

# **Principles of planning a tramway system in an urban environment and its application to the city of Athens**

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## **Abstract**

The tramway is a modern transportation means that consolidates many useful characteristics but works with some limitations. For example, the tramway needs, for its function, certain space on the road, exclusively for it. The question naturally arises: how a well (or even not so well) organized transportation system can accept the application of such a new system, under which circumstances, with what disturbance for the rest of transportation network and finally, what would the results be and how we can set them?

We are able to demonstrate the main advantages and disadvantages that occur with the operation of a tramway system in an urban environment, like the one that is under study in the capital of Greece, Athens. We will examine the capabilities of applying such a system in addition to the existing public transportation networks (trolleys, buses, metro, etc.). We will examine the necessity for applying a tramway system related to the alternative means of public transportation and its complementation. Features concerning the planning demands, the infrastructure and the superstructure of a tramway system, will be mentioned.

Finally, we will lead to the main assumptions and the necessary questions that should be taken into consideration, for the planning and application of a tramway network in the city of Athens.



## 1. Policy and main scopes of the urban transport

The general scopes and the policy of the urban transport are very wide. In the same time they should clearly define the frame within could be applied several politics of development.

The above scopes could be derived in three categories: In these, which concern the users, in these that concern the public and finally these, which concern the system of urban transport itself.

The scopes that concern the user, concentrate at:

- A. The transportation time
- B. Comfort
- C. The commodity of transportation
- D. The accessibility of urban area
- E. The cost for the user

The scopes that concern the public, concentrate at:

- A. The satisfaction of the need for transportation
- B. The protection of the environment
- C. The desired development of the urban area
- D. The cost for the public

Finally the scopes that concern the system of urban transport itself, concentrate in:

- A. The safety of transportation
- B. The effectiveness
- C. The right use of the capital
- D. The creation of the sense of confidence and reliability
- E. The provision of high level services

After the definition of the general scopes, the next step is the "translation of these scopes into specific policies, that the management of the system is going to apply in each day." These functioning policies should be defined for:

A. The area of service:

Which areas should be served out of urban transport. For instance the areas, which lie within a rate of 20,30 or 50 kms of the center of the city. Or despite of the distance from the center of the city occur a mean daily number of movements from to the city that overcomes the 2.000 or 3.000 or 4.000 movements etc.

B. The way that the system must be designed in order to be developed. The system must be designed in a way that allows interventions. (Expansions, removals, institutions of new lines, changes of the schedule etc.)

C. The coverage of the need of transportation to every area:

In addition the functioning policies should be defined for the points bellow:

- D. The time that transportation will be provided
- E. The routes frequency
- F. Re-boarding
- G. The structure of the ticket charges
- H. The policy of the charges
- I. Information
- J. Service facilities

- K. Super structure material and wagons
- L. New methods that will promote the quality level of service (adjustments for the prohibited persons etc.)
- M. The parking areas close to the tramway stations

## 2. Service level of the transportation demand and characteristics of a tramway system

The new tramway of Athens is about to begin its operation, according to the releases of the Hellenic government, until the April of 2004. The total length of the tramway will be 20,7 Km and it's going to connect the two major poles of Athens, the center and the coastal zone. The cost of the whole project will reach the amount of 45 billions drm and it is going to be funded by the Hellenic government and the E.U.

The tramway system from the service point of view is lying between the metro and the road transportation means (buses and trolleys). The size of the city where a tramway is suggested, should overcome the 300.000 habitants and the capacity of the system lies from 3.000 to 15.000 passengers/ hour / direction.

Table 1. Suggested transportation system in relation the size of the City.

| Public Transportation Mean | Population of the city | Capacity of the system (x1000/h/direction) |
|----------------------------|------------------------|--------------------------------------------|
| TRAM                       | > 300.000              | 3 ————— 15                                 |
| METRO                      | >1.000.000             | 10 ————— 45                                |
| SUBURBAN RAILWAY           | >5.000.000             | 20 ————— 60                                |

Especially for the city of Athens the tramway is going to service the following volume (derived by the sections of the routes):

Table 2. Tramway transport volume for the city of Athens.

|                        | Diametric line | Circular line | Total volume of the system |
|------------------------|----------------|---------------|----------------------------|
| Morning peak volume    | 9.700          | 3 400         | 10.700                     |
| Daily volume           | 356.700        | 197 800       | 557.100                    |
| Passengers/Km (Daily)  | 1.355.500      | 220 400       | 1.575.900                  |
| Mean route length (km) | 3,8            | 1,1           | 2,9                        |

The main parameters, which contribute determinably to the planning of an efficient and attractive tramway system, are:

A. The traffic congestion. It is crucial in cities where the traffic problem is intense to ensure that the wagons will be moving without any disturb and the accessibility to the tram stations will be also ensured.

B. The distance between tram stations. According to European models and in the cities where modern tramway systems are operated, a decrease of the distance between two sequential tram stations from 450 m to 350 m, causes decrease of the trade speed of the system from 22-25 km/h to 15-17 km/h. A walking distance of 450 m in an urban area corresponds almost to 7-10 min of walking, where the 350 m correspond to about 5 minutes of walking. The time saving of the route, which is accomplished, with the speed of 20-22 km/h of the system, is regarded very important for the public, so a mean distance between sequential stations is estimated to 400 m. Even though the target is to achieve higher speeds, from a point further it is practically unreachable. So the choice of the place where the station will be constructed, is taking under consideration the bellow elements.

→ The stations should be placed near points where many people concentrate.

→ The safety of the passengers and the comfort of the route as well as the safety of the pedestrians should be taken into account.

→ The tramway stations should not prohibit the rest of the traffic.

C. The signaling and control of the crossroads. During the designing of a tramway system a very important parameter is the care that should be taken as far as safety concerns. In this point we should mention, that in cities where a new tramway was established, there was strained a huge effort in order to inform the citizens about the new traffic signals.

### **3. Evaluation of scenarios for the creation of tramway in the city of Athens**

For the evaluation of the alternative scenarios of the construction or expansion of a tramway, it is necessary to examine several criteria. These criteria should take into consideration the needs and the capabilities of the area, which is going to be served by such a system.

So the criteria, which are connected with topology, in a great degree, can shape its operating characteristics.

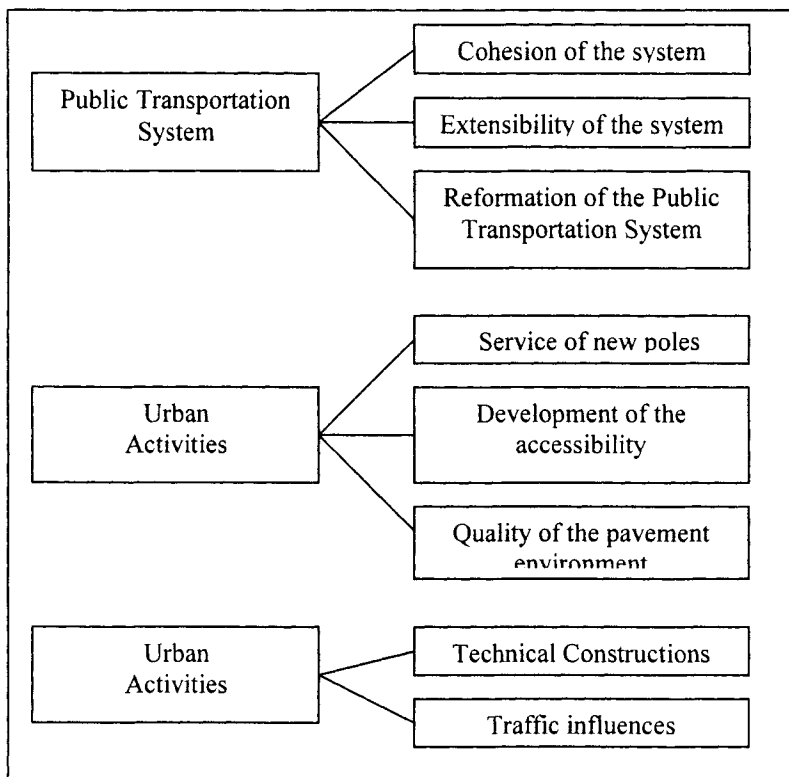


Figure 1. The criteria for evaluation alternative scenarios of the transportation systems.

We consider that the criteria of topology for the city of Athens are as much wick as it needs to conclude that they consist no limitation. The criteria are demonstrated to the above table.

The infrastructure which is needed, is derived in three main categories:

→ **The major constructions:** These are the constructions that cost over than 500.000.000 drs.

→ **The middle size constructions:** These are the constructions whose cost ranges between 100.000.000 – 500.000.000 drs.

→ **The small size constructions:** These are the constructions whose cost comes up until 100.000.000 drs.

Finally, the methodology, which was applied to the evaluation of the alternative scenarios, was the Regime method. This method is based on the multi- criteria estimation and can take into consideration both qualitative and quantitative data. The total cost of the project, as mentioned above, runs into the amount of 45 billions drs.

#### **4. Description of the impulse poles, branches and alternative means and routes for the urban area of Athens**

For the urban area of Athens the description of the impulse poles (existing and future) has as purpose the estimation of the trend for transportation, as they modulate out of the implicitly demand and offer of the areas that will be served. The description is concerning the areas that tram will include (direct and indirect service zone).

- **North to center (from Ano Patissia to Museum)**

This axis, until the 80 decade was neighbored with areas like Kipseli, Ano- Kato Patissia, Koliatsou square, Amerikis sq, that were areas mostly for houses. The height rates of construction and the malign environment conditions lead to the change of the use of the basements. Afterwards these areas were used for activities like warehousing, insurance companies, law and engineering offices. In addition the section from Codrictonos st to Politechnio is characterized from the existence of poles like Pedio Areos (with the Panellinio Gymnastiko Syllogo, National Technical University of Athens and the National Ancient Museum).

Finally should be mentioned that the Patission st is characterized as a main road axe that connects the center with the National road network. Despite of the fact that Patission st is serving urban movements, some sections are used for movements from the center to the National road network.

- **The area of the center**

The area of the center has major importance and consists the most derived pole of impulse for Attiki and for the whole Hellas. It is an area of great value because of its ancient locations. Under this consideration, the main characteristic is the program for unifying the ancient locations of Athens and the target is to restruct the historical center and the exploitation of the trade triangle.

Because of the existence of many poles in the center area, special reference should be made to the aspects bellow:

A. From the entrance of Sygrou and Vouliagmenis will be created a new park and specific the section from Panathinaiko Stadio to Zapio and National Garden and Olympium until the Amallias Avenue. So there will be created an ideal entrance to the center of Athens, which will go through a large urban park.

B. Heading to the west is the area of Acropolis with Filopappou and Makrigianni, where there is under construction the New Museum of Acropolis. The Hirodio will be functioning as a scene and Dionysos Theatre as a monument. Further on there is the ancient and the Roman market with the library of Andrianos and Plaka.

C. To the west there is the Thissio and Gazi with Keramikos. Especially the Psiri sq and Metaxourgio are areas where takes place a great development with many entertainment places.

D. Finally special reference must be made to the trade triangle. This section is characterized by many squares.

The area of the center is an area where trade is overarching. In the trade triangle concentrate more than 3.000 operations. Most of them lying between Ermou and Kolokotroni.



In the same time should be mentioned uses like Parliament, stock market, banks, and several ministries and administration buildings.

- From center to South, (from Zapio to Falliro)

The axe from Sygrou (Fix) to the coast avenue is characterized as an expressway avenue with side roads. All the forehead of Sygrou av is used of tertiary operations. Most of them are insurance companies, hotels, diagnostic centers and Pandio University.

In contradiction, the area bellow the forehead of Sygrou is an area that is mainly used for accommodation (Kalihea and N. Smirni). The area of the ex- factory of Fix (in Sygrou av) is going to be transformed into a great reboarding station.

- The South-east region

The study of stepping up the coast zone of Saronikos Gulf, which was elaborated by the Athens Organization consists several proposals for the development of the zone. The main aspect was the ability of the access to the urban area for the regions above the coastal av (which are destined for accommodation places) and the region bellow the coastal av is destined for entertainment place. Even more to the region bellow the coastal av is planned to create facilities for nautical activities (which will be used in the Olympic Games of 2004). So the coast is tending to change entirely its structure.

- The South- west region

In this region also exist important proposals for the development of the environmental conditions. These proposals come out of the relative study of the Athens Organization. The under construction road section from Kifissou av, to Pireos av, until Posidonos av, will change indeed the "image" of this region.

As far as concerns the sport facilities of the region, the Karaiskakis Stadium has a capacity of 37.000 viewers to the main court and 5.000 to the auxiliary spaces. Also the Peace and Friendship Stadium has a capacity of 16.000 viewers. Both of them are important existing and future poles of impulse, not only for sport activities but also for many other activities such as conferences, exhibitions etc. Finally the important issue of this line is the service of the center of Piraeus the second bigger municipality of Attiki.

## 5. Presentation of the branches

After the presentation of the poles and the analytically description of the activities which take place to the regions around them, now we will present the branches which are going to service them. It is important to take under consideration the volume of the above poles and their orientation. Specifically the branches are:

- Patissia – Falliro

### *Description of the route*

The diametric line from North to South goes through Patission str, Omonia, continues to the Panepistimiou str and then to Amalias av (through Syndagma sq) and finally follows the direction of Sygrou av. In this way the route covers the region from Ano Patissia to Falliro.

The suggested setting of tramway for Patission str., is the setting to both sides of the road.

From Omonia to Sygrou the tram will be following Panepistimiou av and Amallias av.

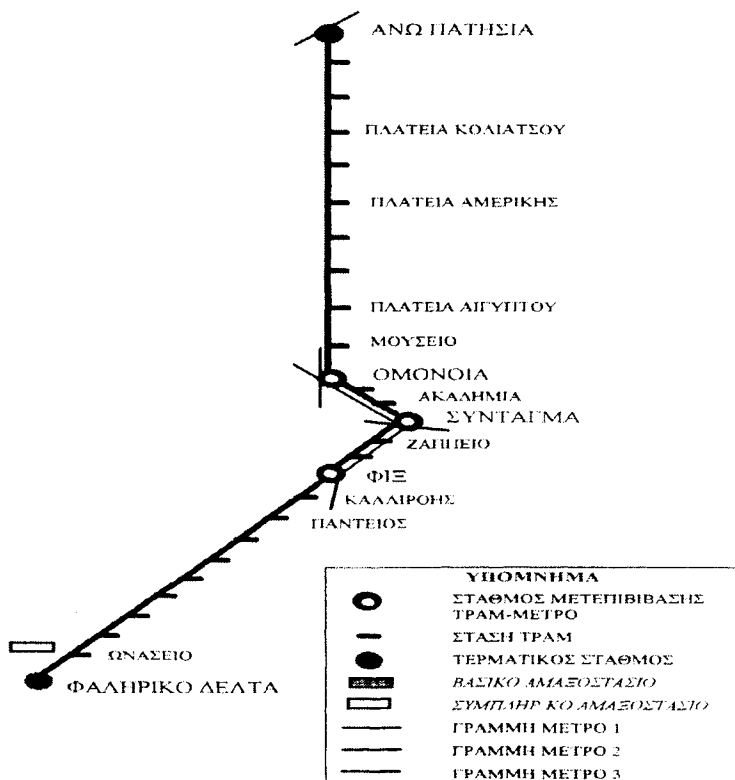


Figure 3. The branches of the tramways in the city of Athens

Because of the ratios of curvature of the circuit in the junction of Patission with Panepistimiou, there should be placed sided the two circuits along the west side of the streets, so that we can reduce the number of streets intersecting from the tram (SEMALY, TRENDS and BECHTEL). Continuing to the Amalias str, the tram way follows the Siggrou str. The circuits keep running to the west side of the road.

The route from Ano Patissia to Falirou is demonstrating above.

## 6. Conclusions

The tram is a transportation mean, which acts as a complement element to other means. The tramway feed and is feeded by the major bus and trolley lines. Also, connects the central metro-stations with its other. Generally, serves greater volumes than a bus or a trolley does, but not as great as subway. The major role of the tramway is auxiliary to the other transportation means. But tram is a steady route mean. So it needs certain space to the road exclusively for the use of tramway. Under the above considerations the tramway is going to be designed in order to operate under the following principles:

- The tramway will take the place of the major bus and trolley lines, which now deliver the public to the metro stations or to the center
- During the construction period of the tramways substruction, precautions must be taken in order to minimize the disturbances to the other mean (buses, trolleys, cars, pedestrians)
- Tramway is going to connect the ancient monuments
- The system of public transportation will be recomposed in order to minimize the re-boarding
- The roads that will be used to operate the tramways, must ensure the appropriate width for the exclusive movement of the wagon. In this way the speed of the system will be increased, and so will the capacity
- In order to encourage the public to use the tramway, it's crucial to provide enough parking seats, near the major (at least) tramway stations. The public must have the ability to Park-and-Ride. So in the same time that tramway is under construction, enough capital must be released for garages and parking stations, and in generally for the increase of the parking area.

Finally, the main purpose of the tramway is to act in addition with the alternative transportation means. Especially for the city of Athens, or any other city with the same traffic conditions, it's crucial to operate a tramway system, because as proven above could serve a great deal of passenger volume. As the Olympic Games of the 2004 are going to be hosted by Athens, the tramway must be ready to serve the addition volume of the visitors.

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