One year of operation and maintenance of the Rion Antirion Bridge

Christophe Pélissié du Rausas
Vice president and Managing Director, GEFYRA S.A.

Abstract:
This paper gives an overview of the first year of Operation and Maintenance of the Rion-Antirion Bridge with particular focus on structural monitoring, traffic pattern, traffic management and tolling characteristics.
For the structural monitoring of the Bridge, numerous sensors send data to specific software that allow surveillance of the project as it stands in an area subject to seismic activity. Regarding operation, the equipment used for traffic management and monitoring is described with particular focus on SCADA and its specific feature for computerized events logbook. Finally, the traffic pattern and tolling features on the Bridge are shown with concise analysis of vehicles characteristics, time pattern and evolution of traffic.

Fig1

The Rion-Antirion Bridge links the towns of Rion (department of Achaia, south coast) and Antirion (department of Aetoloakarnania, north coast). It spans a 3-km-wide strait separating the two portions of the Region of Western Greece.
The Bridge is located at the meeting point of major road links with interregional and international importance, many of which (notably the "Ionian Way" project and the Athens-Patras route) are to be upgraded to motorway standards in the near future. Its proximity to the port of Patras provides access to the Adriatic Sea routes serving the link between Italy and the Balkan countries
The Concessionaire and the Operator of the Rion-Antirion Bridge are Greek-French Companies, shareholders being major Greek Construction and Civil Companies (Elliniki Technodomiki TEB, J&P Avax, Athena, Pantechniki, Proodeftiki) and Vinci Concessions and Cofiroute as French associates respectively in the Concession Company, Gefyra S.A. and in the Operation Company, Gefyra Litourgia S.A.

Structural monitoring and maintenance

The Rion-Antirion Bridge is located in an area where it faces exceptional environmental adverse conditions:

- Weak sea-bed up to 500 m deep
- Water depth up to 65 m
- High-Seismicity area
- Tectonic movements

It was then designed to resist the following typical constraints and loads:

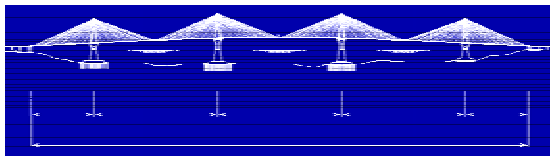
1. EARTHQUAKE
The Bridge is designed and built to take the constraints and loads corresponding to an earthquake with a return period of 2000yrs . (PGA:0.48g on the sea-bed)

2. TECTONIC MOVEMENTS
The Bridge is designed and built to allow movements of the deck up to 2 meters in all directions between two adjacent piers.

3. WIND
The maximum tolerance of the project is wind speed up to 266 km/h.

4. SHIP COLLISION
The project can withstand a collision with a 180,000 tons tanker approaching at a speed of 16 knots, which corresponds to an horizontal impact load of 28,000 tons.

It is a cable-stayed Bridge of 5 spans, with continuous deck fully suspended by the top of pylons. It is equipped with a dissipation system and lies on shallow foundation on reinforced soil.



286m 560m 560m 560m 286m
2252m

Fig2

On the Antirion side, north, the viaduct consists of 6 spans of 38m (228m. long) with concrete piers, pre-stressed beams & concrete slab, isolation and dissipation system and deep foundation (piles up to 38m deep).
On the Rion side, south, the viaduct consists of 7 spans of 58m max. (380m. Long) on concrete piers, composite deck with isolation and dissipation system and deep foundation (On-shore: bored cast in-place piles, Off-shore: Steel tubes).

The organization that was set for the maintenance of the project is as follows:

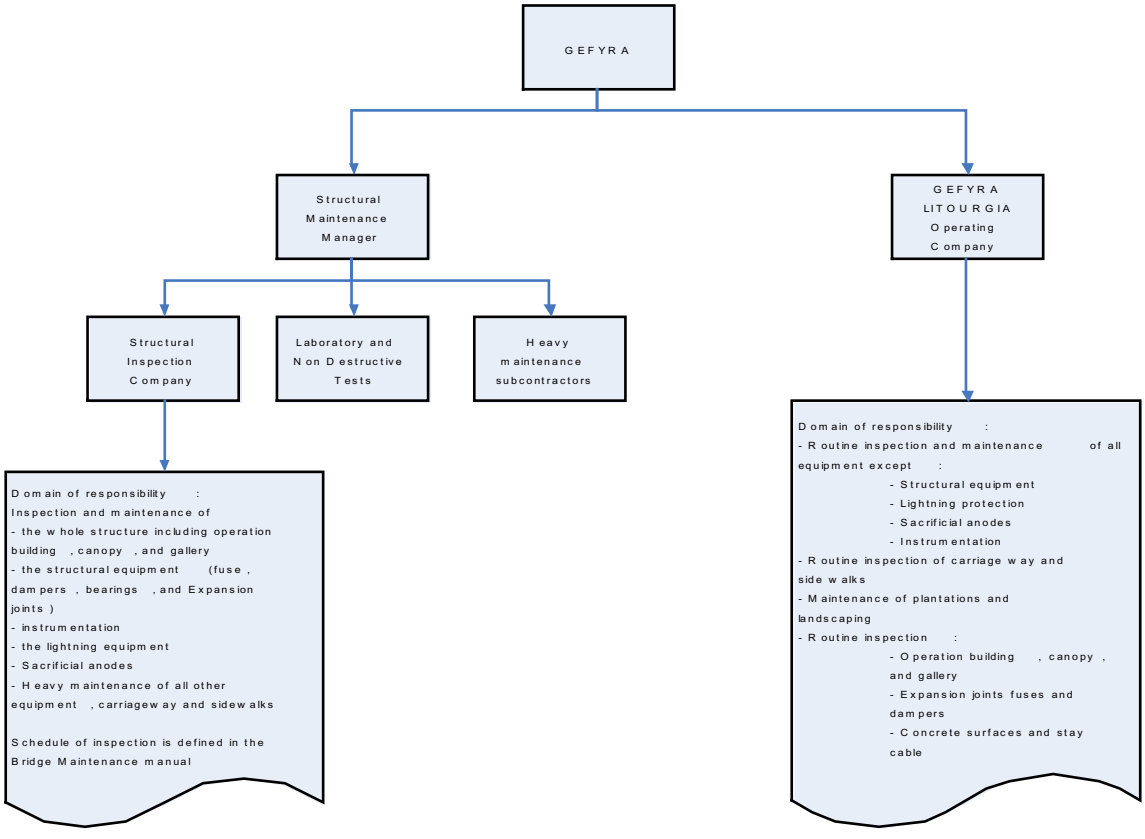


Fig2

A set of contractual document was issued by the Contractor and prepared in common with the inspection company (Advitam), the Designer, the Technical Advisors, the main Subcontractors and approved by the Supervision Engineer. The framework used for document applies for all the works in the operation period. A maintenance manual was drafted that includes most significant subjects as:

- Risk assessment of the Bridge
- Structural Inspection and Maintenance Management
- Non Structural Inspection and Maintenance Management
- Monitoring of the Bridge

Among major risks highlighted in the risk assessment, were identified: material ageing risks, specific structural risks, construction non conformities, post-event risks, bad maintenance risks and risks from supplier's equipment.

The maintenance manual describes the nature of the inspections and their frequency/schedule for the first 20yrs. Revisions are possible according to the Bridge's health evolution and the technological advances. The first schedule was set as:

- Routine inspections
- Type A (every year)
- Type B (every 2 years)
- Type C (every 4 years)
- Type D (every 4 years the first time and after every 8 years)
- Inspections after special events (depending on the type and the magnitude of the event)
  - Level 1
  - Level 2
  - Level 3

All inspections are computerized. Three main systems of Maintenance are acceptable for such a Project:

1. Corrective Maintenance
2. Planned Maintenance
3. Conditional Preventive Maintenance

Of course, maintenance costs are linked to appropriate implementation of the pertinent maintenance scheme.

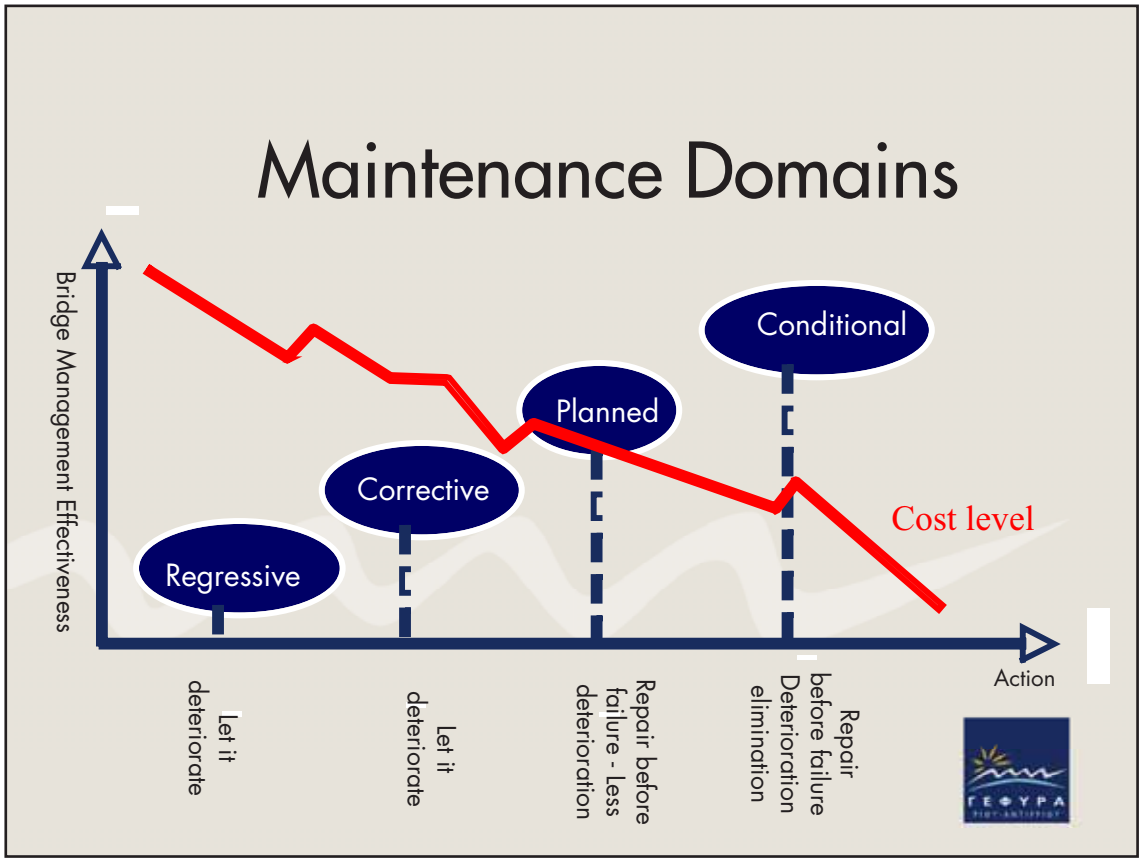


Fig 4.

Monitoring is achieved through instrumentation (Health monitoring), laboratory tests of materials and Non Destructive Tests and follow-up of geometrical control. Following the risk analysis, the monitoring system was defined to reach the following targets: Optimization of the required instruments, Maintenance schedule and Estimation of the heavy maintenance costs. A highly sophisticated system was then designed that features accurate data acquisition, fast data retrieving on a centralized Supervisor Computer and user friendly and parametric software.

Non destructive tests are used for example for the concrete durability follow up: cores are extracted on set periods from a sacrificial wall (i.e. built in splash zone conditions) and are sent to specialized laboratory. The objective is to verify the concrete durability with regards to the main risk which is the corrosion of the reinforcing bars. Weld tests are also performed.
Geometrical controls follow up (on set periods or after a special event) is also performed with the objective of checking:

- Position of Piers and Pylons (in planimetry and altimetry)
- Tilt and possible deformation of Transition Piers and Pylons
- Position of Deck (in planimetry and altimetry)

For that purpose, a global network consisted of 8 geodesic pillars is used as reference for the survey of the structure (164 survey points on the pier and pylons and 372 for the deck). Some additional data are collected from the monitoring system: expansion joint opening, cable-stays forces fuse loads, temperature Delta analysis (from 'zero point' measures). Sensitive points such as traffic flow, loadings on structure (due to wind for example) and temperature are highlighted and monitored.

The structural monitoring is using data collected from:

- 2 Meteorological stations that measures wind speed and direction, ambient temperature and relative humidity
- Road temperature sensors (4 road probes)
- Accelerometers on shore (2), on pylons (12), on deck (15) and on stays (13)
- Load cells on stays (16 load cells)
- Load cell on fuse (4 load cells)
- Joint magneto-strictive sensor (on both expansion joints)
- Water detection sensors
- Strain gauges on gussets (on 16 gussets)

In total 100 sensors, more than 300 channels, are delivering data to the structural maintenance and monitoring system.

Fig 5

The Inspection-Maintenance and Monitoring program applied on the Rion-Antirion Bridge ensures:

1. The continuous structural monitoring of the Bridge and thus maintaining the high-level of safety to the users.
2. The advanced detection of possible deterioration with minimum inspection time with the computerized inspection software (ScanPrint).
3. The storage of all the inspection data in one single database.
4. The time-effective management of inspection data.
5. The optimization of maintenance (cost and time reduction, less traffic restrictions).

Traffic management and Routine maintenance

The Rion-Antirion Bridge is permanently operated through technical and human resources organized as to ensure detection of any event with potential impact on the safety of the drivers and/or the project. Indeed, the organization that is set up has to cope with the tight requirements of the specifications regarding the maximum period of time allowed in order to trigger first aid action or after occurrence of a road accident, or temporary signing action after occurrence of any event that prevent or impede traffic flow.

The Concessionaire, located in Athens, supports on a case by case basis the local Operation Company. The basis of the daily operations management is the two members supervision team (one supervisor and a deputy) that manage a control room on a 24h basis. These supervisors instruct and command a team of traffic and safety officers for the patrols, the assistance to drivers, the temporary signing actions, first level fire fighting and first aid. A maintenance team is present on 2x8 shift basis in order to ensure maximum availability of the systems and equipment for the operation team. Regarding equipment and systems, the Operation team receives information from and commands a Toll system, a SCADA+ system, a CCTV system linked to Automatic Incident Detection and an Emergency Road Telephone network. 17 cameras are installed for traffic monitoring, 3 of them being zoom/pan/tilt cameras.

The SCADA system was developed to offer additional features than those usually met in such system. The SCADA system on the Rion Antirion Bridge features the usual mimic diagram and control/command panels for project equipment (pumps, public lighting, decorative lighting, generator, PLC, access control, electrical network, etc.) but it also includes an automatic communication with pre defined Authorities (Traffic Police, Fire Brigade, Ambulance, etc.) and a computerized log book for events records. Control and command of the Variable Message Signs on both sides of the Concession area are also accessible through the SCADA. For faster information of drivers, a library of messages was created although the Supervision team may use manual entries the case being.

b

In 2005, we had to handle 15 road accidents and incidents and a bit more than 250 breakdowns. Road accidents were not serious and only damages to the vehicles were observed. The assistance to drivers in case of breakdowns is subcontracted to specialized Companies that operate throughout Greece. Those companies offer technical assistance and may mobilize appropriate resources for faster and safer assistance. Approximately 10% of the assistance calls concerned trucks.

Indeed, the major adverse weather conditions faced on the Bridge are high wind speed episodes where, in coordination of Traffic Police, specific traffic restrictions apply. By procedure, when wind speed is stabilized at 70 km/h and above a pre alert is sent to the Authorities in order to prepare the setup of traffic filtering.

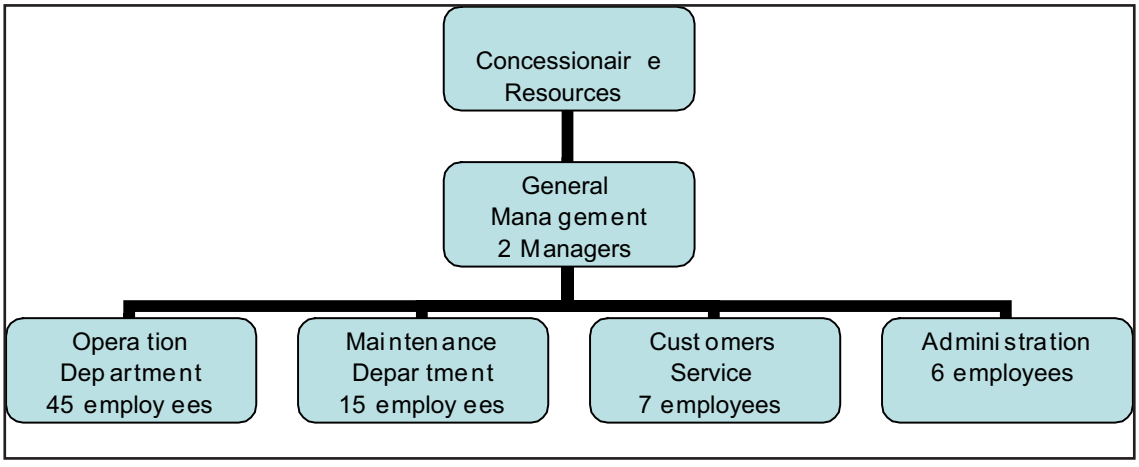


Fig6

When wind speed is stabilized at 80 km/h and above, then vulnerable vehicles are stopped by Traffic Police and diverted. Vulnerable vehicles are bikes and empty trucks and buses because of the particular risk of overturning when submitted to strong transversal wind gusts. A second level of traffic restrictions is set at 120 km/h where all traffic is prevented from crossing the Bridge. Two weather stations located on the Bridge deck send real time data that are compiled through a dedicated SCADA diagram.

Regarding routine maintenance, the resources of the Operation Company allow permanent monitoring of the equipment, systems and civil either through SCADA, remote monitoring and maintenance performed by suppliers or with visual inspection according to pre-defined schedule and assessment procedures. The systems are still in their "learning" period (AID for example), troubleshooting and preventive maintenance are currently the major tasks of the maintenance team. Taking into consideration the rather hard environmental conditions, equipment and civil are more particularly monitored and maintained with regards to fatigue (wind constraint), corrosion (marine environment) and water intrusion (heavy rain episodes).

Traffic pattern and tolling features

With respect to the Concession contract between the Greek State and Gefyra S.A., concessionaire of the Rion-Antirion Bridge, nine different categories of vehicles are considered. One category gathers all motorbikes. A second category gathers private passenger vehicles, what we characterize as cars or any vehicle having a maximum of two axles and height below two meters. Then four separate categories are defined for trucks depending on their number of axles. Finally, buses and coaches are parted in three categories depending on their number of seats.

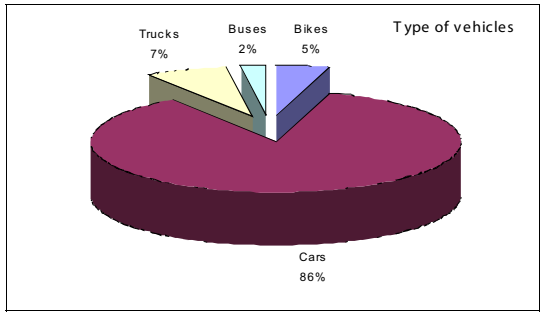


Fig 7

The distribution of the type of vehicles using the bridge is largely centered on cars.
The Bridge is taking approximately 85 % of the light vehicles and 60% of the heavy vehicles traffic across the strait, the other possibility of crossing the strait being the ferries.

Seasonality is highly marked on the Rion Antirion Bridge especially for motorbikes and cars. The Average Annual Daily Traffic exceeds 12,000 vehicles per day but monthly variation is very high with 2.5 times more traffic in August than in February. We record more than 20% of the total annual traffic in July and August. The variation observed for motorbikes goes from less than 200 transactions per day in average in February 2005 to more than 1000 transactions per day in average in August 2005. For cars, the variation goes from 7,500 transactions per day in average in February 2005 to more than 17,000 in August 2005. Variations for the other categories of vehicles are much smaller and correspond most probably to steady volume of business trips whereas motorbikes and cars are more subject to leisure/holiday trips.

In terms of global traffic, all categories included, the seasonality is again a major characteristic on the Rion-Antirion Bridge. Some specific period in the year corresponding to religious or commemorative days show high traffic with usually clear stream in one direction (basically North bound - Athenians on Friday and Southbound on Sunday afternoon). The maximum daily traffic recorded exceeded

30,000 vehicles on the 2nd of May 2005. Such a peak pushes the toll plaza and toll collectors to the limits as a maximum of 7 lanes can be operated in each direction (six "manual" lanes and one Electronic Toll Collection ‡ETC- lane)

and as a large majority of customers uses cash payment.

In terms of weekly distribution, approximately 50% of the weekly traffic is recorded from Friday to Sunday, the latter being in average the heaviest day in the week by far. The "commuting" traffic is not yet very developed as the Bridge could hardly modify the transportation scheme in the area in such a short period. The growing exchanges between the two regions, once parted by the Corinth strait and linked by ferries with the expected delays and sailing restrictions, will undoubtedly increase traffic both through new "commuters" and through business development in the area.

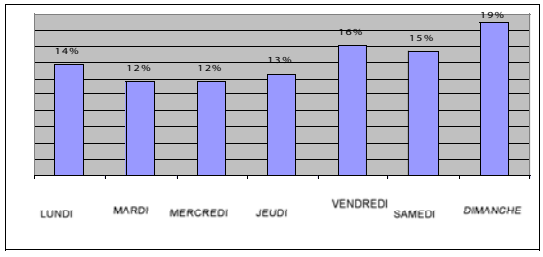


Fig 8

We observe currently an average of 500 Aller-Retour per day (one of the commercial schemes implemented on the Bridge for short interval trips back and forth) and another 500 transactions per day in average are recorded with another commercial scheme designed for frequent users.
The daily pattern of traffic is usual with low traffic at night and growing traffic until mid afternoon.

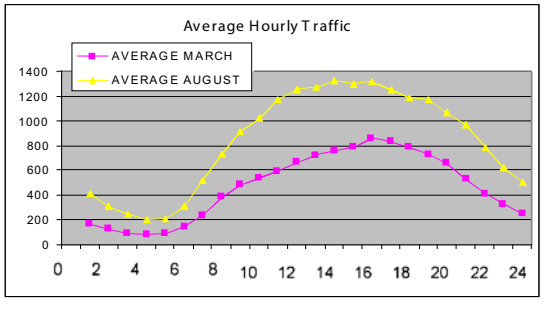


Fig 9

Regarding means of payment, the toll system installed on the Rion Antirion Bridge supports cash payment, contactless "smart" cards use, DSRC technology and magnetic track cards for specific transactions.
The cash payment represents the largest part of the payments in lanes with approximately 88% of the transactions. Contactless "smart" cards that support the commercial products and ETC transactions correspond to the remaining 12 %. The large proportion of cash payment is linked on one hand to a weak proportion of local clients (high proportion of long distance clients), and a cultural trend in Greece not to use credit cards. We think that the main evolution in that field could come in a progressive implementation of interoperability in Greece.

The Rion-Antirion Bridge has entered into its Operation period since the 12th of August 2004 at 6pm We have now roughly 18 months of experience in the operation of this bridge, the main facts and figures characterizing this initial period have been summarized in this article. The construction of this project was a major challenge again the natural conditions of the strait, in several fields that are well known, like the seismic conditions, the configuration of the sea bed, or tectonic movements. The maintenance and operation of such a project are now also a challenge, that has to be overcome on a daily basis through, for instance, a carefully planified maintenance and commercial creativity in order to put in place new products for our clients. Finally, by bridging the natural gap of the strait, we are convinced that we contribute to the economic development of this region of Western Greece, we have every day the confirmation of such a belief, and we think that the University study that has been undertaken recently on that subject will confirm that statement. .

Finally, it is obvious that works or projects such as tunnels and bridges differ widely from basic linear works. Their design, construction, maintenance and operation can hardly be compared to basic motorways as they usually concentrate major challenges in terms of technology, safety and level of service in a very limited area. Specific economical and financial standards linked mostly but not exclusively to technical constraints shall apply that cannot be easily derived from those observed for linear works. For example, the standard costs per km lose pertinence when non linear works like tunnels and bridges are at stake and other criteria shall be benchmarked and taken as parameters.