Motorway Management With GIS: The Example of Attiki Odos

Dr. Eng. *Thanos E. Doganis* Terra Ltd.

Bill M. Chalkias Msc CEO of Attikes Diadromes S.A.

Georgia Gania GIS Specialist Attikes Diadromes S.A.

Abstract

Attiki Odos motorway is the largest Build – Operate – Transfer (BOT) project in Greece. Attiki Odos is a freeway connecting urban and suburban areas of Athens Greater Area (which is the capital of Greece) with the main transportation network of the country. The total length of this toll road is approximately 60 km. The average volume of cars using this motorway is 300,000. For the maintenance, management, security, and service to the users of the motorway a network of interconnecting information systems is set up. Part of this information system is the GIS which collects data from other systems, analyzes, and presents them to the appropriate persons to help them in their every day work. The GIS consists of incident management, road maintenance, traffic volume monitoring, and automatic vehicle location monitoring for the cars of Attiki Odos.

Introduction

The GIS and information technology staff at Attiki Odos have developed spatially enabled enterprise analysis tools and applications that take advantage of a data repository to create an enterprise solution for viewing and analyzing spatial roadway data.

Figure 1: General Map

Attiki Odos maintains many types of roadway data to support daily business operations. Access to accurate and current information on geometrics, traffic volumes, incidents, pavement conditions and history, and other data on infrastructure is essential for ensuring an efficient and well-maintained road system. Most transportation data contains spatial components or refer to spatial objects so Attiki Odos decided to use a GIS system for every day maintenance and management of the roadway.

In order to clarify all the aspects of the GIS solution we developed some general information about Attiki Odos has to be presented.

Attiki Odos motorway is approximately 65 km (40,6 miles) connecting urban an suburban areas of

Athens metropolitan area with the main transportation network of the country. Athens metropolitan area is the capital of Greece with 4,5 million inhabitants which is almost 40% of the population of the whole country.

Planning of this motorway started early 60's but actual construction started in 1997 and was completed before summer Olympic Games (Jule 2004). Part of the motorway which connects Athens with the new International Airport was fully operational at the beginning of 2001. The funding frame of the project is the BOT (Build Operate Transfer). In this frame the contractor invests and constructs the road, operate it for some years the and the transfers it to the state.

The total cost of the project was 1,3 b € (1,7 b$) . The return of investment is done through the tolls that the users pay. An upper limit of the toll (which is approximately 3€ (|~ 4 $) was defined in the offer of the contractor. This upper limit depends on the inflation ratio of our currency.

Some indicative figures are given to the reader in order to understand the magnitude and the complexity of the project.

- Total length 65 kilometers (40,6 miles)
- 32 Interchanges
- 200 bridges
- 41 Toll stations
- 6.2 km (3,9 miles) of tunnels
- 800 employees
- 24 hours / day 7 days a week operation
- 220.000 cars average daily traffic volume.
- 200 vehicles for customer care, maintenance and safety.

Impacts

Attiki Odos has a great impact on the environment economy, and traffic conditions of Athens metropolitan area. It connected Easter to Western Attiki and both of them to the Center of Athens.

Attiki Odos had greate impact in:

Accessibility and connectivity of various areas in Athens Metropolitan area. In figure 2 we can see the change of the pattern of isochronous curves before and after the construction of Attiki Odos. Yellow color indicates half an hour driving from the "center" of Athens , green indicates one hour driving and blue more than one hour.

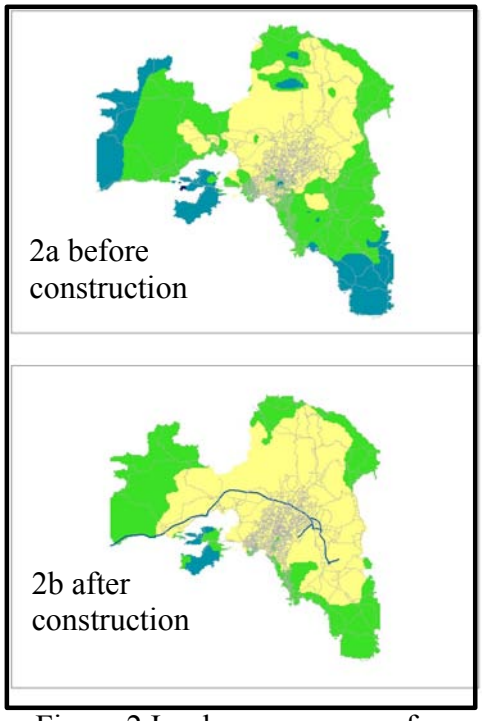

Figure 2 Isochronous curves from Athens center

Economy. It has been measured that the average user saves half an hour using the motorway in each trip. Thus we save about 150,000 hours (18.750 working days) every day

Moreover there are impacts on the physical environment due to the increase of average speed, elimination of time traveled which have not been measured yet.

The Geographic Information System of Attiki Odos

System Architecture

For the maintenance and management of the motorway a GIS system was implemented. This system is part of the IT systems that already operate in AO like toll collection, accounting, traffic monitoring, incident management etc. The three major factors influenced the design of Attiki Odos GIS System were:

1. As GIS's become part of the everyday tasks in many organizations there is a small group of power users that carry out specialized tasks while the vast majority needs only browsing capabilities and access to specific information.
2. The need for a robust and fast central data repository in order to avoid (as much as we can) data redundancy.
3. The existence of various platform (Operating Systems, RDBMS) information systems that had to interact and exchange information with the GIS system.

Compromising the above factors we decided to use one full ArcInfo license, two ArcViews, SDE on SQLServer for the database and ArcIMS for data diffusion. The system architecture is shown on figure 3

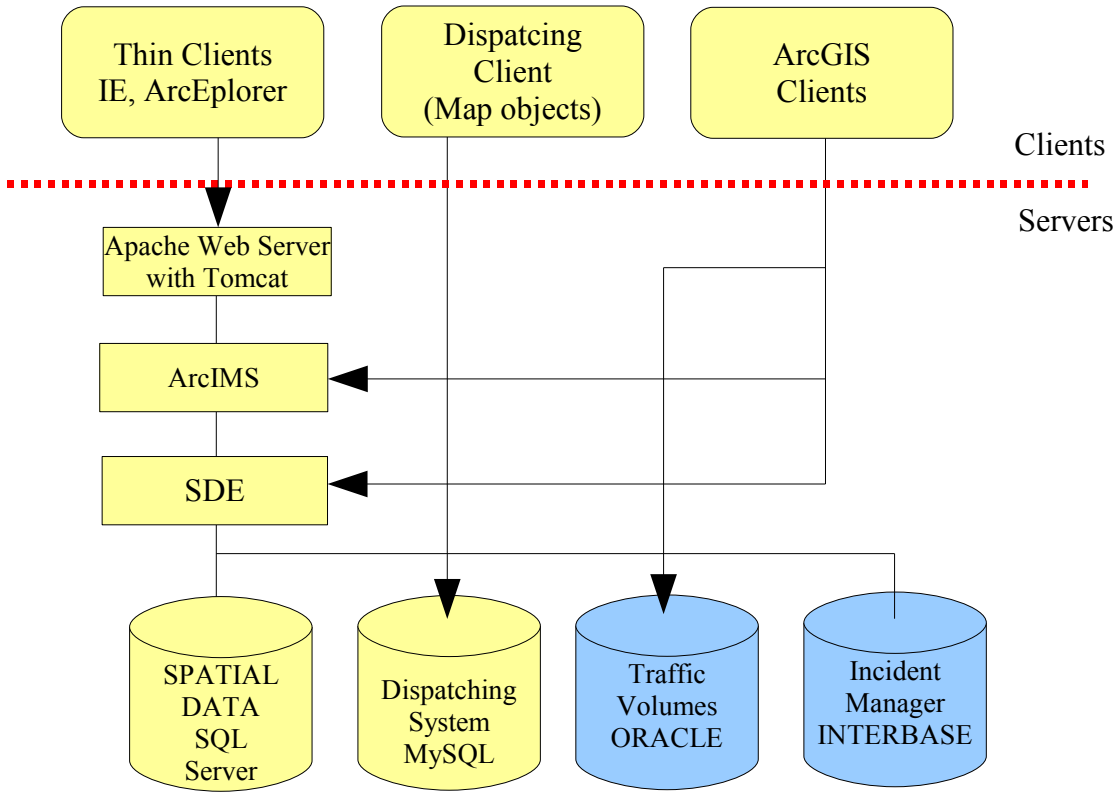

Figure 3 System Architecture

Reference System

The reference system of Attiki odos motorway is the Greek Geodetic Reference System of 1987 as almost all GIS Systems in Greece. For the purpose of A.O. we established a linear reference system (LRS) since all existing systems (maintenance, incident management, traffic volumes etc) are referenced using the section of the motorway and kilomettic position. Each direction is a different route in the route system that was established. The route system is shown in figure 4

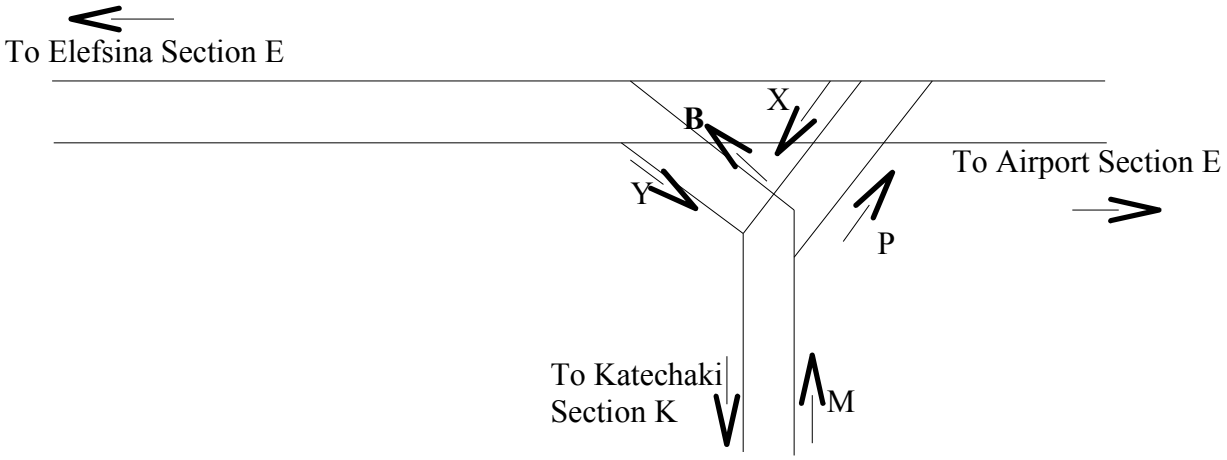

Figure 4 Attiki Odos Route System

Figure 5
Position signs

The reference system is physically implemented on the street. There are signs (figure 5) every 100 meters (appropriately 300 feet) indicating position and direction. Those signs proved to be very useful in incident management. When users have problem they can call the Operations Center indicating their position eliminating the possibility of misunderstanding and improving response system.

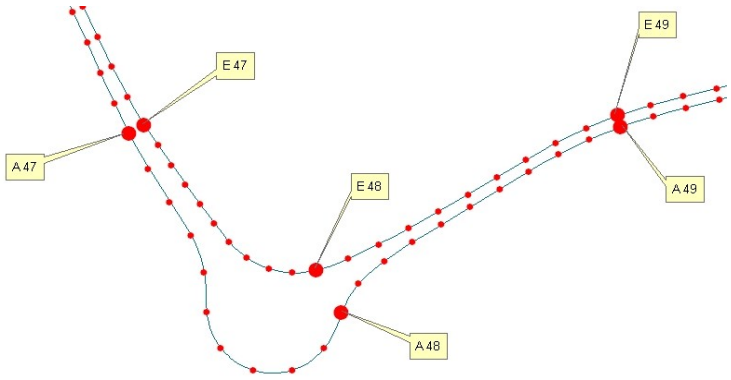

Figure 6

The hundred meter signs are not exactly every 100 meters because it was necessity to have same position in opposing directions (see Figure 6).

As a result in some occasions we can have 100 meter signs varying from 80 to 120 meters.

Incidents Management

A major issue in every day operation in Attiki Odos is the management of incidents. Incidents, which are not always accidents, happen every day. Minor incidents such as a flat tire, run out of gas, an intrusion of a dog in a motorway where the speed limit is 120 km/hour (75 miles/hour) may cause huge queue or an accidents. For the management of incidents there is a fleet of 40 cars that patrol the motorway, 194 cameras , a telephone network, 14 MVMS an AVL system and a command center for those operations.

When an incident is reported (either by phone, a patrol car, a camera or by a toll station) a patrol car is assigned to it. This car goes to the location of the incident and try to resolve the problem. If he can't resolve it he calls the police, ambulance, road assistance service or whatever needed. Every incident is written to a form on the field All those incidents are categorized, and stored on a data base (Borland interbase). The storage in the data base is a manual procedure. Using the direction and kilometric position all the incidents are transformed to geographic features. This procedure is automatic and runs every hour. This procedure finds all the new incidents and stores them to the SDE database. The incidents can be seen either on the web interface or queried and analyzed in the ArcMap.

Figure 7 User Interface of Geocoding Procedure

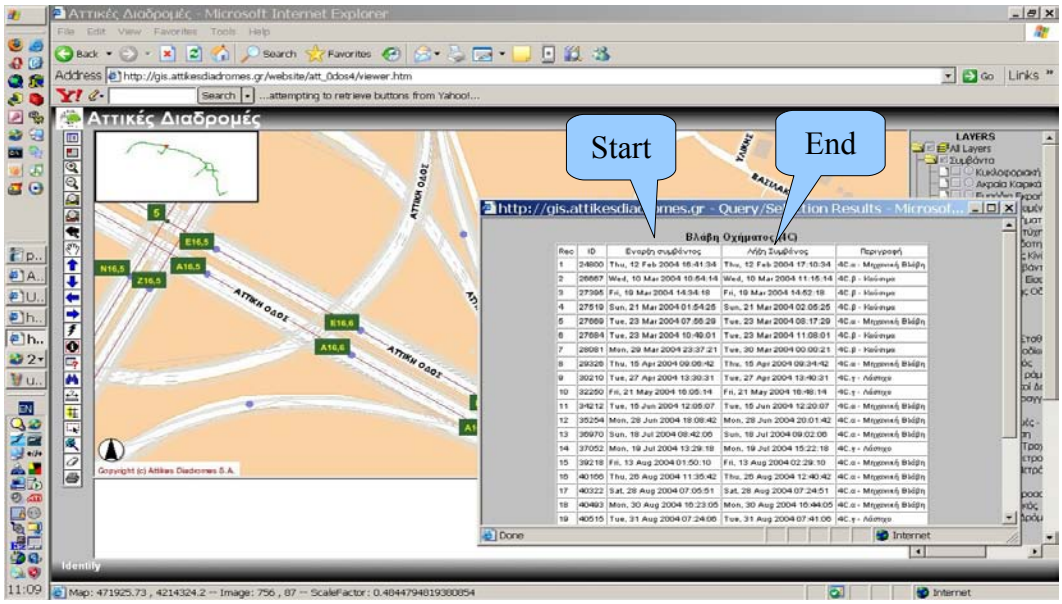

Figure 8.Accidents with involvement of three or more cars

Attiki Odos Dispatching System

Attiki Odos developed and implemented an Automatic Vehicle Location System (AVL) to monitor the vehicles that are for patrol, maintenance and incident management of the road. The AVL System consists of three parts.

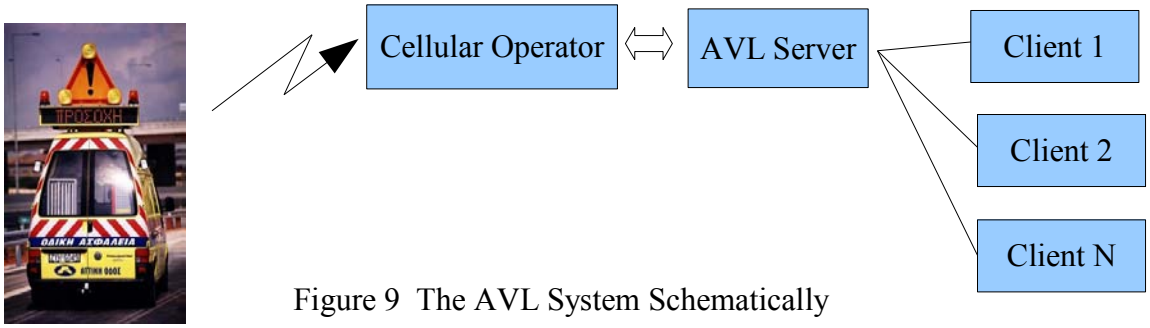

Figure 9 The AVL System Schematically

Vehicle Terminals. Those Terminals (Figure 9) have a GPS receiver and GSM/GPRS Modem. The units have a small board and they are programmable. Among the most important programming functions are the ability to change the rate of the transmited positions and the ability to have '*geofences*'. Geofences are areas that we can assign special functionality to the unit, for example if the vehicle goes to the parking lot to stop sending its position or if the vehicle goes outside of the motorway to send an alarm. For elimination of communication costs the units are programmed to change the transmition ratio if they stop.

Communication Server. The position and the rest of the signals are sent to the communication server via a TCP connection. The server performs the following tasks.

- Authenticates users. Users depending on their rights can see vehicles that are assigned to them. For example traffic control sees only patrol cars. The responsible for cleaning the road sees only vehicles that clean the road. This functionality will be very usefull when all the fleet (180 vehicles) will be on the system
- Receive signals and store them in the database (My SQL)
- Periodicaly communicate with vehicle terminals to check their status (even if the cars are parked)

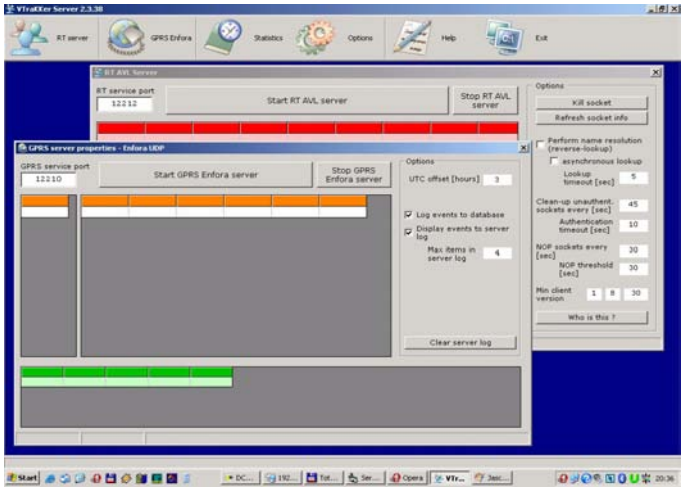

Figure 10 AVL Server

- Through the server programming commands are transmitted to vehicle units to change 'geofences' for example or transmission ratio.
- Manages all the communication flow to to the client application.

The communication server has a Public IP address. This was decided to tackle crisis situations. For example in severe snow storm (which are rare in Athens) all the persons that are responsible may not be able to access headquarters. They can login and connect to the server from home or even from a car if they have GPRS connection.

Client application

The client application which is written in Visual basic with Map Objects has the following fanctionality:

- Interacts with the server.
- Displays maps. The Maps can be in either Raster Format or Vector (shape files). The maps where created in ArcMap using Maplex for enhanced cartographic quality and they are in Raster Format. There are two different raster maps for different scales.
- Displays the position of the car on the map
- Displays information about the car such as driver name, cellular phone number, tetra terminal etc. The user can choose what information needs to be displayed.
- Displays events as they are reported (for example car 31 switched the engine on)
- Produces summery custom reports.

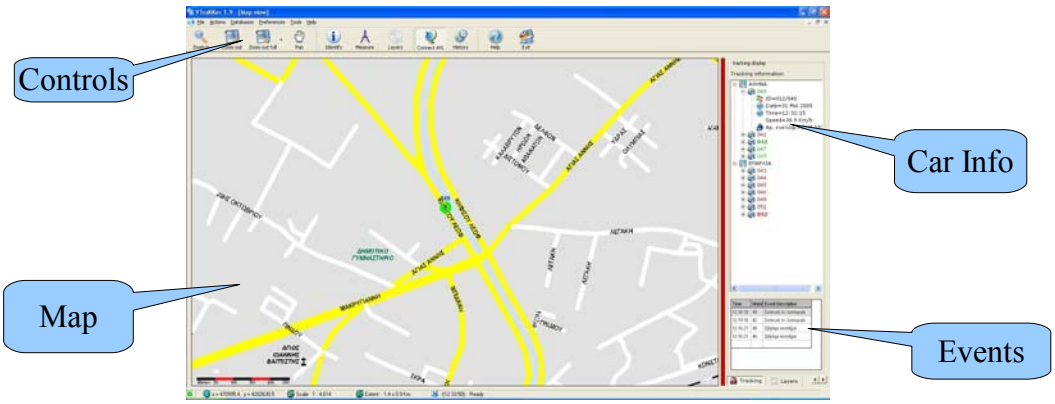

Figure 11 AVL Client

Intranet Geographic Information System of Attiki Odos

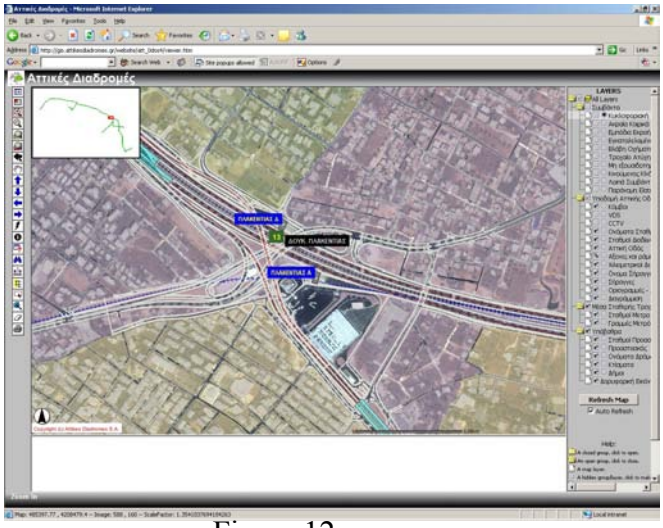

Figure 12

As it was clearly defined in user needs assessment there is a need for almost all departments of the organization to have viewing capabilities of Attiki Odos (Toll stations, VMS signs , signs, Vehicle Detection System (VDS), tunnels , the satellite image, urban blocks and streets around Attiki Odos, fire hydrants etc.) Different departments are responsible for managing different information, but all of them need to exchange information. To fulfill this demand an ArcIMS application was setup where all the departments have

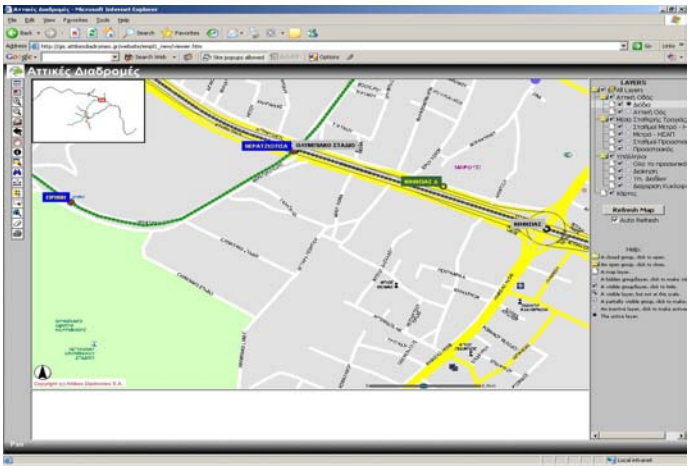

Figure 13

access to it using an Internet browser. Some applications have personal information an was the necessity to have only authorized access.

For example the application which has the address of each employee and his telephone numbers. This application, which can be accessed only by certain authorized personnel, helps in case of emergency to find which employees live near Toll stations or Metro stations. Examples of these applications are shown in figures 12 and 13

Future Plans

The Attiki Odos GIS system is an ongoing project. As the GIS is evolving more departments are involved and new applications are developed. Those applications include:

On going project is to geocode Attiki Odos Customers and analyze them for marketing planning purposes.

The use of Palm devices for the maintenance of drainage system and electric networks.

Online traffic information system. This system will be based on the already traffic volume monitoring system.

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Authors

Bill M. Halkias Msc Transportation Engineer CEO Attikes Diadromes S.A.

Bhalkias@attikesdiadromes.gr

Voice : +30 210 6682000 fax: +30 210 6635578

Dr. Eng. Thanos E. Doganis Surveying Engineer Terra Ltd.

Thanos@terra.gr

Voice : +30 210 6564710 fax: +30 210 6514847

Georgia K. Gkania GIS Specialist Attikes Diadromes S.A.

Ggania@attikesdiadromes.gr

Voice : +30 210 6682000 fax: +30 210 6635578