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Modernization of Greek Railways

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Abstract

ERGOSE S.A. which is a company affiliated to the Hellenic Railway Organisation was formed in 1997 to take over the management of the Hellenic Railways Investment Programme, and in particular to manage the projects co-financed by European Union Funds. The main aims of ERGOSE are:
To maximize exploitation of the Greek and Community funds available for making specific improvements to the railway installations and network for the benefit of the Greek Railways and the National Economy.
To ensure that each of the individually approved Investment Programme items is delivered to Hellenic Railways on time, at a reasonable cost and to a superior quality so that their economic value and appropriateness meet its target.

1 Introduction

In order to achieve these principle goals, ERGOSE applies modern project management techniques. ERGOSE staff, both Greek and internationally experienced engineers, are developing the necessary know-how and experience in the railway project sector. This is especially the case in disciplines which are fairly new to Greece as railway electrification, modern signalling, tunnel construction for high speed alignments and development of freight villages.

OSE's Investment Programme for the year 1989-1993 (331 MECU or 83 billion Drs) was co-financed by the European Union through the 1st Community Support Framework and for the years 1994-1999 (1348 MEURO or 445 billion Drs) by the 2nd Community Support Framework and the A' Cohesion Fund.
A total budget of 3800 MEURO or 1,3 trillion Drs has been approved for the period 2000-2006 funded by the 3rd Community Support Framework and the B' Cohesion Fund.

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In the past two decades, the volume of the underground works worldwide in construction has quadrupled, and it is anticipated to increase further in the immediate future. This is particularly evident in the field of the railway transportation, where new routes have more and longer tunnels than in the past.
There are two principle factors generating these new characteristics:
Firstly, the requirements for high speed corridors limit gradients and curvature and thereby impose rigid geometric alignments which are unable to follow the natural contours of the land.
Secondly, the contemporary tendency to respect the environment during the construction of infrastructure projects imposes the adoption of technical solutions which minimize the effects on the natural environment.
In Greece, these factors are further intensified by the ground's highly irregular morphology. It is ERGOSE' s objective to complete the projects in the most technically and economically sound manner by putting into practice the most appropriate available "know how". This will enable the company to become a marketable organization, capable of expansion in future by offering its railway project management services to other countries such as the Balkans.
The total programme includes the modernization of 1500 km of.main and periferal lines. The most important projects included in the OSE Investment Program 2000-2006 are the following:

- Modernization of the railway corridor Piraeus – Athens – Thessaloniki – Idomeni
- Development of the Attiki suburban railway
- Modernization of the railway corridor Athens – Patra
- Construction of the freight village in Thriassio Pedio and connection with N. Ikonio Port
- Upgrading of the Thessaloniki-Strimona-Alexandroupoli-Ormenio line
- Improvement of West Macedonia standard gauge and Peloponnisos metric gauge networks

2 Athens Suburban Railway

The Athens suburban railway is divided in the following two sections:

2.1 Pireaus - Rentis - Athens - Ska Section

The Rentis – Athens – SKA section which will be finished till 2004, has a length of 17 km and includes:

- The construction of SKA (Aharnon Traffic Center).
- The basic infrastructure (in an initial phase) of the new integrated railway station of Athens in the area of approximately 100 000 square meters presently occupied by the stations to Larissa and Peloponissos.
- The upgrading of the railway line in the current level and grade separated road crossings in the section Rentis – Rouf – Athens – Tris Gefires.

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- The construction - upgrading of the railway line in the section Tris Gefires – SKA with an underground alignment (Cut & Cover) for 1800 m and the upgrading of the remaining corridor up to SKA.
- The construction of an electric traction depot in Rentis RS
- The construction of 7 new suburban railway stations : Rentis, Tavros, Votanikos (interchange with the metro), Thimarakia, Agii Anargiroi, Pirgos Vassilissis, Noties Aharnes.
  The above section will be completed by 2004.
- The Pireaus - Rentis section which will be finished in 2007 has a length of 2 km and includes:
- The construction of a double track railway line on a bridge in the section Piraeus – Rentis (2 km)
- The construction of a new integrated central Railway Station of Piraeus.

2.2 Ska – Airport section

The SKA – Airport section which will be finished in 2004, has a length of 32 km and it includes:

- The construction of the new double track railway line SKA – Airport in the traffic island of the highway Elefsina – Stavros – Spata.
- The construction of 8 new stations in Heraklio, Olympic Stadium – Neratziotissa (interchange with the metro), Kifissias avenue, Penteli avenue, Stravros (interchange with the metro), Pallini, Kantza, Koropi Junction.
  The above section will be finished till 2004.

With the construction of the Suburban railway, the travel time from Athens central station to the Airport will be 30 minutes.

The network of the suburban railway will link major traffic hubs of the Athens area, such as:

- Piraeus Port
- The Railway Stations in the center of Athens
- SKA (Aharnon Traffic Center)
- The new Airport of Spata
- The ports of Piraeus, Rafina and Lavrio (in a later stage)

The above network of the suburban railway in combination with the networks of the other guided transportation modes (metro, tram) as well as the road network (Attiki Odos, Imitos Avenue, etc) as an integrated transport system changes the organization of space in Attica and the adjacent prefectures, as well as the traffic within them. In particular, the possibility of connection with the metro line will be ensured in the following five stations: Piraeus, Votanikos, Larissa Station, Neratziotissa, Stavros.

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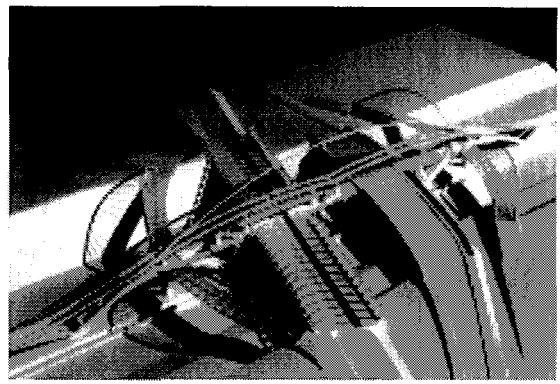

Figure 1: Neratziotissa Suburban Station

The suburban railway is expected to attract a total of 350.000 passengers daily in 2004, 425.000 passengers daily till 2010 and 560.000 passengers daily till 2020. It is noted that in the time period 2004 - 2020 the average passenger traffic of the suburban railway is expected to amount to approximately 70% of the corresponding metro traffic. In particular, the passenger traffic of the suburban railway from/to the Airport is estimated to be at least 36.000 passengers daily in 2004, i.e. 25-30% of the overall traffic from/to the Airport. The extension of the limits of the city planning complex in a radius of 40 km (Attica) & 80-100 km (adjacent prefectures) together with the reduction of the traffic time will contribute to the creation of new population centers with positive effects on the urban, economic, social and cultural development.

3 Athens – Thessaloniki Corridor

Construction of a new double track high-speed railway line, with a length of 500 km. After the completion of the works, the journey time Athens – Thessaloniki will be reduced from currently 5 hours and 30 minutes, to 4 hours and 50 minutes in 2004 and 3 hours and 50 minutes in 2008.
The following projects are under construction along this line:

- Tunnels of a length of 24,8 km
- Cut & Cover of a length of 5,2 km
- Railway Bridges of an overall length of 5,5 km
- 73 Road Overpasses & Underpasses
- Construction of 8 New Railway Stations and renovation of old ones

The main projects of the section are the following:

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3.1 Platamonas project

The Platamonas project has a length of 12 km and it has the following main sections:

- Three Tunnels with a total length of 2537 m which are the following:
- Tunnel (Koukodoni): with a length of 1388 m.
- Tunnel (Moshof): with a length of 465 m.
- Tunnel (Kastro): with a length of 684 m.
- 1736 m. Cut&Cover.
- 1062 m. cuttings.
- 5962 m. embankments.

The project is under construction. The underground excavation has already extended for a length of 2,537 km. The new alignment will allow for speeds of up to 250 km/h. With the new alignment, the length of the line is reduced by approximately 1 km, an intercity train traveling at a speed of 200 km/h will require approximately 10 min to cover the new section. (saving approximately 75% of the journey time).

3.1.1 Construction parameters

- Double line section with electrification
- Minimum curve radius 4000 m.
- Maximum gradient in this section 10 ‰
- Axial distance between lines 4,5 m.
- Net tunnel cross-section 82m.

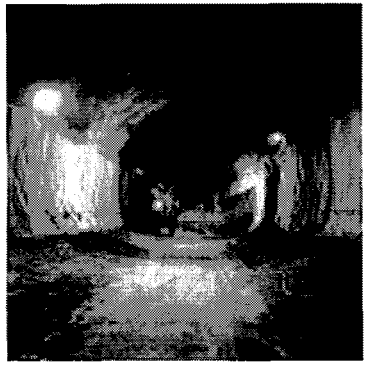

Figure 2: Platamonas Tunnel

3.1.2 Geological characteristics

Mainly the tunnel goes through mixed loose water bearing formation. Consequently excavation is difficult and expensive due to the need for increased supporting measures.

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The same geology continues to the North where there are bad to medium quality rock limestone formations. These also have water in their greater part and are mixed as far as their mechanical properties are concerned. All the tunnel excavation conditions mentioned above are made worse by the wide cracks in the area and the shallow depth of excavation.

3.1.3 Difficulties encountered during the construction (with NATM)

1. Minor collapses within the area of the cross-section
2. Phenomena of collapse of sections of the supporting core
3. Phenomena of Sinking of a section of the tunnel together with the complete Phase A temporary support system mainly due to the small bearing capacity of the side foundation (elephant foot) and worsened by the existing underground water. These phenomena have been dealt with by applying the appropriate support measures depending on the specific on-site conditions.

On top of the hill, above the tunnel, is the Platamonas Castle from the middle-Byzantine period. The protection of this monument was a special technical task within the total project. Before the excavation works began, a complex protection programme was elaborated which included the following activities.

- Control of induced vibration to the structures of the monument
- Control of the dynamic resonance in the structure of the monument
- Control of the plastic behavior of the structure of the monument

A network of instrumentation was installed to monitor the behavior of the castle structure. These included vibration seismographs, static and dynamic crack width gauges, and static vertical gauged. The measurements and records taken from these instruments were analyzed be special software and presented in such a way, that the strain on the monument could be constantly determined and action taken to prevent any structural damage of the castle.

3.2 Tempi project

The Tempi project has a length of 12,5 km and it has the following main sections:

- Main tunnel (4034 m length) excavated using the NATM (New Austrian Tunneling Method).
- 5 railway bridges (20- 240 m length)
- 2 C&C (509 m total length)
- 3 small tunnels (950 m total length)
- 2 grade separated crossings
- Restoration of the road network with the construction of parallel roads

The new line, constructed as a double track railway, is 444 m shorter than the original single track and will save 11 mins on the total journey time when operating at 200 km/h as opposed to today's speed of 50 km/h.The project is largely finished.

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Figure 3: Tempi Tunnel

3.2.1 Construction parameters

- Tunnel design speed 250 km/h
- Minimum curve radius R = 4.000 m
- Maximum gradient 14 ‰
- Distance between track centre lines 4,5 m.
- Net cross-sectional area of tunnel 82m
- Thickness of final tunnel lining 35 cm to 40 cm
- Water proofing of the tunnel with a PVC membrane and geotextile
- Slab track

Inside the tunnel, provision has been made for the security of passengers and staff. In addition to the safety niches arranged every 50 m. on either side along the tunnel, there are three escape tunnels. In the event of an accident, these in combination with the portals ensure that people will not be more than 100 m from an emergency exit. Moreover, in case of a fire, the necessary E/M installations control the direction of smoke.

3.2.2 Geological data

The area of the tunnels consists mainly of crystalline limestone- half-marbles with sporadic horizons of marl or phyllitic schist, probably dating form the kritidic period. These geological sub-base formations are partially covered by more recent (quaternary) relatively loose formations (conglomerates, alluvium) of limited depth.

3.2.3 Geomechanical conditions

The limestones did not present any particular problems, whilst the schists and the tetartogenic formations required as expected additional support measures.

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3.3 Project of Lianokladi-Domokos section

Lianokladi - Domokos section (56km) is considered to be exceptionally difficult, due to altitudinal difference between the beginning and the end, and due to the morphological and geological difficulties of the area. ERGOSE, after having examined various alternatives, proposed an alignment which is an improvement on the existing line. After the completion of the 3rd CSF projects the reduction of Journey Time will be 35′.
The main Characteristics of the proposed solution are:

- Tunnels of overall length of about 7 kilometers.
- Cut & cover, of total length of about 2 kilometers
- Bridges of total length of about 2,5 kilometers

3.3.1 Geological conditions

The ground morphology and the geological conditions exhibit wide variations. The ground profile includes the mountainous bulk of Othris, and the plains north and south of the mountain range. The geological background of the area exhibits intense formation folding and tectonism. Of special interest in this geotechnical context is the design and foundation of fourteen bridges, with a total length of approximately 9 kilometers, in locations, which vary morphologically and geologically. Also the design and construction of 42 kilometers of cuts, walls and embankments in similarly difficult ground, and of course the excavations of the tunnels and cut & cover sections, amounting to about 6 kilometers, are key-projects, the final designs and construction of which are considered as top priorities for ERGOSE S.A.

3.4 Kallidromo project

The Kallidromo project has a total length of 19 kilometers.

- External works south of the southern portal: Km 0+000 - km 5+200.
- Kallidromo tunnel : km 5+200 to 14+225 (twin tube tunnel, 9025 m each track).
- External works north of the northern portal: km 14+225 to km 19+000

The project is under construction and up to now approximately 4 kilometers of underground excavation have been realized.

3.4.1 Technical description of the tunnel

The Kallidromo tunnel consists of two parallel tubes, each 9025m long and with circular cross-sections 9m in diameter. The distance between the tubes is 30m, and every 500m they are connected to each other, for safety and operational reasons. The new alignment will allow a speed of up to 250km/h, saves about 2 kilometers of track, and reduces the journey time by about 30 minutes.

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Figure 4: Kallidromo Tunnel

3.4.2 Construction parameters

- New double line section with electrification
- Minimum curve radius 3000m
- Maximum gradient along this section, outside the tunnel 14 ‰ and inside the tunnel 6 ‰.
- Axial distance between the tracks 4,5m.
- Tunnel cross section net area for each tube about 56m

With the exception of a light curve at the southern part, the tunnel is straight exhibiting an upward inclination in the southern part, and a negative gradient of 6 ‰ towards the northern portal. The expected geological formations are about 1/3 ophiolite, 1/3 limestone and 1/3 marles and aluvium deposits.

The support of the excavation face with reinforced shotcrete, steel frames and rock bolts, is in accordance with the NATM standards, while there are 7 different types of shoring dependent on the ground quality.

The final lining will consist of 30 to 45 cm thick reinforced shotcrete, and will be either the horse shoe type (open cross section) in good soil, or with an invert and a wall thickness of up to 60cm in unfavorable ground conditions. The underground water will be gathered by pipes, which at the same time will act as surface drainage. The waterproofing of the tunnel will be achieved with a PVC membrane, placed between the inner and the outer lining, whilst in contrast to the traditional ballasted superstructure, a slabtrack design is proposed.

3.4.3 Geological conditions

The area of the project consists of four main 2 large geological formations:

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- Clay – marles
- Conglomerates and aglomerates of small to medium cohesion
- Ophiolite
- Limestone

The first two rock categories are to be found mainly at the southern and northern part of the tunnel, as well as at the external sections of the project, while the ophiolite and the limestone are expected in the central section of the tunnel.

3.4.4 Geotechnical conditions

The current tunnel excavations (from both the southern and northern portal), confirm in general the geological formations and their sequencing predicted by the preliminary design, but they exhibit a serious divergence concerning their geo-mechanical properties (as is apparent in the tunnel excavation data), and consequently in the applied cross-section categories of immediate support measures.

3.4.5 Problem confrontation measures

The tunnel is being excavated from four different portals, with the NATM method. During tunnel construction up to now, reinforced cross-section with fore polling has been applied on about 70 % of the total excavation length for the Phase A tunneling. This is indicative of the assessed extent of the low geo-mechanical properties exhibited by the formations. Of course the greater than anticipated use of reinforced cross-sections considerably slows progress and increases the construction cost of the tunnel. This is carefully monitored and controlled by ERGOSE.

4 Athens – Patras Corridor

A new high-speed railway line, with a length of 216 km, is being constructed in this section. After the completion of the projects the journey time for Athens – Patras will be reduced from currently 3 hours and 35 minutes, to 2 hours in 2007.

4.1 Athens – Kiato section

The line infrastructure is being constructed for a standard gauge double line with a design speed of 200 km/h after Thriassio Pedio, with a maximum gradient 15 o/oo, without any level crossings and with fencing along the whole section. The total length of the line from SKA to Kiato is 104 km. Part of the line, with a total length of about 13 km, is being constructed on the traffic island of Attiki Odos.
The travel time between Athens – Kiato after the completion of the projects is estimated in 60 min instead of the 120 min approximately, that it is today.
The following projects are under construction along this line:

- Tunnels of a length of 7.710 m.
- Cut & Cover of a length of 605 m.
- Railway bridges of a total length of 1.845 m. (including the new 230 m long Isthmos bridge)

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- 34 Road Overpasses and Underpasses of a total length of 990 m.
- 11 Railway Stations, the platforms of which are 300 m. long. In all stations underpasses and parking areas are foreseen.

The new line will contribute to the reduction of the journey time from Athens to Kiato by 50 minutes. The main projects of the section are the following:

4.2 Kakia Skala project

The project of Kakia Skala has a length of 8540m. The main sections of the project are:

- Two double track railway tunnels, with a total length of 4500m
- Five escape tunnels
- Four bridges with a total length of 218m.
- Earth works with total length of 4400m

This 8,5 kilometers section will completely substitute the existing metric line in this area. The project is under construction. Until today it has been completed the 50% of the project.

4.2.1 Construction Parameters

- Undisturbed operation of the existing line during the construction of the project.
- New section of double line with electrification
- Minimum curve radius 200m.

Figure 5: Kakia Skala Tunnel

- Maximum longitudinal inclination at this section 11 ‰
- Axial distance between the tracks 4,2m.
- Free cross section space of railway tracks: 72m

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- Free cross section space of escape tunnels: 25,4m During the construction of this project, special attention will be given to the protection and the esthetics of the environment.

4.2.2 Tunnels

The cross section of the tunnels has a horse-shoe form, with a maximum width of 11m and an upper semi cross section radius of R= 5,5m. In the largest tunnel of the three, 1537m long, 2 escape/ air pressure release tunnels are being constructed.

4.2.3 Geological conditions

The intense geo- morphology of the area and the immediate vicinity of the HSRL alignment to the existing railway line and the old National road Athens-Korinth, both of which must remain in continuous operation, leads to a considerable use of pile walls for the support of the embankments and the slopes. The open structure of the "creatace" limestones causes problems to the excavation as well as to the support of the tunnels. Therefore measures must be taken for the improvement of the quality of these rocks.

4.2.4 Main geotechnical problems

The tunnels run through limestones and are located in a major fault zone. Due to the seismic nature and the geological structure of this area, and after the recent earthquake in Parnitha, a change in the alignment has been decided , moving the line further away from the area of the Kakia Skala fault system, and then crossing it vertically. As a result certain tunnels were combined into longer ones and some cross sections were enlarged thus increasing the underground works, as compared to open line sections.

A further important geotechnical issue is encountered in the western part. Here the tunnel passes at a close distance under the national road requiring the construction of a supporting pile wall for the National Road. Because of the geotechnical features of this area and the interconnection of the tunnel with the National road, a detailed stability design for the open line sections and for the excavation of the tunnel is under preparation. Due to the morphological and geotechnical particularities as well as the seismic nature of the area ,the Project of Kakia Skala is considered as one of the most difficult and challenging civil engineering projects currently under construction in Greece.

4.3 A G Theodori project

This project concerns the construction of 11,45 km of the new double, high-speed line.

- The design speed is 200km/h, and the project includes:
- 1222 m long double track tunnel
- 414,5 m Cut & Cover
- Bridges of a total length of 582 m

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- 643 m of shoring walls and pile walls
- Earth works and the high-speed railway line infrastructure in the above mentioned section.

The construction of this project started three months ago.

4.3.1 Geology

Sendimentary (Plio-plistocenic) formations of low to medium cohesion Volcanic rocks intensively fractured and highly surface weathered.

4.4 Thriassio freight station

The project regards the construction of a modern complex in the area of Thriassio Pedio, where railway and commercial activities will be concentrated, which are at present carried out in facilities in various locations in the capital. The transfer of these facilities in one common site, outside of the urban complex of the capital, will have important environmental and land-planning benefits for the entire Greater Athens area.

The Freight Center is being constructed in an area, where a constantly increasing number of transportation companies is being established, and will be connected to the OSE network through the new railway line. The new freight center will be directly connected to the north with Thessaloniki, to the north-east with Piraeus, Elefsina and Ikonio and to the west with Patra and Megalopoli.

Road access is ensured with the direct connection to Attiki Odos and the connection to the Athens – Korinth National Road (through Attiki Odos or the existing road network). The project of the Thriassio pedio Freight Station is directly related with the connection of the railway network to the Ikonio Port.

Figure 6: Thriasio Freight Station

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4.5 N. Ikonio project

The project is part of a new 17km long single railway line with a design speed of 90km/h. This line will be used by freight trains only, and it will connect the port of N. Ikonio with the rest of the railway network.

- The main structures of the project are:
- Tunnels of a total length of 5250 m
- 950 m of Cut & Cover
- 1150 m of Bridges

The construction began in November 2001 and it will be completed in 2005.

4.5.1 Geology

The tunnel is expected to cross Triassic limestones of medium quality along most of its length (over 3 km) and schists and sandstones of poor geotechnical properties along the last 400 m of its length.

4.6 Trikerato project

This project is part of the new double, high-speed line Athens - Korinthos. It has a design speed of 200 km/h and it will contribute to the reduction of the journey time to Korinthos by 45 minutes. The construction of this tunnel has been completed.

4.6.1 Construction parameters

- New standard gauge double line with electrification
- Curve radius 2000m
- Maximum gradient in this section, 10‰
- Axial track distance 4,2m
- Free railway tunnel cross section space, 75m
- Free escape/ ventilation tunnel cross section space, 28m

4.6.2 Geological features

The Trikerato limestones feature medium to good mechanical characteristics and are therefore classified as category II ie. good rock (RMR: 61-80) or category III ie.medium quality rock (RMR:41-60) in the Bienawski scale. The underground water level is approximately 50-60m beneath the tunnel floor.

4.6.3 Special geotechnical problems

The tunnel passes under the new Athens-Korinth national road, for a length of 168m with a very thin overburden (3 to5m) and under unfavorable geological conditions, due by the loose structure of the materials in the top heading area (mainly embankments of the national road) and the asymmetrical loads on the lining exerted by large pieces of limestone which are included in the cross-section. The construction of this section of the project as well as of the section towards the western portal of the tunnel, required high expertise and specialized

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technical approach (fore polling, micro piles, pre-stressed anchors, defense gallery etc.).

4.7 Kiato-Patras section

The construction of the new standard gauge double high-speed railway line will constitute the continuation of the new ATHENS – KIATO line under construction and will connect Athens to the New Port of Patra.
The construction of 7 railway stations is forecasted along the line (Xilokastro, Derbeni, Akrata, Diakofto, Egio, Rio, Patras). The project is in the design phase.

5 Signalling – Telecommunications of Main Corridor Athens – Thessaloniki

5.1 Signalling

It is a priority project for the modernization of the main corridor and a part of the general programme of upgrading the OSE network. The general characteristics of the programme are the following :

- The introduction of a new signalling code including main and secondary signal lights that cover all operational needs of the network.
- The replacement of the existing hand-operated mechanical signals, the mechanical interlocking in the station areas and the old technology signal lights in double line sections by modern signalling controlled through electromechanical systems (with relays) or electronical interlocking systems to secure the train traffic.
- The installation of Central Traffic Control systems (CTC) in order to improve coordination of the anticipated increases in traffic movements, reducing at the same time the operational cost by not staffing the stations. Every CTC system allows the train traffic on a line section to be controlled from the central point. At present the CTC Lianokladi is in full operation controlling the section Tithorea – Domokos, and the CTC Thessaloniki is in partial operation controlling the sections Thessaloniki – Plati and Thessaloniki – Strimona – Promahona. The CTC Athens (controlling the sections Athens – Inoi – Tithorea and Inoi – Halkida) as well as the CTC Larisa (controlling the section Domokos – Plati) are under construction. Completing these CTC systems will improve the traffic safety and punctuality, as well as the network reliability and flexibility, thus enhancing the overall level of service provided.
- The introduction of follow up signal lights on the open line to provide safe control at reduced spacing between the trains and thus achieve higher traffic density.
- The installation of wrong way signalling to make each track two-directional and thus create greater operational flexibility by enabling one track to be

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taken out of use during line maintenance or generally where a line is blocked in any other situation such as a train breakdown.

- The signalling works that have been completed and those still under construction allow a highest train speed of 160 km/h. At this point the requirements for the upgrade of the signalling systems for a speed of 200 km/h are being examined.

5.2 Telecommunications

The existing telecommunications infrastructure of the corridors Piraeus – Athens – Thessaloniki and Athens –Patras consists of a main copper cable of 24 quadruples installed along the line.

This telecommunication carrier covers the total of the current needs in telecommunications. These needs include the critical telephone connections between the stations, light signals and signs along the open line, connections for the traction maintenance, data transmission for the telecommanding of the signalling as well as the electrification.

A fiber optic cable and transmission systems of Synchronized Digital Hierarchy (SDH) are installed in sections of the network (Larisa – Eginio, Thessaloniki – Strimonas – Promahonas). Future extensions are going to cover the whole corridor Piraeus – Athens – Thessaloniki, thus notably improving the capacity and reliability of the OSE telecommunication infrastructure.

6 Electrification of Main Corridor Athens – Thessaloniki

The current project covers the central railway corridor Piraeus – Athens – Thessaloniki. About 410 km of double line and 65 km of single line will be electrified by the completion of the first phase of the current modernization programme.

More specifically, the physical object of the project includes :

- The construction of an overhead line catenary systems for speeds up to 250 km/h in the double line network and a simply supported contact wire for speeds up to 120 km/h in the single line sections, with all relevant supply and switching equipment.
- The construction of 12 traction substations, each one equipped with a pair of transformers 150 Kv / 25Kv and nominal power 15 MVA, connected to the PPC 150 kV network and, through a neutral phase separation zone, to the contact line. The traction substations and all connection and switching positions will be remote controlled from two centers, in Athens and Thessaloniki.
- The protection of the parts of the system as well as of the neighboring facilities against induced electrical currents.

The application of electrification in railway traction provides :

- Increased power available per traction unit, which is necessary in order to achieve high speed and acceleration.
- Saving of energy, because it will be produced in the PPC central stations.

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- Reduction of maintenance costs because of abolishment of the thermal part of the traction units.
- Elimination of exhaust – gas pollution along the railway corridor.
- Reduction of noise of the traction units, especially important in the urban areas close to the railway stations.

Finally, also the Athens-Patra corridor will be electrificated. The project is in the design phase.

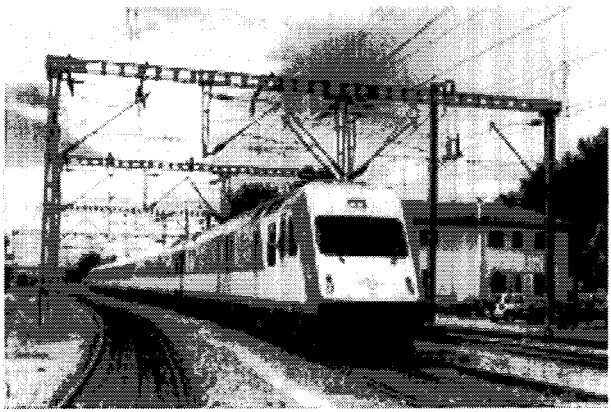

Figure 7: Electrification

7 Connection with Greek Ports

7.1 Thessaloniki Port

Currently there is a connection to the Thessaloniki Port through the urban complex. The proposed alignment directly connects the 6th pier of the Thessaloniki Port with the existing shunting station through the line Thessaloniki - Idomeni, which passes through the city complex at level 0. The alignment passes east of the facilities of the Thessaloniki Overland Bus Station (ΚΤΕΛ) and crosses the West Entrance currently under construction through an underpass and 28th October Str. through a level crossing. Afterwards the alignment continues on the east bank of the Dendropotamos river at the limits of the Barracks and ends on the 6th pier. The length of the alignment is approximately 2,5 km.

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7.2 Patras Port

The project regards the connection of the New Port of Patras to the railway network of standard gauge line. (Currently there is a connection of the metric gauge network to the existing port.). With the construction of the New Port of Patras on a different location than the current one, the city that constitutes the third largest financial center of the Greece, is developing to the western gateway of the country. Its connection to the country's railway network is therefore necessary and especially the connection to the Thriassio Pedio Freight Center, where the commodities will be forwarded in order to be further transported to the rest of the country.

7.3 N.Ikonio Port

The commodity transportation from the facilities of the Piraeus Port Organisation (Ο.Λ.Π.) and the N. Ikonio Port to the thriassio Pedio Freight Center and to the rest of Greece and Europe. In the Freight Center the following works will be executed:

- Railway – road freight transshipment, i.g. management of freight of the Athens area
- Train combination in the framework of the future OSE railway network
- Operation of a station for the service of the ports of Ikonio, Piraeus and Elefsina
- Parking and maintenance of railway vehicles

8 New Technology – Slab Track

The slab track is a new technology of superstructure, where the ballast, as a carrying element of the line and of the sleeper, is replaced by a concrete layer (slab). The first tests were done 30 years ago, but only in the last decade has this technology been applied in large sections of high-speed lines in Japan and Germany. Since then other countries such as Austria, Switzerland and Holland have started using the slab track.

The advantage of the slab track is the excellent passenger comfort it provides due to the exact line geometry and a very low maintenance cost. The total construction cost is approximately 20% higher than the one for conventional ballasted track. However taking under consideration the cost of the whole life cycle (at least 25 years) the slab track is much more economically effective than the ballasted track, ensuring at the same time a much better line quality.
In the case of the Greek Railways the advantage will be even bigger due to the poor quality of the available ballast (reduced hardness).

9 Conclusions

With these large tunnel projects, which are under construction today in our country, and with the other projects such as the new signalling installations,

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modern telecommunications and electrification, which are also progressing day by day on several sections of the line, the image of the Greek railway network is upgraded every day. Our network is being gradually transformed into a modern, trustworthy and competitive means of transportation, which will be able to render services equal to those of other European Railway Organisations.