

Invited Presentation 2

Athens Metro base project and extensions - Project structuring and management characteristics

George Leoutsakos

Interface Coordination Manager, Attiko Metro AE, Athens, Greece

Abstract

Two new metro lines (lines 2&3) were opened for operation in the city of Athens in three phases (12 Km - 14 stations in January 2000, 4 Km - 5 stations in November 2000, 1 Km - 1 station in April 2003), thus completing the "Base Project" of the Athens Metro. Following that, an additional 9 Km with 4 stations plus a connection with the new Athens Airport utilising the line and track of the suburban railway were delivered for operation in July 2004. Following 12 years of intense engineering and construction activities, overshadowed by the wealth of archaeology of the city, a 3.1 billion EURO program came to full realisation and together with the existing metro line 1, provided the transportation backbone of the city, while also serving the 2004 Olympics. The present paper describes the structure of the above projects both from the owner side and the contractors side, outlining all main contractual and project management viewpoints, describing relative advantages and disadvantages of various forms of project structuring and demonstrating the importance of efficient organization and project management to large scale projects. Lessons learned on swift decision making, risks assessment and control measures, contractual structuring and consortiums structure characteristics, through various phases of the projects from civil works through to commissioning are put into perspective on an ambitious 2.5 billion EURO extensions program.

Keywords

Metro, project management, contracts, schedule

1. Project description

The Athens Metro lines 2 & 3 are shaped in form of a large "X" intersecting at the centre of the city and crossing the existing line 1 at three stations, while at the northern part of the city, line 3 interfaces with the suburban railway and the ring road of Athens (see fig.1). The two new lines are serving over 700.000 passengers daily with train headways varying from 3 to 10 minutes, in addition to 400.000 passengers served by line 1. Also 300.000 less car trips are performed daily, with a substantial decrease in pollution levels, despite the increase in car ownership and the rapid development of road networks. With these projects a serious effort was made in Athens to clear its reputation of a city with endless traffic jams and air pollution severe enough to cause harm to its inhabitants as well as to its historic buildings.

The two new lines are all underground. The Base Project tunnelling was done mainly by two 9.5 m diameter TBM's which opened 12 Km of tunnels, while shorter tunnelling sections of 3.3 km were done by Cut and Cover and NATM methods. For the extensions, one 9.5 m diameter TBM-EPB was used for 3.4 Km, while the Cut and Cover and underground NATM excavation methods were also extensively used for the remaining tunnels. Out of the 24 stations that have gone into operation, 18 were constructed by Cut & Cover, 5 using the NATM method while the central station of Syntagma at the intersection of lines 2 & 3,

was partly constructed by the Cover & Cut method and partly by NATM. Most stations are side platform while three stations only being of the centre platform type. Granite, light coloured marble, ceramic tiles and stainless steel have extensively been used in all stations to enhance their architectural image, blending with neo classical buildings in the central parts of the city or with more modern buildings in the outer parts of the city. The extensions stations have followed a more “open type” of architecture with natural light and bioclimatic architecture principles applied to the design.

The main Electomechanical and Railway systems included Ventilation and Air Conditioning, Lifts and Escalators, Drainage, Pumping and Water Supply, Traction power, Medium voltage – 20 KV power supply, Power distribution and lighting, Signalling with Automatic Train Supervision (ATS), Automatic Train Protection (ATP) and Automatic Train Operation (ATO), Radio - Telephone Communications and mobile telephones, CCTV, Clocks, Public Address, SCADA control systems, Automatic Fare Collection of the open non-barrier type and Trackwork

Fourty nine (49) six-car 106 m long trains form the rolling stock, 28 of which were procured under the Base Project and 21 under a separate tender. 7 of the trains are dual voltage trains serving line 3 up to the airport and operating under two different power supply systems, one under the metro 750 V DC network and one under the suburban line 25 KV AC network. There are two depot facilities, one in line 2 which includes stabling and light/heavy maintenance and overhauling, covering an area of 120.000 m2 and one at the northern end of line 3 which is only for train stabling.

2. Project structuring and management

The project structuring and related management was different in the Base Project and the extensions projects constructed so far, and the main characteristics of each alternative are analysed below.

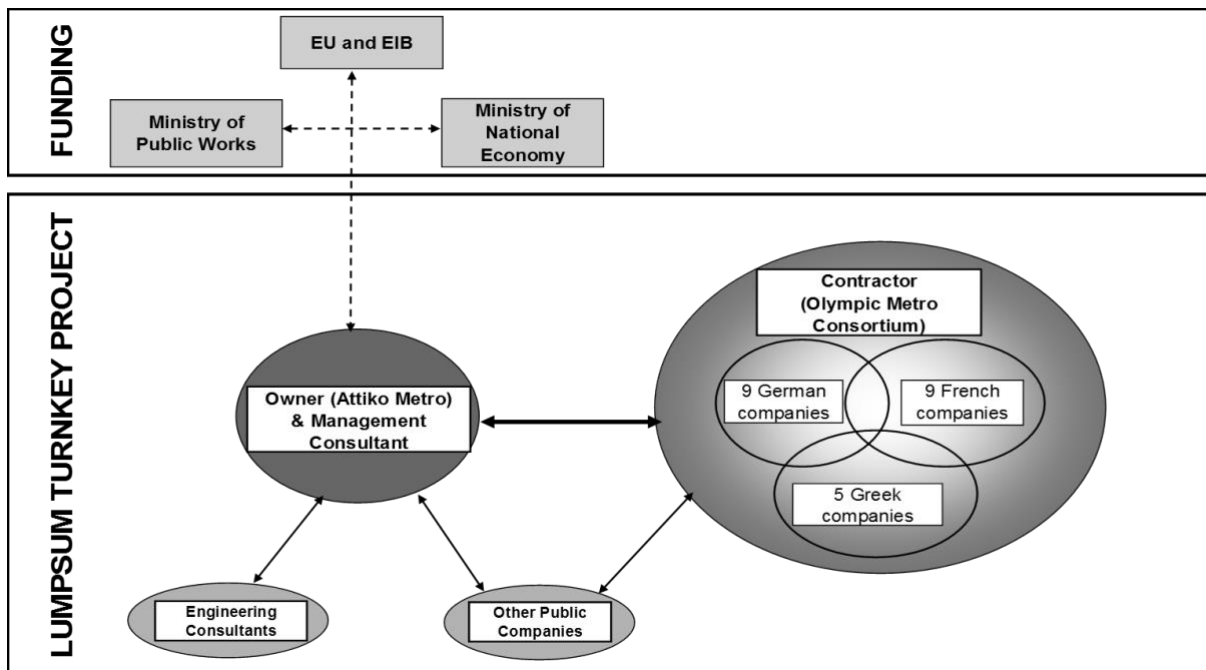


Fig.2: Athens Metro Base Project Management structure

The Base Project was a design and construct lumpsum turnkey project. The project owner (ATTIKO METRO), assisted by a management consultant, was supervising the Contractor (OLYMPIC METRO) who constructed the project. The process was monitored by a special committee with officials from the Ministry of Public Works, the Ministry of National Economy, the European Investment Bank (EIB) and the European Union (EU). The figure below indicates in a schematic form the project structure.

ATTIKO METRO, the owner and client, is a state owned company set up by the government by law in 1991. The company supervised the project implementation and performed design review, construction supervision, project control, quality control, secured the necessary funding and dealt with all public relations with the public and other third parties. A management–technical consultant blended within the company for providing project management and technical expertise. The total cost of the Owner, including management and other consultants as well as setting up and organizing the subsequent system operation, approached 10 % of the total project budget.

The Contracting Consortium which built the project comprised of 23 companies (9 German, 9 French and 5 Greek) appearing as one entity in front of the Owner. The Consortium was divided into a centralized management group and 7 other sub-groups covering Engineering, Civil Works, Power Supply, Low Voltage, Rolling Stock, Trackwork and the Depot. Several internal relationships were set up at various levels between the above companies and subgroups, each one being a different profit center. Overall the Consortium did deliver a safe, reliable and good quality end product with minor problems, with low-moderate budget overruns and moderate-significant time delays, while significant improvements were made to what was initially specified.

For the extensions projects which comprised the four outwards extensions of the Base Project lines 2&3, the project structuring was radically different with each extension being implemented through a series of parallel and independent contracts, as shown below:

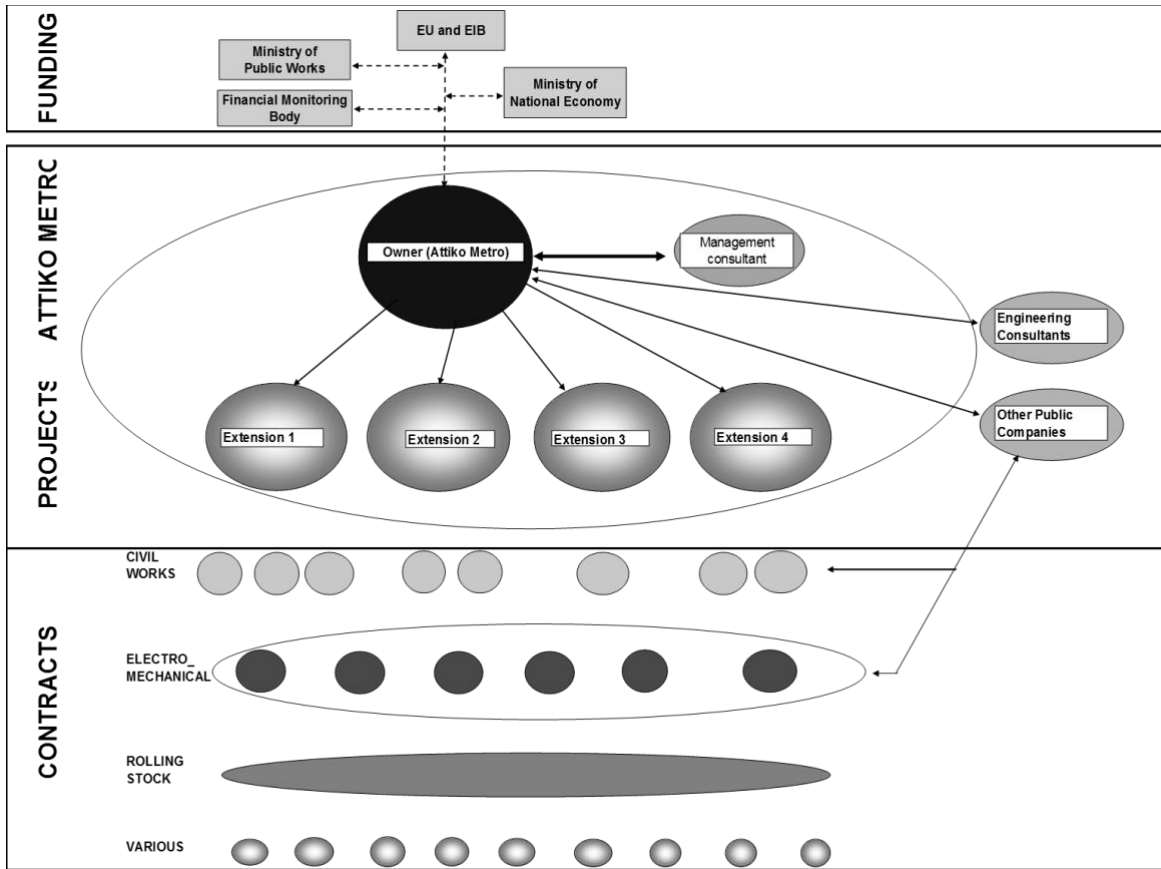


Fig. 3: Athens Metro extensions projects management structure

The civil works contracts were distributed geographically (one or more contracts per metro extension) while the electromechanical and railway systems contracts were distributed by discipline, remaining the same throughout the four metro extensions for reasons of compatibility, equipment similarity and easier maintenance. The necessary additional rolling stock was procured under a separate contract. The funding mechanisms for the projects remained essentially the same with a specialised government body being created for the financial monitoring of the project, together with other large infrastructure projects. The figure below indicates in a schematic form the extensions projects structure.

Under this type of project structure, the Owner was fully responsible for providing the coordination and interfacing between all the various contractors and third parties, for technical, contractual and time scheduling issues. The risk for the correct and timely project implementation as well as the overall cost control was also with the Owner, while each Contractor had only segmental responsibility for his part. The result showed that the projects were implemented in a timely manner (approximately 6 months design, 6 months tender, 24 months of Civil Works and 24 months of Electromechanical and Railway systems installations until operation start, leading to a total phased duration of 4 years), with very limited cost overruns and an overall reduced cost. This process imposed a huge technical, contractual, time scheduling and project control effort on the Owner. A technical consultant assisted the Owner in the above efforts, without however being directly related to the management of these projects.

In the future extension projects of the Athens Metro, a different project structure shall be followed. According to this concept, each one of the new geographically separate extensions projects shall be executed by a main contractor who will undertake the responsibility and the risk for the civil works

construction and the main electromechanical and railway systems installation, while only selected few railway systems (signalling, radio telecommunications, fare collection, SCADA control systems) shall be implemented through separate contracts, each for a special reason related to safety and compatibility with existing systems. The project structure for the future extensions is shown in the figure below.

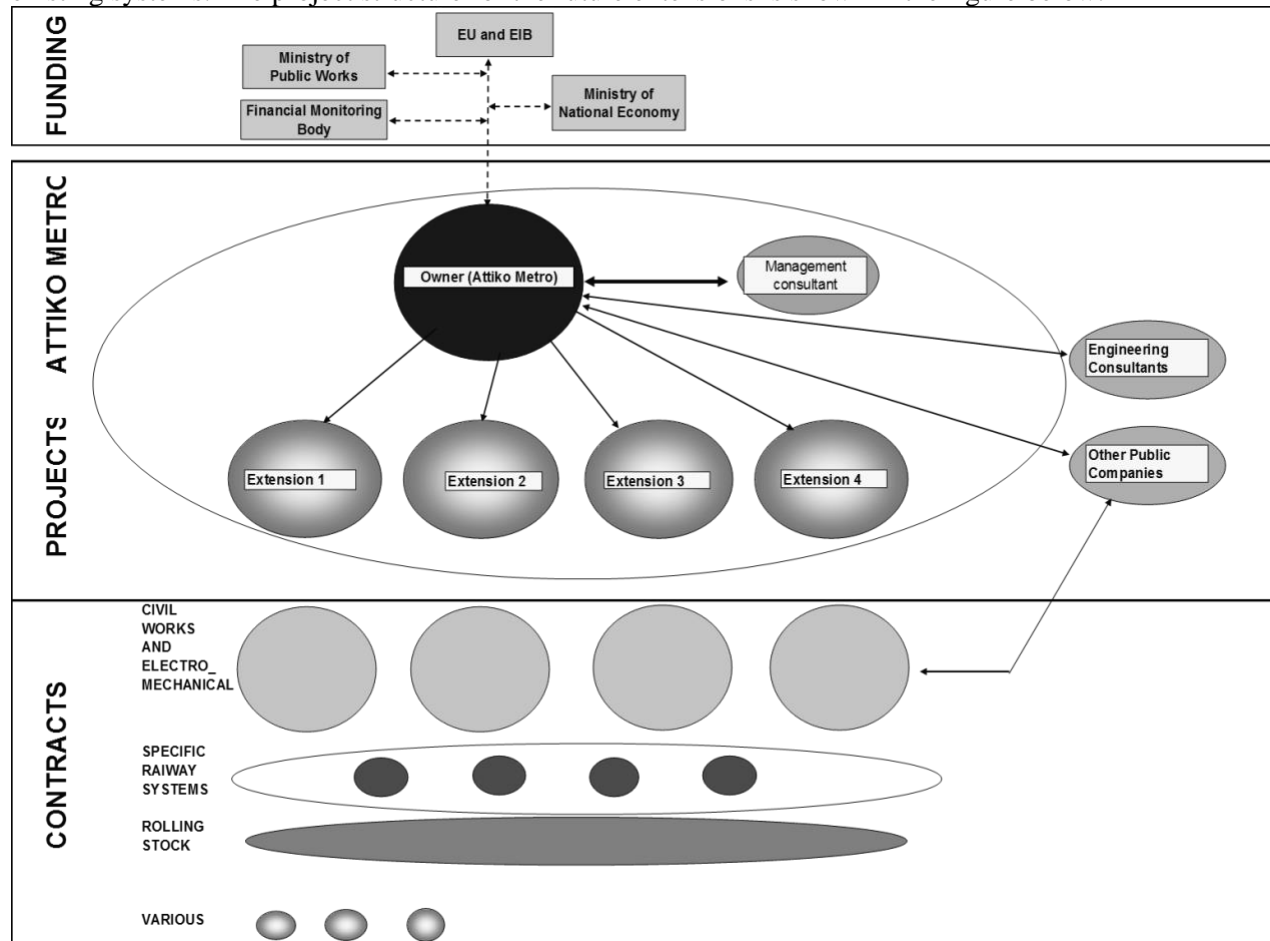


Fig. 4: Athens Metro future extensions projects management structure

3. Comparison of alternatives on project structuring and management

Comparing of the three different structures and related strategies for implementing a metro project as presented above, reveals a multitude of advantages and disadvantages for each option and indicates that a careful assessment is necessary in every case, for selecting the best option. In a grouped manner the main characteristics for each option are as follows :

3.1 Design & Build Lumpsum Turnkey Contract

This type of project structuring is recommended when the Owner has limited technical experience of the project and hence all responsibilities for the project are with the Contractor who has been selected considering also his experience for carrying out the required works. However even in this “turnkey” case, experience has shown that a significant part of the risk which translates into additional cost, is transferred back to the Owner as large scale and multi-disciplinary contracts often have gray areas and are subjected to different interpretations. The following points also characterize lumpsum turnkey contracts:

- All design and construction processes involving several companies and subcontractors, their technical and contractual handling and their coordination are under the full responsibility of the Contractor. This results in overhead costs being increased substantially due to the large staffing requirements, complicated design production and long winded cost control procedures.
- A large number of Contracting Consortium members results in substantial internal inertia within the Consortium, preventing it from responding quickly to design faults and design evolution issues, project scope modifications, contractual matters and in anything that deviates from the signed contract. In the interfacing of the various groups and subgroups, responsibilities and delays for multi-discipline tasks tend to be transferred from one member to another, often creating significant friction, and eventually impacting the project contractual targets and the Owner. In such an environment the Owner inevitably bears an increased responsibility for taking necessary steps to ensure that the Contracting Consortium remains functional and able to deliver the works as the Consortium multiple profit centres, are always eager to share the payments but not the risks. Hence, it is not recommended to have many (more than approximately 5) members
- Large size Consortiums often have the power to negotiate with the Owner and be successful in imposing their opinion on critical and especially on sensitive cost issues
- Due to the overall responsibility, and undertaking the majority of the risk, lumpsum turnkey contracts are usually more expensive. This however allows the Owner to limit his direct resources.

3.2 Multi – contract project implementation

For this type of project structuring to be successful, the Owner must have very good knowledge and experience of all disciplines and areas of the project. It usually leads to cost savings although strict project management is necessary as the parallel handling of several contractors requires extreme contractual clarity regarding schedule deadlines and phasing of the works, as well as simultaneous adherence to the time schedules by every one of the parties involved. The following points also characterize this type of project implementation :

- The overall design and construction processes involving several companies through several contracts are the responsibility of the Owner. This on one hand is very favourable because the Owner gets the final product as he has planned it, however this results in substantial staffing requirements for the design review, the contractual handling and the cost control procedures for the various contractors.
- The overall risk is with the Owner
- The Owner is in a stronger position to negotiate with one out of a multitude of contractors than in the case of the lumpsum turnkey contract where there is only one large size Contractor

3.3 Project implementation with few contractors

This alternative is a compromise between the two above options A and B and utilizes the advantages of each. Its main characteristic is that there is one main contractor doing the majority of the works for a specific project, undertaking also all the coordination requirements and the majority of the risk. Certain safety critical or other special disciplines are left outside the main contract and are awarded as separate specialized contracts. The size of the project and the related contract and cost however is selected to be such that the Contractor can be managed effectively. This type of contract structuring is currently being implemented in the next generation of metro extension projects of the Athens Metro, and is expected to ensure fast track project implementation without however imposing an excessive burden on the Owner.

Irrespective, however of the type of project and contract structuring that is followed in the implementation of metro projects there are lessons learned for the future projects that carry significant importance, and some are outlined below :

- Changes in the contract scope of any contract should be well evaluated and controlled as they form a prime reason for budget and schedule overruns, usually significantly greater than originally anticipated. Schedule changes in a multi-contract environment needs delicate and careful handling.
- Resolution of contractual issues is a time consuming and costly process for both Owner and Contractors. A proactive use of the resources is likely to reduce the number and severity of problems before these arise, to the benefit of both sides.
- Time and money spent in interpreting contract terms is inversely proportional to the clarity of the contract terms themselves. It is thus well worth investing in the preparation of coherent and unambiguous contract documents. In multi contract environments the coordination and interfacing between the related parties is an especially important part of the documentation.
- Comprehensive risk assessment before construction and application of effective risk control measures, should be an integral part of the project evolution process, involving both Owner and Contractor. Classification of risks is imperative and project managers should prioritise and deal with issues that matter the most. Besides archaeology, the main sources of schedule and budget overruns are usually ineffective project management (both from the Contractor and Owner sides), unforeseen ground conditions and unsuitable construction methodologies and their implementation.
- The coordination and management tasks of the Owner bringing together public sector companies (eg utility companies), obtaining all permits, preparing and expediting all town planning, land use and environmental impacts should be well defined and planned from the project inception.
- Owner-Contractors relations based on trust and fair judgments are the foundation of problem solving processes.

4. Time Schedules

Time schedules are an indispensable tool for managing large scale projects, enabling both Owner and Contractors to follow the project progress, implement actions for mitigating delays and keeping the contractual monitoring in order. Metro project schedules range in size from approx. 100 activities during the project planning stage to several thousand activities during the implementation stage (eg 6000 activities for a section of 6.2 Km with 7 stations). Project time schedules are especially important in multi contract environments offering a tool for managing the time windows available to each Contractor for his works. The actual summary schedule for the first part of the turnkey lumpsum Base Project, and indicating typical time durations for the main categories of the works delivered in Jan. 2000 (so called “Partial Opening” with 12 Km with 14 stations on 2 lines) is shown below. The dominating impact of archaeology is observed, indeed being one of the main reasons for a 2 year project delay.

The time schedule for a specific 1.2 Km section “Syntagma – Monastiraki” of line 3 completing the Base Project, although sensitive and very critical for the operation, suffered extreme delays due to a combination of several adverse factors, including archaeology, sensitive adjacent and overlying structures, very unfavourable ground conditions requiring state of the art excavation techniques at low advance rates, as well as the significant redesign of this station (Monastiraki), following the deletion of the original terminal station of line 3, again due to archaeological reasons.

	'92	'93	'94	'95	'96	'97	'98	'99	'00
Contract award	◆								
Design	■	■	■	■	■	■	■	■	
Archaeology	■	■	■	■	■	■	■	■	
Utility relocations	■	■	■	■	■	■	■	■	
Tunnels Civil Works		■	■	■	■	■	■	■	
Stations Civil Works		■	■	■	■	■	■	■	
Trackwork					■	■	■	■	
E/M systems					■	■	■	■	
Train Controls						■	■	■	
Architectural finishes					■	■	■	■	
Integration testing								■	
Trial running								■	
Operation start									◆

	'00	'01	'02	'03	'04
Start	◆				
Design	■	■			
Tenders		■	■		
Archaeology	■				
Utility relocations	■				
Tunnels Civil Works		■	■	■	
Stations Civil Works		■	■	■	
Trackwork				■	
E/M systems				■	
Train Controls				■	
Architectural finishes			■	■	
Integration testing					■
Trial running					■
Operation start					◆

Fig.5: Actual project time schedules for Base Project (left) and Extensions (right)

A fast track philosophy was employed in the extensions projects, implemented in the 2000-2004 period under a multi contract approach, and is shown in the summary schedule above. The smaller size of the extensions projects, the much reduced archaeological impact, the easier public utility relocations and the effective project management, resulted in a much reduced overall time for the projects implementation, as well as in very limited budget overruns, demonstrating that the lessons learned during the Base Project construction were well applied to the extensions projects.

5. Conclusions

Three different project structuring and management alternatives were presented from the recent implementation of metro projects in Athens, covering lumpsum turnkey and multiple contracts approaches to the contractual and management structuring for these projects. Their related characteristics, advantages, disadvantages and special points were outlined and compared, indicating the best suited environment and conditions for their application. Representative project time schedules indicated that the technical and non technical lessons learned from the Base Project implementation resulted in efficient project management which in turn led to a timely and within budget completion of the first phase metro extension projects.

6. References

- ENR World Projects,(1993), “Athens digs through its ancient heritage to construct a subway”
ENR publication
- Ratzer, P. (1998), “ Management of Risk in Projects”,
Tunnel Mngmt Int., Nov. 98
- Anderson, J. (2000) “Tunnel Project Procurement and Processes : Fundamental Issues of Concern” Tunnel
Management International.