated using as variables the anticipated vehicle mean speed (25km/h), the embarking and disembarking time in each bus stop (40s for all stops and 1min at the Telecom passenger terminal), and the distances between bus stops. The time needed for the internal bus to complete its route was calculated to be about 25 minutes. The frequency and hence fleet size for the internal bus service was estimated based on the following assumptions which are related to the level of service provided.

- The frequency of the bus arrivals should be such that stops do not become crowded.

- Passenger arrivals at bus stops are random; however the total demand does not produce any high variations.
- Bus occupancy is set to 80%.
- Two different types of buses may be used; one with capacity 100 passengers and another with 40.
- There should be two spare buses in the case of unexpected events.

The solution that was opted for was the use of 13 buses with capacity of 100 passengers instead of using buses of 40 passenger capacity the required number of which would have been 30, as the first solution postulated bus headways of 2.4 minutes instead of 0.95 which would not have been feasible.

3.2.4 Connection to rail system

The exploitation of alternative means of transport that operated in the vicinity of the Olympic Village and destined for the Olympic Games Venues was a prerequisite (Figure1). As the terminal station of the metro network of Athens is close to the area of the Olympic Village, a dedicated bus service that would transfer guests from the waterfront area to the rail terminal, would enhance the use of the metro service and would also improve comfort and safety for the transfers of those guests from the Olympic Village to the metro terminal. The terminal of this shuttle bus was located in the Telecom sub-zone (north-eastern end of the apron) and the number of guests anticipated to be using this service during morning peak period was estimated to be 3.495 guests. Returning from the terminal to the waterfront area, guests would first pass through the accreditation check at the transport mall area of the Telecom sub-zone and the security check at the respective passenger terminal. The transfers within the waterfront Area, to and from the Telecom passenger terminal, were provided by the internal bus service.

4. Design of the Parking Areas

4.1 Parking gates

The utility of the parking gates was to link parking areas with transport mall areas, hence in each parking gate one entrance and one exit gate segregated from each other were designed. Within this area, security controls were being performed at the entrance gate, and hence provision had to be made for dedicated areas where such checks would take place. At the exit gate vehicles were allowed to depart without any inspections, however vehicles were not allowed to enter. Therefore, special attention had to be given for the optimisation of the operation at the entrance gates.

Entrance through the entrance gates to the parking areas was only allowed to the drivers of the vehicles, as the rest of the passengers had already disembarked at the transport mall areas. This was decided in order to minimise the security control time and also to increase security in the area. In most cases, the drivers of vehicles entering the parking areas would be personnel (appointed or volunteers) of the Organising Committee.

The first step towards designing the parking gates was to estimate the demand for the entrance gate. To estimate the demand, the control strategies had to be defined. The control strategies mainly involved the possible number of check points for each vehicle category and the control duration; the latter was defined by the Organising Committee. Several scenarios were considered to cater for different needs in terms of vehicle fleet and security control strategies that depended on alternative scenarios of the guest numbers and categories. The designed capacity at the entrance parking gate and the security control strategies were identified and are presented in Table 5.

**** Table 5 to be inserted here****

The chosen design was evaluated and special arrangements were made in relation to offering efficient service at the parking entrance gates. The operational performance parameters that were investigated were the queue length and waiting times before passing the security control, the number of control points and the number of served buses and passenger cars. For estimation purposes, vehicle arrivals were assumed to be random, following the Poisson distribution. Furthermore, the queue system operated with two distinct queues; one formed by passenger cars and one by buses. The first vehicle in the queue would proceed to the next available control point of this vehicle category. As an evaluation tool the queuing theory was applied (Dshalalow, 1995) with the use of specialised software (Thomson et al., 2001) to calculate the sensitivity of the estimated parameters.

Furthermore, basic assumptions were made to estimate the performance of the parking gates.

- Typical dimensions: 2.9m x 12.0m for a bus and 2.0m x 5.0m for a passenger car.
- Required time for arrival completion: 3 hours for bus passengers and 5 hours guests arriving by passenger cars.

Generally, special attention was paid to designing the parking gates in such a way to cater for the maximum estimated queue lengths, so as not to disrupt traffic further upstream at the transport mall areas. For this reason, the maximum waiting time before passing the control was set to one hour. Taking into account the available space, the maximum allowable queue length was set to 110m for buses and 110m for passenger cars. Furthermore, the security control point capacity should not exceed the capacity of the parking area, in each of the sub-zones. Hence, the planning in terms of number and allocation of control points for each vehicle category in each of the sub-zone entrance gates during the arrival peak period as well as parameters that described the level of operation at the entrance gates were estimated. Those are illustrated in Table 6.

**** Table 6 to be inserted here****

4.2 Parking areas

Parking areas operated as areas where long-term parking was provided for vehicles serving the guests at the Olympic Village. Drivers entered inside the areas through the parking gates, after having passed successfully the security control at the gates.

In order to provide efficient infrastructure for the parking areas specific operation principles had to be adopted. These were:

- Avoidance of reverse manoeuvre by buses.
- Segregation of entering and exiting traffic flows.

- One-way corridors adjacent to bus parking spaces.
- Maximum utilisation of the parking area space.
- The design of the area should follow a rectangular gridline pattern aligned at least at one of the area sides.
- Comprehensive and clear road and parking space markings.
- Provisions should be made for the existing infrastructure of the area.

Furthermore, the following design principles for the parking spaces and corridors were also adopted:

- Typical vehicle dimensions: 2.9m x 12.0m for a bus and 2.0m x 5.0m for passenger cars.
- Typical dimensions parking space: 13.0m x 15.0m (in a 45^{o} angle) for a bus and 2.5m x 5.0m for a passenger car.
- Minimum accepted horizontal curve radius 25m.
- Minimum corridor width: 4.0m for buses and 3.5m for passenger cars.

The estimation of the allocated parking spaces in each sub-zone was made taking into consideration the available space and the number and category of the guests accommodated in each of them. The number of parking spaces along with the entrance parking gate capacity and the surplus of parking spaces are presented in Table 7.

**** Table 7 to be inserted here****

Wherever there was available space at the parking areas of each sub-zone, higher number of spaces than the gate capacity were planned to create a surplus of parking spaces. This was planned to cater for vehicle arrivals outside the morning peak period or for vehicles arriving from totally secured areas which did not have to pass through security checks. The design of the parking areas in each of the sub-zones was investigated separately and different characteristics were identified in relation to the location and specific arrangements of the different elements of the parking areas such as the parking spaces, corridors, and entrance and exit gates.

5. Design of the Transport Mall Areas

5.1 Transport Mall Gates

Transport mall gates served as connectors between the road network of Piraeus (areas outside of the Olympic village) and the transport mall areas. At the entrance gates the accreditation control of all vehicles and pedestrians would take place. Hence, only accredited guests were allowed to pass through the transport mall gates. At the exit gate vehicles were allowed to depart without any inspections, whilst the only operation performed was prohibiting vehicles to enter. Therefore, special attention had to be paid towards the optimisation of the operation at the entrance gates.

5.1.1 Vehicle Gates

Based on the alternative scenarios related to the guest numbers and categories that were accommodated in the Olympic Village, different scenarios were identified in relation to the vehicle fleet and the control strategies. Similarly to the parking mall gates, the capacity of the transport mall gates was estimated in relation to the space available and the same assumptions as in the case of the parking mall gates in relation to the vehicle dimensions, capacity and occupancy and the required time for arrival completion. A few additional assumptions were made for the design of the areas:

- Vehicle capacity and average occupancy: 50 and 35 passengers respectively for buses and 4 and 2 passengers excluding the driver respectively for passenger cars.
- Accreditation time for buses and passenger cars would be the same, and it was set to 15 s (240veh/hour).
- Taxis were not allowed to enter through the transport mall gates for security reasons.
- Vehicles that would not pass the accreditation control should exit from the gates without causing disruption to the vehicles entering through the entrance gates.

The entrance of vehicles through the transport mall gates had a distinct difference from the entrance through the parking gates. All vehicles appointed by the Organising

Committee (all accredited vehicles) to transfer guests from the Olympic Village entered through the transport mall gates, whereas only a proportion of these vehicles would pass through the parking gates. Hence the number of vehicles entering the transport mall gates was significantly higher than those entering through the parking gates. For this reason, transport mall gates were designed to cater for higher demand than the capacity of the parking entrance gates. The design of the entrance gates in terms of control points and gate capacity, for the estimation of which the same procedure as with the parking gates was adopted, is presented in Table 8.

**** Table 8 to be inserted here****

The estimated maximum demand at the transport mall entrance gates was equal to the maximum capacity provided to the parking areas in each of the five sub-zones. The calculations indicated that the proposed design would achieve no formation of queues at the gates for the 95% of the arriving vehicles. Subsequently, there was no need for the implementation of an additional dedicated area for vehicles waiting to enter the Olympic Village.

5.1.2 Pedestrian Gates

Additional to the vehicle entrance gates, provisions were made for guests arriving to the Olympic Village on foot. Those guests would pass through accreditation and security control before entering the Olympic Village. It was decided to have these two checks conducted in separate locations, to increase design efficiency. Security control took place for all guests at the passenger terminals, and accreditation control had to be performed once entering the area, as in the case of vehicles in the transport mall gates, and subsequently specially designed pedestrian gates were implemented at the transport mall entrance gates.

The critical parameters for the design of the pedestrian gates were the number of guests arriving at the Olympic Village on foot, the duration of the morning peak period and the accreditation control time, based on which the necessary width of the entrance and exit gates was estimated to be 3 meters per gate. The design was tested against the maximum demand of pedestrians entering the gates, and was proven to be efficient for the needs of the Olympic Village.

An additional operation of the pedestrian gates, which was of crucial importance, was the area for evacuation in cases of emergency. Hence, efficient design of the gates, in terms of capacity, would make provision for fast evacuation of the Olympic Village. A number of parameters were included in the estimation of the evacuation times. These were:

- The total number of individuals in the area involves the guests, cruise-ship and emergency personnel and the personnel of the Organising Committee.
- The arrival and departure of all guests is completed within 5 hours and 3 hours respectively.
- Mean pedestrian flow rate is 23 persons per minute per meter (level of service B) and in cases of emergency 82 persons per minute per meter (level of service E).
- Width of the pedestrian entrance and exit gate is 3 m for each.
- In cases of emergency a section of the road (3 m) will also be used for the evacuation of the transport mall area.

The proposed elements of the pedestrian gates were calculated to be sufficient for the anticipated pedestrian movements. The evacuation times under the proposed design were estimated for each of the sub-zones and are presented in Table 9.

**** Table 9 to be inserted here****

Estimated results (Table 9) indicate that the evacuation in case of emergency of all people at the Olympic Village through the transport mall pedestrian gates would be accomplished within 8.29 minutes which constitutes a quite satisfactory evacuation time. It must be noted that this time only describes the performance of the pedestrian gates, and does not include the time needed for people in the different areas of the Village to walk towards the gates.

5.2 Transport Mall areas

The Transport mall areas were areas for short-term parking, and hence vehicles entered from the road network of Piraeus through the transport mall gates, passengers embarked or disembarked in those areas, and vehicles then departed from the area, through the transport mall gates for destinations outside of the Olympic Village or through the parking gates to the parking areas. The entrance to the transport mall areas was allowed for all vehicles that had passed successfully the accreditation control.

The number of spaces required in the transport mall areas had to be at least equal to the number of vehicles entering through the transport mall gates minus those entering the parking areas. Additionally, provisions were made for a number of parking spaces (5% of the total) for vehicles transferring people with special needs and for the introduction of the necessary sidewalk arrangements (increased pavement width and ramps). No provisions were made for taxi spaces as taxis were not allowed to enter the area for security reasons. The estimation of the available space for the parking spaces included as parameters the design of the road network and the design of a parking space. The design of the road network in the transport mall areas should adopt the same design principles to those used for the design of the parking areas. Additionally to those, specific principles were adopted to meet the needs of pedestrian movement in the area. These are:

- Provision of pedestrian infrastructure such as pavements and footways to cater for the pedestrian movements. This led to the allocation of a 5 meter pavement wide next to the passenger terminal and a 3 meter pavement wide next to the bus parking spaces.
- Minimisation of the walking distance from the parking areas to the passenger stations.

Finally, the design of the specific characteristics and allocation of parking spaces in the transport mall area were also defined based on the same assumptions as those used for the design of the parking areas. The only difference involved the alignment of the bus parking spaces, which was designed in such a way to allow for bus movements being performed without any rear movement being necessary

Taking into account these principles, the available space in each sub-zone and the minimum required capacity of the transport mall areas, the parking spaces allocated in each transport mall sub-zone were estimated and are presented in Table 10.

**** Table 10 to be inserted here****

Each of the five sub-zones was also investigated separately to identify the different elements of the transport mall areas in relation to their location and specific arrangements.

6. Implementation and Operation

The transportation scheme for the Olympic Village was finalised in summer 2002, two years before the Olympic Games. However, the implementation of the plan took place in several stages, as not all required areas were available for use in the summer of 2002. These areas became gradually available, and the related infrastructure was developed accordingly. The works were intensified in early 2004, some months before the start of the Olympic Games and were ready on time in August 2004. Several modifications to the proposed scheme were necessary following the updated requirements (the actual number of guests was gradually becoming known) and new particularities of the area, which were identified during the implementation stage. However, all the design principles set and presented in the previous Sections remained unchanged. A bird's eye view of the western part of the Olympic village is illustrated in Figure4.

**** Figure 4 to be inserted here****

In parallel, a detailed traffic and management plan was developed, designed to accompany the transportation scheme of the Olympic Village. Consequently, the success of the implementation of the transportation scheme was also a result of the appropriate systematic enforcement of the proposed traffic and parking rules both inside the Olympic Village but also in the neighbouring areas.

Another success factor of the proposed transportation scheme was the securing of the capacity of the neighbouring road network (Piraeus in the examined case). All relevant infrastructure improvements as well as all traffic and parking management arrangements in the Piraeus road network were implemented on time, as part of the overall Olympic transportation system. These improvements involved providing priority to public transport, operation of “Olympic lanes” (road lanes dedicated for the exclusive movement of Games related vehicles), parking restrictions and massive public information campaigns.

Several other issues of less importance were encountered and tackled, concerning the Greek legislation on cruise-ships, the need for adopting higher security standards and subsequent changes in the cruise-ship berthing positions. It is noted that the initial demand forecasts were not fully confirmed and some transportation elements were over or under-estimated. However, special management adjustments by the Organising Committee as well as the quick adaptation of the guests' behaviour to the provided infrastructure and services (already from the second day of the Games) resulted to a successful operation of this Olympic Village. The scheme, implemented on the basis of the above presented design, met successfully the needs of the Olympic quests. The frequency and passenger capacity of the internal bus service as well as the service and capacity of parking and transport mall areas met the standards set and no significant queues and delays were observed.

7. Conclusion

The present study deals with the design of the different transportation elements of one of the Olympic Villages, located at the Central Port of Piraeus (exclusively passenger port), which served the Athens 2004 Olympic Games. Serving successfully such a large number of Olympic guests with high transportation demand peaks (to and from the Olympic venues) is a great challenge for transportation planners, especially when the final transportation demand cannot be precisely defined well in advance.

Within this study an integrated scheme for traffic and parking arrangements in the Olympic Village is proposed, comprising a common secure area (apron or waterfront area), five distinct secure parking areas with respective control gates and five distinct transport mall areas with respective vehicle and pedestrian control gates connecting the various areas of the Olympic Village between them. For the design of all sub-systems of the integrated transportation scheme, a series of assumptions, standards and calculations was used, which proved to be meeting the real needs of Olympic guests and could hence be used in other similar cases. The final implementation of the proposed integrated scheme together with the special transportation management measures resulted in a high level of service offered to the Olympic guests during the Athens 2004 Olympics. Given its success, this scheme could be used as an example in other similar cases being supported with appropriate adjustments to the specific prevailing conditions.

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Table 1. Guest Category and Number in Each Sub-Zone

Sub-zone	Cruise-ship	Guest category	Guest number
Kanellos	CS1	National Olympic Committees	2 034
	CS2	National Olympic Committees	1 308
Lion	CS3	Intern. Federations	490
	CS4	Intern. Federations	490
	CS5	Sponsors	1 804
Central	CS6	Media	1 186
	CS7	Sponsors	832
	CS8	Sponsors	1 928
Customs	CS9	Spectators	1 196
	CS10	Spectators	854
Telecom	CS11	Spectators	1 308
TOTAL			13 430

Table 2. Modal Split for Trips Departing from the Olympic Village (Morning Peak -3h)

Sub-zone	Cruise-ship	Buses	Passenger Cars	Pedestrians	Railway
	CS1	66.0%	13.0%	9.9%	11.1%
Kanellos	CS2	66.0%	13.0%	10.0%	11.1%
	CS3	57.1%	16.1%	10.0%	16.7%
	CS4	57.1%	16.1%	10.0%	16.7%
Lion	CS5	60.1%	16.2%	10.0%	13.7%
	CS6	50.2%	7.6%	9.9%	32.3%
	CS7	52.0%	7.8%	10.0%	30.2%
Central	CS8	52.0%	7.8%	10.0%	30.2%
	CS9	32.4%	12.5%	9.9%	45.2%
Customs	CS10	32.4%	12.5%	10.0%	45.1%
Telecom	CS11	42.8%	13.5%	0.0%	43.7%
TOTAL		52.9%	12.1%	9.0%	26.0%

Table 3. Distribution to Bus Passengers and Pedestrians for Trips Departing from the Olympic Village (Morning Peak -3h)

Sub-zone	Cruise Ship	Buses		Passenger Cars		Pedestrians		Railway		TOTAL	
		Bus	Peds.	Bus	Peds.	Bus	Peds.	Bus	Peds.	Bus	Peds.
Kanellos	CS1	863		170		130		145		1308	
	CS2		1342		264		203	225		225	1089
Lion	CS3		280		79		49	82		82	408
	CS4		280		79		49	82		82	408
	CS5		1085		292		180	247		247	1557
Central	CS6	595		90		118		383		1186	
	CS7		433		65		83	251		251	581
	CS8		1002		151		192	583		583	1345
Customs	CS9		388		149		119	540		540	656
	CS10		277		107		85	385		385	469
Telecom	CS11		560		176				572		1308
TOTAL		1458	5647	260	1362	248	960	2923	572	4889	8541

Table 4. Internal Bus Service Demand (Morning Peak - 3h)

Type of trip	Number of users
Towards passenger terminals	1 966
Towards the Railway station	2 923
Internal guests trips (5% of the no of guests)	606
Cruise-ship personnel trips (10% of the personnel)	489
TOTAL	5 984

Table 5. Parking Entrance Gates Characteristics

Sub-zone	Capacity at arrival peak	
	Bus (3h)	Passenger Car (5h)
Kanellos	41	134
Lion	23	199
Central	45	134
Customs	9	128
Telecom		88
TOTAL	118	683
Security control time (min)	6	4

Table 6. Parking Entrance Gate Operational Performance Parameters

Sub-zone	Control Points		Capacity at arrival peak		Max Queue Length (m)		Max waiting time (min)	
	Bus	Pass. Car	Bus (3h)	Pass. Car (5h)	Bus	Pass. Car	Bus	Pass. Car
Kanellos	2	2	41	134	75	110	16.5	40.5
Lion	1	3	23	199	100	110	56.4	25.2
Central	2	2	45	134	100	110	24.3	40.5
Customs	1	1	9	64	12.5	77	9.5	59
		1		64		77		59
Telecom		1		37		16.5		13.2
		1		51		27.5		24
TOTAL	6	11	118	683				

Table 7. Parking Space Allocation at the Parking Areas

Sub-zone	Parking gate capacity		Parking Spaces		Surplus	
	Bus	Pass. Car	Bus	Pass.Car	Bus	Pass.Car
Kanellos	41	134	41	148	0	14
Lion	23	199	45	286	22	87
Central	45	134	50	247	5	113
Customs	9	128	9	241	0	113
Telecom		88		88		0
TOTAL	118	683	145	1010	27	327

Table 8. Transport Mall Entrance Gate Characteristics

Sub-zone	Maximum demand		Control Points		Capacity at arrival peak	
	Bus	Pass. Car	Bus	Pass. Car	Bus (3h)	Pass. Car (5h)
Kanellos	63	217	1	1	576	960
Lion	47	225	1	1	576	960
Central	58	153	1	1	576	960
Customs	19	128	1	1	576	960
Telecom	16	88	1	1	576	960
TOTAL	203	811	5	5	2880	4800

Table 9. Guest Evacuation Times at Transport Mall Gates

Sub-zone	Guests	Cruise-ship Personnel	Emergency personnel	Total no of people	Evacuation time (min)
Kanellos	3342	1671	167	5180	7.02
Lion	2784	1392	139	4315	5.85
Central	3946	1973	197	6116	8.29
Customs	2050	1025	103	3178	4.31
Telecom	1308	654	65	2027	2.75
TOTAL	6715	6715	672	20817	

Table 10. Parking Space Allocation at the Transport Mall Areas

Sub-zone	Bus	Pass. Car	Vehicles for people with special needs
Kanellos	22	83	5
Lion	24	26	2
Central	13	19	1
Customs	10	1	1
Telecom	16	1	1
TOTAL	85	130	10

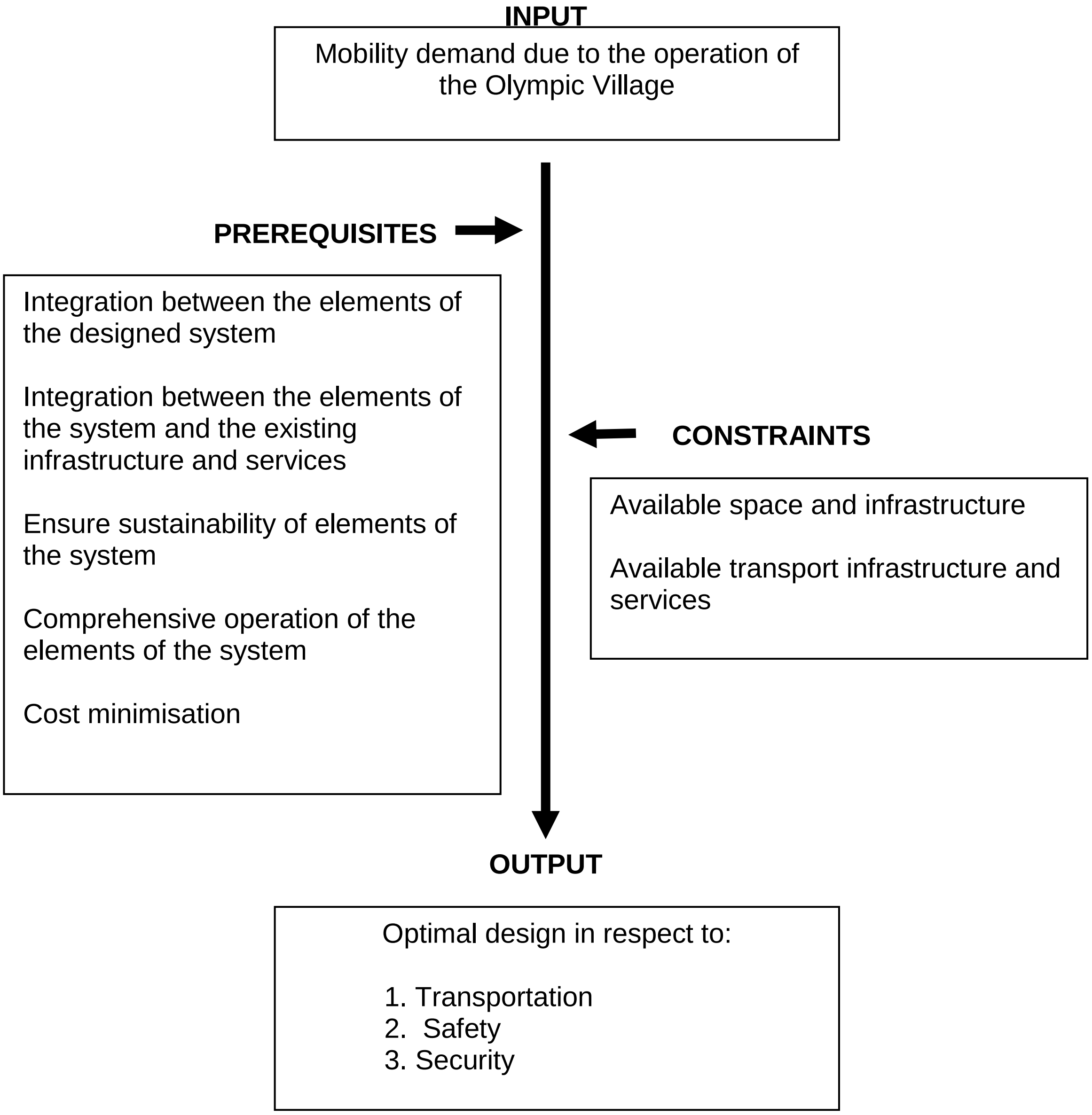

Figure1. Core axis for the design of the transportation scheme

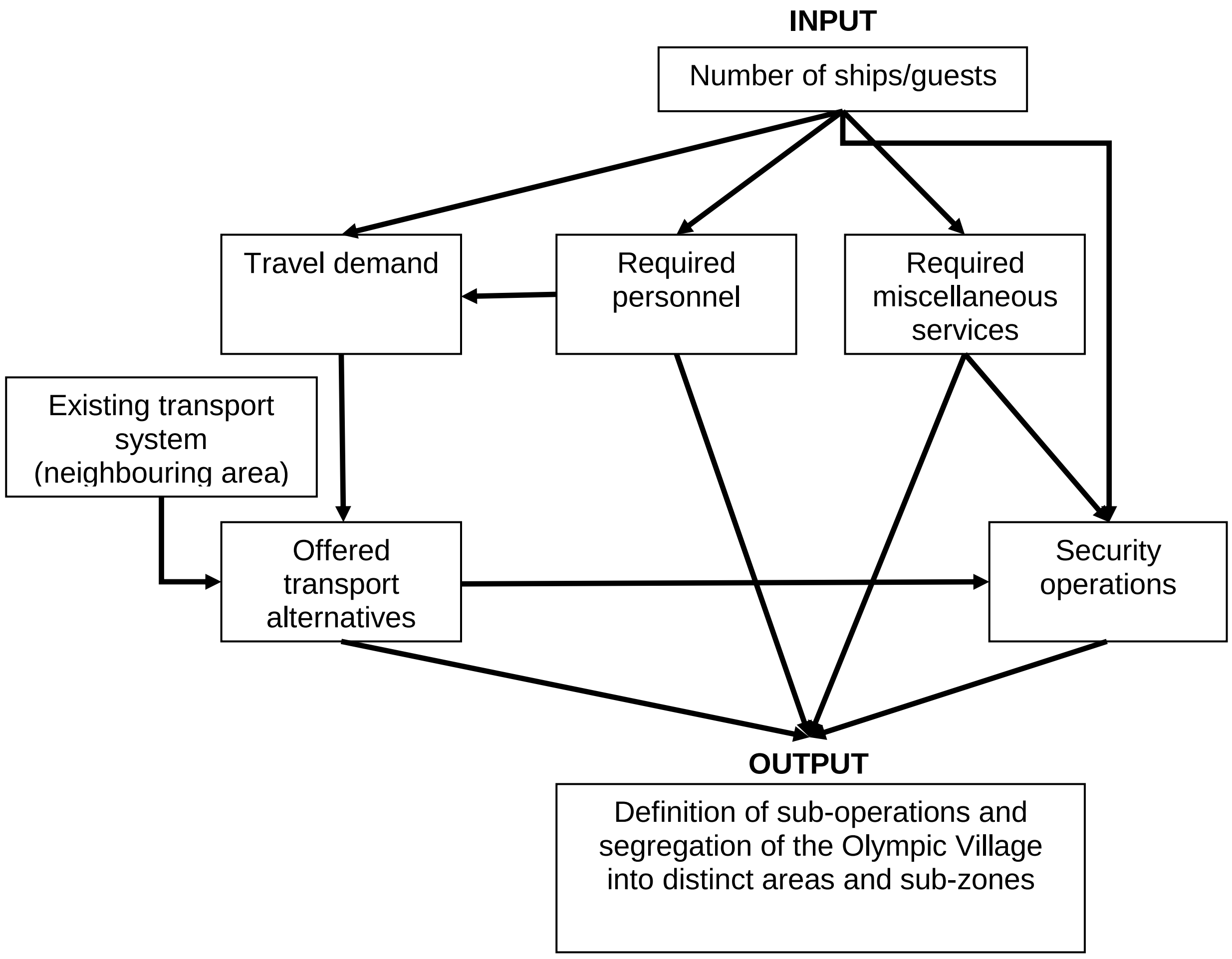

Figure2. Methodology towards the design of the operations in the Olympic Village

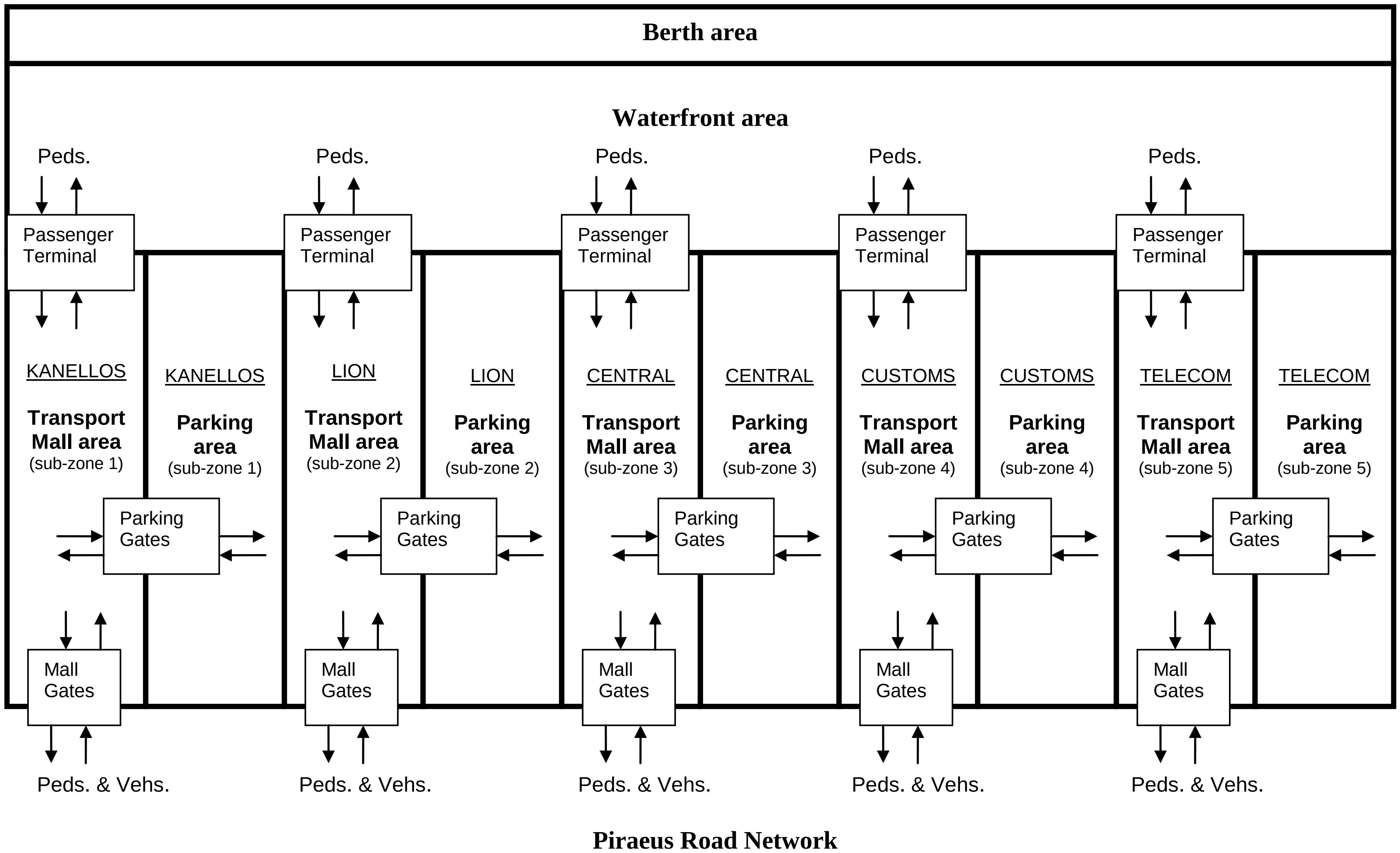

Figure3. The Areas, sub-zones and their respective connectors in the Olympic Village

Figure 4. Bird-eye view of the Kanellos area and its sub-zones