Technology foresight in the transport sector: a Delphi survey

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Abstract

The predominant characteristic of the last decades is the continuous increase of the vehicular traffic and the increased need for more and better transport infrastructure, requiring space and continuous investments. Despite the initial growth of transport infrastructure in order to meet the demand, nowadays such approaches are strengthened. Within an era of continuous technological progress, the possible solutions should be hunted from this direction, i.e. the technological developments and applications in the transport sector. Thus new transport policy objectives have been settled and the researchers have taken a step further: they have started to investigate the possibilities of applying or using the most promising technological perspectives in the future, according to the dynamics of the territory under investigation. The aim of this paper is to present the technological perspectives and their applications in the transport sector for the next fifteen years within the Region of Central Macedonia, Greece.
Keywords: technological perspectives, transport demand, environmental protection, transport system, transport networks, Delphi, SWOT.

1 Introduction

Transport is a dynamic area of study and research. Transport systems sprawl spatially and determine the degree of accessibility or the easiness to reach markets and services. The spatial development and the transport system are interrelated and interconnected, as the existence of the first presupposes the existence of the second and vice-versa, as in order to meet the desired degree of

mobility for the population and goods relies on the existence of transport infrastructure.

This syllogism gives a crucial characteristic of the last century, which is the continuous increase of the vehicular traffic. Generally speaking, during the first decades this trend was expressed through road widening and the pressure for better road infrastructure. Afterwards, this attitude of the public was replaced from a picture: the picture of a congested road network that results in a seriously damaged environment and depredated quality of life, covering areas from the city centers to the neighborhoods. Traffic management and traffic calming techniques started to form the framework for traffic control of the congested networks since 1963 [1].

Nowadays, within the era of continuous technological developments, their applications in the transport sector form the framework to tackle the adverse effects of transport. New technologies aiming to improve the traffic control of networks, to assist the construction and the maintenance of transport systems, to develop new instruments for the planning process and appraisal of transport schemes as well as "clean" modes and various types of vehicles are the current answer to the traffic problems and the environmental degradation of the city centers.

In order to investigate the technological perspectives in a thematic field it is essential first of all to determine the areas of special interest, i.e. the sub-areas on which technological developments are possible to be applied. This step forms the basis for the research work and the source is usually the experience of the researchers and the experts who participate in the investigation and similar works in national and international level. Therefore this paper includes the following:

- A brief review of the most promising fields for technological developments within the transport thematic area
- The thematic sub-axes under investigation
- The methodological framework of research
- A scenario for the transport system in the Region of Central Macedonia, Greece, in the time horizon of 2020.

2 Transport and technology

Wide ranges of technological developments are applicable in the transport sector. They form innovative solutions for the construction, maintenance and operation of transport networks and modes, able to accommodate the demand for transport in a user and environmental friendly way. From this range of applications the most promising at regional, national and international level for the next fifteen to twenty years are those referring to [2,3,4,5]:

- Planning and construction methods for transport infrastructure
- Maintenance and management of transport infrastructure
- Planning and manufacture of new types of vehicles, in terms of new makings and engines in road, rail, air and sea modes of transport

- Driving abetting technologies and navigation technologies for vehicle fleet management
- Informational systems and systems for users charging
- Traffic abetting and traffic control systems
- New types of modes for urban transport
- Urban railway mass transit systems
- Traffic management of road networks
- Traffic management and control of railway systems
- Intelligent systems for air traffic control
- Navigation systems – Global navigation and positioning systems Environmental friendly transport systems

The above-mentioned points form the focal points for the development of the transport systems and the associated technologies worldwide. Nevertheless the degree of application and the trends in implementing the developments are function of the internal and external pressures in the area of interest, i.e. the regional policy and government (internal), the national policy, the European Union policy (external), the distribution of funding in spatial level, etc.

3 Research and technological perspectives

3.1 Research framework

As mentioned earlier the first step in this research work was to determine the core thematic sub-axes of the central issue, i.e. the transport sector. The distinction that was made from the research team took into account the particularities of the geographical area, the previous experience of the researchers in such works and especially in the National Foresight and the information gained from reviewing similar works in other countries. The output of this step was the set of the thematic sub-axes and a comprehensive description for each within the Region of Central Macedonia, Greece [2].

Afterwards (second step), an analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis has been implemented for the transport sector (as a whole) in the Region of Central Macedonia, Greece. It has been implemented from the team, in order to identify issues that need further exploitation. The exploitation formed the third step of the process. The basic points of the SWOT analysis were the source for the majority of the statements of the Delphi survey, which was addressed to a panel of experts within Central Macedonia [6].

The final output came from a synthesis of the Delphi results and it is a scenario for the transport in the area at the time horizon of 2020. The scenario incorporates the possibility for utilization of each statement with the respective time horizon in order to create a snapshot of the future situation.

3.2 Thematic axes and current situation

From the first instance special interest has been placed in eight thematic axes, able to cover the transport sector. More specifically the thematic axes and the current situation for each of them are:

- Networks development: the most characteristic problem of the current situation is the segmental consideration of the transport system at national and regional level, resulting to a partly investigation and allocation of the transport demand and the opportunities for alternative routes and modes.
- Network and traffic management: there exists a great development during the last years, which will continue at least for another five years. The potential in this axis has to do with the traffic management of networks.
- Mass urban transport: all the urban centers within the Region and especially Thessaloniki, face serious traffic problems, resulting to serious socioeconomic and economic problems.
- Vehicle fleet management: this involves mainly road and rail transport and refers to the city of Thessaloniki, where the actors are based and appears the majority of the inefficiencies.
- Transport and the environment: the urban environment within the Region is seriously damaged, due to the traffic problems, the high demand for transport and the private car dependency.
- Transport safety: the research on this topic made a great progress abroad and gave remarkable results in international level. Unfortunately the penetration degree of these research results in Greece is too low.
- Freight transport: the geographical position of the region is of special interest at country level, as two basic motorways for the road freight movements in the South – East Europe cross the region. At the same time the rehabilitation of axis X will give a boost to the freight movements in the area.
- Combined transport: the inadequate transport infrastructure at regional and national level results to limited combined transport.

3.3 SWOT analysis

After the brief description of the thematic sub axes and the current situation it is important to present the SWOT analysis performed for the needs of the present research about the transport system in the Region. Table 1 that follows gives the results of the SWOT analysis.

Table 1: SWOT analysis for the transport system in the region.

Strengths	*Weaknesses*
1. Substantial research efforts from organizations and bodies with local activity **2.** Existence of experts and legal framework able to boost further the research work in the field **3.** Activation of a great number of organizations and scientific boards on transport issues **4.** Expertise in specific thematic areas **5.** Potential for the utilization and implementation of scientific results **6.** Public awareness for the confrontation of traffic and environmental problems.	**1.** Lack of an integrated transport policy. Lack of coordination and cooperation between the various bodies with authorization on transport **2.** Inadequate transport infrastructure **3.** Insufficient funding and investments **4.** Lack of projects and proposal of high impression up today **5.** Poor results from the implementation of transport policy measures, due to the political cost **6.** Inexistence of transport appraisal studies for the area
Opportunities	*Threats*
1. Completion of a number of transport infrastructure projects **2.** European Union funding **3.** Releasing and inflow to the region of experts after the completion of transport projects related with the Olympic Games **4.** Betterment of the role of Greece as financial and political centre within the greater Balkan area **5.** Securing of the role of Thessaloniki as hub in the area **6.** Accession of Thessaloniki to the Olympic Cities for 2004 **7.** Rehabilitation and completion of the road and rail axis (corridor) X **8.** Tourist development of the area **9.** Expansion of the urban mass transport in Thessaloniki. New institutional framework for the operation of public transport	**1.** Low development rate in the Balkan area **2.** Political instability in the neighborhood countries **3.** Inefficient exploitation of the various opportunities **4.** Reduction of the European funding, due to the European Union enlargement **5.** Promotion of tourist areas in neighborhood countries for holidays at cheaper prices **6.** Slowdown or even cancellation in utilizing important transport projects in the area **7.** Reduction to the use of MACEDONIA airport in Thessaloniki from the air companies **8.** Delays to the completion of the Pan-European axes (IV & X).

3.4 Delphi survey

The basic methodological choice of the overall research work in order to conclude in concrete results was the use of a Delphi sample survey. According to this method, the conclusions come from the compilation of the results of a structured questionnaire conducted in two phases from a panel of experts on the

issue at hand. The main objectives of the research team in order to conclude in reliable results are the collection of the sample and the statements of the structured questionnaire [7].

The experts that took part in the survey (sample) were coming from all the public and private organizations and bodies with a role in the transport sector in the Region. In total, 119 experts were asked to participate. Nevertheless, the response rate was rather low. This was balanced from the fact that the experts that finally took part were scientists with a great contribution to the transport sector within the country and the region. Table 2 that follows gives some details about the sample composition and Table 3 some indicative information about the consistency between the sample and the objectives of the Delphi survey.

Table 2: Sample composition.

	Academics	*Researchers*	*Industry*	*Public administration*	*Others*
Asked to participate	16	3	35	60	5
Participants to the 1st / 2nd phase	2 / 6	0 / 1	3 / 4	1 / 2	0 / 2

Table 3: Consistency between the sample characteristics and the objectives.

	Academics	*Researchers*	*Industry*	*Public administration*	*Others*
Very consistent	6				
Consistent		1	4	1	2
Little consistent				1	

The contents of Tables 2 and 3 demonstrate that the responders (final sample) were able to nominate and to allocate the crucial issues for the next fifteen years to the transport sector through their attitude to Delphi survey statements. The statements of the Delphi survey are based on the SWOT analysis output (presented earlier). It is of some importance at this point to summarize the highlights of the weaknesses and the threats to the following points:

- The geographical position of the Region and the political situation in the area
- The position and the role of the Region of Central Macedonia in Greece and the national transport policy
- The insufficiency of transport infrastructure and networks
- The completion of important transport projects with national importance
- The necessity for innovative solutions at urban and interurban level
- The necessity for change of attitude and public awareness on transport issues.

These six points were the driving forces for the Delphi statements that are presented in Table 4.

Table 4: Delphi statements.

	Statement
1	Wide use of electric cars in the urban areas
2	Introduction of hydrogen vehicles in the urban areas
3	Wide use of up to day methodological instruments during the planning process of the transport infrastructure, able to give reliable estimations of the impacts
4	Disruption of the network cohesion in the greater area, due to the continues political instability at the neighborhood countries
5	Increase of the cross border cooperation, due to the completion of the Tran European Networks and the upgrading of the national road network
6	Boost of freight transport movements, due the network completion and the simplification of the entrance procedures to the border stations in the Region
7	The geographical position of the Region in combination with the interoperability of the networks will give a boost to the combined transport
8	Staple use of new technologies for the management and the monitoring of the HGVs' fleet, due to the increase of the freight movements in the Region
9	Transfer, to the neighborhood countries, of the expertise gained to the Region from the investments and the transport infrastructure utilized during the last years
10	Tourist development of the Region as a result of the operation of the Egnatia Motorway and its vertical axes in combination with the axis X and the Ionian – Adriatic Corridor
11	Wide use of new technologies for ramp metering with the completion and operation of basic motorways within the area
12	Wide use of the weight in motion (WIM) technology will assist the control of overloaded HGVs, resulting in road accidents reduction
13	Prevention of road pavement damages due to the WIM technology at national level
14	The improvement of transport infrastructure in the Region will cause a change to work and residence patterns, that is expected to lead in commuting
15	Confrontation of problems related with the discontinuity and lack of coordination in the transport planning process within the Region
16	Wide use of telematic techniques for the transport management of the central areas of the cities in the Region
17	Reduction of the travel time between work and home with the development of traffic monitoring techniques and the transmission of real time information for drivers navigation
18	Improvements to the level of service for the passengers / customers due to the wide use of new techniques for fleet management and incident detection in passenger and freight transport
19	Increase of the number of passengers of public transport as result of their upgrading and the preferential treatment
20	Accessible public transport system for people with special needs
21	Reduction of the congestion to the urban centers of the Region, due to the alternative modes of transport (railway based systems)
22	User charging policies in combination with better public transport will lead to traffic reduction and an opportunity for urban space allocation and upgrade
23	The operation of Centers for Drivers' Training and Examination will promote the safety level
24	Introduction of traffic simulation techniques to the Centers for Drivers' Training
25	Construction and operation of a modern suburban rail, which will improve the accessibility to Thessaloniki from the other areas within the Region
26	Wide use of the informatics by the Port of Thessaloniki and by the carriers will reduce the average waiting time of a container to the Port from 4 to 3 days
27	Development of new organizational and institutional methods to the transport bodies
28	Integrated environmental management to the ports of Central Macedonia
29	Improvement of the opportunities to carry out various activities through the Internet, able to reduce the demand for movement and the associated congestion problems

It is obvious that the statements cover three thematic areas: the development and the application of new technologies in the Region, the completion of the transport networks in the greater area and the boosting of freight transport and finally, the implementation of innovative transport policies and institutional frameworks within the various governmental levels within the Region.

From the statements that involve the development of new technologies and techniques for the transport management, special interest has the one that refers to the wide use of electric vehicles, as this technology is already in use. Conversely, the one that involves the hydrogen technology, has not been promoted enough, and results in doubts for future introduction and use. Together with the development of new vehicles, the application of various technologies for traffic management and fleet management are integral part of every scientific – research work in the field and a continuous proposal to the responsible bodies for implementation.

The evolutionary course of the Region for the forthcoming years is affected from the transport systems in the greater Balkan area and the integrated operation of the Trans-European networks. The social and political instability in the Balkan area during the last decade caused serious discontinuity to the transport infrastructure and international cooperation in the area and the formation of alternative transport routes with direct impact to the freight transport. Believing that these difficulties have been overcame and considering the contribution of international public organizations and the European Union, it is expected that the Region will be a nodal point in the area for freight movements and combined transport. In addition, the geographical position of the Region and the physical potential to combine all the means of transport (terrestrial, air and sea) redoubles its role to the area.

Finally, at both national and regional level it seems that there exists the necessary maturity for the introduction and the acceptance of new policies, trends and attitudes. Thus, the metropolitan governance forms a strong recommendation for the future and a lot promising for the transport sector, in order to coordinate and to integrate the transport system in the urban areas. This point has special interest considering the perspectives for transport infrastructure development within the Region, which involves the construction and operation of suburban rail system, the improvements in public transport and the respective improvements of the level of service and finally, the innovative training of the drivers and the users in general of the transport systems. Of course, the improvements to the public transport give the necessary supply for changes to travel and living patterns of the individuals.

4 The region of Central Macedonia on the way to 2020

From the analysis of Delphi survey it is possible to give a broad description of the Region on the way to 2020. Thus, in a first stage the cooperation in the Balkan area will be established and increased with the completion of the transport networks in the area. This will result to an increase of the number of passenger and freight movements within the area and through the area (transit

movements), something with adverse impacts. In order to overcome the negative impact, new methodological instruments for the appraisal in first place and afterwards during the operation stage for the monitoring of the transport infrastructure projects will be used. During this stage, entities like the Observatories and the Traffic Management Centers could be very useful.

In a second phase (up to 2013) the economic role of the Region in the area will be established through the improvements of transport infrastructure at national level and the substantial increase of the amount of freight and combined transport movements [8,9,10]. More knowledge and expertise will be gained from this process, as the generated passenger and freight transport must be accommodated through traffic management and control techniques and especially on motorways. With such improvements the average daily kilometers traveled per person will be increased and the sub-urbanization will form a new living pattern. Within this time the Region will be the resource for the "pumping" of valuable human resources with great knowledge and degree of expertise on the field for the neighborhood countries and a ground for research initiatives and cooperation.

In the final stage to 2020, the new generation of vehicles and fuels, the development of alternative working and living patterns and innovative policies related with the Metropolitan Governance will form the picture of the Region. All these perspectives suppose a change to habits and attitudes and for this reason they characterized as long-term perspectives.

Concluding, on the way to 2020, the city of Thessaloniki and the Region of Central Macedonia will consist a dynamic development pole of the country and the Balkan area. They both expected to be served by a transport network of high level and a modern network of mass transport. The environmental conditions will be improved or at least remain the same, as the technological improvements will be able to overcome the environmental burden from the increased traffic.

5 Conclusions

After the previous analysis it is profound that in order to achieve a balanced development to the transport sector with respect to the national and international environmental norms, the national and European transport policy targets and the social cohesion, special emphasis should be placed to the following issues:

- The transport networks completion and integration
- The complementarily of transport networks and modes, the parallel development of road rail and sea motorways according to the European Union White Paper
- The modernization of the existing infrastructure through the new techniques aiming at the improvement of the level of service and the level of safety in the networks
- The use of new techniques and planning and monitoring instruments during the construction and operation of transport projects
- The use of peak technologies for the management of the transport chain

- The use of peak technologies for the transport system and the environmental protection, through a new generation of transport modes and fuels
- The training and attitude of transport users
- The publicity, information and public awareness in issues relating with the use of public transport, driver behavior, travel behavior and environmental protection.

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