PRESERVING THE BYZANTINE ANTIQUITIES WHILE RETAINING THE OPERABILITY OF THE VENIZELOU - THESSALONIKI METRO STATION: CONTRIBUTION TOWARDS A COMMON CONSENSUS

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Abstract. *This paper reviews the alternative design solutions contributed by the Department of Civil Engineering when it was assigned by the Aristotle University of Thessaloniki the task to investigate the possibility of retaining the unique antiquities that were found during the construction works of the new city Metro main line, without canceling the station. It was shown on the basis of cost over the respective benefit that, such a challenging engineering task is indeed feasible from both a technical and a financial viewpoint. Given that the proposal of the Department of Civil Engineering was the first feasibility study made at a city level, it is deemed as a significant contribution to the public debate between the local and governmental authorities that essentially established a fair compromise between the involved parties and opened the path for other ideas.*

1 INTRODUCTION

The new Thessaloniki Metropolitan Railway infrastructure is a challenging engineering project of 1.1billion € investment, in a difficult engineering environment due to the proximity with the seaside and the exposure to a considerable level of seismic hazard. Above all, the construction of the main Metro line is faced with the challenge to accommodate the fact the city has been historically built over different layers, each one corresponding to a different era: Macedonian (Hellenistic), Roman, Byzantine, Ottoman and modern Greek. Recently, significant archaeological findings were revealed at the Venizelou Metro station involving the 75m long and 5.5m wide, Roman *Decumanus Maximus* road, also called Byzantine *Middle Road* ("Μέση Όδὸς") of Thessaloniki built by the Roman emperor Galerius in the 4th Century and reconstructed two centuries later. Next to it, the four pillars ("*tetrapylon*") of the most important crossroad of the city at the time, this of the Middle Road with another significant pathway, *Cardo* were also discovered; This spot essentially marked the commercial heart of the Roman and Byzantine city right below the contemporary downtown. The historical and cultural significance of these findings raised the question of whether the construction of the Metro station was indeed feasible without detaching and transferring the archaeological findings elsewhere. The necessity to keep the construction within the limits of the initial design and the already constructed perimeter diaphragm walls, posed an additional constraint to the engineering problem on top of the tight already limiting budget and time constraints. Along these lines, Aristotle University of Thessaloniki formed three working groups on the task of comparatively assessing alternative solutions on the basis of their feasibility, cost over and respective benefit. The scope of this paper is to describe the challenging engineering problem and provide an overview of the alternative solutions introduced by Department of Civil Engineering.

2 BACKGROUND

2.1 Technical specifications of the project

The construction of the Thessaloniki Metro started in June 2006. The idea of an underground railway for Thessaloniki was first put forward by Ernest Hébrard, in the framework of the redesign of the city back in the early 1920s after the great fire of 1917 [1]. The first phase of the project consists of 9.6 km of underground line (with two independent single track tunnels), 13 stations and a depot at the southeast end of the line (Figure 1). The total budget for the project is about 1.1 billion euro, as of 2012. Part of the budget (250M€) is funded from the 3rd EU Common Strategic Framework while another €250 million has been provided as a loan by the European Investment Bank. Thessaloniki's metro shares many similarities with the Copenhagen Metro as it features 18 AnsaldoBreda Driverless Metro trains that will run in separate tunnels in each direction. Most of the

line (7.7 km) has been constructed by means of two Tunnel Boring Machines while the remaining section of the line is constructed with the Cut and Cover method.

Figure 1. Layout of the Thessaloniki Metro. Source: Attiko Metro.

2.2 Historical framework

The wealth of archaeological findings at the Venizelou Metro station (Figure 2) revealed a core sample of the cosmopolitan center of Thessaloniki and brought to light a unique assemblage of the city's walled area (*intra muros*). These findings illustrate vividly the urban evolution of the city and constitute an exceptional case of seamless and cohesive stratigraphy of different layers that portray the successive historical phases of Thessaloniki from the Hellenistic period since the Modern Greek era. One of the most substantial features that characterize the urban development of the city is its continuous history, uninterrupted by significant material destructions.

As already mentioned, the archaeological scenery at the specific spot depicts the commercial heart of the ancient city right below the commercial heart of the modern one, marked by a significant crossroad which involves the 75m long and 5.5m wide, Roman *Decumanus Maximus* road, also called Byzantine *Middle road* (*Μέση Όδὸς*) of Thessaloniki and it is located underneath the contemporary roadway of Egnatia Street [2]. The designation of Latin term *Decumanus* indicated the great streets of Roman cities with an eastern direction to the west and they were usually decorated by large squares at the initial part of the roads or the endpoints. The city's main paved road was built on an Early pathway by the Roman Emperor Galerius during the 4th century A.D. along with the extensive palace complex in the eastern part of the city. Thessaloniki was designed according to the so-called Hippodamian system, which is based on a grid of horizontal and vertical streets that bisect each other in order to form a city block. The *Decumanus* road was reconstructed two centuries later during the absolute monarchy of Constantine the Great, when Thessaloniki became the second city of the Roman, and later Byzantine Empire after Constantinople. This well-preserved marble-paved Byzantine avenue of the Justinian era is crossed with another important pathway, *Cardo*, that was discovered and is located in the axis of today's Venizelou Street and led to the harbor of the city. A monumental gate of four pillars (*Tetrapylon*) that was placed on the conjunction of these two roads was also discovered and characterizes the road axis as *via colonata*, as well as it depicts the history of Thessaloniki during the 6th to 9th century.

The remains of public buildings, a vast complex of fountains, retail stores and workshops alongside the *Decumanus* road signify the urban development and constitute the monumental evidence of the social, commercial and administrative structure of Thessaloniki during the Early Byzantine era. In the course of the Ottoman period the main road (*Decumanus)* became a pathway again and the *Cardo* road, that remained on the same direction to Venizelou street, was renamed *Sambri Pasa* road [3]. During the approximately five centuries under the Ottoman rule the city became "multinational" [4], the Greeks were placed in the eastern part of the city along the length of the modern Egnatia Street and the center of the city market was situated at the same position [5]. In the case of Venizelou station, the well-preserved archaeological ensemble "interacts" with the landmarks of the Ottoman era, Bezesteni and Alkazar (Hamza Bei Tzami), which were built during the 15th century and represented the city trade center and also the modern commercial use of the area [2]. The growth of trade and the economic prosperity consequently led to the expansion of the marketplace. In the mid-19th century the city began to be transformed and spread out beyond its walls. The modern period of the city is marked by the Great fire of 1917, which destroyed the most of the buildings at Venizelou Street and the center was reconstructed according to the urban plan by Ernst Hébrard.

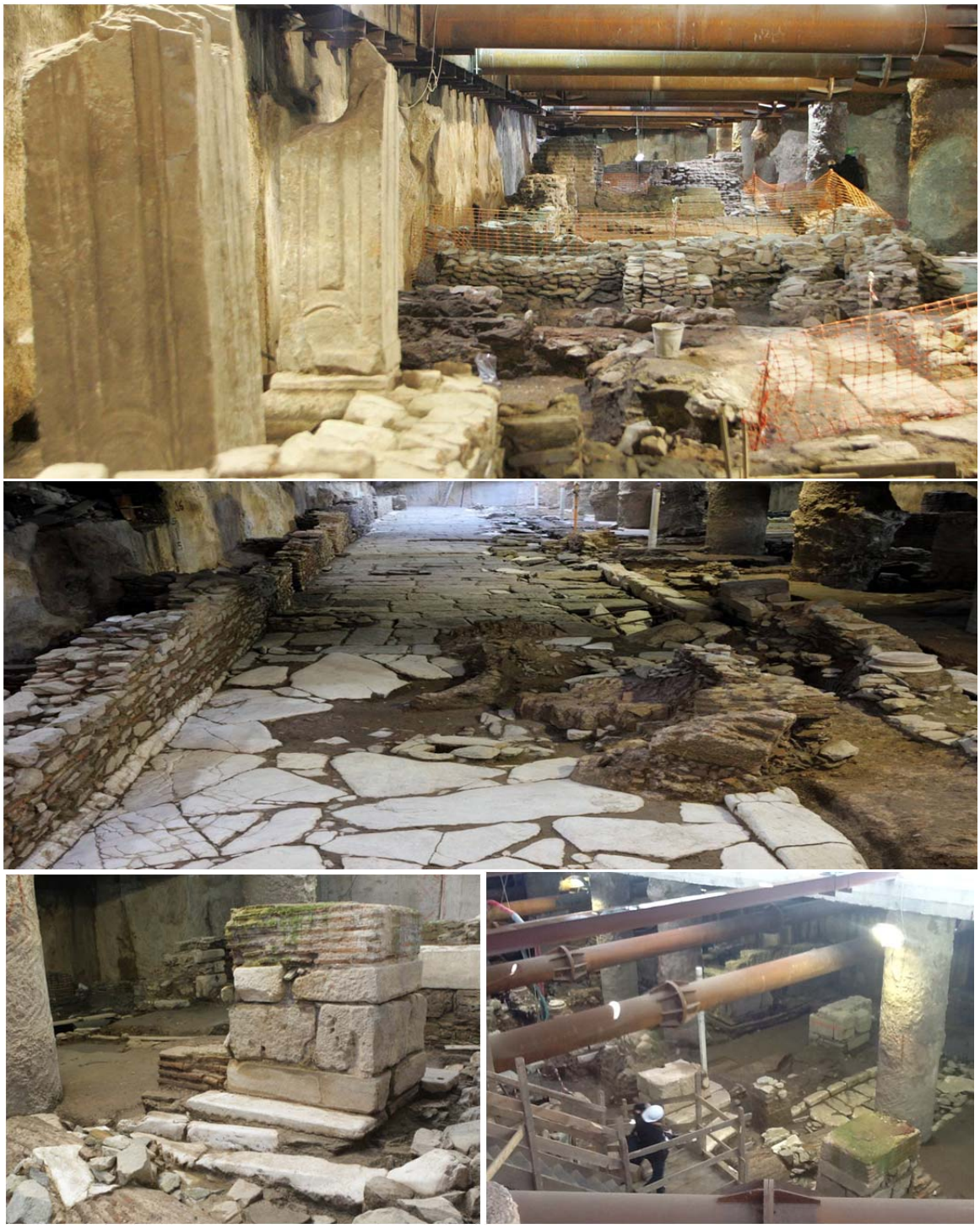

Figure 2. Overview of the antiquities found at Venizelou Station during excavation.

2.3 Rector's Mandate

Due to the importance of the archaeological findings, a major debate burst between the company implementing the metro, Attiko Metro SA, local authorities and scientific associations, following a decision by Greece's Central Archaeological Council, authorising the transfer and exhibition of the antiquities to the former barracks of "Pavlos Melas", in another municipality. Along these lines, Aristotle University of Thessaloniki offered to act as an independent expert to contribute in resolving this controversial and highly important for the city issue. According to the Rector's Mandate of 5/3/2013, the University set its scientific capacity in the service of the city and formed a Working Group consisting of Professors of Civil Engineering, History and Archeology and Architecture, to study all the relevant archaeological and technical data and evaluate all possible scenarios on a cost-benefit basis. The Working Group was then split into three Committees corresponding to the three Departments involved.

3 STARTING POINT

When the Committees were appointed, two were the main approaches examined. The first solution was associated with the remaining of the findings in their position without the slightest disruption. The possibility was investigated to construct a number of extended micro tunnels under level -1, as this is defined in Figure 3, for the support of the antiquities according to the model solution that was implemented at the "Sintrivani" Station. It was deemed that due to the extent of the archaeological findings, the particular solution would imply the elimination of level -2 because of the required height for the excavation of the micro tunnels. Furthermore, perimeter zones of significant height and width would be required out of the diaphragmatic walls, in order to enable access for the excavation. As a result, a series of roadside buildings would need to be demolished along the Egnatia Street, especially towards its northern side. Moreover, because of the elimination of level -2 there seemed to be no available space for the development of critical mechanical and electrical equipment. Overall, this solution was rejected due to the associated project cost and delay.

Due to the lack of an available solution to retain the archaeological findings in place, the authorities considered that either the "Venizelou Station" had to be cancelled or the company implementing the metro, Attiko Metro SA, would have to follow the ministerial decision after the Central Archaeological Council indicating removal, transfer and exhibition of the findings at another site. This did not necessarily exclude the possibility of ever returning some of the findings at their original location, however, the latter was not explicitly guaranteed. The above position was also officially announced during an Attiko Metro Press Conference, as it is reflected on the respective press release in February 12th, 2013 [6]. This is considered to be the starting point for the involved University Committees.

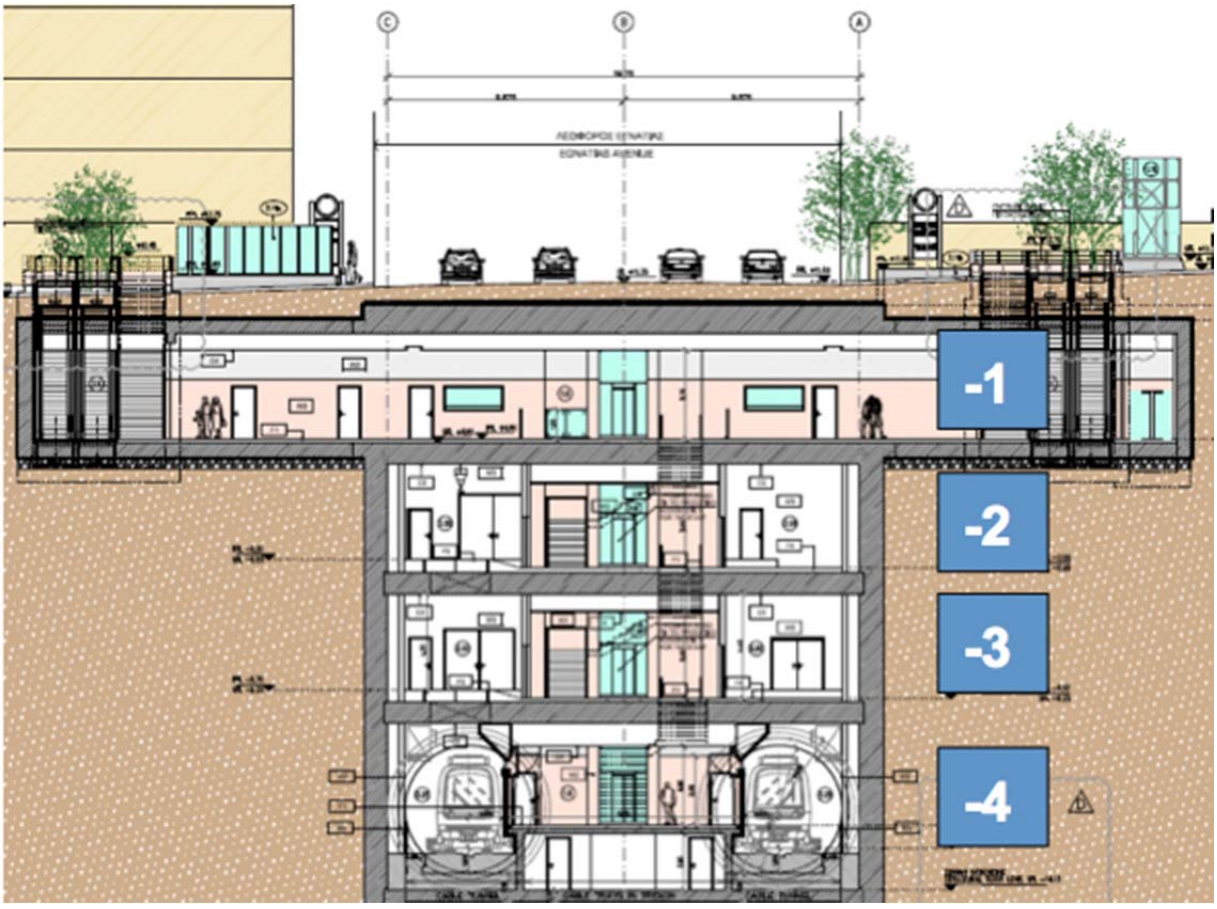

Figure 3. Cross section of the Venizelou Station. Source: Attiko Metro.

4 PERFORMANCE OBJECTIVES

Due to the inherent technical nature of the initial dilemma regarding the feasibility of retaining the antiquities without canceling the operation of the station, the Civil Engineering Committee was inevitably the first that had to interact with all involved parties. Along these lines, a visit was organized on site (4/3/2013) together with representatives of the 9th Ephorate of Byzantine Antiquities and the Association of Greek Archeologists.

Subsequent meetings were also arranged at the Headquarters of Attiko Metro where detailed calculations were made based on actual data and drawings in cooperation with the Metro representatives. A meeting in Athens followed (11/3/2013) between the Head of the Civil Engineering Department, the Rector of Aristotle University, the President of the Attiko Metro and the Director of the Thessaloniki Metro. This is when the solution of the temporary removal and the replacement of the antiquities was addressed for the first time by the Department of Civil Engineering. Other visits were also made again at the Venizelou Station (14/3) together with the Director of Thessaloniki Metro, the 9th Ephorate, and other associations such as the "Hellenic Society" which was one of the first that triggered response on this issue.

This extensive exchange of ideas and effort to establish a common ground based on justified engineering data resulted into the definition of the foreseen performance criteria that any proposed solution should satisfy, namely, the:

- Preservation of the antiquities on-site for obvious reasons of unique historical importance, through temporary detachment, construction of level -1 and re-installation of the majority of the antiquities at their original place,
- Operation of the Venizelou Station. It's cancellation was deemed as a "no-option" for mechanical (related to minimum required distance to attract the driveless trains from two successive stations), commercial and social reasons,
- Utilization of the already constructed diaphragm wall
- Avoidance of extensive additional excavations or archaeological investigations,
- Tolerable delay in the construction of the Venizelou Station and the Metro line as a whole,
- Tolerable additional financial cost,
- Retaining the highest safety and serviceability standards,
- Preservation of a sense of archaeological "entirety",
- Demonstration of the "timelessness" of the city, particularly in terms of its successive archaeological layers that have to be adequately demonstrated,
- Establishment of an interactive relationship between the passengers and the antiquities, by driving the passenger's flow within the preserved archaeological findings thus creating a *living museum* at the heart of Thessaloniki city center.

5 ALTERNATIVE SOLUTIONS EXAMINED

5.1 Underpipping

To meet the above objectives, a first investigation involved the "underpipping" of level -1 according to the construction model of Central Artery/Tunnel Project (CA/T) of the Boston Subway (else known as "Big Dig"), as a means to override the level of the archaeological findings through concrete injection under pressure. This technique permits the strengthening of the ground and the formation of supporting shell for every underground level, into which the electromechanical equipment is to be installed. This solution, though innovative and feasible in other cases, was considered of high cost, necessity of lateral access and complete re-design of the station. It is noted that The Big Dig (Figure 4) was the most expensive highway project in the U.S. and was plagued by escalating costs, and scheduling overruns [7]. In general it related to the unresolved problems of lateral excavation of the station, hence, it was not deemed practically applicable.

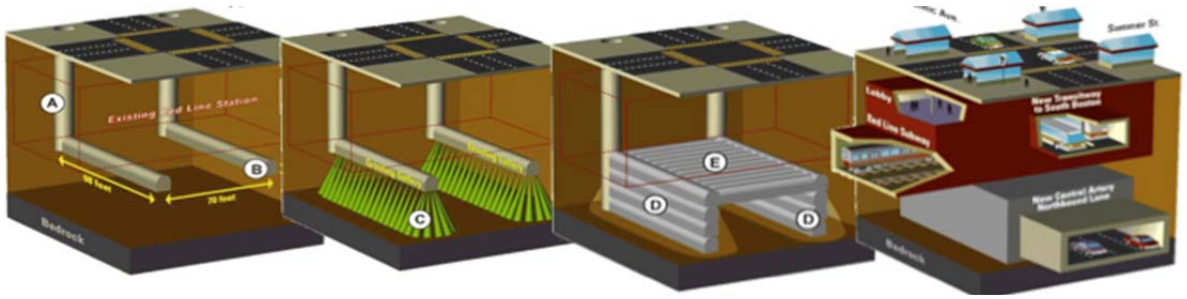

Figure 4. Example of station underpipping according to the novel solution of Boston Metro.

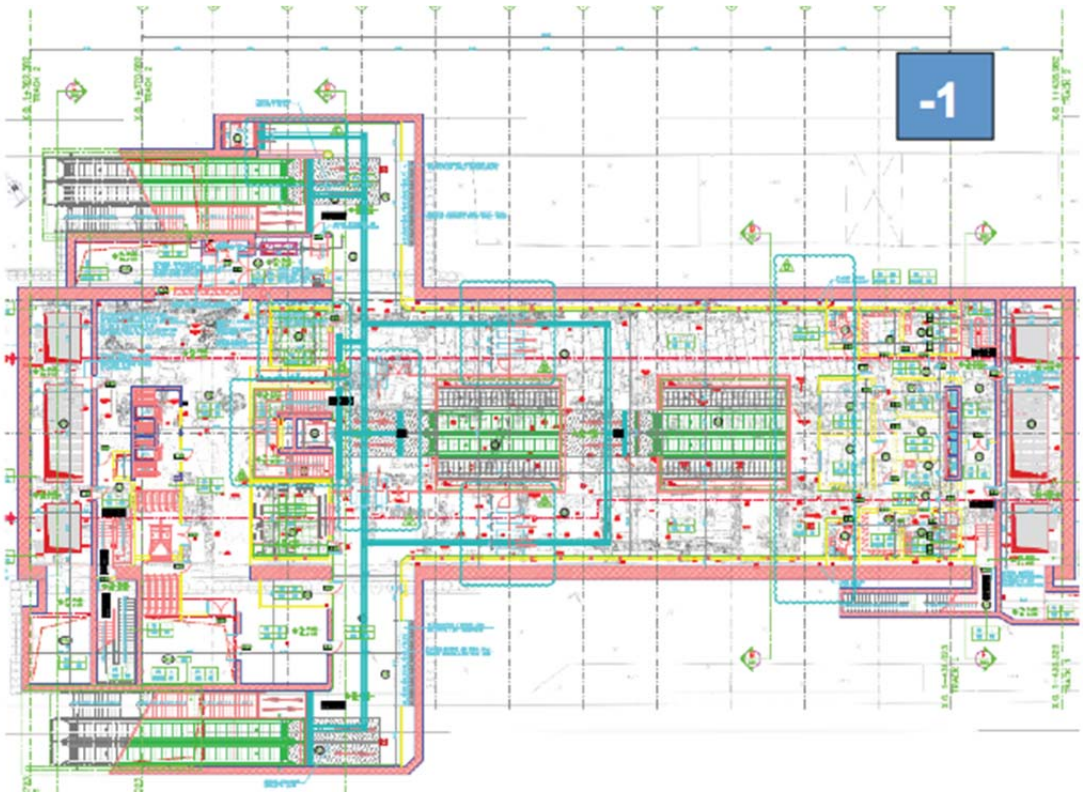

Figure 5. Overlapping between the initial design of the station and the archaeological findings, illustrated in grey color. Source: Attiko Metro.

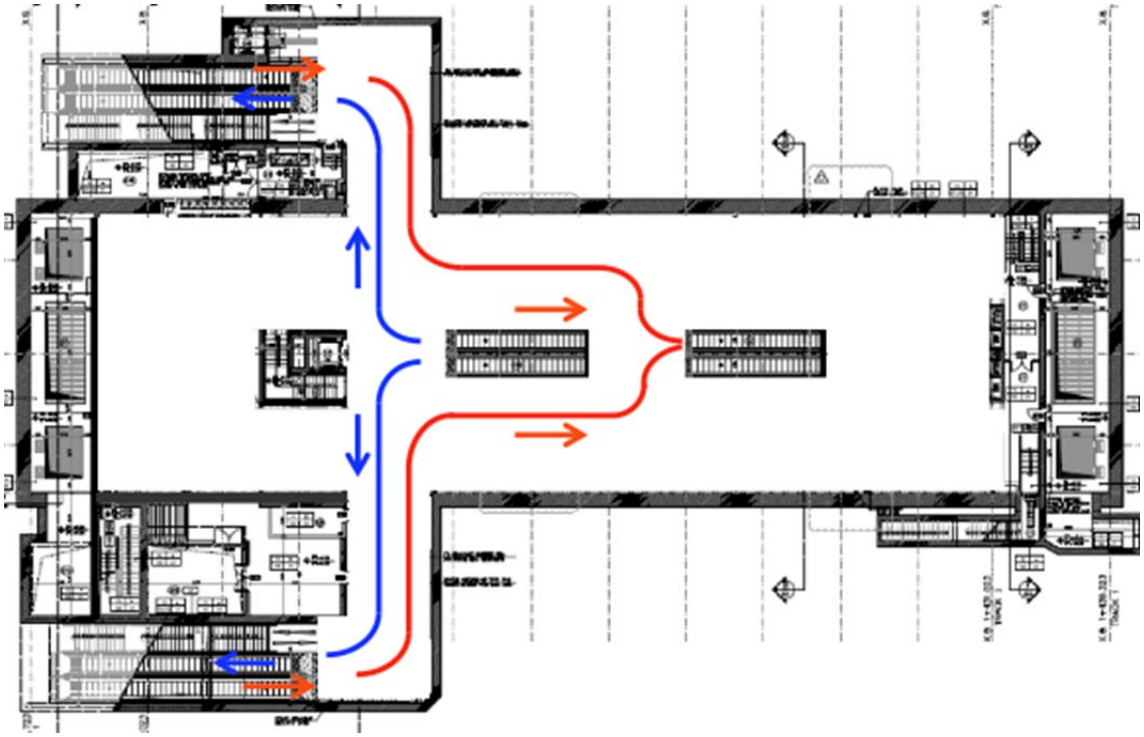

Figure 6. Passenger's flow according to the proposal of the Civil Engineering Committee after significantly reducing the Metro facilities at level -1.

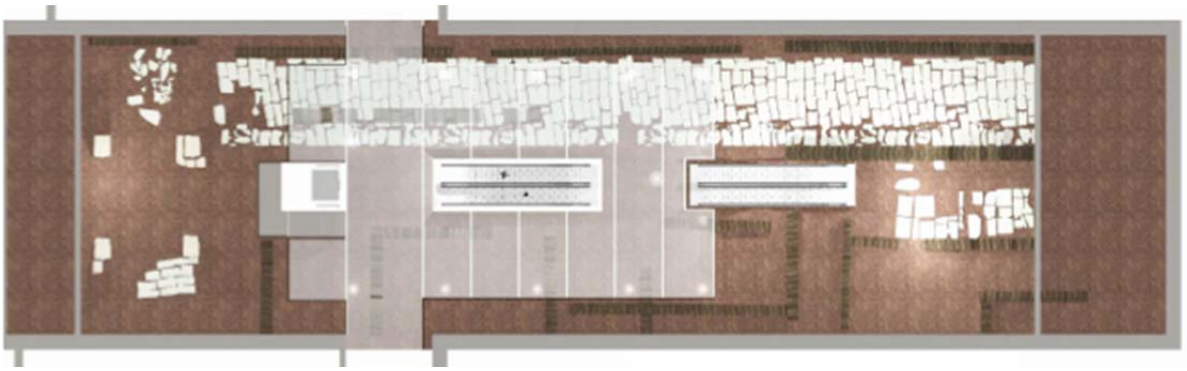

Figure 7. Top view of the glass floor over the preserved antiquities at level -1.

Figure 8. 3-Dimentional illustrations of passenger's interaction with the vast majority of the archaeological findings preserved site.

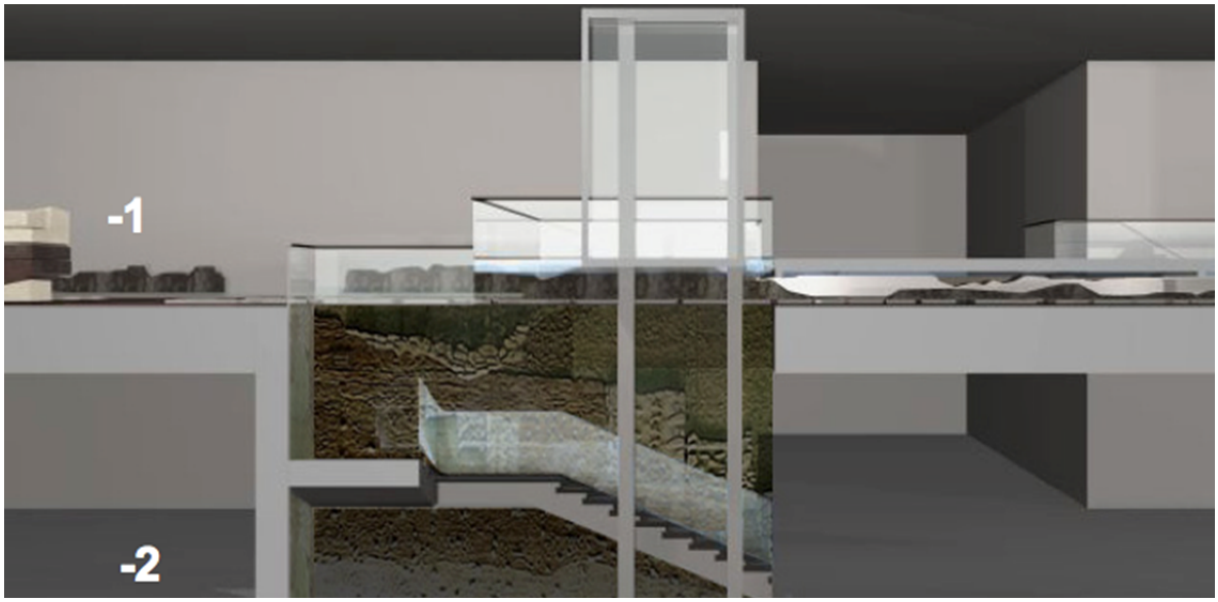

Figure 9. Cross section of the envisioned re-designed station, retaining an evident witness of the ancient stromatography of the city.

4 OVERVIEW OF THE PROPOSED SOLUTION: TEMPORARY DETACHMENT AND RELOCATION OF THE ANTIQUITIES

Aligned with the initial concept of the Department of Civil Engineering Committee, the solution that was studied and proposed involved the temporary detachment of the archaeological findings in their entirety, their temporary relocation at another site, the excavation down to -23m (level -4), construction of the station up to level -1 at a depth of -6m and then the replacement at the maximum possible extent of the antiquities at their original position. Two alternative designs were investigated together with the Attiko Metro and the archeologists:

(a) Cancelation of the escalators at level -1 and direct diversion of passengers flow at level -2 or level -3. By this way the preserved antiquities at level -1 are maximized, but some problems also exist, as the need of re-installation of the electromechanical equipment at another level. Moreover, bypassing the archaeological findings at level -1 does not satisfy the criterion set for continuous interaction of the passenger's with the archaeological site and the sense of a living museum. Overall, the antiquities may be preserved in their entirety but ultimately, they will be decoupled from the everyday life of the station. Similar examples exist along the lines of the Athens Metro, where the maximum preservation concept, when diverged from the actual passenger's traffic, lead to minimum visibility and dead archaeological spots.

(b) Use of one of the, initially two, escalators at level -1, according to the primal planning and driving of the passengers through the "archaeological" floor. This solution involves cancellation of a number of electromechanical equipment at level -1 and replacement in other levels along with some management facilities and control rooms as seen in Figure 6. It then drives the passenger's flow over a specifically designed glass floor (Figure 7). Limited excavation was planned at level -1 to accommodate some facilities to be transferred thus limiting the risk of an additional tender that could substantially affect the project schedule. Detailed engineering calculations and drawings justified the feasibility of the proposed solution and the minimum effect on the project cost and timeframe, however, they are not presented herein due to space limitations. Overall, the solution proposed was deemed to be doable, which simultaneously meeting all the performance objectives set as:

- it preserves the paved road across its entire width and the maximum possible length (almost 85-90%),
- maintains the "tetrapylon" (four pillars gate) including the six constituting pillars,
- retains the ventilation manholes at their original location, thus avoiding the substantial additional cost of their relocation,
- limits the escalator's width only at the necessary space but at the same time alters the traffic flow by distinguishing between the downward and the outward passengers's wave in order to maintain the high standards for safety and comfort
- shifts the control rooms which are at the east and west wing apart form level -1, without any serviceability implications
- retention of antiquities of the southern section at the possible height and length, ultimately leading to a total preservation of the entirety of the most important antiquities (paved road and tetrapylon) and the vast majority (approximately 80%) of the findings as a whole.

5 ASSESSMENT AGAINST MULTIPLE CRITERIA

The evaluation of the proposed solution based on the multiple archaeological, financial and engineering criteria set is summarized in Table 1. It is noted that the solution may be improved and adapted to additionally meet museological, serviceability or urban planning criteria, however, these were considered as out of the scope of the Civil Engineering Committee. As a reference it is also noted that the contractual cost of the project is of 800M€, with a given timeframe for completion of 31 months as of March, 1st, 2013 according the contractor data. According to this schedule, the contractual delivery date is November 26th, 2016, with a requirement of final line testing on November 26th, 2015. For the Civil Engineering Committee, the above timeframe was considered as a given time restriction. Potential extensions, though probable, were not examined as they were not guaranteed at the time that the proposal was made.

Archaeological criteria	
Requirement for temporary detachment	Yes
Preservation of the middle road	Yes
Preservation of the four Pillars	Yes
% of antiquities relocated on-site after detachment (in terms of occupied area)	76%
Demonstration of the historical stromatography of the city	Yes
Passenger's flow within the antiquities	Yes
Feeling of a complete archaeological site	Satisfactory
Financial Criteria	
Additional cost	2.8-3.0M€
Project Management Criteria	
Venizelou Station construction delay	aprx. 9 months
Overall construction delay	aprx. 9 months
Requirement for additional archaeological surveys	Limited
Requirement for additional tenders for the station lateral expansion	Probably not
Design Criteria	
Additional structural, geotechnical, architectural and electromechanical designs	Limited
Construction Schedule Criteria	
Technical feasibility (structural, geotechnical and electromechanical works)	Yes

6 ALTERNATIVE DESIGN APPROACHES

The presentation of the above concept was officially made on 24 April 2013 under the auspices of Aristotle University along with the other two design approaches presented by the two other University Committees. In brief, the first (Professors Kalogirou and Skalsta and Technical Chamber of Greece) makes the assumption of utilizing additional space out of the perimeter of the diaphragm wall, thus being able to preserve a higher percentage of antiquities while it also presents the advantage of more comfortable management of the passenger's flow within the station. Apparently, it is conditioned to potential legal implications related the approval of this lateral expansion of the station without causing major delay to the construction schedule. The second approach (Professors Papakostas and Alexopoulou) also makes use of (even more ample) additional lateral space to transfer critical facilities outside the perimeter of the present excavation. The idea is to entirely bypass level -1 and drive the passenger's flow directly to the level -2, while preserving the entirety of the antiquities. It is the author's view that this approach does not take advantage of the potential to design a working Metro station *within* the antiquities, thus building a living and interactive relationship of the passengers with the city's past.

The comparative assessment of the three different approaches is out of the scope of this paper, although an estimate of the cost/benefit ratio was indeed performed as per the Rector's Mandate. It is deemed that all the ideas are useful and contribute to the main objective, which is the preservation of the antiquities and the operation of the Venizelou Metro station. It is noted that proposal of the Civil Engineering Committee has to be seen in the perspective of the timing it was made: a crucial intervention when all negotiations were blocked and the probability of either permanently moving the antiquities or canceling the station was extremely high. Currently, after one year of fruitful interactions between the city key players, it can be seen that all three approaches provided by Aristotle University are based on the initial concept justified and quantified by the Department of Civil Engineering, which is the temporary detachment, further excavation, construction of level -1 of the station and finally, re-establishment of the antiquities. This *concept of temporary detachment and re-location on-site* of the unique archaeological findings is deemed therefore to be the critical, though at some extent overlooked, contribution of the Civil Engineering Committee towards a common consensus between the state and local authorities that opened the way for a fair compromise between the involved sides and the ultimate preservation of this unique archaeological findings on-site. This consensus currently consists the common ground between the Attiko Metro, the Central Archaeological Council and the Municipality of Thessaloniki as declared in a recent press release [8]. Other ideas also have been put forward towards an international completion for constructing the station without detaching the antiquities, within a different time frame. The debate is still ongoing but the city is optimistic that one way or another, its long-awaited new Metro construction will be impressively coupled with its historical past.

7 CONCLUSIONS

This paper provides an overview of the contribution of the Civil Engineering Department in an important and long lasting public debate regarding the feasibility of preserving the unique Byzantine antiquities found during the excavation of the Venizelou Metro Station in the city of Thessaloniki, Greece without cancelling the operation of the station. The paper describes the various stages of this investigation and the merits and drawbacks of all the alternative solutions examined. Independently of the final solution that is to be eventually adopted, the Department of Civil Engineering of Aristotle University of Thessaloniki is pleased to have contributed towards a common consensus between the involved parties and the remarkable coupling of the modern city with its own past.

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