«ACCESS MANAGEMENT AT PEAK HOURS ON AN INTERURBAN CORRIDOR UNDER CONSTRUCTION.

THE CASE OF "KORINTHOS-PATRA" SECTION OF OLYMPIA ODOS"»

Gerasimos Koklas[1], Kostas Papandreou[2], Yannis Handanos[2]

[1] Ministry of Infrastructure, Transport & Networks, Special Service of Public Works /Concession Projects Operation & Maintenance, Panormou 70, 11523 Athens, Greece

[2] Olympia Odos Operation S.A., Nea Peramos Interchange, South Service Road, 19006 Nea Peramos Attica, Greece

1. Introduction

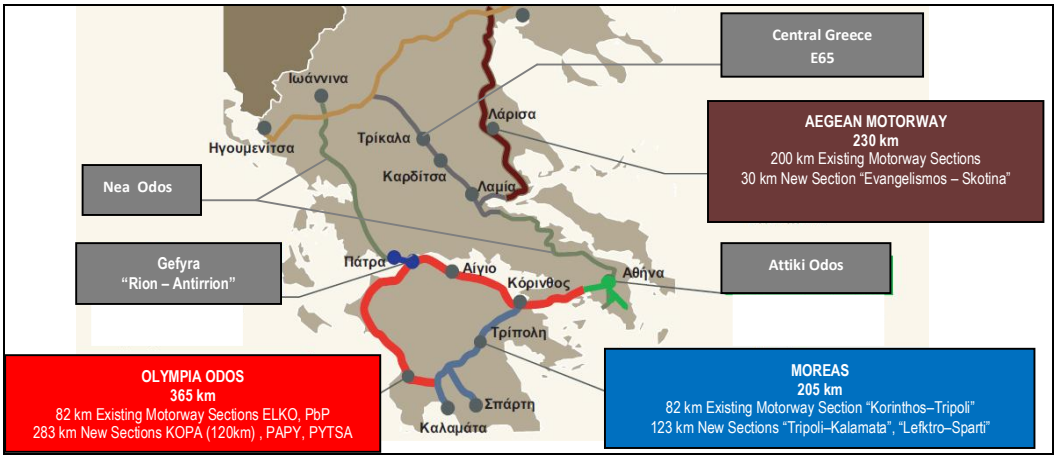
The paper presents operational practices for access and traffic management implemented on an interurban road section 120 km long, the "Korinthos-Patra" (KOPA) section of Olympia Odos, which is under-construction/ upgrade to a new motorway while operating at the same time. The coexistence in limited space of the construction activities together with traffic in combination with the high fluctuations of traffic demand presented on said corridor during the year (seasonal, holidays, weekend traffic) raises a number of issues which have to be considered and designed accordingly from operational as well constructional point of view.

Chapter 2 provides a brief description of the Olympia Odos project. In Chapter 3 a specific description of KOPA follows, including KOPA's geometrical characteristics, tolling regime, work zones and implemented traffic arrangements. In Chapter 4, the need of developing specific access/traffic management plans for the peak hours is explained, analyzing the capacity of critical cross sections and the peak traffic demand both at KOPA and the alternative routes and finally the design and implementation of this plan for the period of Easter, which represents the highest annual peak period for the corridor, is presented. Chapter 5 summarizes the main conclusions from the above analysis.

2. General Description of Olympia Odos

2.1 The Project

Olympia Odos is one of the Motorway Concession Projects, nowadays in Greece (see red line in the map below).



It includes existing as well as new –under construction- sections. When completed it will be a 365 kilometers long motorway including 82 kilometers of existing motorway sections and 283 kilometers of new sections. More specifically Olympia Odos includes the following sections:

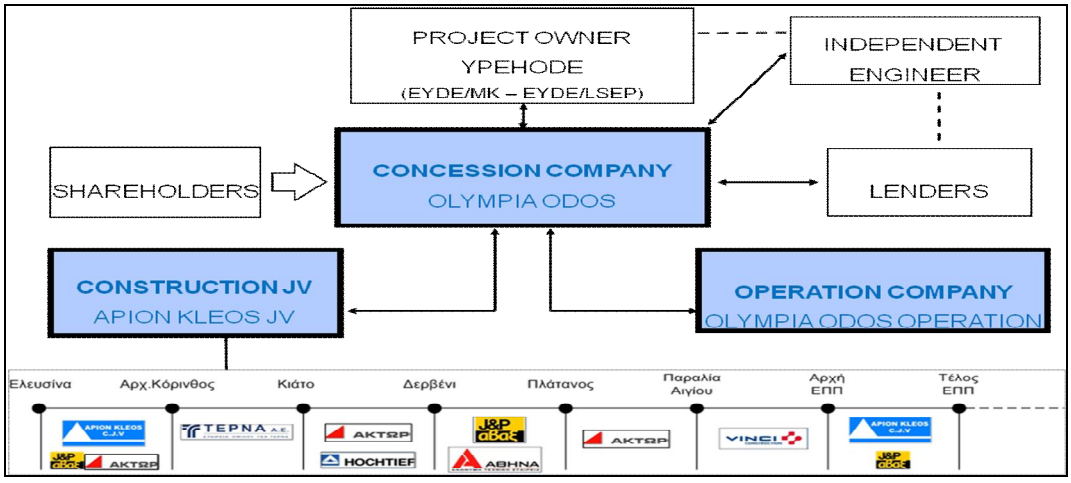
- **"Elefsina – Korinthos" (ELKO)**, which is a 64 km existing motorway section, with 3 lanes and emergency lane per direction, including the Kakia Skala complex of tunnels with 4.5 kilometers total length and 2 big toll plazas at Elefsina and Isthmos. ELKO has an Average Annual Daily Traffic (AADT) of 30,000 vehicles per direction which may exceed 70,000 during peak periods.

- **"Korinthos – Patra" (KOPA)** is an existing 40 years old operating interurban corridor, 120km long, with 1 lane and shoulder per direction, with poor geometric characteristics, mostly undivided, and high accident rates in the past. KOPA traffic in ADDT terms varies from 7,500 to 11,000 vehicles per direction depending on the section and may exceed 30,000 during special peak periods (summer holiday traffic, weekends). In the frame of the concession, KOPA is currently under construction in order to be upgraded to a new motorway with 2 lanes and emergency lane per direction.
- **"Patra by Pass" (PbP)**, which is an 18 kilometers existing motorway section with 2 lanes and emergency lane per direction, including a complex of tunnels of 4.7 kilometers total length. PbP has an AADT of 8,000 vehicles per direction which may exceed 15,000 during peak periods.
- **"Patra - Pyrgos – Tsakona"**, which is a 163 kilometers new "green-field" under-construction section.

From the above sections, KoPa constitutes a very specific case of particular interest in access and traffic management terms. More specifically, nowadays extensive construction work are under way on the existing carriageway or adjacent to it, all along the 120km of its length, with simultaneous operation.

2.2 The Contractual framework

The operation of the existing road sections has been undertaken by Olympia Odos Operation SA (Operator), by virtue of an operation & maintenance agreement with the Concessionaire company Olympia Odos SA. The Operator is supervised by a Special Agency of the Ministry of Transport, Infrastructure and Networks, (EYDE/LSEP). Through a parallel construction agreement with the Concessionaire, the Construction Joint Venture "Apion Kleos" (Constructor), has undertaken the refurbishment of existing sections and the construction of the new sections of the Motorway, which is divided to a number of geographic units where different allottees are responsible.



3. "Korinthos-Patra" New National Road

3.1 Road characteristics

KOPA was constructed at the late 60's, serving as the New National Road (NNR) connecting the Greek capital of Athens with Patra, which is the third biggest city of the country and the main gate to West Europe through its port, as well as with all the cities and villages in-between which act both as permanent residence but also as country houses for many inhabitants of the capital. It starts from Ancient Korinthos I/C (k.p. 87+480) and ends at Rio I/C (k.p. 206+310) including 9 more I/C in between, as shown in the following map.

The typical cross section of KOPA, with no median for most of it length, is one lane per direction of 3.75 meters wide with an asphalt paved shoulder 2.50 meters wide, which operates mostly as an auxiliary lane, used mainly by heavy vehicles and/or slow moving traffic, thus leaving room for overtaking where possible (in sections with relatively more appropriate characteristics).

There are also some isolated sections of about 30 km out of the total length of 120 km with dual carriageway, mainly at the area of the interchanges, which have 2 lanes and emergency lane per direction. Construction works are carried out though along the entire KOPA, either of single or dual carriage way cross section.

1 lane and shoulder per direction

No median

2 lanes and shoulder per direction

With median

3.2 Toll Stations

There are two frontal unidirectional toll stations, one at each direction, located at the two extremities of KOPA section. The first one in direction to Patras is at k.p. 94+600 at "Zevgolatio" area, while the second one in direction to Korinthos is at k.p. 205+300 at "Rio" area. Each of them has totally 6 toll lanes, 5 manual with toll collectors and 1 electronic lane.

3.3 Work Zones

According to the Concession Agreement, the KOPA section of the new motorway has to be constructed within a very short period of time, making necessary the development of a great number of work sites on and adjacent to the existing NNR, as the new alignment provides widening of the existing road on one or the other side or even on both sides, as well as the construction of numerous technical works in order to meet the necessary standards of the motorway, including intersections, 12 tunnels and cut & covers (16km in total length), 11

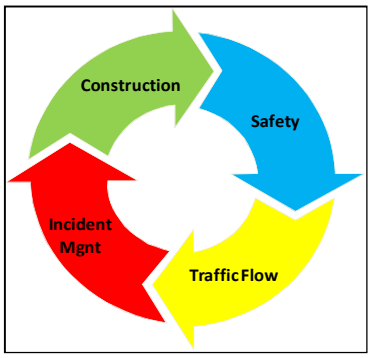
over and 267 under passes, 15 bridges, 101 culverts and flood preventing ditches, extensive retaining walls and earthworks.

The worksites are developed simultaneously all along the 120 km of KOPA, most of them in close vicinity to traffic and very often occupying part of the existing carriageway, thus creating the need for the implementation of relevant traffic arrangements, affecting the capacity of the road, which results to subsequent significant problems from the operation point of view, especially during peak hours.

It has to be mentioned that the selected alignment, which means construction works next to the existing NNR, as described above, creates adverse conditions for the operation of the road for a number of reasons. First of all the capacity of the road is reduced, creating problems to the traffic flow, which become more significant during peak hours, causing delays to the road users. On the other hand, traffic signing needs constant monitoring both for maintenance reasons as well as adaptation to the continuous changes of the adjacent worksites. Furthermore, the maintenance works of the road, i.e. cleaning, grass cutting, replacement of damaged barriers etc., often require the full closing of the road, as no adequate number of lanes is available, in order to accommodate both traffic and the maintenance works.

Traffic Arrangements

The applicable traffic arrangements should take into account and accommodate multiple parameters at the same time, sometimes conflicting with each other:



- Provide the necessary space for the safe execution of works within the contractual deadlines
- Ensure safety for traffic and construction activities in a very unfavorable road environment due to the bad past experience in terms of road safety
- Maintain as much as possible a minimum level of service to traffic, in terms of capacity and traffic fluidity both during off peak and peak hours
- Taking into account the limited available space for traffic, especially in the vicinity of the work zones, the traffic arrangements should accommodate incident management needs, for quick response and limitation as much as possible of the impact to traffic in case of incident

It is noted that all the above objectives cannot be accommodated always at the same level. Depending on the conditions, the level of service of traffic flow is the only parameter which may be partially discounted at the expense of constructability and safety, which are always prevailing, in order to solve the above puzzle.

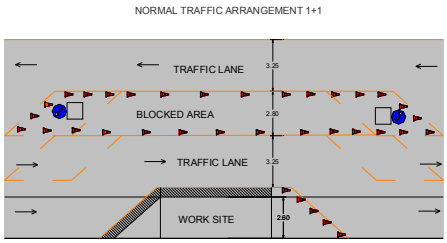
The selection of the cross-section to be implemented takes into account many contributing factors, such as: the construction requirements, the sequence, type and length of traffic arrangements, the expected traffic conditions, including seasonality and traffic peaks and the eventual special local conditions.

Up to now, excluding some cases where temporary local narrowing of the shoulders or traffic lanes has taken place, two major types of long term traffic arrangements have been implemented as described below.

2+1/1+2 type

Special effort is made in coordination with the Constructor and the Public Services in order to implement this type of traffic arrangement in the longest possible part of KOPA. More specifically "2+1" traffic arrangement is implemented in areas with higher traffic and/or where the alternative route is of limited capacity and of course under the condition that the required width is available.

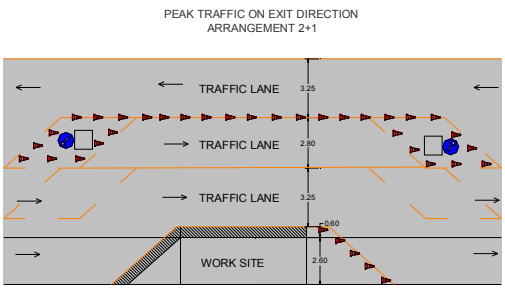
This arrangement practically ensures carrying out works on a net width of 2.60 m (larger than the area which may be used by closing the emergency lane) and is based on arranging the traffic of each section in question in 3 lanes (3.25 + 2.80 + 3.25 = 9.30 m) starting in each direction with a flashing arrow (FLR) as shown below:

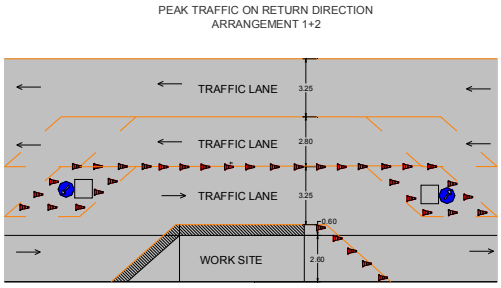


The three lanes are marked with continuous yellow lines (prohibition of overtaking) and are available to traffic as follows:

- during weekdays and low traffic weekends the edge lanes (3.25 m wide) are available to traffic (i.e. 1 lane per direction, like "tube") and the middle lane (3.0 m wide) is closed with a double row of cones in each side (as closed buffer area).
- from Friday noon until Sunday morning, as well as during peak traffic periods in direction to Patra, the middle lane becomes available to traffic in direction to Patra, thus providing an arrangement of 2+1.
- from Sunday morning until Monday morning, as well as during peak traffic periods in direction to Athens, the middle lane becomes available to traffic in direction to Athens, thus providing an arrangement of 1+2.

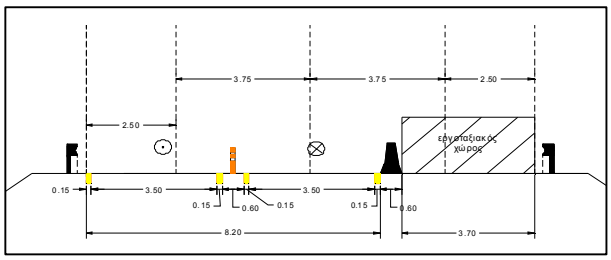
The previous apply accordingly in case of peaks of the holiday period (e.g. Christmas, Easter etc.).





<u>1+1 type (with lay-bys)</u>

However, in most cases and depending on the nature and the location of the works, the available width for traffic doesn't allow for 1+2 type traffic arrangements. In these cases only one lane per direction is provided, with a light mean of visual separation (bollards) in between, which can be easily moved in case of incident/blockage of traffic. An indicative photo of the above arrangement as well as its typical cross section are shown below:



It is obvious that the work zones, especially those of "1+1" type, further to the zone management requirements due to the changing conditions of operation and construction and the needs for equipment maintenance (damaged bollards and safety barriers), cause significant problems to traffic management. Most of the incidents are immobilized vehicles and obstacles, while more serious traffic accidents, quickly lead to blockage of traffic and

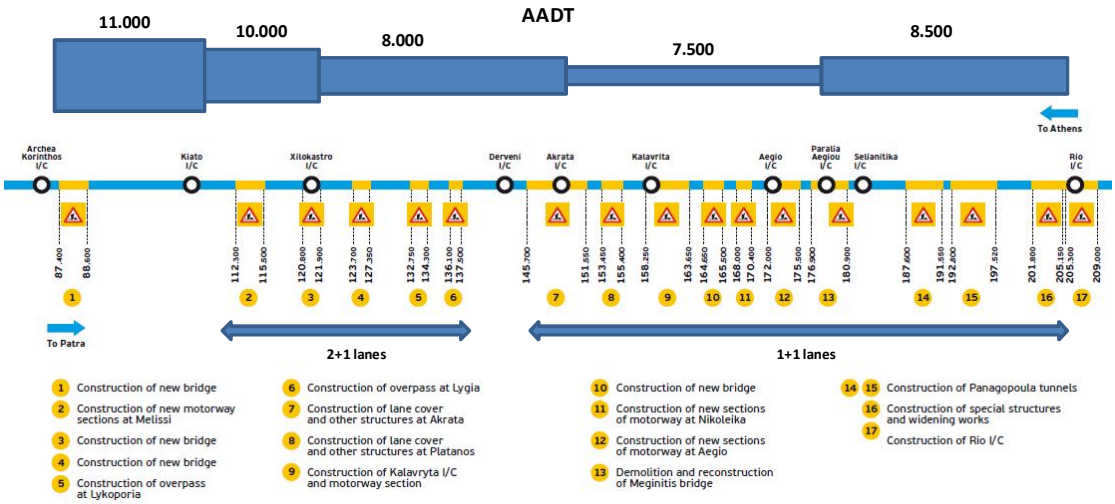
thus to extensive congestion. Factors that encumber such incidents are the high traffic volume and the bad weather conditions.

In order to accommodate incident management in all above sensitive areas, especially in the sections with 1 lane per direction, specific measures have been applied, such as

- Lay-bys about 30 m long every 500 m for moving immobilized vehicles (car or truck) and clearing quickly the carriageway in case of incident.
- A special SOS 4-digit number (1025) connecting to the corresponding Traffic Management Center has been put to operation, in order for the users to provide quick and immediate notification about problems that may have occurred inside these narrow zones and thus resulting to total blockage of traffic.
- Intensification of the patrolling and road assistance services at the vicinity of these sensitive areas
- Specific emergency plans have been agreed and set up among the implicated parties (Operator, Police, Fire Brigade, Ambulances) for the specific areas, including intervention access routes, diversion routes and relevant traffic management plans in case of incident.

In any case, the above traffic arrangements, safely delimit the areas where works are carried out, but they strangulate traffic and require constant support by the mechanism of the responsible Constructor (Allottee), the Traffic Police and the Operator's participation.

The following synoptic illustrates the current situation regarding the work zones already implemented along the entire KOPA section:



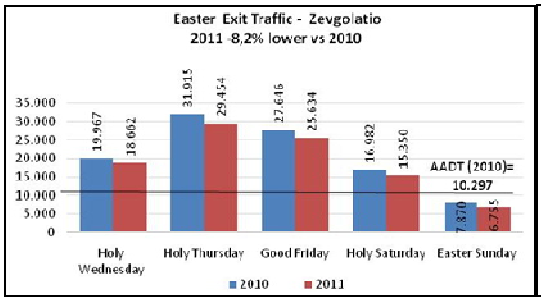
In brief, on the eastern sub-section "Ancient Korinthos-Derveni", where the average annual daily traffic is more significant, traffic arrangements of variable cross-section "2+1" are implemented, as the required width was available. On the western sub-section "Derveni-Rio", where traffic is lower on average, as a significant part of traffic exits at the cities of Kiato and Xylokastro, traffic arrangements of constant cross section of "1+1" type are implemented. All the above traffic arrangements together, represent approximately 40% of the total length of KOPA (48 km out of 120 km).

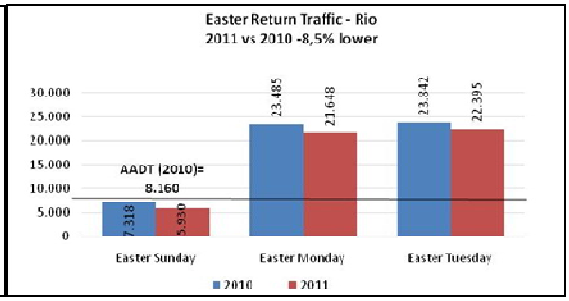
4. Access management at peak periods.

4.1 Peak Traffic of Easter and the Necessity of specific access management plan

Greek Easter represents for Olympia Odos and at national level one of the periods of the year with high traffic load. Similar traffic conditions are observed also during specific weekends, bank holidays and summer holidays. On such days traffic reaches peaks 3 times higher than on an average day (AADT). The following diagrams present the daily traffic during the mass

exit and return traffic of Easter against the ADDT as recorded at the toll stations of Zevgolatio and Rio for the outbound and inbound peaks respectively.





Despite the extensive development of the work zones all along the corridor, KOPA operates at an acceptable level of service in terms of traffic fluidity and journey times, during normal working days or low traffic weekends, are maintained at a relatively satisfactory level compared to the past, before the implementation of the work zones. In particular, the journey time for the entire KOPA (120 km) before the works was approximately 80 minutes (with an average speed of 90 km/h), while after the implementation of the traffic arrangements presented above it has reached approximately 100 minutes (20 minutes delay), that is an average speed of 72 km/h, 60 km/h in the working zones and 90 km/h in the sections without works.

However, the traffic conditions on KOPA cannot remain the same during high traffic peak periods of massive exit and return from/to the capital before/after special holidays and weekends, when traffic demand for many hours is more than 3 times higher than the peak traffic of a typical day. For such periods there is a need for special access and traffic management measures in order to avoid uncontrolled deterioration of the LOS, which would lead to absolute chaos.

4.2 Peak Traffic Demand versus Capacity at critical locations

In order to realize the magnitude of the problem that can appear during peak periods on KOPA, it is necessary to examine the available traffic capacity of the critical cross-sections of the road network and whether it is adequate to accommodate the expected traffic demand of peak periods. It is obvious that in those cross-sections where traffic capacity is less than the traffic demand, access and traffic management plans have to be implemented in order to accommodate at the best possible level this excessive traffic.

The traffic capacity of KOPA depends on the capacity of its critical cross-sections. Such critical cross-sections consist of

- the two pre-existing old small toll stations, Zevgolatio and Rio, at both extremities when entering KOPA, from Korinthos or Patras side respectively and
- the traffic arrangements implemented in the work zones along KOPA, reducing the capacity of the road and thus restricting traffic.

More specifically, concerning the **Toll Stations**:

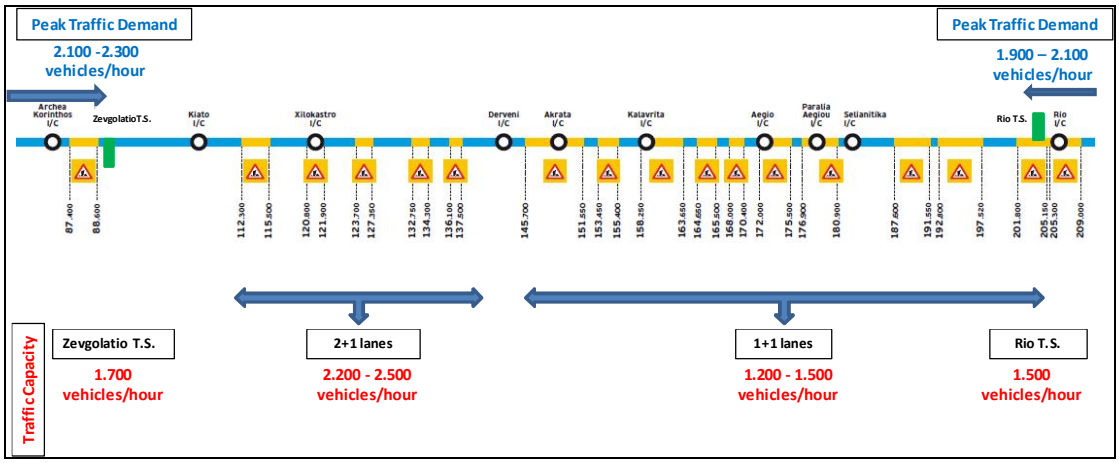
- In direction to Patra, Zevgolatio toll station at kp 94+600 operates with 5 manual toll collection lanes and 1 electronic lane and can serve as maximum 1,700 vehicles per hour.
- In direction to Athens, Rio Toll Station at kp 205+300 operates with 5 manual toll lanes and 1 electronic lane, and the capacity reaches 1,500 vehicles per hour, relatively lower than Zevgolatio, because of the lower level of electronic users.

Concerning the **Work Zones** and the relevant traffic arrangements:

- In the eastern section, from k.p. 87+600 (Ancient Korinthos interchange) up to k.p. 145+700 (a little after Derveni interchange), the existing traffic arrangements of "1+2" type can accommodate at peak hours (with the proper shifting of cones in order to provide 2 lanes to the peak direction and 1 lane to the off peak direction) a maximum traffic of 2,200-2,500 vehicles/hour on the peak traffic direction.

- In the western section, from k.p. 145+700 (i.e. the start of the first work zone, a little after Derveni I/C) up to k.p. 208+200 (i.e. the end of the last work zone), in the area of the entrance to Patra and up to "Harilaos Trikoupis" Bridge, where several working zones of "1+1" type are implemented, the capacity is limited varying from 1,200 to a maximum of 1,500 vehicles/hour depending on the local geometry, the particularities of each work zone, the weather conditions and the composition of traffic.

On the other hand the traffic demand from Korinthos to Patra (traffic entering KOPA from the east side) during the peak hours of mass exit reaches 2,100-2,300 vehicles per hour, while in the opposite direction during the return period traffic demand reaches 1,900-2,100 vehicles per hour.



On both directions, the first critical bottleneck location is at the toll stations, each one serving approximately 400-600 vehicles less than the real demand. Other candidate locations strangling traffic, downstream of the toll stations, are the working zones of "1+1" type which limit the capacity of the corridor to 1,200-1,500 veh/hour, which is at a lower or marginally at the same level like as capacity upstream of the toll stations.

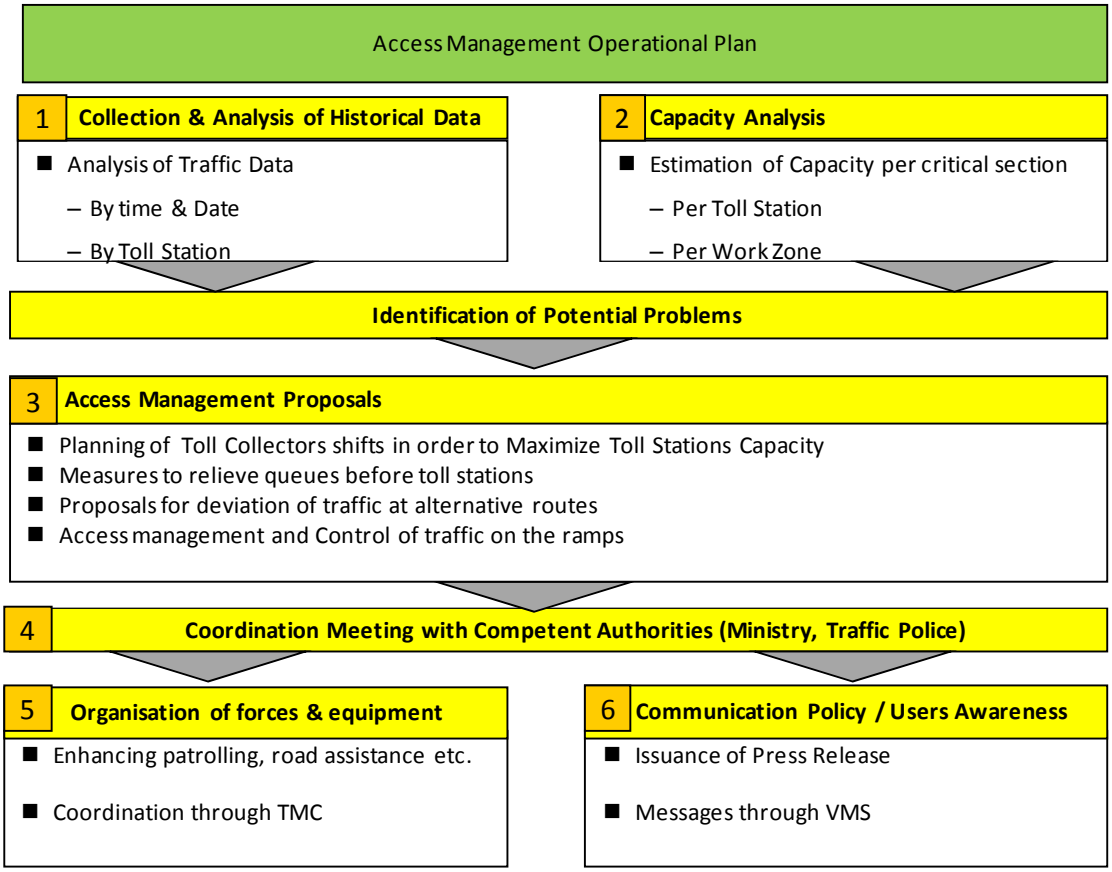
The only alternative route that can accommodate partially or on the whole the above excess traffic is the Old National Road (ONR). The ONR passes through a number of cities, the most important of which are Kiato, Xilokastro, Derveni, Aigeira, Akrata and Aigio. Concerning the ONR in relation with the working zones of KOPA, it has to be mentioned that in the eastern section "Ancient Korinthos – Derveni" one of the reasons that the "2+1" arrangement is implemented is the absence of a continuous secondary network, as the continuity of ONR is interrupted when passing through the cities of Kiato and Xylokastro, due to the local physical, land use and traffic restrictions. At the western part, "Derveni-Rio", where the "1+1" arrangements are implemented on KOPA, similar problems are limited only at the city of Aigio.

Thus, the most reliable alternative route is the ONR from Derveni up to Rio, providing a capacity of 800-1,000 vehicles per hour, half of which is already accommodating local traffic. Thus, the ONR may accommodate an excess traffic of approximately 400-500 vehicles per hour, deviated from the NNR.

The interim entrances between Rio and Derveni are Akrata, Kalavryta, Aigio and Selianitika. However, the uncontrolled entrance of additional traffic through these interim ramps during rush hours would create additional disturbance on KOPA, which already operates at capacity level with "1+1" limited capacity cross- sections. For this reason, it was necessary for Operator and Police forces to monitor continuously the traffic conditions, in such way as to block/control the entrances and depending on the conditions to identify time gaps and locations (interchanges) where traffic could reenter into KOPA without affecting the fluidity of the mainline traffic.

4.3 The Access Management Plan: From Design to Implementation

The Access Management Operational Plan was set as shown in the following diagram:



Through the analysis of historical data (Easter of 2010), as well as the capacity analysis, the critical cross sections where traffic demand exceeds the capacity at specific periods of time are identified. Further to the planning of Toll Collectors shifts in order to maximize the toll stations capacity for the (long) peak period of each day, the proposals include the following actions:

- Implementation of Measures to relieve queues before toll stations, when traffic demand exceeded the toll station capacity
- Implementation of deviation of traffic in order to manage the traffic exceeding the capacity of work zone areas and
- Access Management and control of traffic on the ramps of the Interchanges located between Rio and Derveni.

Concerning the toll stations and more specifically in direction to Patra, when relevant delays exceeded 30-40 minutes **at Zevgolatio toll station, short toll suspensions were implemented**. The duration of the suspensions at Zevgolatio do not exceed 15 minutes. During each suspension, approximately 650-700 vehicles pass, relieving upstream traffic. This is the only way to face the queue which is formed before Zevgolatio Toll Station. The option of diverting the traffic to the ONR from the previous Interchange of Ancient Korinthos cannot

be implemented due to the absence of a continuous secondary network, as already mentioned.

After Zevgolatio towards Patra and just before the "1+1" traffic arrangements **short duration deviations were implemented**. More specifically, as Zevgolatio TS under normal operation conditions accommodates maximum 1,700 vehicles per hour and given that 15-20% of this traffic exits at the next two interchanges, with destination the cities of Kiato and Xylokastro, it is estimated that when the remaining traffic reaches the first work zone with "1+1" traffic arrangement, a queue starts to build up at a slow pace of 100-200 meters per hour. However, when toll collection suspension is imposed, a significantly larger number of vehicles may pass through the Toll Station (up to 2,000-2,200 vehicles per hour) and the aforementioned queue will be build up at a faster pace, up to 2-3 km/hour and it is expected to reach the previous interchange, 1-2 hours after the suspension. In any case, when this queue gets quite long and reaches the previous interchange, Traffic Police implements short deviations to the Old National Road, in order to relieve the above mentioned queue, as well as to avoid the blockage of Derveni interchange.

At the same time, the **entrance ramps to Patra of all the remaining interchanges were closed** by Police Forces, as for the diverted vehicles not to re-enter and disturb the marginal operation of those circulating on the NNR, in most cases along an "1+1" traffic arrangement, otherwise a significant traffic congestion would occur again downstream.

On the other direction, **at Rio Toll Station such a toll suspension practice does not provide any advantage**. Rio Toll Station can accommodate under normal operation conditions maximum 1,500 vehicles/hour. This traffic can be marginally accommodated by the work zone developed downstream right after the Toll Station. Thus, it is impossible to implement toll collection suspension at Rio toll station, as traffic will not be able to go through the available width of "1+1" traffic arrangement that follows right after the station and will be instantly blocked in the area.

For this reason when queues before Rio Toll Station were reaching the previous interchange of Rio (1,2 km long), traffic police was implementing **short deviations of traffic in direction to Athens** to the Old National Road.

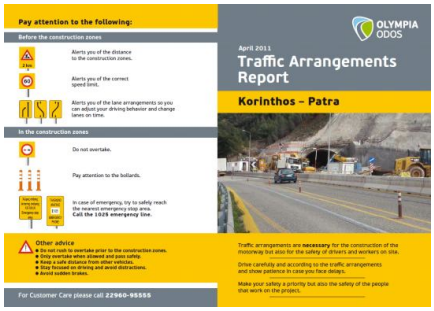
At the next section, "1+1" traffic arrangements are succeeded one after the other up to Derveni, while traffic on KOPA increases gradually as it approaches Athens, due to the inflow of vehicles from the in-between interchanges. Thus, traffic exceeds the capacity of the road and local congestions may be created before each zone. Thus, it was **necessary to physically close all entrance ramps to Athens** in the interchanges of the section up to Derveni interchange, in order to avoid allowing both the local traffic and the deviated vehicles to re-enter the NNR from the ONR to before Derveni interchange.

All the short duration deviations described above were implemented when necessary, following a dynamic monitoring of traffic passing from adjacent toll plazas and interchanges. It has to be mentioned that **traffic of heavy vehicles was not deviated,** as they would create significant problems in the urban areas where the Old National Road passes through.

All the above have been agreed and planned between the Ministry, the Traffic Police and the Operator in a **coordination meeting** which took place some days before.

In order to implement the access management plan described above, the Operator and the Traffic Police organized their forces and equipment adequately. **Both human forces and equipment were enhanced**. Patrolling, road assistance for passenger cars and heavy vehicles through subcontractors was increased. This way the better and continuous monitoring of traffic was succeeded. Problems were identified on-time, relevant exchange of information between involved parties was coordinated through the Traffic Management Center and the decision making process for the implementation of specific interventions in order for the whole mechanism to adaptto any new conditions was as fast as possible. At the same time, the operational support of the ONR by Local Traffic Police forces, especially in locations where difficulties were expected, as well as in the urban / commercial areas was also arranged.

Finally, for the better information of the users, **Press releases** both by the Operator and the Ministry have been issued the previous days and **leaflets** with traffic safety advices have been distributed at the toll stations.



Last but not least, during the peak period the Operator introduced relevant **messages on the VMS**, informing the road users for the conditions they will face accordingly.

5. Conclusions

The case of Olympia Odos and especially the section of Korinthos Patra has introduced a **new point of view in the construction of roads under traffic**. The construction adjacent to and on existing operating sections requires **special traffic arrangement plans** and **close cooperation** between implicated parties (Constructor, Operator, Police, State Administration), in order to **secure safe execution and progress of the works, safety for users and workers, a minimum level of service to traffic**, in terms of capacity and traffic fluidity.

Furthermore, as the construction progresses and the work sites move along the road, **continuous readjustment and update of all traffic arrangements and operational plans** is required.

Especially during the peak periods, special operational plans have to be implemented. Despite the fact that a comprehensive ITS is not yet in place, as the road is still under construction, the Operator together with the Police must continuously **monitor traffic by all available means, in order to respond on time at the dynamic variations of traffic**.

It was proven in practice that the **timely preparation and collaboration of all parties**, involved with the Operation (Ministry's Service, Traffic Police, Operator) and also the Construction (Ministry's Service, Independent Engineer, CJV), is a decisive factor for the effective management of the infrastructure during peak hours.

It was also proven how vital it is **to integrate the alternative routes to the relevant traffic management plans.** In the case of KOPA, this means maintaining unobstructed operation all along the Old National Road and avoiding impact thereupon by constructions, since a lot of the critical cross sections on KOPA operate marginally at capacity level.

The case of KOPA during Easter period proved how **access management contributed,** under adverse traffic conditions and physical restrictions, **to the provision of the best possible level** of service along KOPA section. Under normal traffic conditions (typical work days), during which the traffic is less than the aforementioned traffic capacity and if there are no unpredicted incidents, the total travelling time in KOPA (with 40% of its length occupied by 17 work zones) is currently burdened on average by approximately 20 minutes. In periods of high traffic, the delays reach some times in total even 1-1,5 hours. It is estimated that without the implementation of an access and traffic management plan, the uncontrolled entrance of vehicles in saturated sections would lead to practical immobilization of vehicles for long periods, creating even double delays for one way trip.

Finally, the example of KOPA verifies that the implemented traffic arrangements, together with the 24 hours monitoring of the network and the cooperation of Operator and Police, **not only ensure a better management of traffic but also provide a safer environment for the road users**. The 70% reduction of fatal accidents and fatalities which has been achieved in the first 2,5 years of the Concession is the best evidence and obliges all involved parties to work further to this end.