EXPECTED SAFETY AND SOCIOECONOMIC BENEFITS FROM THE APPLICATION OF TELEMATICS IN THE GREEK MOTORWAYS: THE CASE OF EGNATIA ODOS

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ABSTRACT

Transport Telematics Applications, also known as Intelligent Transportation Systems (ITS) create important benefits for road users, for infrastructure operators and for the society in general. Telematics Applications aiming at managing traffic and incidents are considered to be a necessary component in every modern motorway that is meant to offer high level of service. In Greece, such applications have been implemented in a few so far cases, such as the ATTIKI ODOS motorway, at the fringe of the Greater Athens Area. Another case is the EGNATIA ODOS motorway that is still under construction, whilst almost 65% of its total length is already in operation. Egnatia Odos with a total length of 680 km includes over 50 tunnels and a equal large number of bridges, including several long tunnels that in some cases form quite complex road sections. Managing traffic in case of an incident in these sections is a quite difficult task and eventually leads to significant economic and social benefits for all involved. The respective study for a specific section, Polymylos - Veria, with a length of 25,5 km comprising 14 tunnels and 12 bridges indicates that the benefits from the implementation and operation of ITS exceed the investment and operations / maintenance costs of these systems. Road safety improvements alone account for approximately 1,0 ml € for year 2005. Additional benefits emerge from time savings in case of incidents, as well as from operating cost reductions. The total investment cost for a Traffic Management System for this particular road section has been calculated to approximately 6,0 ml €.

INTRODUCTION

It is well known that the Intelligent Transportation Systems (ITS) have a wide range of applications worldwide. The most common applications of the ITS refer to the following:

- Vehicles (e.g., passenger cars, taxi, HGV, buses, rolling stock etc)
- Infrastructure (e.g., urban and rural road networks, transfer stations, ports etc.)
- Equipment (e.g., computers, mobile phones etc.)

The main application areas can be categorised based on their function, as follows:

a) Traffic Management Systems (TMS): This category refers to the technologies used for monitoring and control of traffic in real time. These technologies include sensors, cameras and communication systems etc. Example of TMS includes the optimisation of traffic lights, traffic surveillance, traffic flow control etc.
b) Public Transport Management Systems (PTMS): This category refers to the automatisation of management, programming and operation of Public Transport systems. Example of PTMS includes tracing of Public Transport vehicles and provision of priority at signalised junctions.

c) Electronic Payment Systems (EPS): This category refers to the electronic payment of tolls, parking fees etc. As an example it can be mentioned at this point that the electronic toll payment allows drivers to pay the fee without stopping their vehicles and thus to suffer less delays at the toll stations.
d) Systems for Heavy Goods Vehicles (HGVs): These systems include the automatic location of HGVs, their automatic classification, the estimation of their weight (this can be achieved through the use of various technologies including Weigh-In-Motion/WIM systems), the estimation of the level of their emissions etc.
e) Incident Management Systems: The scope of these systems is to allow the police, the fire department, the ambulances etc. to reach the location of an incident at the soonest possible time. The technology used in these systems includes route guidance systems, priority systems at signalized junctions etc.
f) Advanced Vehicle Control Systems (AVCS): These systems include a variety of safety mechanisms and collision avoidance mechanisms (e.g., ABS, ESP etc). Through the use of these systems the monitoring of the physical and psychological condition of the drivers can be achieved. In extreme cases (where the driver is not in the position to continue driving for various reasons) these system can safely control the vehicle.

BENEFITS FOR THE IMPLEMENTATION OF THE ITS TECHNOLOGY

Benefits from the implementation of ITS are many-sided. A large amount of reliable data is needed in order to evaluate the impact of ITS technologies to a transportation system. This demanding process is made by ITS America in USA and by ERTICO in Europe. The evaluation results show that the benefits from the implementation of the ITS technology include the following:

- Reduction in the number of fatalities and serious/light injuries in accidents (all transport modes are concerned)
- Reduction of delays and time taken for a trip
- Reduction of the negative impacts of the transport system to the environment (e.g., emissions, energy consumption etc)

Some of the ITS benefits can be easily quantified but this is not the case for all the impacts. According to the reports of the ITS Joint Program Office there are three types for the estimation of the benefits:

- Measurable benefits: reliable results from field measurements
- Estimations: made by people involved in ITS projects. These results are reliable but not as far as the quantitative estimations are concerned
- Forecasts: results come up from analysis and simulation programs. They are useful tools for the estimation of the benefits in cases where, for example, field measurements do not exist

EGNATIA ODOS AND ITS APPLICATIONS

The Egnatia Motorway is the biggest road infrastructure project under construction in Europe nowadays. It has a total length of 680 km., it crosses Northern Greece and it connects the Eastern and Western part of the country. The Egnatia Motorway has access to 5 ports and 8 airports. Moreover there are 8 road axes connecting Egnatia Motorway with the neighbouring Balkan countries. Figure 1 presents Egnatia Motorway (in red) in relation to the road network in Northern and Central Europe.

Figure 1: Egnatia Motorway in relation to the road network of Northern and Central Europe

Source: Egnatia Odos S.A., Department of Public Relations

Due to the fact that it is a very demanding project (difficult terrain etc.) it was decided by the authorities in 1996 to create Egnatia Odos S.A. that is the responsible company for the design, construction, management, operation and maintenance of the Motorway. The total cost of the project is in the area of 4.600 million euros (VAT is not included). A percentage of 7% of this amount refers to the management and supervision of the project, 5% refers to the design of the project, 8% refers to expropriations and finally a percentage of 80% refers to the construction itself. Finally it must be mentioned that around 8.000 employees (engineers and technical personnel) are involved in this project.

Architecture of ITS for the Egnatia Motorway

Egnatia Odos S.A. realised in its first steps the necessity to adopt ITS technology. In the year 1999 a study for the architecture of ITS applications was assigned to the Canadian company Delcan. Adopting the U.S.A national architecture for ITS was considered as the most appropriate solution at that time. The phases of the Delcan study are presented in Table 1.

Table 1: Phases of the study for the Architecture of ITS concerning Egnatia Motorway

Phases	Project / Steps
A. System Analysis	Targets of the telematics system
	User needs
B. System Design	User services
	System operation – Logical design (System architecture)
	Telematics sub-systems – Physical design (Physical architecture)
C. Implementation Strategy	Motorway characteristics and segmentation
	Implementation strategy – Cost model
	Supply methods

Source: Study for the Telematics Applications for Traffic Management and Toll Collection in Egnatia Motorway, DELCAN – DHV BV, 2001

According to the results of phases A and B of the Delcan study, the following five basic services had to be provided:

- Traffic data collection
- Traffic management and supervision
- Weather condition monitoring
- Incident management
- Drivers' information

Initially the services packages (which theoretically could be included in a telematics system for the Egnatia Motorway) are determined and a list is constructed. Hereafter this list was limited to fewer, basic, services packages as they are presented in Table 2.

PRESENTATION OF THE EGNATIA MOTORWAY SECTION: POLYMYLOS – VERIA

The road section Polymylos-Veria is located in North-Western part of the country and has a total length of 25,5 km. It has 2 lanes (plus an additional emergency lane) per direction. It is considered as one of the most interesting parts of the Egnatia Motorway due to the fact that it includes a large number of tunnels and bridges constructed in a difficult terrain (Figure 2).

Figure 2: Road section Polymylos-Veria

Source: [GIS Department of Egnatia Odos S.A.]

The new study for the implementation of the ITS technology to the specific motorway section took into account the Delcan study. According to the new study the proposed basic services include the following:

- Traffic management along the whole road section
- Incident tracing along the whole road section
- Drivers' information for traffic conditions
- Drivers' information for weather conditions
- Traffic data selection

Table 2: Relation between ITS service packages and user services provision

	Traffic Management				Electronic Payment	Incident Management		Road Management	
Service Packages	Traffic Control	Incident Management	Demand Management	Monitoring of Environmental Conditions	Toll Electronic Payment Services	Notification for emergency situations – Personal safety	Management of Emergency Vehicles	Assessment of Weather Conditions and Pavement Conditions	Management of Data Files
Network Surveillance	■								
Motorway Control		■	■						
Traffic Data Transmission	■								
Regional Traffic Control	■								
Incident Management		■							
Traffic Forecasts and Demand Management			■						
Electronic Toll Collection					■				
Management of Reversible Lanes	■		■						
Road Weather Information System				■					
Weigh-In-Motion	■							■	■
Management of Dangerous Goods		■			■				■
Respond in Emergency Situations							■		
Support of Emergency Calls						■	■		
ITS Data Files									■

Source: Study for the Telematics Applications for Traffic Management and Toll Collection in Egnatia Motorway, DELCAN – DHV BV, 2001

Figure 3 presents the ITS System Architecture for the Polymylos-Veria motorway section (where CCTV: Closed Circuit TV, VMS: Variable Message Signs, LCS: Lane control Signs, BOS: Blank Out Signs and OHVD: OverHeight Vehicle Detectors).

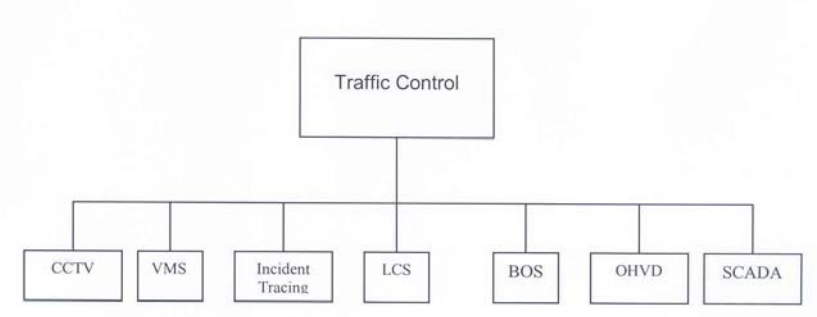

Figure 3: ITS System Architecture for the Polymylos-Veria motorway section

Source: Egnatia Odos S.A., Department for the Operation, Utilisation and Maintenance of the Egnatia Motorway

The equipment, which originally had been decided to be installed in the motorway section Polymylos-Veria is presented in Table 3.

Table 3: ITS equipment in the motorway section Polymylos-Veria

Equipment	Number
LCS	82
VMS	4
BOS	20
CCTV	82
CCTV PZT	16
Inductive Loops	92
OHVD	6
RWIS	4
Traffic Lights	8

Source: Egnatia Odos S.A., Department for the Operation, Utilisation and Maintenance of the Egnatia Motorway

EVALUATION OF THE ITS CASE STUDY IN THE EGNATIA MOTORWAY

State of the Art

Benefits from ITS applications can be considered at various levels. There is a rich bibliography about the way benefits from ITS applications should be considered and if Cost Benefit Analysis is the right approach to evaluate such systems (Zavergiu 1996, Brand 1993 & 1998, Li et.al. 1999, Stamatiades et.al. 1998, Ran et.al. 1997). According to ITS Joint Program Office (JPO - ITS Benefits Database and Cost Information, 1999), benefits should be measured against the specific targets ITS is supposed to offer. These targets are safety, mobility, efficiency, productivity, energy and environment. Some of the targets pertain to the individuals, some to the Infrastructure Operator and some to the Society as a whole. It is therefore clear that benefits can be distinguished at these three levels as well. Finally, another way to consider ITS benefits is by looking the supply and the demand side. Table 4 provides % figures for benefits emerging from the implementation of ITS applications

Table 4: Quantification of ITS benefits per target from existing studies

Benefits	% difference	Source
Safety:		
% of accidents with injuries	15%-18% Reduction	Henk (1997), McKeever (1998)
% of fatal accidents	15%-18% Reduction	Evanco (1996), McKeever (1998)
Regular travel delays	20% Reduction	Inman et al (1996), Glassco (1996), (Meyer (1989)
Delays due to incidents	50% Reduction	
Efficiency:		
Flow/capacity	10% Increase	Van Aerde & Rakha (1996)
Productivity:		
Increased performance	No data available	
Cost reduction	No data available	
Energy and environment:		
Air quality	15% Reduced emissions	Van Aerde & Rakha (1996)
Fuel consumption	6%-13% Reduction compared to normal conditions	City of Los Angeles Department of Transportation
	40 % Reduction compared to cases with incidents	Siemens Automotive
Noise	No data available	Early Deployment (1994)
Users' satisfaction:		
Perceived improvement	86% of users	Henk (1997)
Reduced stress	63% of users	Inman et al (1996)

Source: ITS Benefits: Continuing Successes and Operational Test Results, United States Department of Transportation, Washington, D.C., 1997

When it comes to safety, benefits mainly pertain to reductions of secondary accidents – following the first accidents – and in case of tunnels, reduction to accident frequency and consequences as well. Table 5 includes values of safety indicators in sections with tunnels for different countries.

Table 5: Safety Indicators for road sections with tunnels for different countries

Type of tunnel	Country	All Accidents / millions of vehicles	Fatal Accidents / millions of vehicles	Injury Accidents / millions of vehicles
Long tunnels				
	Norway	0,789	0,213	0,454
	Austria	0,812	0,028	0,040
	Sweden	0,520	-	-
Weighted average		0,800	0,111	0,226
Motorway tunnels				
	Austria	0,734	-	-
	Sweden	0,273	0,021	0,216
	Denmark	1,290	0,098	0,170
Weighted average		0,765	0,063	0,191
Urban tunnels				
	Norway	0,271	0,670	0,120
	Austria	0,666	-	-
	Sweden	0,926	0,069	0,205
	Germany	1,190	0,104	0,300
	Holland	1,296	0,048	0,130
	U.K.	0,301	0,037	0,100
Weighted average		0,642	0,087	0,160

Source: Release and Fire Incidents Rates for the Transport of Dangerous Goods through Road Tunnels and Surface Routes, University of Waterloo for PIARC, 1998

Evaluation methodology for the Veria – Polymylos section of the Egnatia Motorway

The implementation of the Traffic Management System in the Veria-Polymylos section of the Egnatia Motorway offers the following benefits:

- Smoother and safer traffic flow as a result of appropriate information to the drivers about the road and weather conditions through the installed Variable Message Signs (VMS's).
- Avoidance of unexpected incidents due to over-height vehicles that could enter the tunnel sections should no OHV detectors were available.
- Reduction of accidents and their impacts due to the operation of TMS.
- Reduction of delays/vehicle operating costs in case of incidents due to reduction of the number of incidents but also due to the time reduction of the mean duration of incidents

The expected average benefits per benefit category were taken from the international bibliography after proper adjustment to the specific conditions of the Polymylos-Veria section. The current traffic volume level as well as its evolution over time was also taken into account. Table 6 presents the current safety indicators for the Polymylos-Veria section.

Table 6: Safety Indicators for the Egnatia Motorway

Type of tunnel	Overall safety Indicator	Fatal Accident Safety Indicator	Injury Accident Safety Indicator
Long Tunnels - Weighted average	0,800	0,111	0,226
Motorway tunnels - Weighted average	0,765	0,063	0,191
Polymylos – Veria section Adjusted average	0,781	0,085	0,207

Resulting benefits

The expected reduction of road accidents after the implementation of the ITS technology in the specific section of the Egnatia Motorway, based on the previous methodological approach, are presented in Table 7 (Dodos, 2004).

Table 7: Expected reduction of road accidents after the implementation of the ITS

Year	Road accidents refer to all types of vehicles			
	Total	Fatal Accidents	Accidents with injuries only	Rest of accidents
2005	7,469	0,813	1,980	4,677
2006	7,818	0,851	2,072	4,895
2007	8,167	0,889	2,165	5,113
2008	8,516	0,927	2,257	5,332
2009	8,865	0,965	2,350	5,550
2010	9,214	1,003	2,442	5,769
2011	9,650	1,050	2,558	6,042
2012	10,086	1,098	2,673	6,315
2013	10,522	1,145	2,789	6,588
2014	10,958	1,193	2,904	6,861
2015	11,394	1,240	3,020	7,134
2016	11,743	1,278	3,113	7,353
2017	12,092	1,316	3,205	7,571
2018	12,441	1,354	3,297	7,790
2019	12,790	1,392	3,390	8,008
2020	13,139	1,430	3,482	8,227

The economic benefits per accident type are presented in Table 8. These are the figures suggested by the EU directives. Therefore the safety improvements of Table 7 are translated into economic benefits. Table 9 presents these benefits in Present Values (Dodos, 2004).

Table 8: Unit benefits per accident type

Accident type	Cost in Euro
Fatal	1.000.000
Heavy Injuries	125.000
Light Injuries	38.462
Property Damage Only	4.739

Source: Despontin et.al., 1998

Table 9: Net Present Value of the annual benefits due to the road accident reduction

Year	Total (in Euro)				
	Total	Fatal Accidents	Heavy Injuries	Light Injuries	Rest of accidents
2005	934.684	812.894	33.926	65.702	22.162
2006	922.187	802.025	33.472	64.823	21.866
2007	963.344	837.820	34.966	67.716	22.842
2008	975.244	848.169	35.398	68.553	23.124
2009	985.634	857.205	35.775	69.283	23.370
2010	994.591	864.995	36.100	69.913	23.583
2011	1.011.333	879.555	36.708	71.090	23.979
2012	1.026.255	892.533	37.250	72.139	24.333
2013	1.039.450	904.009	37.729	73.066	24.646
2014	1.051.006	914.059	38.148	73.878	24.920
2015	1.061.007	922.757	38.511	74.581	25.157
2016	1.061.647	923.314	38.534	74.627	25.172
2017	1.061.351	923.056	38.524	74.606	25.165
2018	1.060.171	922.030	38.481	74.523	25.137
2019	1.058.159	920.280	38.408	74.381	25.090
2020	1.055.365	917.850	38.306	74.185	25.024
Total	16.261.428	14.142.553	590.237	1.143.067	385.571

Benefits due to minimization of delays

The implementation of the ITS technology will lead to the minimization of delays due to an incident in this motorway section. For every incident it is assumed that there will be a delay of 10 minutes. Table 10 presents these benefits in Present Values (Dodos, 2004).

Table 10: Net Present Value of the annual benefits due to the reduction of "lost" vehicle-hours because of incidents along the specific section (with ITS)

Year	Euro associated to Passenger Cars	Euro associated to HGVs	Total
2005	105.066	192.645	297.711
2006	109.335	203.882	313.217
2007	113.631	215.137	328.768
2008	117.828	226.406	344.234
2009	122.046	237.684	359.730
2010	126.283	248.894	375.177
2011	131.075	257.801	388.877
2012	135.841	266.557	402.398
2013	140.451	275.015	415.466
2014	144.905	283.397	428.302
2015	149.334	291.481	440.816
2016	150.296	304.805	455.102
2017	151.168	317.878	469.046
2018	152.080	330.624	482.704
2019	153.029	343.123	496.152
2020	153.885	355.380	509.265
			6.506.964

Investment and Operations / Maintenance Cost

The investment Cost of the ITS applications in the Polymylos-Veria has been calculated to be approximately 6,0 ml € in 2004 prices. This cost is on top of the standard tunnel equipment (SCADA, fire defectors, water shield systems, etc.), that has to be installed any way and it burdens the tunnel construction cost The corresponding figure for the annual operations and maintenance cost for this extra ITS application is estimated at a percentage of 8% of the investment cost. This latter figure is only an estimate, because there are no real figures so far.

CONCLUSIONS

The evaluation of the implementation of ITS application for the Management of Traffic (TMS) in the Polymylos-Veria section of the Egnatia Motorway in Greece indicates that the expected benefits from safety improvement are not by themselves enough to justify in economic terms this investment. However, by taking into account the time savings that result either from the avoidance of subsequent incidents or by other minor incidents, it turns out that the benefits exceed the investment cost plus the operation/maintenance cost of the ITS applications. This of course is only the economic side of the ITS evaluation. Managing traffic also results to operating savings for the Operator of the infrastructure and the other State Agencies that are involved in the various incidents (Traffic Police, Fire Brigade, Ambulance Services etc.). Finally, it results to improved levels of service and satisfaction to the Motorway users. The value of this improved service can be valuated through Stated Preference Surveys that would provide the Willingness to Pay for such ITS based services. The revisiting of incident related data in the future, after some years of operation will certainly provide valuable information about the evaluation of the ITS applications towards safety and other savings for all involved parties, users, the Operator and the Society as a whole.

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