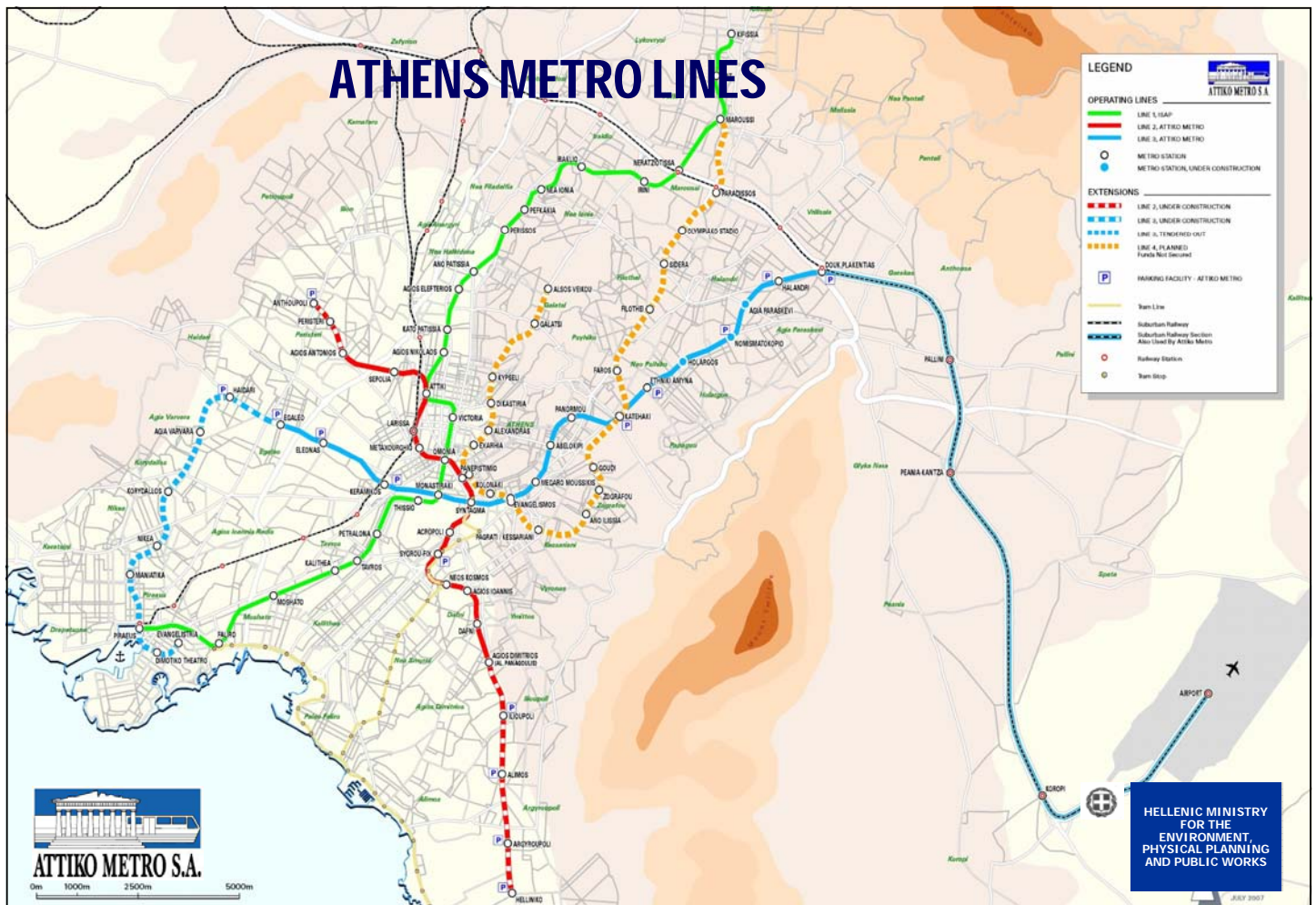




# ATHENS METRO Past, Present & Future

Dr. G. Leoutsakos  
ATTIKO METRO S.A.

46<sup>th</sup> ECCE Meeting  
Athens, 19 October 2007





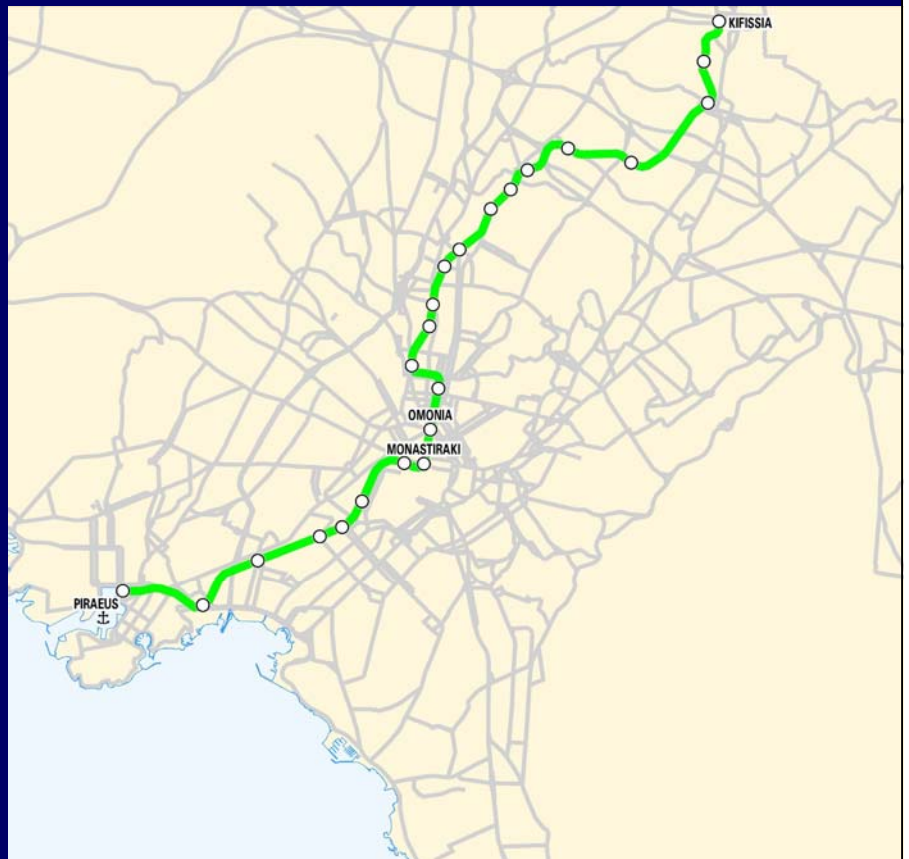
## METRO NETWORK PHASES

- Line 1 (26 km, 23 stations, 1 depot, 220 train cars)
- Base Project (17.5 km, 20 stations, 1 depot, 168 train cars) [2000]
- First phase extensions (8.7 km, 4 stations, 1 depot, 126 train cars) [2004]  
+ airport link 20.9 km, 4 stations (shared with Suburban Rail) [2004]  
+ 4.3 km, 3 stations [2007]
- Extensions under construction (8.5 km, 10 stations, 2 depots, 102 train cars) [2008-2010]
- Extensions under tender (8.2 km, 7 stations) [2013]
- New line 4 (21 km, 20 stations, 1 depot, 180 train cars) [2020]



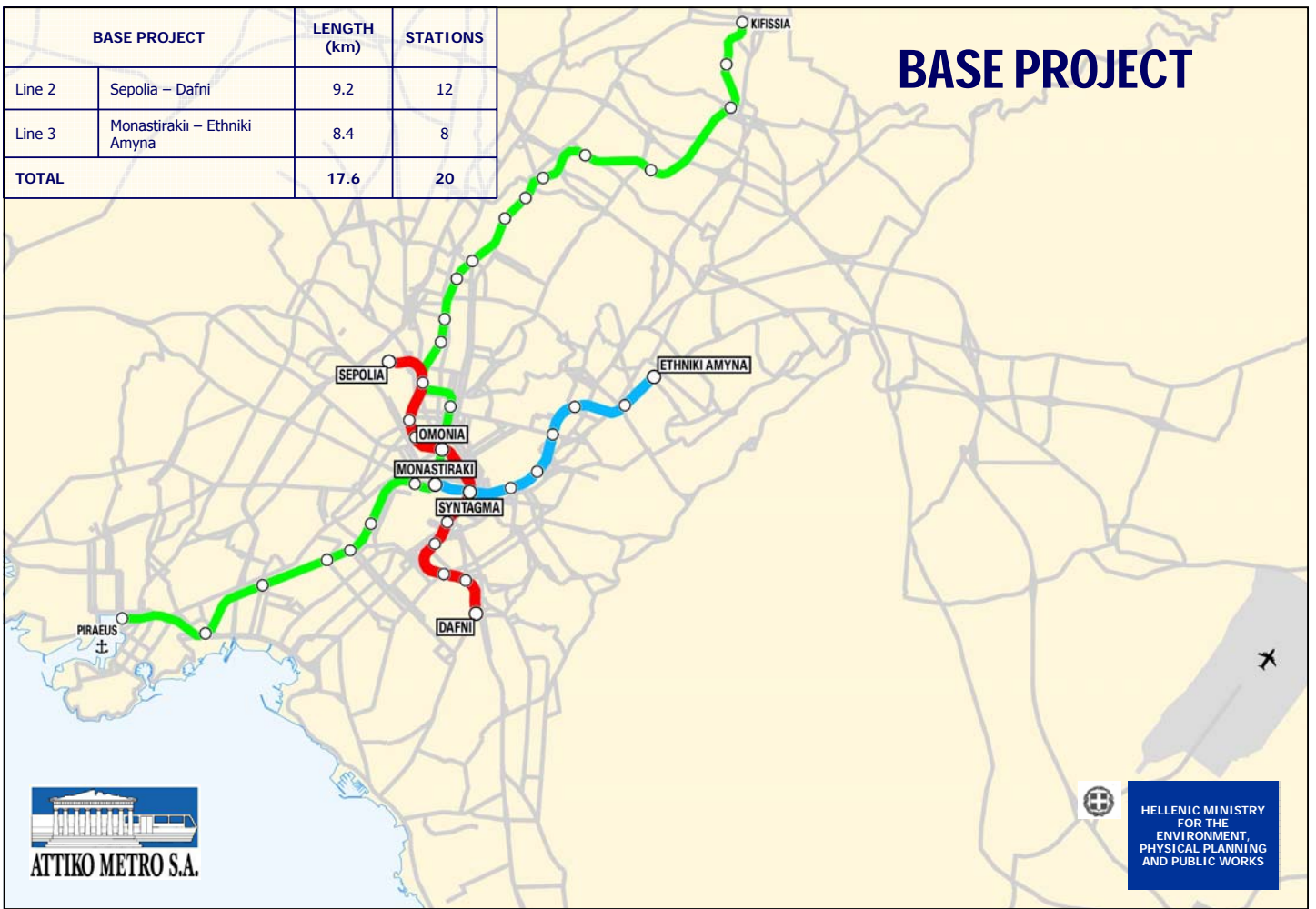
## LINE 1 – ISAP

- ✓ 26 km long
- ✓ 24 stations
- ✓ 3.1 km of underground line
- ✓ In operation since 1869
- ✓ 450,000 passengers/day



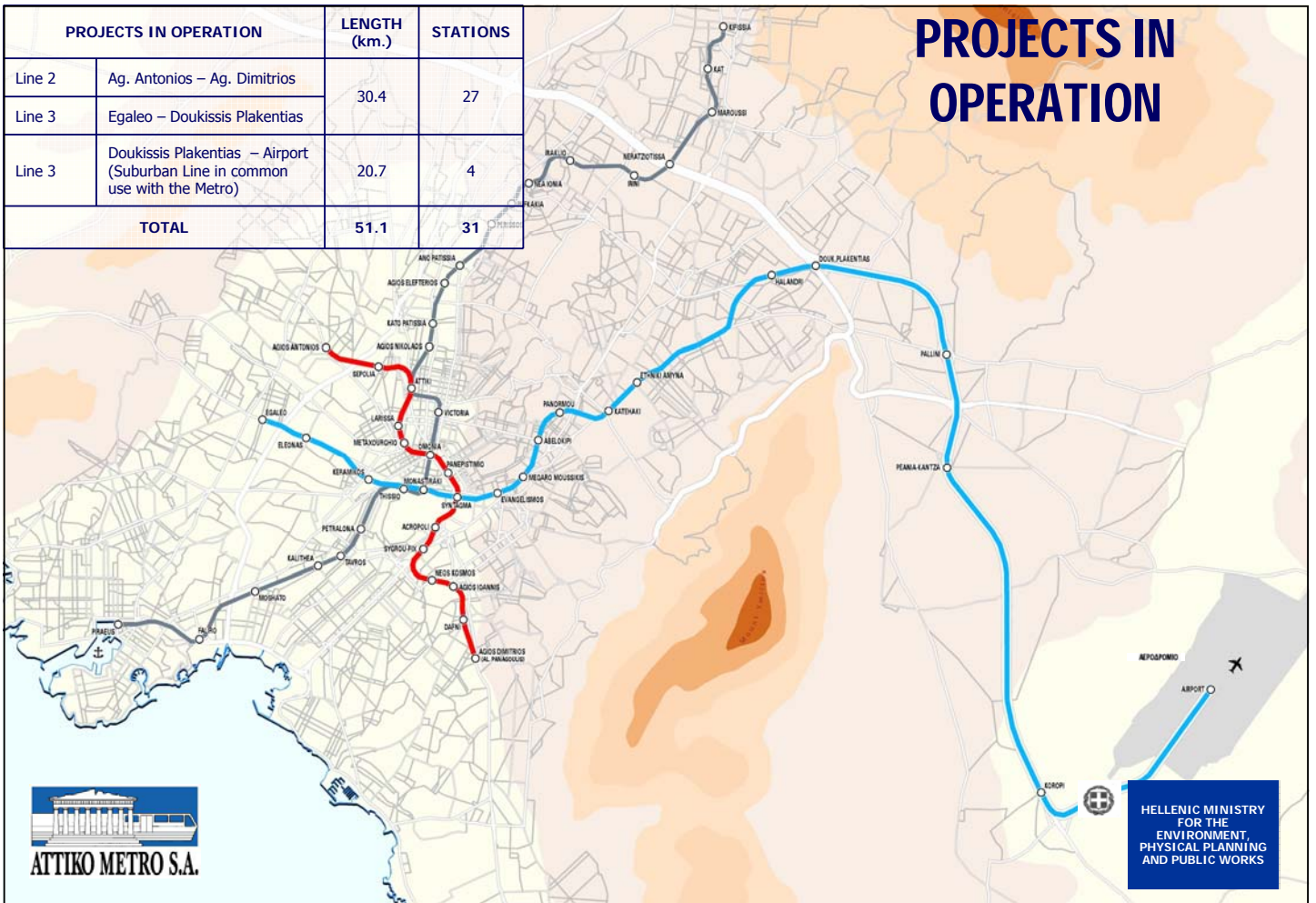
BASE PROJECT		LENGTH (km)	STATIONS
Line 2	Sepolia – Dafni	9.2	12
Line 3	Monastirakii – Ethniki Amyna	8.4	8
<b>TOTAL</b>		<b>17.6</b>	<b>20</b>

# BASE PROJECT



PROJECTS IN OPERATION		LENGTH (km.)	STATIONS
Line 2	Ag. Antonios – Ag. Dimitrios	30.4	27
Line 3	Egaleo – Doukissis Plakentias		
Line 3	Doukissis Plakentias – Airport (Suburban Line in common use with the Metro)	20.7	4
<b>TOTAL</b>		<b>51.1</b>	<b>31</b>

# PROJECTS IN OPERATION



- 650,000 passengers / day (average number of passengers in the network in 2006)
- 51,1 km of network in total
- 31 stations in total (27 stations + 4 commonly used with the Suburban Railway)

### INDICATIVE TRIP DURATION:

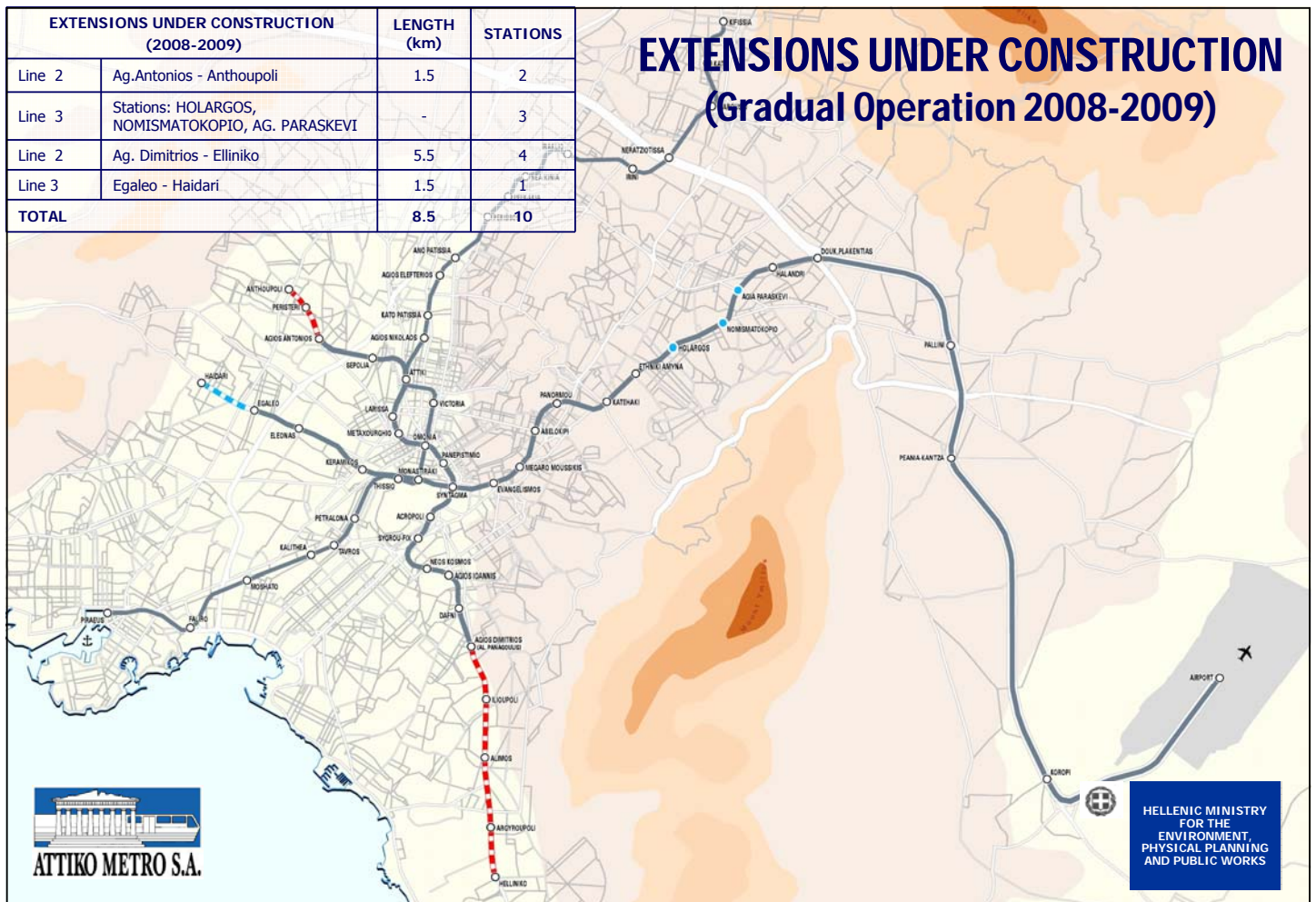
- HALANDRI-SYNTAGMA: 15 min
- EGALEO-SYNTAGMA: 7 min
- Airport-SYNTAGMA: 37 min
- Airport-Piraeus: <60 min (one transfer)

### TRANSFER:

- METRO: 1 station (SYNTAGMA)
- ISAP: 3 stations (MONASTIRAKI, OMONIA, ATTIKI)
- SUBURBAN RAILWAY: 1 station (DOUKISSIS PLAKENTIAS)

EXTENSIONS UNDER CONSTRUCTION (2008-2009)		LENGTH (km)	STATIONS
Line 2	Ag. Antonios - Anthoupoli	1.5	2
Line 3	Stations: HOLARGOS, NOMISMATOKOPIO, AG. PARASKEVI	-	3
Line 2	Ag. Dimitrios - Elliniko	5.5	4
Line 3	Egaleo - Haidari	1.5	1
<b>TOTAL</b>		<b>8.5</b>	<b>10</b>

## EXTENSIONS UNDER CONSTRUCTION (Gradual Operation 2008-2009)



- 300,000 additional passengers / day in the network
- Extensions of both Metro Lines
- + 8.5 km  $\Rightarrow$  59.6 km of network in total
- + 10 stations  $\Rightarrow$  41 stations in total

## INDICATIVE DURATION OF TRIPS:

- NOMISMATOKOPIO-SYNTAGMA: 10 min
- ANTHOUPOLI-SYNTAGMA: 11 min
- ELLINIKO-SYNTAGMA: 14 min
- HAIDARI-SYNTAGMA: 8 min

NEW EXTENSIONS (under tendering process)		length (km.)	STATIONS
Line 3	Haidari – Piraeus - Evangelistria	8.2	7
<b>TOTAL</b>		<b>8.2</b>	<b>7</b>

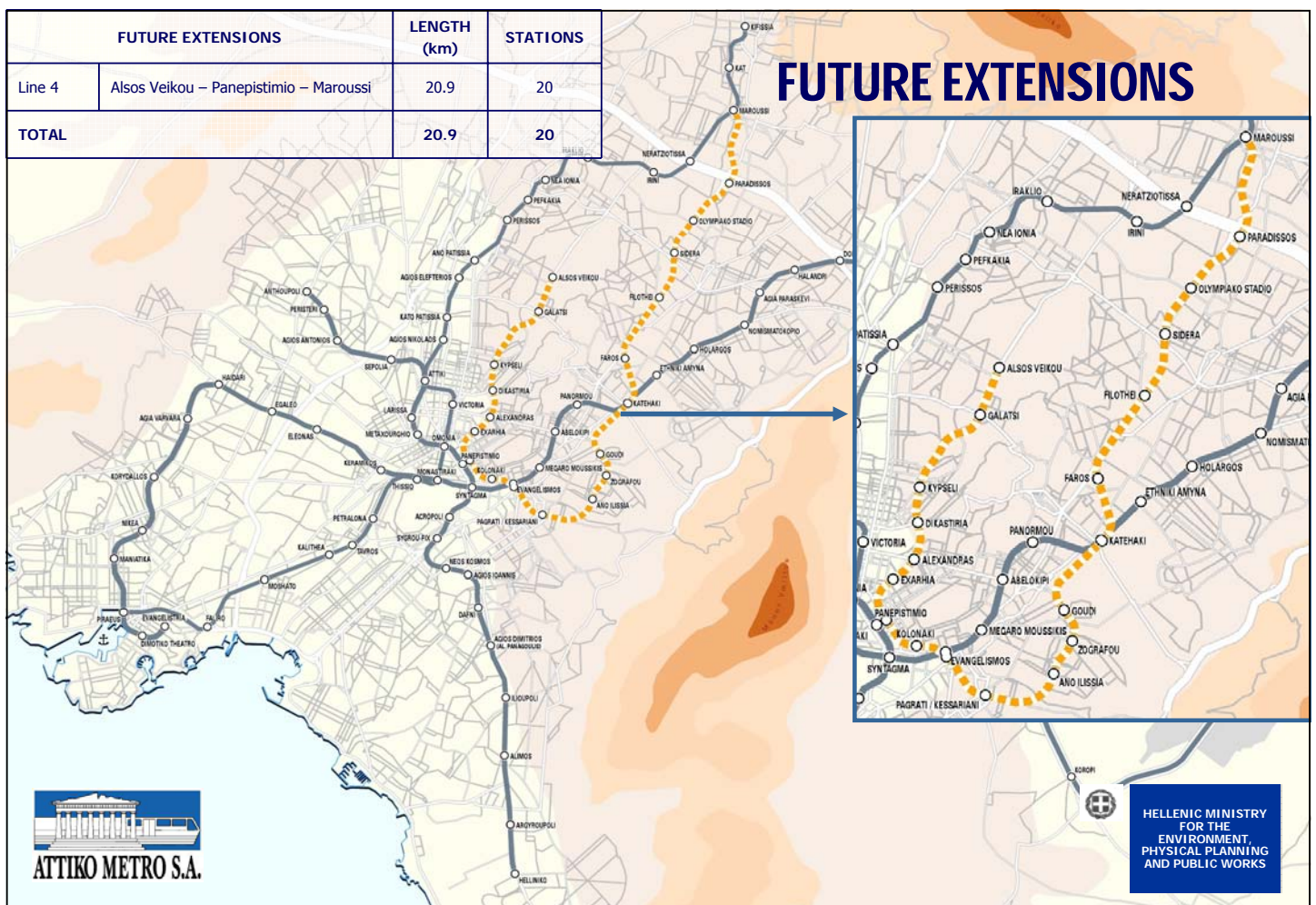
## NEW EXTENSIONS (under tendering process)



# NEW EXTENSIONS (under tendering process)

- Haidari – Piraeus - Evangelistria: 160,000 additional passengers / day
- + 8.2 km  $\Rightarrow$  67.8 km of network in total
- + 7 stations  $\Rightarrow$  48 stations in total

On June 26<sup>th</sup> 2007, the first phase of the Tender was completed, while all candidates who had expressed interest were pre-qualified. The second phase of the Tender (submission of financial offers) shall commence in Autumn 2007. It is anticipated that the Tender will be completed at the beginning of 2008 (on condition that no objections, appeals, etc. are filed by the bidding technical companies), while the construction of this extension of Athens Metro Line 3 will commence right afterwards.

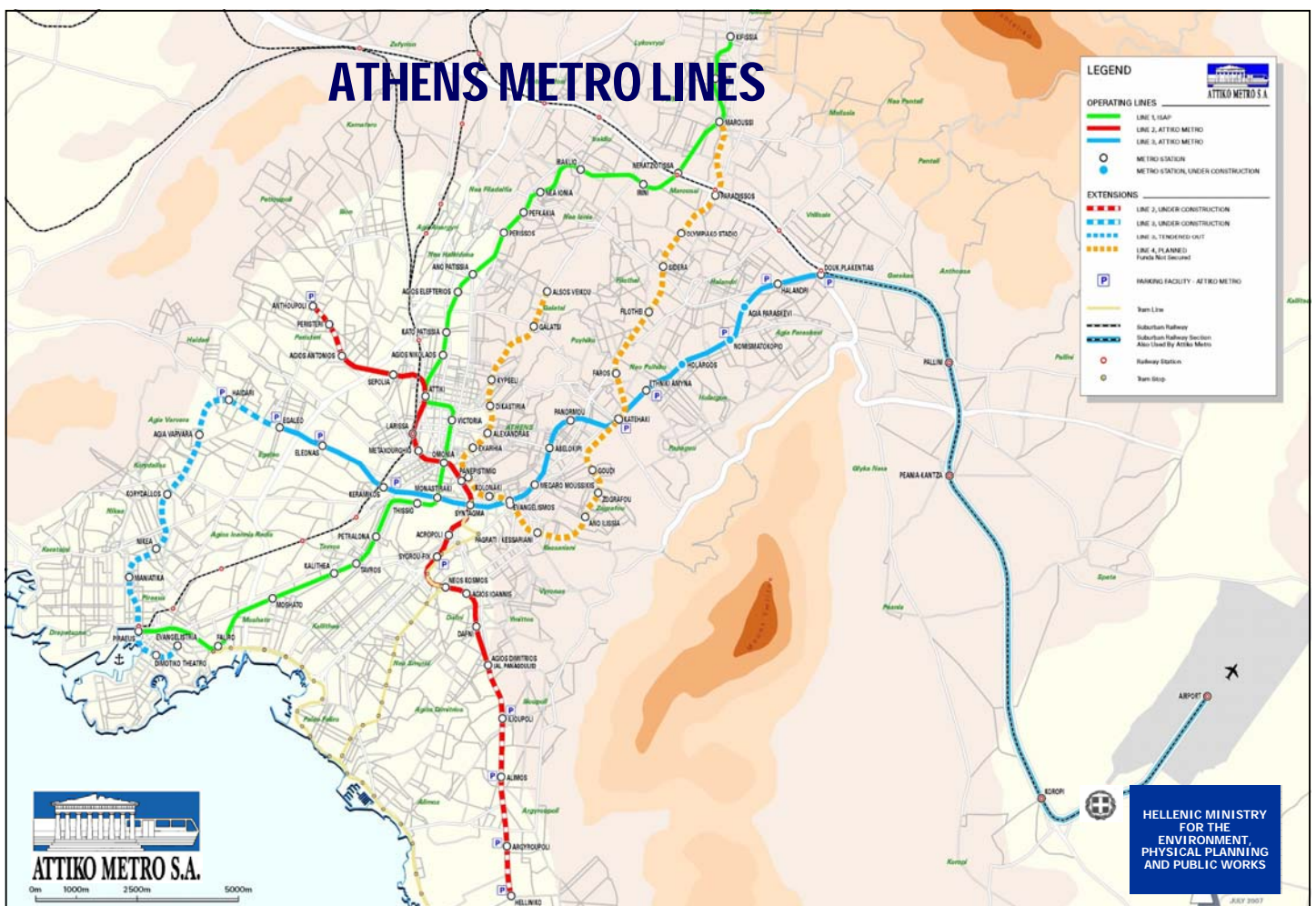


# FUTURE EXTENSIONS – LINE 4

- Line 4: over 400,000 additional passengers / day
- Provide transportation service to densely populated areas of the city
- Provide transportation services to many important facilities: Hospitals, University Foundations and Courts.
- Provide transportation services to business development areas.
- 3 new correspondence services with the existing Metro lines (Line 3 : KATEHAKI, EVANGELISMOS & Line 2: PANEPISTIMIO) and one new correspondence with ISAP line (MAROUSSI Station).
- + 20.9 km  $\Rightarrow$  88.7 km of network in total
- + 20 stations  $\Rightarrow$  68 stations in total

## FUNDING:

- Line 4: the method of funding the Project through the securitization of Attiki Odos future toll revenue is under consideration





# CONSTRUCTION METHODS & TUNNEL BORING MACHINES

For the construction of the underground Metro stations and tunnels, up-to-date methods, which ensured safe and rapid completion of the Project, were applied. The Project construction methods and the Tunnel Boring Machines were used either separately, or combined one to another, as deemed applicable, always in relation with the geological conditions and the in-situ conditions of the surrounding area.

## CONSTRUCTION METHODS

- Underground Conventional Boring Method (New Austrian Tunneling Method - NATM)
- Cut & Cover Method
- Cover & Cut Method

## TUNNEL BORING MACHINES

- Full Face Cutterhead Tunnel Boring Machines (TBMs)
- Earth Pressure Balance, Tunnel Boring Machines (EPB)
- Open Face Shield Tunnel Boring Machine (OFS)



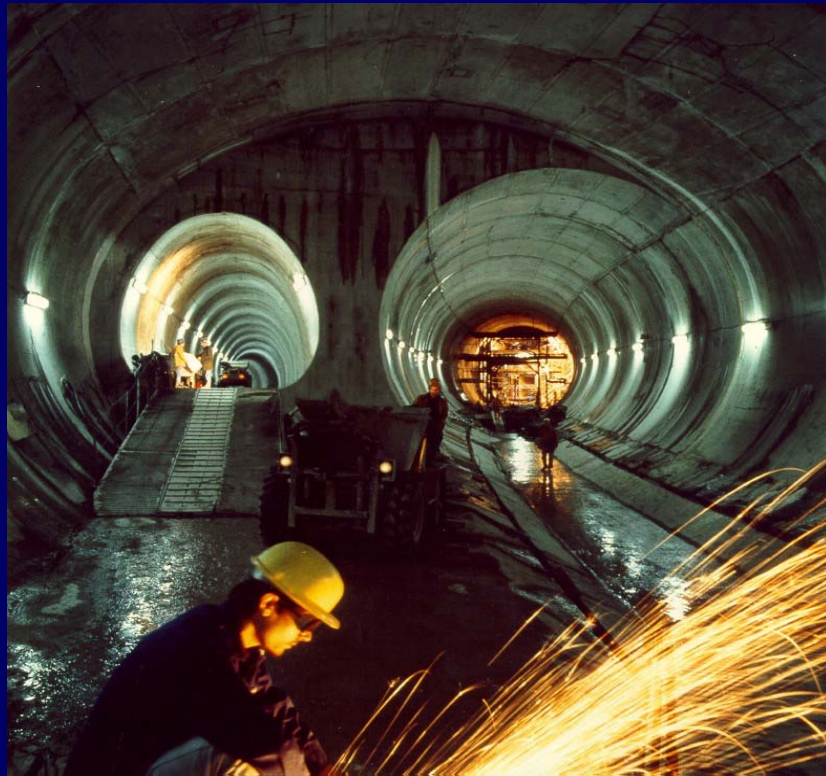
# CONSTRUCTION METHODS

## Conventional Tunnel Boring Method (NATM)

It was used for tunnel boring at soils with poor mechanical characteristics. This method has been applied in 8 stations so far as well as sections of single, double and triple track tunnels as needed.

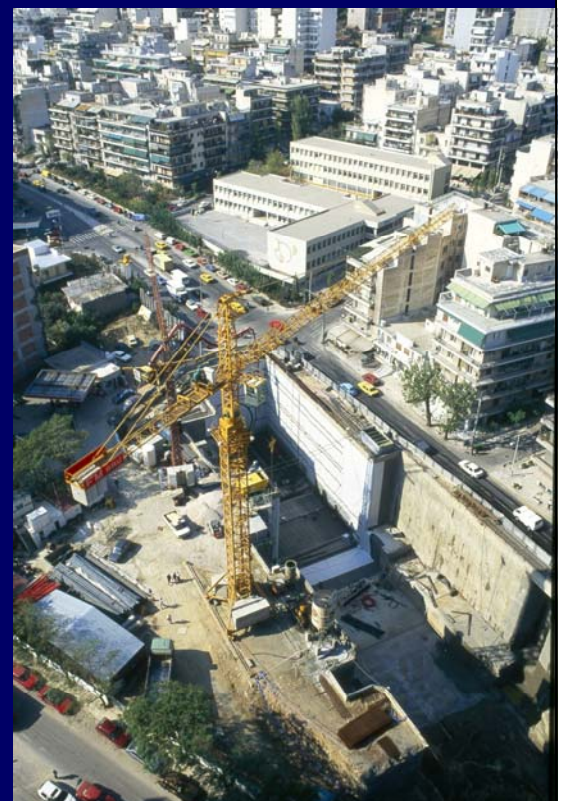






## Cut & Cover Method

This method was mainly used for the excavation of the stations of the Project, as well as in a few cases, for the excavation of tunnels at locations where problems were encountered due to poor mechanical characteristics of the soil.



## C & C Station – TBM Launching



## CONSTRUCTION METHODS

### Cover & Cut Method

This method constitutes a variation of the Cut and Cover Method and was used only at SYNTAGMA Station (Line 2) due to the particularity of the area.



# TUNNEL BORING MACHINES

## Tunnel Boring Machines (TBMs)

This method was applied for the boring and construction of 16.2 km of tunnels so far, while an additional 4.8 km are under construction.

D = 9.5 m, double track



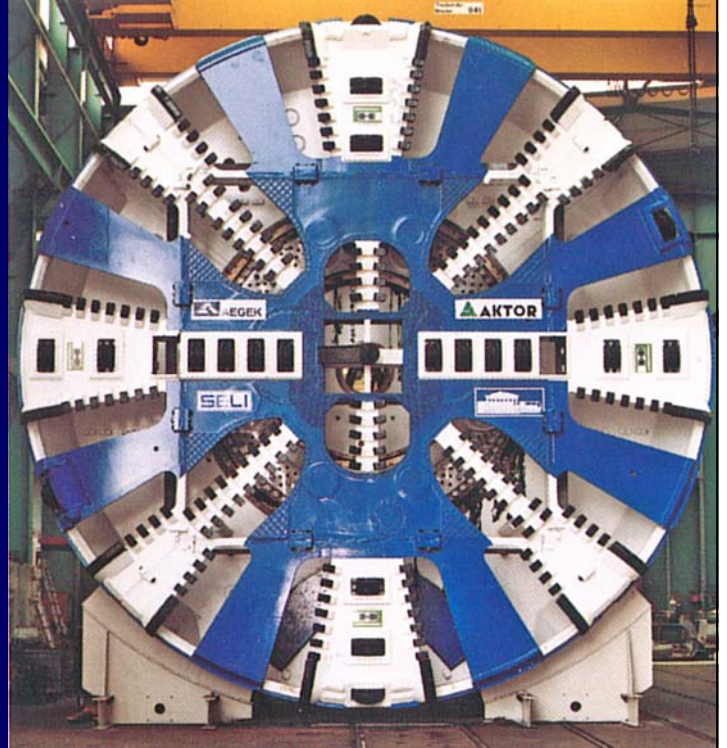
# TBM through a NATM Station



# TUNNEL BORING MACHINES

## Earth Pressure Balance Machine (EPB)

This method was applied for tunnel boring and construction and, namely, for the construction of 3.4 km in the Line 3 extension to D.Plakentias and is currently being applied in the Line 2 extension to Elliniko (4.8 km).



## Elliniko extension – tunnel under construction



**Elliniko station breakthrough**



**Trumpet shaft passing through**

## Open Face Shield Tunnel Boring Machine (OFS)

This method was used for tunnel boring and construction and specifically for the construction of Dafni – Ag. Ioannis tunnel section (765m. long) as well as for Anthoupoli – Peristeri tunnel section (910m. long).



## Ground Improvement – Risk Mitigation Measures

- Forepoling in advance of the excavation face under sensitive areas.
- Micropiling in the vicinity of selected buildings foundations.
- Tube-a-manchettes / pressure grouting from street level.
- Other (microtunnels umbrella etc.)

## Pilot Tunnel – TBM Cutter Head

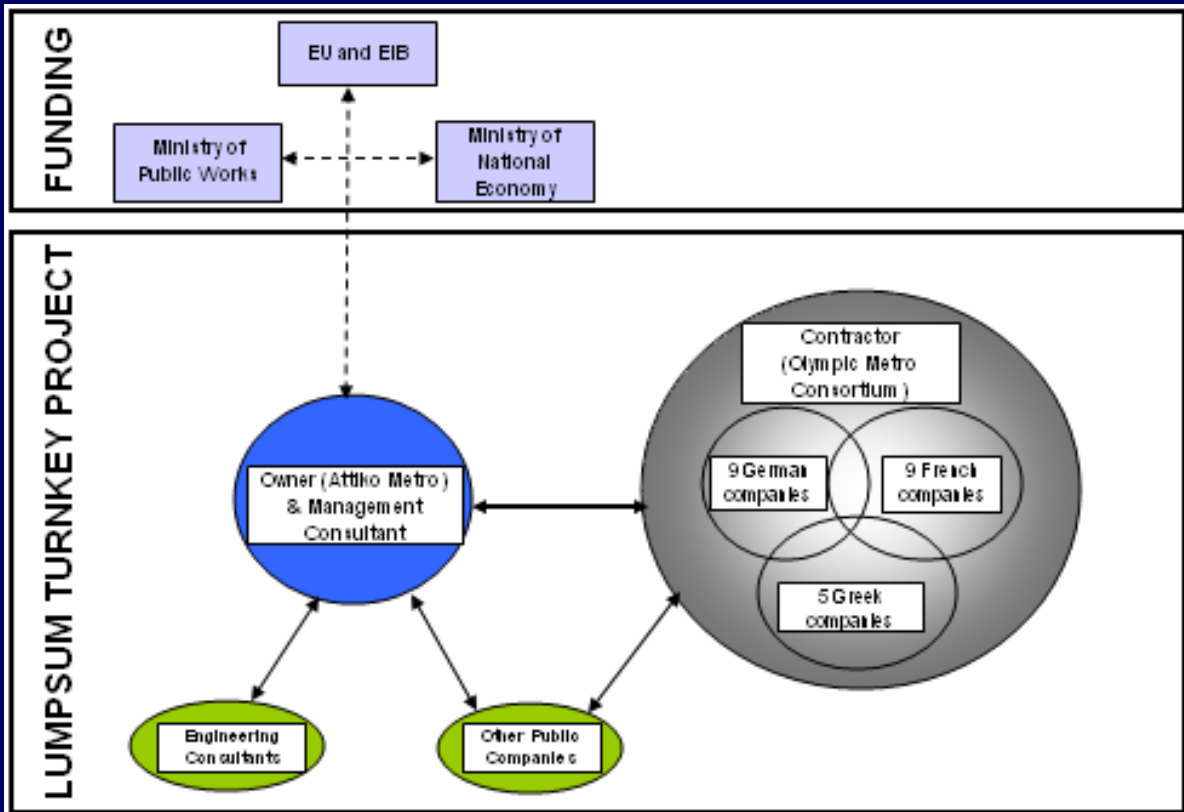


## Ground Improvement – Street Level

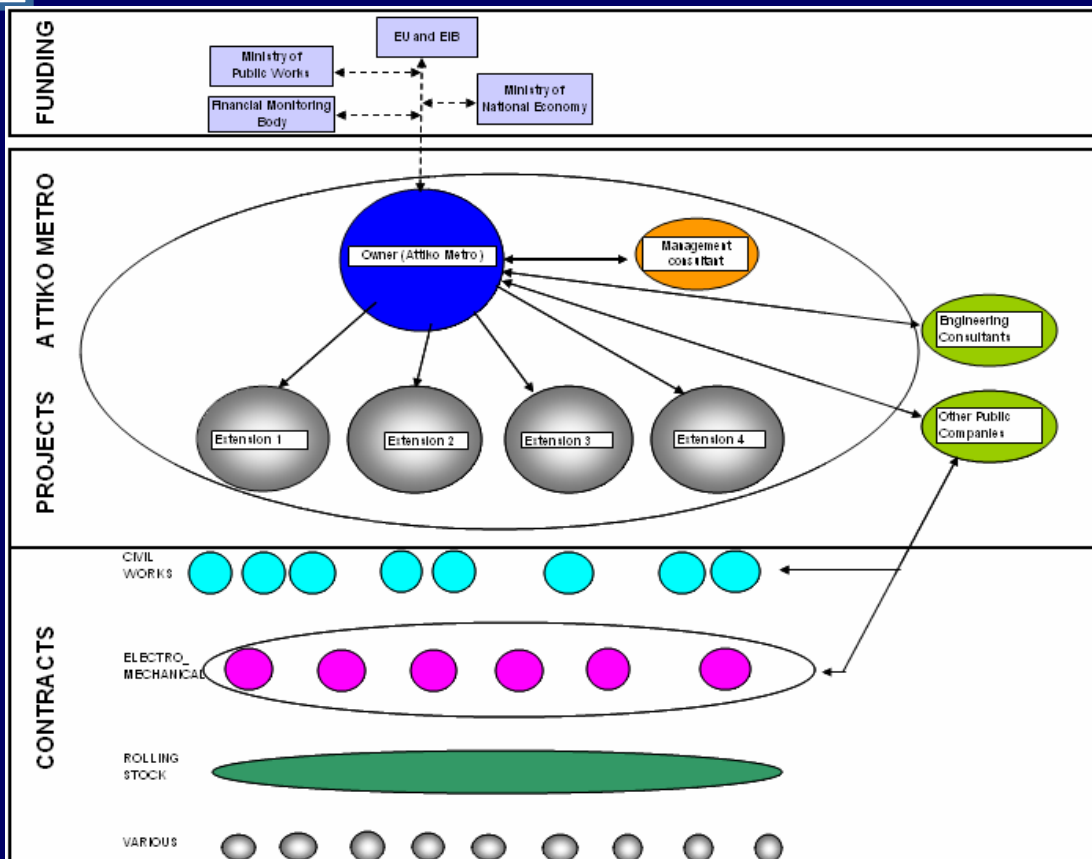




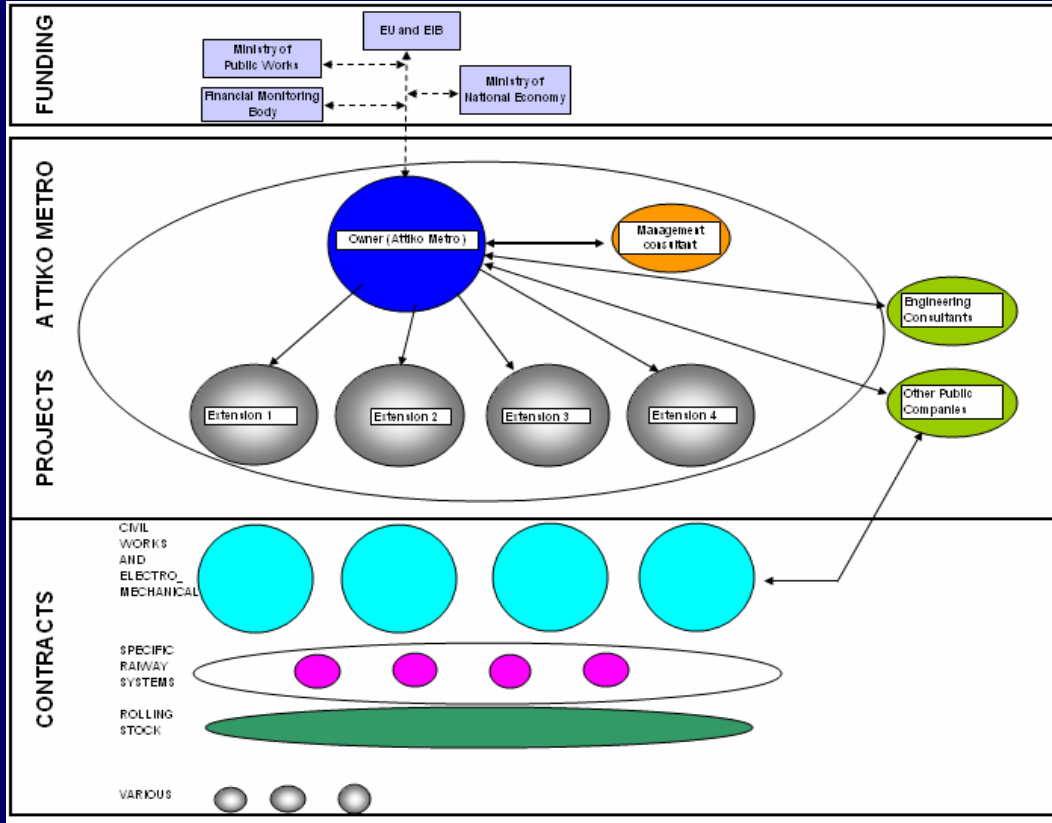
# ATHENS METRO BASE PROJECT MANAGEMENT STRUCTURE LUMP SUM TURNKEY CONTRACT



# ATHENS METRO EXTENSIONS PROJECTS MANAGEMENT STRUCTURE - MULTI CONTRACTS STRUCTURING



# ATHENS METRO FUTURE EXTENSIONS PROJECTS MANAGEMENT STRUCTURE FEW SELECTED CONTRACTS STRUCTURING



## Example of multi-contracts implementation Plakentia Junction









# MONASTIRAKI STATION TIME SCHEDULE

	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03
Start	◆											
Archaeology		█										
Utility relocations	█											
Tunnels Civil Works					█							
Stations Civil Works			█									
Trackwork										█		
Power supply										█		
Low Voltage										█		
Architectural finishes										█		
Integration testing											█	
Trial running												█
Operation start												◆



# 1st PHASE METRO EXTENSIONS TIME SCHEDULE

	'00	'01	'02	'03	'04
Start	◆				
Design	█				
Tenders		█			
Archaeology	█				
Utility relocations	█				
Tunnels Civil Works		█			
Stations Civil Works		█			
Trackwork				█	
Power supply				█	
Low voltage				█	
Architectural finishes			█		
Integration testing					█
Trial running					█
Operation start					◆



## Archaeology (in Base Project)

- Largest dig in the city's history (70.000 m<sup>2</sup>)
- Antiquities revealed ranged from small size artifacts to large scale water and sewage networks of the ancient city. Findings ranged from Classical Greek to Roman and Byzantine periods.
- Archaeology was a prime reason for delays in project schedule.
- One station (Keramikos) plus adjacent tunnels deleted from scope of project due to archaeological risks
- Certain findings are displayed in the central stations.

## Archaeological Exhibits – Syntagma Station



## Archaeological Exhibits – Evangelismos Station



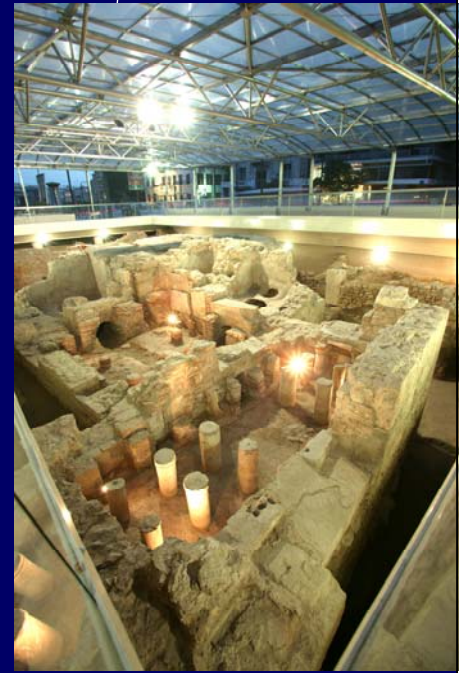
Evangelismos station  
Archaeological exhibits  
Photo by A. Smaragdjs

## REVEALING OF ARCHAEOLOGICAL FINDS

"Amalias" Shaft –  
Display of  
archaeological finds



SYNTAGMA Station –  
Display of archaeological  
finds



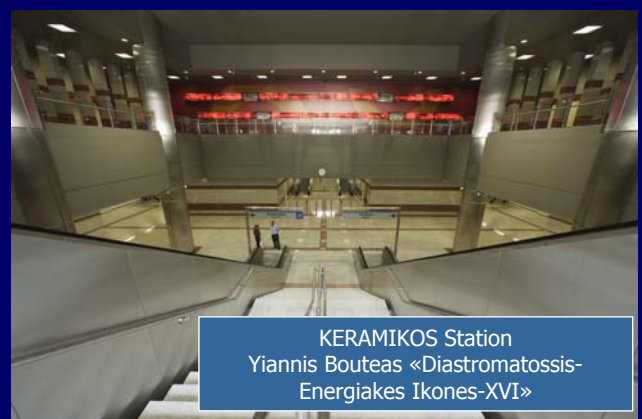
## IRIDANOS RIVER



## ART PROGRAM

- Display of archaeological finds and works of art of modern Greek artists in 28 stations of the Athens Metro.
- Display of 21 works of art of modern artists in Metro stations.
- Highlighting ideas of younger artists through art program related tenders for specific stations.
- On-going implementation of the art program in the new stations of the Athens Metro extensions, as well as in the Thessaloniki Metro Base Project.

## WORKS OF ART





## A MODERN METRO PROJECT IN THESSALONIKI

### System Design & Functional Characteristics

- 13 center-platform modern Stations
  - Construction of Stations using the “cover & cut” method
  - Distance between Stations: 500-600 m.
  - Center platform length: 60 m.
- 9.6 km of the Line (with two-single track tunnels)
  - 6.4 km of the network will be constructed using the two Tunnel Boring Machines
  - 1.7 km of the network will be constructed using the “cover & cut” method
  - 1.5 km of the network will be constructed using the “cut & cover” method.
- 18 state-of-the-art fully automated, air-conditioned and driverless trains, with central control of the operation of all trains (presence of a well-trained attendant on-board).
- Designed transportation capacity: 18,000 passengers/hour/direction.
- Depot of an area of 50,000 square meters in the area of Pylaia (Votsi).



## LINE 2 – ELLINIKO EXTENSION (site visit)

- 5.5 km, 4 stations, 1 stabling depot
- Serving 80,000 passengers daily
- Reduction of 50.000 car trips, 630.000 car-km, 140 tons CO<sub>2</sub>
- Excavations 980.000 m<sup>3</sup>
- Temporary supports 44 km concrete piles & 144 km anchors
- 190.000 tons concrete, 32.000 tons reinforcement
- 12.000 m<sup>3</sup> granite architectural finishes
- Currently under construction:
  - Tunneling mainly with TBM, sections with C&C and NATM
  - TBM tunneling rates ≈ 10 m/d (average)
  - Special condition: Worksites are searched and cleared by the Army for buried bombs/ammunition from 2<sup>nd</sup> World War
- 48 months project duration
- 400 m € budget including rolling stock