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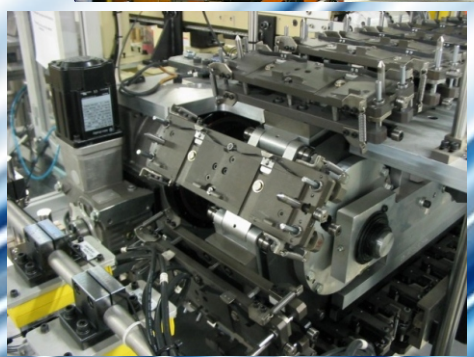



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The study of the possibility to use smartphone in vehicle acceleration measurement

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Abstract: *Modern mobile phones with advanced functionality, known as smartphones, have many applications. A triaxial accelerometer is used to determine the current position of the smartphone in space and therefore the screen orientation. It is known that accelerometers are used to determine important operational properties of vehicles, such as dynamics and acceleration. In this regard, the purpose of this paper is to study the possibility of using a smartphone to measure the vehicle acceleration.*
Keywords*: SMARTPHONE, ACCELEROMETER, VEHICLE DYNAMICS*

1. Introduction

The dynamic performance of the car can be determined in real road conditions or by proving ground tests. For this purpose, equipment is required that ensures sufficient accuracy of the results. The classic way to determine the dynamic properties involves the use of a fifth wheel type measuring device. It is an additional bicycle-type wheel mounted on a special frame on the side or on the rear part of the test car. Its design provides a pulse sensor that detects the speed of rotation of the wheel and thus provides information about the distance traveled. To obtain values for the speed of movement, numerical differentiation of the signal for the traveled distance is applied. The obtained speed values can be subjected again to numerical differentiation and the values of the vehicle acceleration can be obtained. This type of measuring device has a high cost and is not suitable for testing in real road conditions. They increase the dimensions of the car laterally and longitudinally and lead to a reduction in road safety.

An accelerometer can be used instead of a fifth wheel to determine the dynamic properties of the car, for example the acceleration and braking processes. In this case, the values for the most important indicator for these modes – the acceleration of the car – are obtained directly. To obtain the speed values, the acceleration signal must be subjected to numerical integration. The obtained speed values can be integrated once more and the results for the distance travelled can be obtained [1].

Using an accelerometer is a cheaper and safer option for experiments in real road conditions than a fifth wheel. However, in addition to the accelerometer, we also need a mobile computer. If the accelerometer is analog, we also need an analog-to-digital converter (DAQ). In this way the measuring equipment becomes more complicated and expensive.

Modern smartphones have different sensors, one of which is the accelerometer. It is built into the mobile device and its main function is to determine the current position of the smartphone in space and therefore the screen orientation.

Through various applications it can also be used to measure the accelerations of moving objects [2]. The purpose of this publication is to measure the acceleration of an electric car simultaneously with a specialized accelerometer and a smartphone and to compare the results obtained.

2. Measurement Equipment

To determine the acceleration parameters of a compact front wheel drive electric vehicle (shown in Fig. 1) a specialized accelerometer with the necessary equipment and a smartphone with a specialized application simultaneously are used.

Since its output signal is analog, a company's Hottinger Baldwin Messtechnik (HBM GmbH) analog-to-digital converter is used, DQ 401 model. In this way, the signal received from the accelerometer can be visualized and recorded on a mobile computer (Fig. 2).

A smartphone with an application Sensor Kinetics Pro Version 3.1.2 is used. Figure 3 shows a screenshot of the results obtained during the test.



Fig. 1 *The tested compact electric vehicle.*



Fig. 2 *Accelerometer and smartphone used in road experiments.*

Sensor Kinetics Pro is an advanced viewer and monitor for all of the standard sensors available in Android device. The app provides a comprehensive view of the total dynamics of the combined operations of all the sensors. The app demonstrates the use of the Accelerometer, Gyroscope and the Rotation Sensor to control a tilt-based view navigation. It also demonstrates the operation of the Magnetic sensor, the Linear Acceleration sensor and the Gravity sensor within special graphical displays.



Fig. 3 *Screenshot of the Sensor Kinetics Pro application.*

3. Results

The experiment was performed for a standing start of the electric car with full pressure on the accelerator pedal. The results obtained from the accelerometer are saved directly on a mobile computer as Excel files, while those from the smartphone are saved as Microsoft Excel Comma Separated Values File (.csv). Then the results from the smartphone were transferred to a mobile computer and from there were converted into Excel files so that the results could be compared.

The orientation of the smartphone is consistent with the orientation of the accelerometer axes (see Fig.4). The axes are oriented as follows: the z-axis is perpendicular to the plane of the screen and its positive direction is towards the user; the y-axis is pointing away from the camera; the x-axis complements the previous two to the right coordinate system [3].

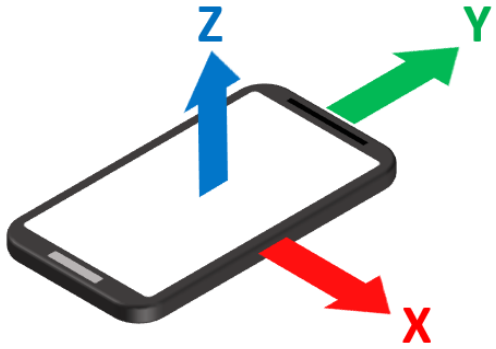

Fig. 4 *Coordinate axes direction of the smartphone [4].*

The results for acceleration against time for straight-line acceleration are shown in Fig. 5.

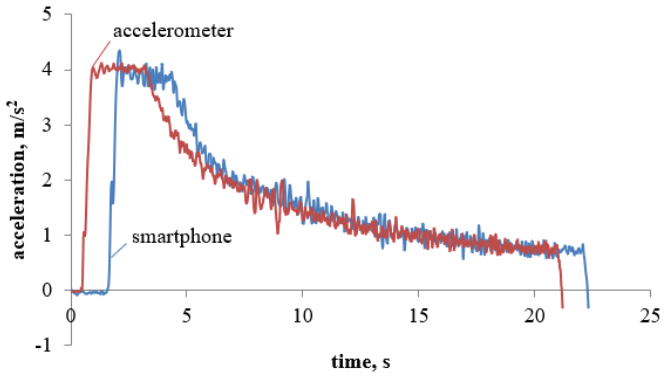

Fig. 5 *Acceleration against time.*

After applying numerical integration, the results for the speed of the electric car are obtained and the speed against time graphs are plotted (shown in Fig. 6).

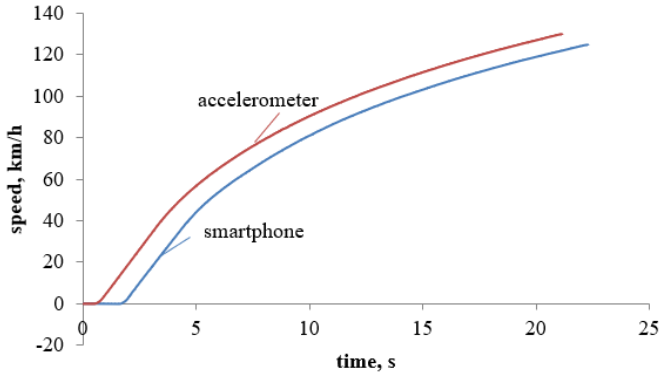

Fig. 6 *Speed against time.*

The graphs are intentionally shifted in time for better readability of results.

The graphs of the acceleration against obtained speed are shown in Fig. 7.

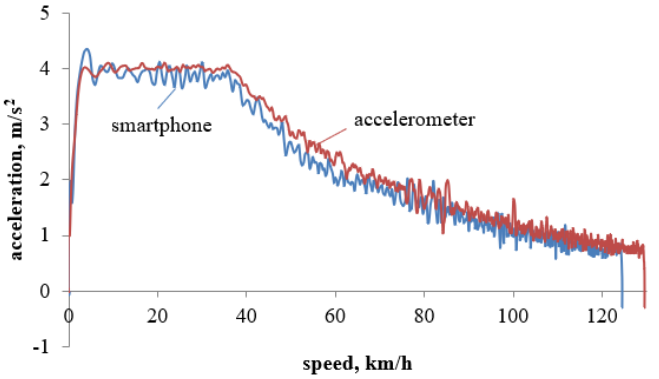

Fig. 7 *Acceleration against speed.*

4. Conclusion

In this paper, we have studied the possibility of using a smartphone in determining the dynamic properties of a car. For this purpose, we studied the process of accelerating a front-wheel drive compact electric car. A smartphone and a specialized accelerometer were installed in the electric car. The results obtained from the two devices are similar and have good comparability. The same maximum values of accelerations are observed. Higher peak values are observed in the smartphone results. After numerical integration of the accelerations, analogous graphs of the velocity against time are obtained. When plotting the acceleration versus speed, similar results are again observed from the two devices. This gives us reason to believe that the accelerometer built into the smartphone has sufficient accuracy and the smartphone can be used to determine the dynamic performances of cars when accelerating or braking. An additional advantage is that it is compact and affordable equipment and for research that does not require high accuracy or do not require the proof of certificates of the relevant equipment are a good alternative.

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Structure of the Model of Hybrid Electric Vehicle Energy Efficiency

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Abstract: *The hybrid electric vehicles (HEV) are promising vehicles with low exhaust emissions and increased autonomy of movement including internal combustion engine (ICE) and electric motor (EM) which is powered by the battery (B). The main advantage of HEV over classic cars is the reduced fuel consumption, especially in urban traffic [1]. This is a prerequisite for good energy efficiency of HEV, which is determined by the fuel consumption and consumption, respectively the regeneration of electricity of HEV. These values depend on many factors such as speed, mileage, acceleration, mass, drag, climatic conditions and more. The modelling of the energy efficiency of HEV is related to the study and structuring of the factors that determine the fuel consumption and electricity consumption and the dependencies between them and their connection and construction in a model. The model of energy efficiency of HEV gives a quantitative assessment of the fuel consumption and the consumption (regeneration) of electricity of HEV, according to the main influencing parameters. In addition, the HEV energy efficiency model indicates the influencing parameters and their analytical or experimental determination. The correct modelling of energy efficiency is related to the correct determination of energy parameters and their logical connection in a selected model. The optimal model of energy efficiency of HEV is built from these factors that can be directly measured or calculated, which increases the accuracy and reliability of the results. This article discusses building an energy efficiency model of a hybrid electric vehicle.*
Keywords*: HYBRID, VEHICLE, MODEL, EFFICIENCY*

1. Introduction

Modeling is the study of the studied objects with the construction of models - approximations, reflecting certain aspects of the objects [1].

Analytical modeling, also called mathematical modeling [2,3] is the process of building a model using a priori knowledge of the object of study, available before conducting an experiment with the object. Analytical modeling has the advantage that it is based on the specific patterns in the studied processes [4]. The models obtained in this way are usually too complex. On the other hand, it is not always possible to analytically specify the class, the appropriate structure of the model, the significant factors influencing its outcome, etc.

Therefore, the experimental modeling is applied, which is based on the processing of input-output data for the studied system or object.

In modeling the HEV energy efficiency (HEVEE), it is appropriate to combine theoretical dependencies with experimental research to achieve reliable results [5].

2. Factors

According to the accepted approach and the a priori information, the structure of the HEVEE model is chosen, presented in Fig.2.1.

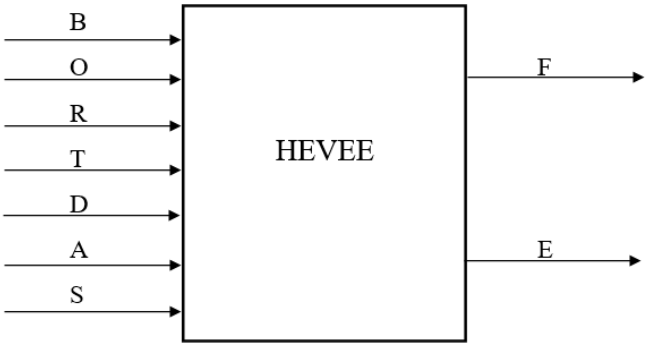

Fig.1. *Structure of the HEVEE model*

The structure of the HEVEE model consists of input factors and output indicators which designations is as follows:

- B – basic factors;
- O – operational factors;
- R – road factors;
- T – traffic factors;
- D – driver select factors;
- A – ambient factors;
- S – subjective factors;
- F – fuel indicators;
- E – electrical indicators.

The input factors influencing the studied object are represented by the vectors of: basic factors, operational factors, road factors, traffic factors, driver selected factors, ambient factors, and subjective factors. The input factors are described in detail in table 1.

Table 1. *Structure of the input factors of the HEVEE model*

№	Factors	Parameters	Designation	Dimension
1	Base factors	1.ICE volume	V_{ICE}	m^3
		2.ICE power	P_{ICE}	W
		3.ICE torque	M_{ICE}	Nm
		4.EM power	P_{EM}	W
		5.EM torque	M_{EM}	Nm
		6.Battery capacity	C_B	Ah
		7.HEV kerb mass	m_0	kg
		8.Gear box ratios	$i_{1...n}$	
		9.Final drive ratio	i_0	
		10.Tyre sizes:		
		Rim diameter	D	m
		Tyre width	B	m
		Tyre height	H	m
		11.HEV dimensions:		
		Length	L_{HEV}	m
		Width	B_{HEV}	m
		Height	H_{HEV}	m
		12.Gravity center height	h_g	m
2	Operational factors	1.ICE speed	n_{ICE}	min^{-1}
		2.EM speed	n_{EM}	min^{-1}
		3.ICE load	L_{ICE}	%
		4.EM load	L_{EM}	%
		5.HEV load	m_L	kg
		6.HEV maximum design total mass	m_{HEV}	kg
		7.Battery state of charge	SOC	%
		8.ICE coolant temperature	T_{cool}	^{0}C
		9.Tyre inflate pressure	P_{infl}	bar
3	Road factors	1.Tractive effort coefficient	φ	
		2.Rolling resistance coefficient	f	
		3.Road inclination	i	%
		4.Road turn radius	R	m
4	Traffic factors	1.Driving distance	L	m
		2.Driving speed	v_d	m/s
		3.Average speed	v_A	m/s
		4.Driving time	t_d	s
		5.Stay time	t_s	s
		6.Total time	t_t	s
		7.Day time interval		

5	Driver selected factors	1.Manual or automatic gear shifting		
		2.Economic, sport or standard driving mode		
		3.Switching the consumers		
6	Ambient factors	1.Ambient temperature	T_a	^{0}C
		2.Weather conditions		
		3.Variable and occasional events		
7	Subjective factors	1.Driving habbits		
		2.Driver psychological and physiological condition		
		3.Driving aim		

The output indicators of the studied object are presented by the vectors of the fuel indicators and the electrical indicators (table 2).

Table 2. *Structure of the output indicators of the HEVEE model*

№	Indicators	Parameters	Designation	Dimension
1	Fuel indicators	1.Fuel consumed	Q_f	l
		2. Time rate of fuel consumption	G_h	kg/s
		3.Road fuel consumption	G_L	l/m
2	Electrical indicators	1.Battery voltage at idle	E_B	V
		2.Battery voltage under load	U_B	V
		3.Discharging current	I_{disch}	A
		4.Recharging current	I_{rech}	A
		5.Regenerating current	I_{regen}	A
		6.Discharging time	t_{disch}	s
		7.Recharging time	t_{rech}	s
		8.Regenerating time	t_{regen}	s
		9.Electricity consumed	Q_{disch}	Ws
		10.Electricity regenerated	Q_{regen}	Ws
		11.Electricity recharged	Q_{rech}	Ws

3. Parameters

According to the fore mentioned structure of the HEVEE model and the analysis of the input factors and the output indicators and the related parameters, a parametric model of HEVEE is presented, shown in fig.3.

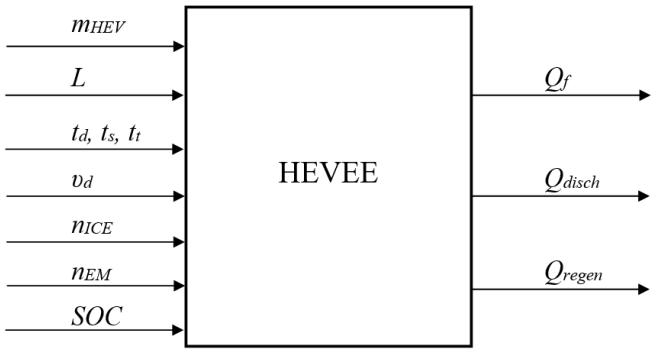

Fig.2. *Parametric model of HEVEE*

The input HEVEE parameters are variable parameters which can be measured or calculated [5]. The output parameters depend on the input parameters and determine from them by the mathematical equations. Therefore, the mathematical description of the output parameters represents the whole HEVEE model.

4. Mathematical description of the HEVEE

The mathematical description of the HEVEE model is connected to the mathematical equations, by which the input and output parameters are determined.

4.1.Determining the input parameters

The HEV maximum design total mass m_{HEV} is determined by:

$$(1) \quad m_{HEV} = m_0 + m_L = m_0 + (m_P + m_{PL})n \text{, kg.}$$

Where m_P is the passenger mass, kg; m_{PL} is the passenger luggage mass, kg; n is the passenger's number.

The HEV driving distance L is a basic parameter on which its energy efficiency depends. There are various methods and methods for determining the L, which are used according to the goal. In the present study, it is assumed that the mileage is determined by three methods:

1) Cartographic method

In this method, the driving distance L is assumed to be equal to the mileage L_m determined on the terrain map.

$$(2) \quad L = \sum_{k=1}^{m} L_k \text{, m.}$$

Where m is the number of distances.

2) Indicator method

In this method, the driving distance L is assumed to be equal to the mileage L_{IND} determined by the HEV indicator instruments:

$$(3) \quad L = \sum_{k=1}^{m} L_{IND,k} \text{, m.}$$

The indicator devices measuring the HEV driving distance can be 1) Mileage indicator; 2) On-board computer; 3) Diagnostic interface.

3) Navigation method

In this method, the driving distance is assumed to be equal to the mileage L_{GPS} determined using a meter (on-board or special) via the global GPS positioning system:

$$(4) \quad L = \sum_{k=1}^{m} L_{GPS,k} \text{, m.}$$

Driving distance L is assumed to be equal to the arithmetic mean of the results obtained by the three methods.

The driving time t_d is the time during which the HEV is in motion. The stay time t_s is the time during which the HEV does not move, but stays in place due to waiting at intersections, crossings and other reasons related to the organization of traffic. The stay time t_s does not include the time spent in parking lots and garages. The total run time t_t is the sum of the driving time t_d and the stay time t_s. In the present study, it is assumed that the determination of the above times should be performed by indicator (3) and navigation (4) methods.

The driving speed υ_d is determined by:

$$(5) \quad \upsilon_d = \frac{L}{t_d} \text{, m/s.}$$

The ICE speed n_{ICE} can be determined by the expression [6]:

$$(6) \quad n_{ICE} = \frac{30\upsilon_d i_n i_o}{\pi C_{sr}\left(\frac{D}{2} + B\frac{H}{B}\frac{1}{100}\right)} \text{, min}^{-1}.$$

Where C_{sr} is the converter speed ratio which is take from HEV converter specifications. In case of manual gear box, the $C_{sr} = 1$.

The EM speed n_{EM} can be determined by [6,7]:

$$(7) \quad n_{EM} = \frac{30\upsilon_d i_{t,m}}{\pi\left(\frac{D}{2} + B\frac{H}{B}\frac{1}{100}\right)} \text{, min}^{-1}.$$

Where $i_{t,m}$ is transmission ratio from the EM the driving wheels.

The battery SOC instantaneous capacity of the battery [6,8]. The battery SOC can be represented as a percentage of the full state-of-charge SOC_{max}:

$$(8)\quad SOC = \frac{SOC_{\max} - \int_0^{t_{disch}} I_{disch}(t)dt}{SOC_{\max}}.100\ ,\ \%.$$

4.2.Determining the output parameters

The fuel consumed Q_f is calculated according [5]:

$$(9)\quad Q_f = \frac{g_e \upsilon_d t_d}{\rho_f \eta_t}\left[0{,}01\left(1+\frac{\upsilon_d}{160}\right)m_{HEV} g\cos\alpha + \frac{1}{2}\rho_a C_d A \upsilon_d^2 \pm g m_{HEV}\sin\alpha + m_{HEV}\left(1+\delta_1+\delta_2 i_n^2 i_0^2\right)\frac{d\upsilon_d}{dt}\right],\ \text{l}.$$

Where ρ_f is the fuel density, kg/m^3.

The value of the brake specific fuel consumption g_e comes from the HEV internal combustion engine fuel economy characteristic and corresponds to the required power P_{ICE} from the ICE plotted against the ICE speed n_{ICE}. The P_{ICE} is equal at the expression in brakes in the (9):

$$(10)\quad P_{ICE} = 0{,}01\left(1+\frac{\upsilon_d}{160}\right)m_{HEV} g\cos\alpha + \frac{1}{2}\rho_a C_d A \upsilon_d^2 \pm g m_{HEV}\sin\alpha + m_{HEV}\left(1+\delta_1+\delta_2 i_n^2 i_0^2\right)\frac{d\upsilon_d}{dt},\ \text{W}$$

The electricity consumed Q_{disch} is determined by [5]:

$$(11)\quad Q_{disch} = \frac{\upsilon_d}{\eta_t}\left[0{,}01\left(1+\frac{\upsilon_d}{160}\right)m_{HEV} g\cos\alpha \pm g m_{HEV}\sin\alpha + \frac{1}{2}\rho_a C_d A \upsilon_d^2 + m_{HEV}\left(1+\delta_1+\delta_2 i_n^2 i_0^2\right)\frac{d\upsilon_d}{dt}\right]t_{disch} + Q_{add},\ \text{Ws}.$$

Where Q_{add} is the electricity consumed from the additional HEV consumers (heating, ventilation, air-conditioning, servo-steering etc.), Ws.

As HEV batteries is a DC sources so for the determination of the Q_{disch} can be used also the formulae for the direct current power through the combination of the Ohm law and Jaul-Lenz law [9,10]:

$$(12)\quad Q_{disch} = U_B I_{disch} t_{disch}$$

When (12) is substituted in (11) is obtained:

$$(13)\quad U_B I_{disch} t_{disch} = \frac{\upsilon_d}{\eta_t}\left[0{,}01\left(1+\frac{\upsilon_d}{160}\right)m_{HEV} g\cos\alpha \pm g m_{HEV}\sin\alpha + \frac{1}{2}\rho_a C_d A \upsilon_d^2 + m_{HEV}\left(1+\delta_1+\delta_2 i_n^2 i_0^2\right)\frac{d\upsilon_d}{dt}\right] + Q_{ad}$$

The equation (13) gives the calculation of the discharging current I_{disch} in dependence of the voltage under load U_B for certain time t_{disch}, and then by (12) the HEV electricity consumed Q_{disch} can be obtain.

After the calculation, the value of the Q_{disch} can be transformed to kWh.

The HEV electricity regenerated Q_{regen} is determined by the Jaul-Lenz law [9,10]:

$$(14)\quad Q_{disch} = P_{regen} t_{regen}$$

Where P_{regen} is the power regenerated, W.

The HEV regeneration of the electricity is realized during its inertia movement or during its regenerative braking. The regeneration of the electricity is performed by the grade resistance at descending and inertia resistance at coasting. In this case the equation (11) is changed:

$$(15)\ Q_{regen} = \frac{\upsilon_d}{\eta_t}\left[0{,}01\left(1+\frac{\upsilon_d}{160}\right)m_{HEV} g\cos\alpha + \frac{1}{2}\rho_a C_d A \upsilon_d^2 - g m_{HEV}\sin\alpha - m_{HEV}\left(1+\delta_1+\delta_2 i_n^2 i_0^2\right)\frac{d\upsilon_d}{dt}\right]t_{regen},\ \text{Ws}$$

The regeneration is useful only when the state of charge of the HEV battery SOC_0 is lower than SOC_{max}, i.e., there is regeneration current I_{regen} [11] flow which is equal to the recharging current I_{rech}. This is explained at the next dependance:

$$(16)\quad SOC_{\max} \geq SOC_0 + \int_0^{t_{regen}} I_{regen}(t)dt$$

Therefore, is made the limitation of the regenerative current I_{regen}:

$$(17)\quad \int_0^{t_{regen}} I_{regen}(t)dt \leq SOC_{\max} - SOC_0$$

When (17) is not fulfilled, i.e., at higher I_{regen} there are undesirable overcharging processes in the battery which decrease its time life.

According to above mentioned, the HEV electricity regenerated Q_{regen} can be determine by the combination of the Ohm law and Jaul-Lenz law [9,10]:

$$(18)\quad Q_{regen} = E_B I_{regen} t_{regen}$$

Hence the regenerative current I_{regen} can be obtained:

$$(19)\quad I_{regen} = \frac{Q_{regen}}{E_B t_{regen}}$$

The obtained value of the I_{regen} from the (19) is verifying by the (17), hence the permissible regenerative time t_{regen} is obtained:

$$(20)\quad \int_0^{t_{regen}} \left[\frac{\upsilon_d}{E_B t_{regen}\eta_t}\left[0{,}01\left(1+\frac{\upsilon_d}{160}\right)m_{HEV} g\cos\alpha + \frac{1}{2}\rho_a C_d A \upsilon_d^2 - g m_{HEV}\sin\alpha - m_{HEV}\left(1+\delta_1+\delta_2 i_n^2 i_0^2\right)\frac{d\upsilon_d}{dt}\right](t_{regen})dt \leq SOC_{\max} - SOC_0$$

After the calculation, the value of the Q_{regen} can be transformed to kWh.

The obtained data from the mathematical calculations must be evaluated according to the corresponding criteria. Such evaluating criteria is proposed in [7].

5. Conclusion

The structure of the hybrid electric vehicle energy efficiency is established, which is consists of input factors and output indicators.

The mathematical description of the parameters of the input factors and output indicators is made and include twenty basic mathematical equations.

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Influence of the different brands of braking pads in performance of vehicle braking system

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Abstract: *In the Republic of Kosovo, the unemployment rate has an increasing trend, the average monthly income is still low, which makes it impossible to buy a new vehicle, so they are forced to buy vehicles imported from European countries, which have a high rate of amortization.*

Citizens who own used vehicles are obliged to perform services that cost less by avoiding quality equipment and replacing them with non-know manufactures for spare parts which cost cheaper compared to manufacturers of well-known and guaranteed brands. The use of such spare parts is directly affecting the increase in the number of accidents in the territory of the Republic of Kosovo.

In this paper is study the efficiency of brake pads from different manufacturers – brands in the term of the braking system in passenger vehicles such as: braking time, maximum deceleration and braking distance. The tests were done with used vehicles equipped with the ABS system, on roads with dry asphalt. The used tires are from radial construction with summer characteristics. Depending on the treated methodology, the adequate equipment such as Xl meter, video cameras and meter are used. The obtained results through the decelerometer device (Xl meter) for deceleration of the vehicle and other indicators of the efficiency of the braking system has done with the case of emergency braking. Prior to each test, the predicted used vehicle has performed also technical inspection of the vehicle braking system in the Licensed Centers for technical inspection of the vehicle.

Keywords: DISK BRAKE, BRAKE PADS, ROAD, TIRES, FRICTION, DECELERATION, BRAKING DISTANCE, VEHICLES.

1. Introduction

Most of the vehicles circulating in the territory of the Republic of Kosovo are used and imported from various European countries. Statistics that are public on the official website of the Police of the Republic of Kosovo show that the number of accidents with material damage and fatalities is increasing from year to year.

The vehicle's braking system is one of the main elements of active vehicle safety. Citizens lack awareness of the role of the braking system and the consequences in the event of its failure. The actuating elements of the brake system, such as brake discs and brake pads have a certain service life and should be replaced with new ones.

In the Republic of Kosovo, the unemployment rate has a growing trend, the average monthly income is still low, drivers provide the necessary services in unauthorized workshops and at the same time supply parts - equipment of dubious origin and unverified or certified that do not provide information on their composition and effectiveness.

If even regular services are applied, they are made in cheaper forms, and then cheap parts-equipment are applied. These devices can also be used, dismantled by a wrecked vehicle or waste, or they can be a new second or third class, but from manufacturers who are cheaper and more present in the market.

There are different types of brake pads, the friction layer is treated with a combination of different materials that are bonded to the metal plate. Usually, three main categories of materials are used for the friction layer: semi-metallic, organic and ceramic. Each material has its advantages and disadvantages with respect to the driver rating.

Different materials are combined for maximum possible vehicle braking efficiency. Brake pads and disks can be found in car shops, garages and other places that can be ordered online.

The aim of the research is the influence of different brand of brake pads such us SCT, BREMBO, COMELINE, TEXTAR and brake disc from brands FEBI on the performance of the brake system.

2. Motion Equations that Describe Vehicle Braking Process

Depending on how braking force is transmitted to tires, the vehicle braking system may be:

- Mechanic,
- Hydraulic, and
- Pneumatic.

The hydraulic and the pneumatic systems are the most used ones. In these systems, the pressure is proportional to the force of the brake pedal. The moment of braking is proportional to the pressure of the braking system, which mathematically can be expressed as follows [1-4]:

$$M_b = K_p \cdot p_b \tag{1}$$

The proportional coefficient K_b is a function of a large number of factors. However, the value of this coefficient can be considered constant in passenger cars.

The moment of braking by the force Fb which acts on the contact surface of the tire with the road, is:

$$F_b = \frac{M_b}{r_d} \tag{2}$$

The braking force F_b can be increased up to the value of the tangential reaction of the path, i.e., until it does not reach its maximum value for given conditions; the value of the force of adhesion is:

$$F_{bmax} = \varphi_x \cdot G \tag{3}$$

When moving on dry paved or concrete roads, modern passenger cars' braking systems can realize moments (braking forces) that are significantly greater than the frictional force. As a result, the wheels are often stuck and slip on the road during rapid braking. Fig. 1 shows the most important forces that act on the vehicle during vehicle braking.

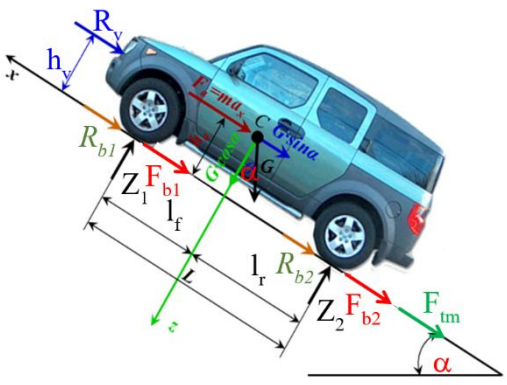

Fig. 1. Forces that act on vehicles

The horizontal components in relation to the road plane are [1-2, 5]:

$$F_{b1} + F_{b2} + R_{b1} + R_{b2} + R_{\alpha} + R_v + F_{tm} + F_{xx} - R_a = 0 \quad (4)$$

$$F_b + R_{\psi} + F_{tm} + F_{xx} + R_v - R_a = 0 \quad (5)$$

If engine is disconnected, braking is carried out only by the braking system, thus allowing the cancellation of the traction force on the wheels or $F_{tm} = 0$. Since the drag resistance effect is minimal when the speed of motion braking process is reduced, the drag resistance's overall impact can be discounted, resulting in $R_v = 0$. The magnitude of the friction force of F_{xx} transmitters compared to the overall braking force is also quite small or negligible allowing for
$F_{xx} = 0$ [1-5]. After considering the assumptions made above, equation (5) can be written as:

$$F_b + R_{\psi} - R_a = 0 \quad (6)$$

$$\varphi_x \cdot G + \psi \cdot G - \delta \cdot G \cdot \frac{a}{g} = 0 \quad (7)$$

From equation (7), the maximum deceleration can be calculated, which is:

$$a_{max} = \frac{g}{\delta} \cdot (\varphi_x + f) \quad (8)$$

It is considered that: $\delta = 1$ and $g = 9.81$ [m/s^2] which is significantly greater than the roll friction coefficient. Therefore, it can be concluded that the highest or maximum value of deceleration that can be realized with all-wheel braking would be:

$$a_{max} = 9.81 \cdot \varphi_x \quad (9)$$

3. Methodology of Measurement of the Braking performances with the "XL METER"

The place where the tests were performed is located in the outskirts of the city of Pristina, ie in the village of Shkabaj, the road leading to the facility where the fairs are held. At this point the road is at a sufficient distance to perform tests. The part of the road used for the tests has a length of 500 meters (Fig. 2), a width of 7 meters and a longitudinal slope <1%. The condition of the road is new asphalt.



Fig. 2. Orthophoto of the location and space where the tests were performed

XL Meter ™ Gamma Pro is designed to measure acceleration/deceleration in two axes (longitudinal and transverse). The main purpose of the XL Meter device is to make the evaluation of the braking system performance as easy and accurate as possible. The rules for measuring braking efficiency are described in ECE regulation R13. According to this regulation, "The efficiency of the braking system is determined by the braking distance or the average deceleration during braking".

Then, the braking distance (S_f) is calculated from the double integration of the acceleration data in the braking interval. The Successful evaluation gives the following results:

- distance in the time of braking T_{br} (S_f [m]),
- initial vehicle speed at the time of braking (V_0 [km/h]),
- time from the start till the end of braking (T_{br} [s]), and
- averaged maximal vehicle deceleration (MFDD [m/s^2]).

The deceleration (MFDD = a_2) is calculated as the average deceleration of the vehicle motion distance in the range from speed V_b to speed V_e according to the following formula:

$$MFDD = \frac{V_b^2 - V_e^2}{25.92 \cdot (S_e - S_b)} \quad (12)$$

According to ECE R13 regulation, the vehicle's deceleration accuracy with XL Meter during braking should be within the range ± 3%. For the testing of any vehicle, the braking performance should be measured during vehicle braking under the conditions specified in ECE Regulation R13 [12].

In Figure 3 are presented equipment for measuring vehicle braking performance: a) process of controlling the quality of the brake fluid before performing the vehicle braking tests; b) tire tread depth gauge; c) XL meter device fixed in front vehicle windshield; d) smartphone camera for recording vehicle speed in vehicle odometer fixed to the steering wheel; e) brake pedal force gauge – dynamometer; f) tyre pressure gauge – manometer; g) strip meter; h) Golf IV dashboard; i) measurement of the braking distance by strip meter.

Braking distance is the distance from the point of braking up to the front end of the front-wheel tires.

a) b)



c)





d)

e)



f)



g)

h)



i)

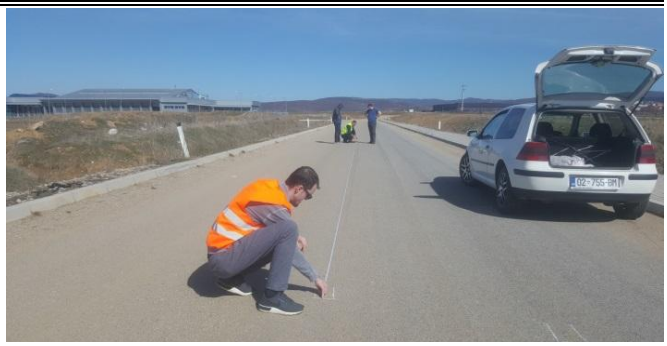

Fig. 3. Equipment for measuring vehicle braking performance [3]

4. Measuring results from test drive

Type of the vehicle used to test braking performance [3] has been Golf IV, 1998 model year, breaking system with ABS, and test drives have been performed in the testing polygon (Fig. 2). The evaluation of the braking performance has been carried out with an XL Meter device.

New brake discs of the Febi brand are installed in the car, which have not been replaced, while brake pads have been replaced with new ones, after each test (Fig. 4). The following brands are used for this work: SCT, BREMBO, COMELINE, TEXTAR [3].

The tire brand is FULDA, with size 205/55 R16 for summer season. The asphalt is dry and new.



Fig. 4. Installation of new brake discs Febi brand and new brake pads at the Golf IV

4.1. Test drive with new brake pads brand SCT

In Fig. 5 are presented the new brake discs brand FEBI and brake pads brand SCT: a) braking discs for front axles brand FEBI; b) braking discs for rear axles brand FEBI; c) front axle brake pads brand SCT and d) rear axle brake pads brand SCT.



Fig. 5. New brake discs brand FEBI and brake pads brand SCT

During the test drives, the following parameters have been maintained: air temperature 26 °C and dry asphalt. Tires characteristics have been as follows: tire brand Fulda for summer season, size 205/55 R16. Vehicle with brake disks FEBI brand and brake pads brand SCT.

The results of the test as illustrated in Figure 6 indicate that:

- initial vehicle speed at the time of braking: V_0 = 78.4 [km/h],
- time from the start till the end of braking: T_{br} = 2.52 [s],
- distance in the time of braking: S_f = 29.1 [m] and
- averaged maximal vehicle deceleration: MFDD = 8.78 [m/s^2].

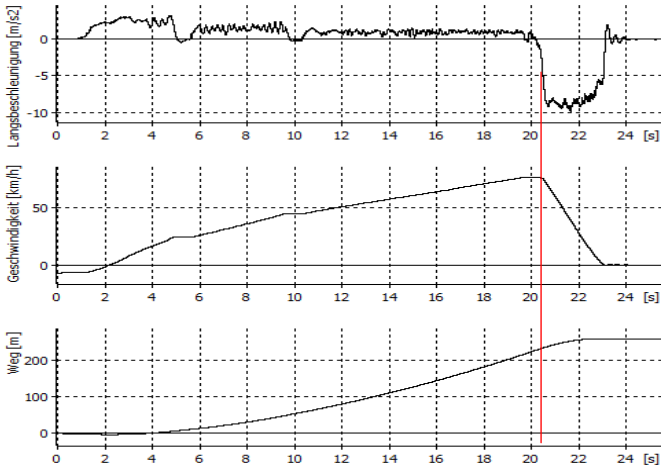

Fig. 6. Diagrams of measured braking performance performed with XL Meter for the "Golf IV" with brake pads brand SCT at initial vehicle speed at the time of braking V_0 = 78.4 [km/h]

4.2. Test drive with new brake pads brand BREMBO

During this test drives, is used new brand of brake pads BREMBO (Fig. 7) and the following parameters have been maintained: air temperature 28 °C, dry asphalt. Tires characteristics have been as follows: tire brand Fulda for summer season, size 205/55 R16. Vehicle Golf IV with new break disks FEBI brand and brake pads brand BREMBO.



Fig. 7. Installation of new brake pads brand BREMBO in the Golf IV

The results of the test as illustrated in Figure 8 indicate that:

- initial vehicle speed at the time of braking: V_0 = 81 [km/h],
- time from the start till the end of braking: T_{br} = 2.93 [s],
- distance in the time of braking: S_f = 31.82 [m] and
- averaged maximal vehicle deceleration: MFDD = 8.35 [m/s^2].

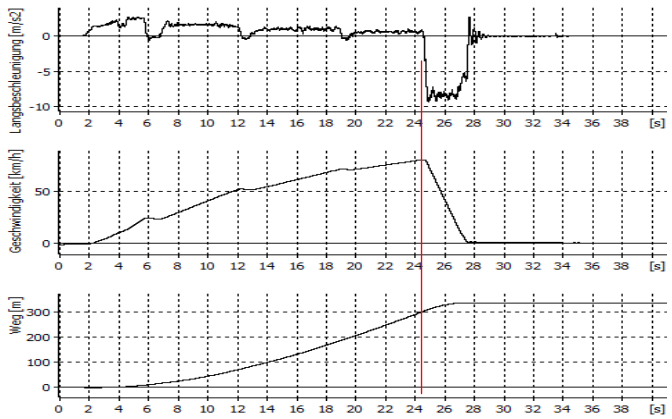

Fig. 8. Diagrams of measured braking performances performed with XL Meter for the "Golf IV" with brake pads brand BREMBO at initial vehicle speed at the time of braking V_0 = 81 [km/h]

4.3. Test drive with new brake pads brand COMELINE

During this test drives, is used new brand of brake pads BREMBO (Fig. 9) and the following parameters have been maintained: air temperature 28 °C, dry asphalt. Tires characteristics have been as follows: tire brand Fulda for summer season, size 205/55 R16. Vehicle Golf IV with break disks FEBI brand and new brake pads brand COMELINE.



Fig. 9. Installation of new brake pads brand COMELINE in the Golf IV

The results of the test as illustrated in Figure 10 indicate that the:

- initial vehicle speed at the time of braking: V_0 = 82 [km/h],
- time from the start till the end of braking: T_{br} = 3 [s],
- distance in the time of braking: S_f = 29.8 [m] and
- averaged maximal vehicle deceleration: MFDD = 8.67 [m/s^2].

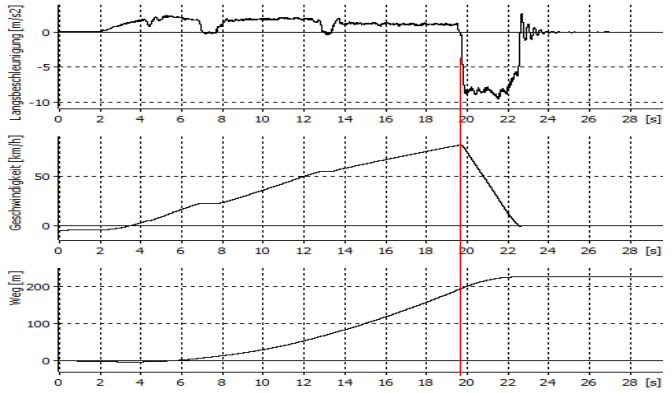

Fig. 10. Measured diagrams of braking performances performed with XL Meter in the "Golf IV" with brake pads brand COMELINE *at initial vehicle speed at the time of braking V_0=82 [km/h]*

4.4. Test drive with new brake pads brand TEXTAR

During this test drives, is used new brand of brake pads TEXTAR (Fig. 11) and the following parameters have been maintained: air temperature 27 °C, dry asphalt. Tires characteristics have been as follows: tire brand Fulda for summer season, size 205/55 R16. Vehicle Golf IV with break disks FEBI brand and new brake pads brand TEXTAR.



Fig. 11. Installation of new brake pads brand TEXTAR it the Golf IV

The results of the test as illustrated in Figure 12 indicate that the:

- initial vehicle speed at the time of braking: V_0 = 81 [km/h],
- time from the start till the end of braking: T_{br} = 3 [s],
- distance in the time of braking: S_f = 32.71 [m] and
- averaged maximal vehicle deceleration: MFDD = 8.40 [m/s^2].

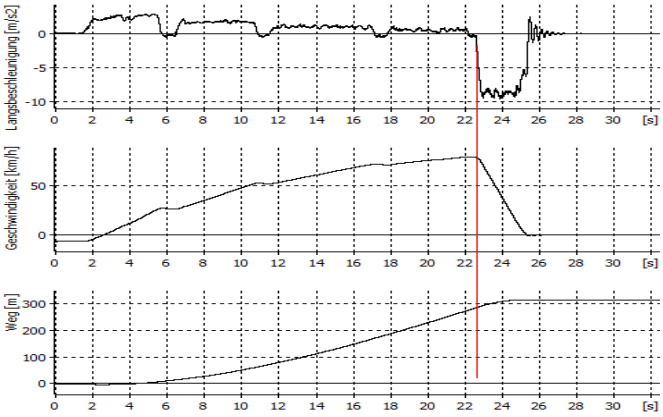

Fig. 12. Diagrams of measured braking performances performed with XL Meter for the "Golf IV" with brake pads brand TEXTAR at initial vehicle speed at the time of braking V_0 = 81 [km/h]

5. Result discussion

The used brake pads for this research have been new. After their installation, the vehicle covered about 200 km and then continued with testing. The presented tests were done at a speed of about 80 [km/h]. Prior to each test, the predicted used car Golf IV has performed also technical inspection of the vehicle braking system in the Licensed Centers for technical inspection of the vehicle. After the tests made for each brake pads brand, these results were obtained.

SCT brand brake pads have a large contact surface with the surface of the braking disc with a vertical channel for dust removal. During braking the averaged maximal vehicle deceleration is MFDD = 8.78 [m/s^2] and the braking forces of the left and right wheel on the same axle have a small difference (front axle 2% and rear axle 6%). Weakness which is presented during the testing is the creation of noise during the braking process. These tiles are characterized by low consumption.

Brembo brand brake pads has a smaller contact area with the disc surface compared to SCT brake pads. During the braking process does not create noise, the results of braking forces the left and right wheel on the same axle have a small difference (front axle 5% and rear axle 4%). Also during the braking process the average maximum deceleration is achieved: MFDD = 8.35 [m/s^2].

Comline brand brake pads which in their structure contain metal elements that negatively affect the consumption of the brake

disc and a large increase in temperature during the application of frequent braking on long slopes. Their weakness are that it makes noise, heats up quickly and the large difference in braking forces left and right wheels of the same axle (front axle 20% and rear axle2%). During the braking process, the average maximum deceleration of the vehicle is MFDD = 8.54 [m/s^2].

Textar brand brake pads offer good grip with the brake disc. They have good properties during the braking process because not create noise, do not heat up during the application of long braking and the braking forces of the left and right wheel on the same axle have a small difference (front axle 1% and rear axle 4%). During the braking process, the average maximum deceleration of the vehicle is MFDD = 8.40 [m/s^2].

6. Conclusions

Obtained results from this research are important for traffic safety. From the braking system is required a large value of maximum average deceleration and a small difference of braking forces on the right and left wheel of the same axle.

SCT and **COMELINE** brand brake pads have a low price on the market of Republic of Kosova, but they make high level of noise during braking process. Therefore, when choosing brake pads, drivers should pay attention to **BREMBO** and **TEXTAR** brands, which have higher prices on the market of Republic of Kosova but provides better performances.

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The future of the auto world in the COVID era

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Abstract: *The eco car of the year 2020 was the "Corolla HB" 1.8 HSD. The French made the original car, after the new "Peugeot 208", the base is the same as in the model "2008", which is 25 cm longer, the wheelbase is 2.6 meters and it is dominated by power. Its maximum speed is 198 kilometers/h. No one can compare to the French "lion". "Mercedes" announced that Formula 1 drivers will drive completely black cars instead of the "silver arrow" in the upcoming season, thus promising the fight against racism and increasing diversity in their champion team.*

The auditing company "Deloitte" claims that the automobile industry in the world is about to collapse due to the consequences of the Corona virus pandemic. The Covid-19 pandemic is not subsiding, now Mexico and the Brazil are the most endangered. During the epidemic in Serbia in April this year, the production of motor vehicles and trailers decreased by 84%, and in Kragujevac based "Fiat" was faced not only with a lack of demand, but also with a lack of parts for production. During the state of emergency, truckers were particularly endangered and suffered heavy losses. Losses in the passenger domestic and international bus traffic were then estimated at 28 million euros.

Despite the pandemic that reigns, "Renault" has confirmed its leading position on the European electric car market. The "Renault Zoe" is the best-selling vehicle in its class. "Renault Kangu ZE" achieved the highest sales in the class of electric commercial vehicles. And the offer of electric vehicles for the new 2021 will be enriched by "Renault Twingo Electric" and "Dacia Spring".

At the end of 2020, the two automotive groups received the consent to merge. "Fiat" and "Peugeot" have joined forces to neutralize the negative effects of the slowdown in demand and more easily bear the costs of producing cleaner vehicles, in order to meet the requirements of the stricter gas emission regulations. The emergence of "Stellantis" will contribute to the expansion of the market.

Introduction

"Hello, world. My first look at my forever home" (NASA's Perseverance Mars Rover).

The first car magazine was published in the United States in 1895 under the title "The Horseless Age", which clearly showed that the old mode of transportation was outdated.

It is interesting that on February 19, 2021, the NASA Rover successfully landed on Mars. After 7 months of travel and 270 million kilometers, the largest and strongest rover of the American space agency "Persevirens" /perseverance/ landed on Mars. The landing happened at 9.55 pm and photos soon arrived. This is the most technologically sophisticated mission on Mars. And the predecessor of this rover landed in 2012, was the rover "Curiosity", which remained in operation.

In April, NASA announced that NASA's Rover ("persistence") has transformed carbon dioxide from Mars' atmosphere into oxygen, what was the first transformation done on another planet. This was a crucial first step towards converting carbon dioxide into oxygen on Mars and will help astronauts who go on a mission to Mars, not to carry large amounts of oxygen with them, in order to be able to return to Earth.

News from the Automotive Industry in the World and Serbia

Since the factory in Kragujevac, Serbia, is one of the most modern in the "Fiat Chrysler Automobiles" (FCA) group, in which most of the production has been digitized, it is expected that the joint company will find a new car model faster. Together, the FCA and PSA groups will have a projected production of 8.7 million vehicles per year and will become the fourth largest car manufacturer in the world, behind "Volkswagen", "Toyota" and "Renault - Nissan - Micubishi.", but in front of the companies "General motors" and "Ford".

It is interesting that in October 2020 in Italy the production of the new electric model "Fiat new 500" has already started. "Fiat" has refreshed its best-selling models, e.g. "Fiat typo cross" and "Fiat typo city sport".

The Korean manufacture "Hyundai" will go to public with the official technical data of the sports model "Kona N".

According to the research, Chinese consumers are more willing to accept alternative drive assemblies than European or American customers. Otherwise, the electric car market has experienced rapid growth and evolution. "Tesla" is the most famous company that produces electric cars, and one of the new companies is the Chinese "NIO" company of electric cars, which announced the ET7 model, an electric sedan with autonomous driving technology, as well as the new luxury electric crossover EC6.

Despite the pandemic that reigns, "Renault" has confirmed its leading position on the European electric car market. (with a total of 115,888 vehicles sold, what is a sales growth of 101.4% compared to 2019). It will be a company worth about 50 billion euros, illuminated by stars at the end of this difficult year.

The factory "Continental Automotive Serbia" was opened in Novi Sad in Serbia, which will produce the most modern displays and screens in cars, innovative electronics. It is planned to purchase 10 new electric buses for Belgrade, and two factories have applied for the tender, one from Bulgaria together with one Serbian company and one from China.

During the March in 2021, the purchase of 10 new electric vehicles was announced, these are "Hayger" electric buses that performed well on the streets of Belgrade.

It is expected that the metro in Belgrade will be finished only in 2030.

Cycling Initiative and Traffic Safety in Serbia

There is a constant struggle in Belgrade for the improvement of bicycle traffic.[1] Cities and municipalities should commit to constantly improving cycling and pedestrian infrastructure. In addition, it is necessary to see bicycle[2] traffic as an equal mode of transport with other types of traffic. Around the world, for example, Berlin and Budapest are expanding or turning parts of roads into bicycle lanes, in Vienna there are expanded zones of calm traffic within the settlement, in Milan, pedestrian and bicycle space is being expanded, while in Brussels, in the wider city center, a speed limit of 20 km/h has been introduced and pedestrians have been given an absolute advantage.

The Association of the Western Balkans deals with the development of urban mobility and the popularization of bicycle traffic.

Unfortunately, the Traffic Safety Agency published that from the beginning of the 2020 till June 11th 2020[3], on the roads throughout Serbia 180 people died. Special attention was paid to the extra caution of drivers in the summer months. However, today, at a time when the corona is not letting up, information are still coming on the renewed restrictions in Italy, while restrictive measures are

[1] The association "Streets for cyclists" demands that the sloping and jagged curbs be removed and that they be flat, just as the transition to completely flat curbs is being made throughout Western Europe. This controversy was conducted during the summer of 2020 in Belgrade and Novi Sad with the company "Belgrade Road" and the Directorate for Construction Land and Construction of Belgrade.

[2] The General Assembly of the United Nations in April 2018, declared June the 3rd – the **World's Bicycle Day**.

[3] Just in the first 11 days of June, 16 people were killed and about 260 people were injured on the roads in Serbia.

being eased in Israel. The transport of goods[4] also suffered losses. Some firms have a problem maintaining the liquidity.

Also, there are more and more cases of violent driving and driving under the influence of psychoactive substances. As part of the International Action, which was carried out in 29 member states of the organization "Road Pool" (European Traffic Police Network), the traffic police discovered 15,501 violations and 81 criminal offenses. During the action, 577 traffic accidents were registered on the roads in Serbia, in which six people were killed and 143 people were injured. Of the total number of dead, 3 people were killed in motor vehicles, 2 as drivers and 1 passenger. These 3 people were not wearing seat belts at the time of the accident.

Conclusion

The eco car of the year 2020 was the **"Corolla HB"** 1.8 HSD. And in the exceptional competition for European cars in 2021, the "Toyota Jarris"[5] was chosen, as the completely new car, except for the name it bears, which is still synonym for reliability. "No more boring cars" is a strategy by which the Japanese brand wants to attract new drivers.

The new third generation of the "Peugeot 308"[6] model, which comes with a new logo of the French manufacturer, has been officially presented.

"KIA" showed the EV6 model, the first exclusively battery electric vehicle (BEV), and the Bavarians, i.e. the Munich-based manufacturer[7] has presented a production E-version of its new electric model "14" with a sporty look with best-in-class driving dynamics and zero emissions.

In 1972, the United Nations adopted the decision to celebrate the World Day of Environmental Protection every June the 5th with a series of various events[8]. A "Caravan of electric vehicles" was organized in our capital on the 5th of June, thus indicating the impact of traffic on the air quality in our metropolis. Participants were the drivers of electric vehicles, as well as scooters and motor scooters, who promoted the importance of driving that does not disturb our environment and contributes to the reduction of exhaust gases.

And on the 22-nd of April 2021 a Climate Summit was organized, a two-day online discussion on climate issues. The administration of the American president has committed to halve greenhouse gas emissions by 2030, i.e. that the goal is for the United States to reduce emissions for 50 to 52% compared to the level from the year 2005. On the Earth Day, President Biden virtually hosted 40 leaders at the White House Summit, and UN Secretary-General Antonio Guterres warned that global warming had already reached 1.2 degrees Celsius and was "rushing to the brink of disaster." It is significant that Japan has also increased its target carbon reduction rate to 46% by 2030, from 2013 levels.

At the time of the current Covid-19 epidemic, we launched moral forces in order to affirm true values in all segments of life and work. At the end of April 2021 many lives were lost all over the world. It is evident that a culture of support and solidarity is a strong stimulus in crisis situations.

[4] About 10,000 companies are operating in the transport sector, of which 1,700 in the international sector.

[5] The maximum speed of this new car is 180 km/h.

[6] A plug-in hybrid with 180 hp is also available to customers.

[7] They offered the serial "14", as one of a total of 25 electrified models - novelties until 2025, of which 12 are fully electric.

[8] This year's slogan of the World Environment Day was "It's time for the nature".

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Overview of the potential of Mobility as a Service

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Abstract: *Mobility as a Service (MaaS) is a solution, which unites travel services by integrating multimodal route planning, reservation, payment, and ticketing options. MaaS development mainly focus on the provision of a user-centered, intelligent, and personalized urban solution with the cooperation of public and private transportation service providers. The main point of the concept is that a new actor, the MaaS operator, is being established between the transportation service and the user. The establishment of the MaaS concept might happen on different integration levels. Examining the international market, the applications in the comparison do not differ to a great extent. The basis of the realization when developing MaaS is the provision of a high level of service with real time route planning and electronic payment for public transport services. There is a huge interest of providing a suitable MaaS solution by overcoming the technological challenges, by setting of business models, and by examining its applicability in a real-world environment.*

Introduction

In urban mobility management several already existing and upcoming questions, which make an impact on the travelers' life and the development of cities, have to be answered. The rapid development of digitalization provides an opportunity to create new mobility services, such as multimodal route planning, setting of travel preferences, appearance of on-demand transportation modes, or the use of modern travel media. In today's transportation system from the travelers' point of view, it is an advantage that several services and possibilities are offered to organize trips. Mobility as a Service (MaaS) is a solution, which unites travel services by integrating multimodal route planning, reservation, payment, and ticketing options. Thus, making the services to appear on the same platform possible.

Demonstration of the concept

In the focus of MaaS development, primarily the provision of a user-centered, intelligent, and personalized urban solution with the cooperation of public and private transportation service providers can be found. Due to the novelty of the concept, several definitions of MaaS can be found in the literature. In 2014, the father of MaaS, Hietanen provided a basis for the MaaS concept with the following definition: "Mobility as a Service (MaaS) is a mobility distribution model in which a customer's major transportation needs are met over one interface and are offered by a service provider" [1]. In a white paper from 2016, the European MaaS Alliance set some guidelines and recommendations for MaaS: "Mobility as a Service (MaaS) is the integration of various forms of transport services into a single mobility service accessible on demand" [2]. The British Department for Transport and the Transport System Catapult Intelligent Mobility Technology and Innovation Center states that MaaS should include: "navigation, journey information, cashless payment as well as managed access to transport services including taxi, bus, rail and shared transport journeys" [3]. While MaaSLab defines the new paradigm as a "new mobility model that aims to bridge the gap between public and private transport operators on a city, intercity and national level, and envisages the integration of the currently fragmented tools and services a traveler needs to conduct a trip" [4].

The main point of the concept is that a new actor, the MaaS operator, is being established between the transportation service and the user (Figure 1). By integrating the supply and the demand, the task of the MaaS operator is to offer service to the users, to create pricing models, and to reach agreements between the transport service providers, the users, and the transportation authorities.

An important component of MaaS concept is the payment mode of the transport services. Based on the travel time and/or the travel distance, the travelers can pay either in a pay-as-you-go system or for mobility packages. The mobility packages are similar to the monthly subscription packages of telecommunication companies, i.e., a joint price is paid for a chosen package including service elements (e.g., talking, SMS, mobile net) based on the demand.

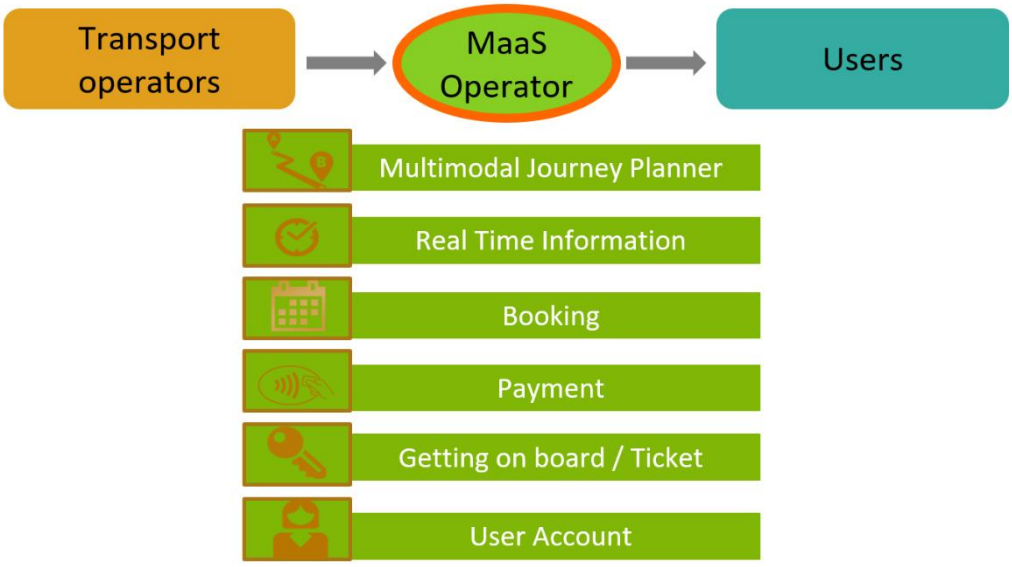

Figure 1 *MaaS operator as the new actor between transportation service providers and users [4]*

In 2016 MaaS Global started the testing of the Whim application in Helsinki, and after a year, the application, which offers mobility packages to the users, appeared on the market. Recently, Whim has been spreading to other European cities (e.g., Amsterdam, Antwerpen, West Midlands). However, the first MaaS pilot has been introduced in Sweden, where the concept was tested as part of the GOSMART project [5]. In this project, the UbiGo application, which had been tested for 6 months among a chosen group of travelers, was developed. Based on the evaluation, it can be concluded that the users gave positive feedback, but some problems appeared (i.e., regulations, policies, barriers) concerning the

cooperation of the service providers and the organizations, which restricted the further development of MaaS. As a result of the project, studies were written about the demand of service providers and users, the integration of all aspects of mobility (i.e., user, commercial, social) and about the challenges of integrating the mobility services into one service [6].

Definition of integration levels

The establishment of the MaaS concept might happen on different integration levels, which based on the analysis of the literature and the various definitions, are the followings (Figure 2).



Figure 2 *MaaS integration levels*

At the base level, there is no integration, which means that separated applications help the travelers to conduct their trips. Today's traveler information systems are primarily on this level. On the 1st level, the integration of the information appears, which basically provides centralized travel information and multimodal route planning including several services. On the next level, the route planning is connected to payment and ticketing services. Unlike the previous level, services of this level provide an easier access to the overall travel process. On the 3rd level, agreements are made by various service providers, which results in mobility packages, subscriptions, and other discounts. On the 4th level, through rules and incentives, the regulators, the local authorities, and the government are involved, as well. The main aim here is to maximize the social benefits, to provide an accessible transportation system and a livable environment.

Comparison of applications

Examining the international market, those applications that can be found on higher levels are gathered (Table 1). The area describes the special coverage of the application, while the year demonstrates the appearance of the application on the market. The transportation service lists those modes and services which appear in the application. The payment indicates the possibilities to pay, while the available functions present those service elements, which are included in the application but not necessarily apply to all transportation modes. For example, in WienMobil, the available tickets to buy is exclusively to public transportation (i.e., other services cannot be paid via WienMobil). The mobility provider shows the type of MaaS operator, which might be the public transport service provider, a private transport service provider, or another company, too. Regarding the technology, the GPS is required for the localization process, the ePay symbolizes the payment possibilities, the smart card is suitable for payment and vehicle access. The personalization includes those functions that the user of the application can generally set, where the settings are mainly connected to the demands for a given trip.

Name of the application	NordwestMobil	WienMobil	Mobility Shop	Compte Mobilité	Whim
Area	Basel	Wien	Hanover	Mulhouse	Helsinki
Year	2017	2015	2014	2016	2016
Transportation service	public bike-sharing car-sharing ride-sharing taxi parking railway long-distance bus	public bike-sharing car-sharing taxi parking	public suburban railway car-sharing taxi	public bike-sharing car-sharing parking	public bike-sharing car-sharing car rental taxi
Payment	one-time travel and payment	one-time travel and payment	fix monthly membership payment, one-time travel and payment	monthly accounting	bimonthly package, one-time travel and payment
Available functions	real time information, route-planning ticketing, payment, accounting	real time information, route-planning reservation payment, accounting	real time information, route-planning reservation ticketing, payment, accounting, emergency hotline	real time information, route-planning reservation ticketing, payment, accounting emergency hotline	real time information, route-planning reservation ticketing, payment, emergency hotline
Mobility provider	public transportation service provider	public transportation service provider	public transportation service provider	public transportation service provider	company
Technology	GPS/ePay	GPS/ePay	GPS/ePay/smart card	GPS/ePay/smart card	GPS/ePay
Personalization	saving favorite routes	individual transport profile saving,	saving favorite routes and recall previous ones	setting monthly max. consumption	implementing calendar, sharing personal

		car- and bike-sharing membership			information
Settings	preferred modes	preferred modes, time, money, CO2 emission	reservation and payment cancellation		cancellation, subscription, upload

Table 1 *The comparison of some integrated application*

The applications in the comparison do not differ to a great extent. The Swiss application is an exemption, as it provides a service not only in an urban area and agglomeration but at a country level. Furthermore, NordwestMobil integrates the highest number of transportation modes and services. WienMobil is distinct in its wide range of criteria which can be set for route planning. The applications of Hanover and Mulhouse integrate a small number of transportation modes and services, but regarding the functions, these applications present the biggest variety. Moreover, both Mobility Shop and Compte Mobilité provide a smart card option to the travelers. Compte Mobilité is the only application, which is available to the users via a web-based platform besides the application. Solely, Whim is the application which is provided by a non-public transport service provider.

All the applications have in common that a registration is needed to reach every mode, and both public and private transportation modes are available. The Swiss application and WienMobil integrate the greatest number of transportation modes besides providing reservation, payment, and ticketing functions. Thus, these applications reach Level 2. By buying a monthly membership, Mobility Shop provides discounts in car-sharing, taxi, and railway services. Compte Mobilité gathers the monthly expenses and gives the account at the end of each month. The applications of Hanover and Mulhouse can be found between Level 2 and Level 3. Out of the applications, Whim is the one which offers a preset mobility package for the users thus reaching Level 3.

Realization possibilities

The basis of the realization when developing MaaS is the provision of a high level of service with real time route planning and electronic payment for public transport services. If the latter function is not available, even Level 2 cannot be achieved. A positive aspect is the extension of transportation modes (including public bike-sharing, public cars, public scooters), which in case of integration, might provide a wide range of mobility possibilities, once cooperation is reached. The most crucial question regarding the sustainability and the effectiveness of the concept is what kind of relationships can be set between the actors run by the government and by the private companies to cooperate successfully.

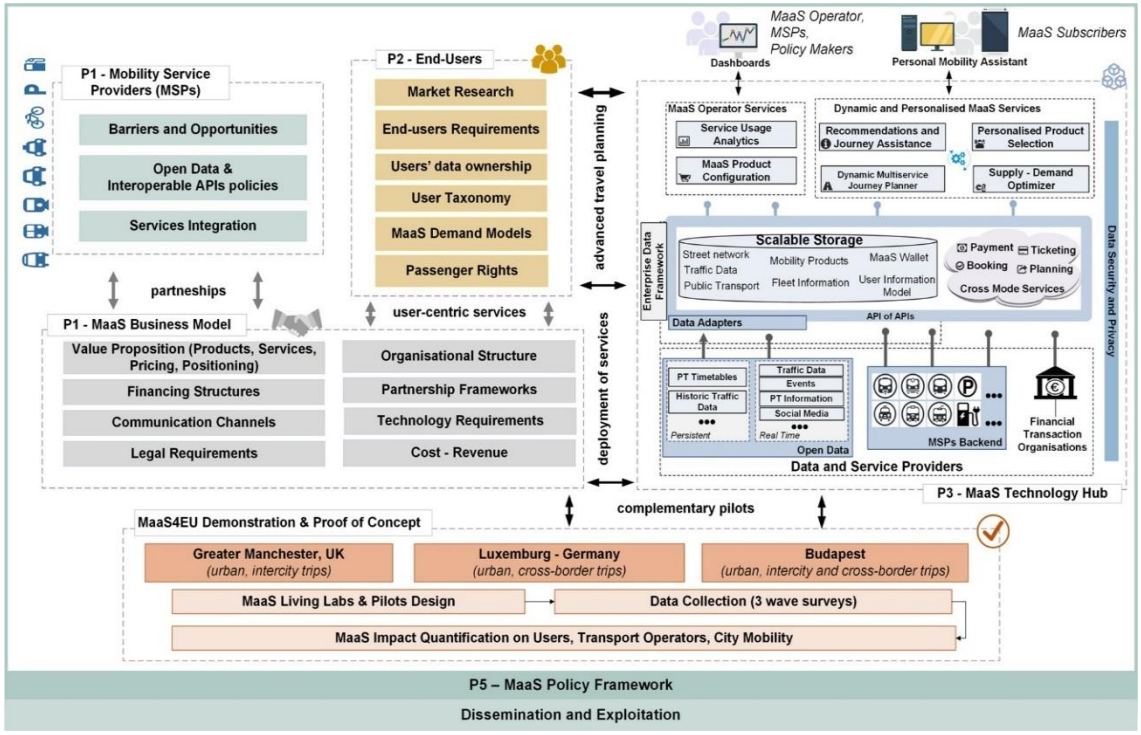

Figure 3 *Suggested MaaS framework [7]*

To start the realization process of MaaS concept, a framework was introduced with the goal to develop a traveler-based, intelligent mobility service with the promotion of sustainable transportation modes. The aim is to examine the demands of the transportation service providers and the possibilities of service integration, to analyze the travel characteristics of the users, to develop business plans, which bring benefits for all the actors in field of transportation. Furthermore, the technological questions have to be answered to be able to connect the services successfully. The service concept is planned to be realized on Level 4: the elaboration of business models, the consideration of the travelers' demands, the overcoming of technological challenges, the setting of guidelines and policy (Figure 3).

To reach the above goals, living labs have to be created, which aims to connect the stakeholders, the companies, the transportation services, the authorities, the research centers, and the users thus providing a possibility to take part in the pilot development. During the realization process, workshops and meetings for focus groups have to be organized to conduct a debate on the business models and technological demands of MaaS. This has to be followed by the testing phase with the possibility to try the integrated transport services, which help the development of a MaaS service based on real business observations.

A potential solution to overcome the scattered mobility solutions is provided by Urban Mobility Operating System (UMOS), which aims to build a seamless, open, collaborative, and interoperable solution. The service will facilitate data exchange, widen transport options, and overcome barriers between the travelers and service providers. With the cooperative business model and a suitable technical background UMOS will be able to provide a high-level mobility service.

Conclusion

In conclusion, MaaS concept is in its early phase, though it can be seen that there is a huge interest in the overcoming of the concept's technological challenges, the setting of business models, and the examination of its applicability in a real-world environment. The introduction to the market has to be well prepared with the support of a variety of agreements for a high-level integration, while the uncertainty of the economical use case and the real demand has to be considered. In addition, the user expectations are high, the service providers are interested to assess the new possibilities, and slowly the advantages of the new service are recognized on a strategical level. Thus, it can be concluded that it is expected that soon more and more MaaS services will be available in cities.

Acknowledgment

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Status and characteristics of freight traffic with special reference to road traffic in Montenegro and comparison with the EU

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Abstract: *The subject of this paper is the review and analysis of freight transport in Montenegro. Road freight transport has been growing steadily over the past few years. Rail, sea and air transport of the third are accompanied by numerous oscillations. The article provides an overview of freight transport for EU countries as well. Freight transport in Montenegro differs from EU countries. In the last few years, work has been done on improving freight transport in Montenegro. These improvements are specifically related to infrastructure improvements, especially in road transport.*

Keywords*: FREIGHT TRANSPORT, ROAD TRAFFIC, RAILWAY TRANSPORT, MARITIME TRANSPORT, AIR TRANSPORT*

1. Introduction

Freight transport technology is different from passenger transport technology. It is characterized by numerous processes that can be complex but also long. The length and complexity of these processes depends on the type of items being transported, the mode and type of transport, the means of transport and the length of the transport itself. The essence of the technology of transporting goods is the processes by which goods are transported from one end to the other. In the process of transporting goods, classical and modern technologies are applied. Classical technology means a technological process with all phases without the establishment of a transport chain with several different branches of traffic and without the use of transport devices. Classical technology includes three key phases of the technological process: loading, transport and unloading. Modern transport technologies imply that goods or passengers are not transported by only one means of transport, but the overall functioning of the transport chain is observed. Modern technologies are characterized by the establishment of a transport chain in continuity in traffic, which is performed by moving goods from source to destination. Appropriate loading units are used and in this way higher speeds are achieved, but also favorable economic effects. A significant part of freight transport is realized by a combination of means of transport of different modes of transport. Combined transports are necessary in certain cases, because it is not possible to use only one mode of transport on the entire transport route due to the lack of infrastructure. The combination of transport achieves lower transport costs. Transport time is also reduced compared to cases where one mode of transport is used. When transporting cargo, it is necessary to ensure the optimal use of all resources used to produce transport services. [1]

2. Traffic policy

The European Commission approved a common transport policy in 1992. This transport policy is contained in the White Paper. The following objectives apply: the formation of a trans-European network, fair prices in transport, environmental protection, traffic safety, strengthening the internal market, strengthening the external dimension of the single market. This transport policy serves to shape the transport system of the European Union, but also the candidate country for membership.

3. Freight transport in Montenegro and comparison with the EU

Data related to statistical surveys were collected from [2,8]. This chapter provides an overview of transported goods in Montenegro and EU countries for: rail, road, sea and air transport.

3.1 Freight transport by rail

The statistical survey in railway traffic is conducted according to Regulation (EC) no. 91/2003. The current length of the railway in Montenegro is 250 km. It is a single-track railway with a single-phase power supply system of 25 KV, 50Hz. Table 1 and Figure 1 show the turnover of goods (in thousands) for Montenegro.

Table 1: *Goods transported (in thousands) by rail in Montenegro for the period from 2014-2018*

	Year				
	2014	2015	2016	2017	2018
Transported goods in thousands of tons	903	988	1395	1603	967

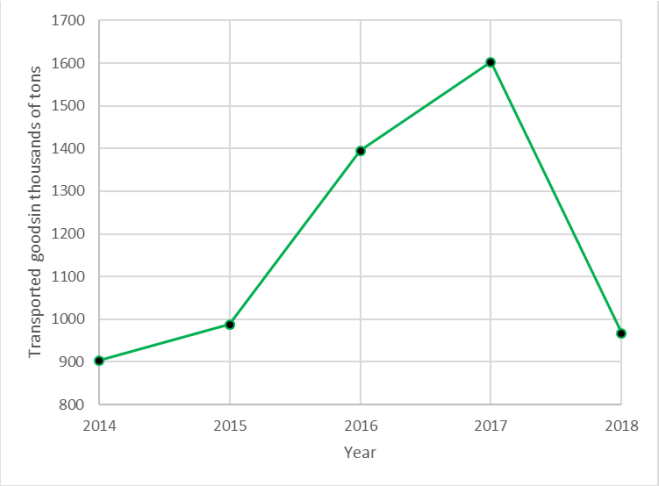

Fig 1 *Traffic of goods by rail in Montenegro for the period from 2013 to 2018*

From Figure 1 it can be seen that from 2014 to 2017 there was a constant increase in the turnover of goods by rail in Montenegro. While in 2018 I have a decline compared to 2017, but also 2016 and 2015.

3.2 Freight transport by road

Changes in the methodology for conducting the survey on road freight transport have been made in order to achieve alignment with the acquis. Surveys on road freight transport have been conducted since 2014 according to a new survey, which was prepared according to regulations (EC) no. 1172/98 and 70/2012. This research differs significantly from the research conducted until 2014. The research is conducted on a sample, and the data are collected by the survey method. Trucks for the transport of goods with a payload of 3,500 kg and more are observed, as well as tractors. The source of data are legal and natural persons who are owners or users of vehicles. The selection of the sample was made on the basis of data on registered vehicles obtained from the Ministry of Interior of Montenegro. Data on transported goods in thousands of tons are shown in Table 2 and Figure 2.

Table 2: *Goods transported by road in Montenegro*

	Year				
	2014	2015	2016	2017	2018
Internal transport	548	636	753	739	744
International transport	91	132	99	100	66
Total	639	768	852	839	810

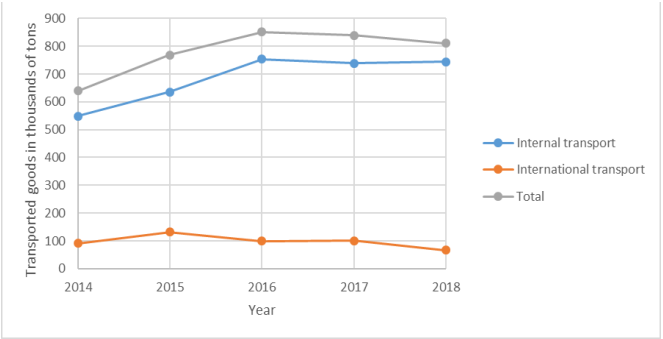

Fig 2 *Traffic of goods by rail in Montenegro for the period from 2013 to 2018*

Goods transported by road in EU countries (with available data) for the period from 2014 to 2018 are shown in Table 3. Data for Malta but also data for Belgium (2018) were not available.

Table 3: *Goods transported by road in EU countries (except Malta for which no data are available)*

	Year				
	2014	2015	2016	2017	2018
Belgium	299 476	295 057	291 521	300 121	...
Bulgaria	153 077	161 567	146 636	151 479	143 199
Czech Republic	386 243	438 907	431 889	459 433	479 235
Denmark	178 146	181 232	184 726	179 062	167 534
Germany	3 052 628	3 035 329	3 111 858	3 161 837	3 200 925
Estonia	27 358	28 162	34 581	28 969	28 494
Ireland	112 825	117 090	140 743	146 543	148 765
Greece	403 327	420 005	419 222	388 898	361 947
Spain	1 184 586	1 258 261	1 285 164	1 409 090	1 474 486
France	1 918 572	1 796 755	1 727 611	1 714 292	1 806 476
Croatia	66 157	66 503	72 516	72 343	74 009
Italy	963 056	957 006	901 503	885 451	920 732
Cyprus	14 585	14 402	19 682	25 595	29 308
Latvia	62 239	62 569	63 389	68 013	76 701
Lithuania	57 591	58 601	63 571	76 980	89 105
Luxembourg	58 723	45 715	50 824	47 292	48 846
Hungary	193 112	198 744	197 759	188 250	206 669
Netherlands	639 777	641 538	656 428	666 069	680 065
Austria	349 544	351 068	376 399	386 858	393 313
Poland	1 300 382	1 264 960	1 313 657	1 501 811	1 390 184
Portugal	149 829	150 358	147 792	157 924	156 650
Romania	190 938	198 824	216 107	226 345	237 157
Slovenia	74 143	70 509	75 033	86 212	85 406
Slovakia	142 608	147 225	156 179	176 750	177 131
Finland	280 131	271 912	278 957	280 744	274 346
Sweden	381 263	422 891	433 065	455 480	481 319
United Kingdom	1 348 887	1 468 144	1 450 280	1 417 482	1 425 178

As for the EU countries for the period from 2014 to 2018, some countries have a constant growth of goods transported by road, while other countries have smaller or larger oscillations in the amount of goods transported by road. Countries that have a constant growth of goods transported by road are: Ireland, Spain, Latvia, Lithuania, the Netherlands, Austria, Romania, Slovakia and Sweden. Other EU countries have more or less fluctuations in the amount of goods transported for the observed period. When it comes to the amount of goods transported by road in Montenegro, we have an increase from 2014 to 2016, after which there is a constant decline, which can be clearly seen in Figure 1. Montenegro is characterized by the fact that in the total transported goods has

the largest share internal traffic. The quantity of goods transported by domestic road transport is higher than that transported by international road transport.

3.3 Transport of goods by sea

Transported goods by sea in montenegro for the period from 2013 to 2016 are shown in Table 4. From 2016, these statistics are not taken anymore.

Table 4: *Goods transported by sea in Montenegro for the period from 2013 to 2016*

	Year			
	2013	2014	2015	2016
Transported goods in tons	51000	54640	52441	41668

3.3.1. Traffic of goods in ports

The statistical survey is conducted in accordance with Directives (EC) No 2009/42 and No. 2012/186. Ports are places of embarkation and disembarkation of passengers and cargo on the coast, which are specially built for this purpose. Table 5 and Figure 3 show the turnover of goods in ports in Montenegro for the period from 2014-2018.

Table 5: *Goods transported in ports in Montenegro for the period from 2014 to 2108*

	Year				
	2014	2015	2016	2017	2018
Export	533780	837470	809559	1210380	776425
Import	705991	649747	807571	883448	1179686
Total	1241431	1488399	1645797	2095122	1963204

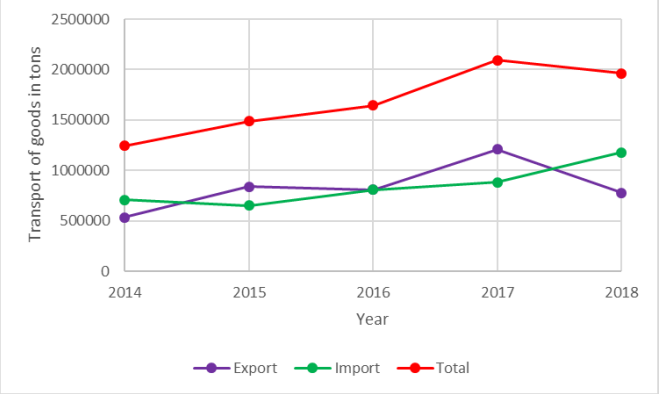

Fig 3 *Transport of goods in ports in Montenegro for the observed period*

3.4 Transport of goods by air

Data on goods traffic at airports are the result of regular quarterly and annual surveys. Statistics Statistics on the transport of goods at airports are partially in line with Regulation (EC) no. 437/2003. Statistics of goods transport at airports from 2016 are harmonized with Regulation (EC) no. 437/200. The data do not include non-commercial general aviation operations as well as state flights (army, customs, police).

Table 6 shows the data related to the amount of transported goods at the airports of EU countries and Montenegro. Figure 4 shows a graphical interpretation of the turnover of goods at the airports of Montenegro for the period from 2014 to 2018.

Table 6: *Goods transported (in tons) at the airports of the EU countries and Montenegro*

	Year				
	2014	2015	2016	2017	2018
Belgium	1 014 586	1 126 234	1 088 734	1 251 173	1 416 428
Bulgaria	23 073	31 520	32 977	34 807	29 867
Czech Republic	58 312	58 445	77 704	89 279	90 526
Denmark	208 590	210 570	200 133	235 937	242 068
Germany	4 336 163	4 325 665	4 467 022	4 773 359	4 842 716
Estonia	19 432	16 034	13 868	11 233	11 475
Ireland	138 203	148 714	145 769	163 123	156 265
Greece	60 324	62 332	69 949	69 074	96 889
Spain	593 902	594 393	639 237	742 443	806 518
France	2 361 510	2 380 931	2 401 593	2 450 326	2 407 878
Croatia	6 908	7 189	7 691	9 510	11 934
Italy	876 495	916 755	991 688	1 077 874	1 066 221
Cyprus	28 095	27 626	28 430	30 880	32 186
Latvia	31 439	16 809	17 922	21 204	24 628
Lithuania	13 210	14 904	14 245	15 064	16 779
Luxembourg	707 150	736 880	801 058	892 660	895 004
Hungary	61 970	65 783	77 535	87 277	101 411
Malta	15 602	16 405	15 690	16 194	17 677
Netherlands	1 727 455	1 712 031	1 831 792	1 865 106	1 854 272
Austria	217 785	216 621	223 421	227 643	237 701
Poland	84 386	92 690	1 307 600	121 303	134 673
Portugal	134 982	133 416	136 578	164 732	173 493
Romania	31 113	33 399	37 456	41 692	45 310

Slovenia	8 563	8 891	8 970	12 025	12 337
Slovakia	18 498	21 216	23 028	27 188	24 565
Finland	190 586	182 089	186 471	188 722	196 810
Sweden	141 887	146 287	147 214	159 130	158 632
United Kingdom	2 406 673	2 405 225	2 511 011	2 738 784	2 748 539
Montenegro	862	889	910	876	931

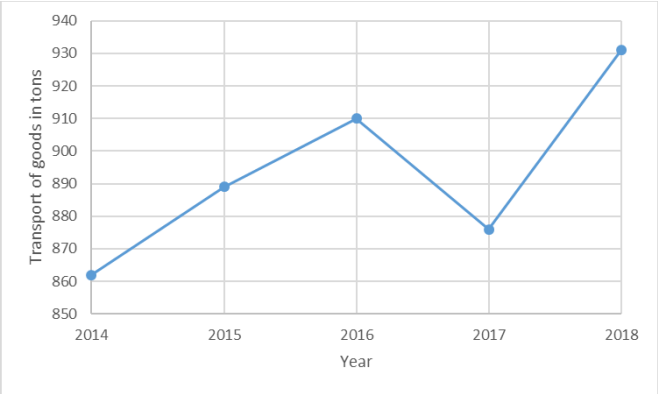

Fig 4 *Goods transported at EU airports and in Montenegro for the observed period*

4. Conclusion

Teretni saobraćaj u Crnoj Gori nije na zavidnom nivou. Stanje u kojem se nalazi teretni saobraćaj u Crnoj Gori posledica je nedovoljno efikasnih strategija za transport, nedovoljnog ulaganja u saobraćajno transportnu infrastrukturu, ali i geografski položaj Crne Gore kao netranzitne zemlje. Analizirajući prethodne podatke teretni drumski saobraćaj je u konstantnom porastu, dok železnički, pomorski i vazdušni imaju oscilacije. Prevoz tereta drumskim saobraćajem ima konstantan rast zahvaljujući unutrašnjem drumskom saobraćaju. Konstantan rast u prevozu robe primjećen je i u vazdušnom saobraćaju (izuzev 2017 godine). Imajući u vidu sve navedeno potrebno je obratiti posebnu pažnju na poboljšavanje teretnog saobraćaja u Crnoj Gori, kroz izbore adekvatnih (efikasnijih) strategija i dovoljnog ulaganja u saobraćajnu infrastrukturu i saobraćajnu mrežu. Strateški interes Crne Gore trebao bi biti razvoj drumske i železničke infrastrukture na relaciji Bar-Beograd-Budimpešta jer uz ogromni potencijal i dobar geografski položaj luke Bar, Crna Gora bi se pozicionirala kao atraktivna tranzitna zemlja za mnoge transporte tereta, ka Istočnoj Evropi.

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Issues regarding the rolling highways

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Abstract: *Very popular among the environment activists and public authorities, the rolling highways prove to have a poor commercial viability. Therefore, the paper tries to find the reasons for this fact. The analysis starts with the descriptions of the technical solutions, then the traffic volumes recorded on different transport relations / countries are presented, together with the main findings from the European experience. The trends are explained considering the operational issues, the transport costs, the factors influencing the demand, the state support and the railway regulations, as well as the requirements of the customers. Special comments are focused on the Romanian experience, indicating the operational issues specific to Romania, the necessity for state aids with intensities of 45 - 60% from the costs, as well as the savings in external costs. The main conclusions are that the rolling highways are environmentally friendly, but costly and that they could develop only if the public authorities implement appropriate support measures and aids.*
Keywords: ROLLING HIGHWAY, RAILWAY, ROAD TRANSPORT, TRAFFIC VOLUME, TRANSIT TIME, COST, EXTERNAL COST, AID INTENSITY

1. Introduction

The rolling highways or the Ro-La transport services represent the actual implementation in civil life of a solution used, for the first time, in the World War I for the quick supply of the road and armored vehicles in areas with complex military operations. The idea was to carry such vehicles on railway wagons. Later, in the fourth decade of the 20th century, French and German companies performed experiments with semitrailers loaded on flat wagons.

The first trains carrying lorries were organized and ran [1]:

- in 1954, on West German Railways, on the relations Mühlheim – Hamburg and Frankfurt am Main - Hamburg;
- in 1960, on French Railways;
- in 1964, on Swiss Railways, between Basel and Lugano.

2. Technical solutions

The first trains which ran in West Germany included in their composition two axle flat wagons in the series Rmmso 33, adapted for road vehicles and having the floor at 1250 mm above the rail. Loading and unloading needed a concrete platform built along the trains and located at the same level with the wagon floor. A wagon could carry a simple lorry, a tractor, a trailer or a semitrailer. Passenger cars were not being attached to these trains and the drivers were having to travel in the cabins of their vehicles [1].

Then, in more than 50 years, companies in Germany, France, Switzerland, Ukraine, Russia, and India have developed solutions adapted to the railway infrastructures in these countries. Table no. 1 depicts the characteristics of the actual Ro-La wagons.

In Northern and Central European countries, small wheel and low floor wagons have spread. They were developed so that to be compliant with the loading gauges specific to the railway lines in Europe. Depending on the route characteristics, the trains include in their composition 19–24 wagons (carrying the same number of road vehicles) and passenger cars for drivers [2].

Loading and unloading processes are performed horizontally, the lorries rolling on or off the wagons on their own wheels, in a sequential manner. The processes need mobile ramps at one of the edges of the train and usually last 30–45 minutes [2].

The specialised terminals have relatively simple layouts and could be built as sections in freight/container terminals, respectively as independent facilities connected to a railway station. Besides the railway tracks, their main components and equipment are the loading platforms located at the edge of the tracks or between the tracks, parking areas, truck circulation lanes, buildings for administrative procedures and loading profile gates. Costs for terminal development are estimated at 800000 - 1 million euro.

The small wheel and low floor wagons are criticised for [3-5]:

1.Wheel – rail contact characterised by a high pressure, that:

a) Imposes the use of special steel having very high quality and costs for the construction of the wheel tyres and other wagon components.
b) Generates high and quick wear of the wheels and other bogie components, due to more revolutions per kilometre. The consequence is a frequency of the repairs greater than in the case of the wagons with normal wheels, respectively the necessity to send the wagons to the specialised workshops after running 80000-100000 km. The effect is seen in the maintenance costs, that are three times greater than in the case of the port-container wagons [6].
c) Generates wear of the rail greater than in the case of the normal wheels.

2.Phenomena of wheel heating, generated by the number of the rotations which is greater than in the case of the normal wheels. This fact imposes to stop the train run from time to time, with the effect of an increase of the transport duration.

3.Difficulties in the transmitting the braking power from vehicle mass to the rail surface, imposing sophisticated and expensive solutions for the braking systems;

4.Difficulties when running in track sections with curves;

5.Risk of derailment at the passage over the switches, generated by the small diameter of the wheels.

In France, the Lohr company manufactured an articulated wagon having normal wheels and two low platforms (Modalohr wagon). A platform can carry two tractor heads or a semitrailer.

The main feature of the Modalohr wagons is the fact that they allow simultaneous, horizontal loading and unloading of the trucks. For this purpose, the two platforms of one wagon must rotate by 30° with the help of a sophisticated equipment mounted between the rails, along the tracks in terminals. The duration of the process including unloading of trucks followed by the loading of other road vehicles can be reduced to only 40 minutes [7-8].

The Modalohr concept also leads to special layouts for the terminals. The tracks and the special equipment rotating the wagon platforms are located in the middle. Platforms necessary for the trucks rolling on or off the wagon are built along the tracks, while lanes for truck access and exit are surrounding all these facilities.

The Modalohr wagons in the first generation are used only on the Alpine Rolling Highway, connecting the terminals Aiton (near Chambery, France) and Orbassano (near Turin, Italy). The trains have in composition 2 end wagons, 12 intermediate wagons and one club car, being hauled by two interoperable BB 436 000 electrical locomotives. They are able to carry 28 semitrailers or 18 full lorries.

Modalohr solution has lower maintenance and operation costs than in the case of the small wheel and low floor wagons. However, it comes with high costs of the initial investments for the terminal construction (12/18 million euro) and the wagon purchasing [7].

The third solution for normal gauge (1435 mm) is implemented in the case of the shuttles through the Channel Tunnel, between Coquelles (France) and Folkestone (UK). In this case, the wagons design take benefit from generous loading gauge specific to the tunnel, so that the result are special, semi-open wagons with normal wheels and floors located at normal height above the rails [9-10].

Loading and unloading of the road vehicles are performed in a serial manner, on one of the lateral sides, using three wagons without walls located at the edges and in the middle of the trains (loader). Consequently, the terminals must have, along the tracks, platforms made in concrete at the same level with the wagon floors.

Tabe1: *Technical and operational characteristics of the Ro-La wagons [7, 10, 11, 12, 13, 15, 16, 17]*

Wagon series / type / model			Saadkms 690 Bombardier	Saadkkms 741 Greenbrier	Sdmmrs	Modalohr AFA (1st generation)	ARBEL		WBN			Model 13-4095 (Ukraine)	Model 13-9009 (Russia)	Model 13-9961 (Russia)	Model 13-5205 (Russia	BRN adapted (India)
							Loader	Carrier	Loader edge	Loader centre	Carrier					
Gauge		[mm]	1435	1435	1435	1435	1435		1435	1435	1435	1520	1520	1520	1520	1676
Number of axles			8	10	12	6	4		4	4	4	4	4	4	4	4
Tare	Wagon with end section	[kg]	19500	21300	23600	40000	54000	34000	53000	52000	34000	28000	33500	30500	26500	24390
	Wagon with no end section		18000	20000												
Length over buffers	Wagon with end section	[mm]	19745	20200	19060	32480	:		25197	24848	20000	22520	25590	21440	19500	:
	Wagon with no end section		19090	19390												
Loading length	Wagon with end section	[mm]	18600	18400	18800	2 x 14010	25200	20000	:	:	:	17800	24300	20000	18280	:
	Wagon with no end section		19000	18750					:	:	:					
Width		[mm]	2990	3000	2600	3095	4380	4120		:	:	:	3060	3200	3226	:
Width between guides for wheels of lorries		[mm]	-	2520 / 2560	:	:	2700		:	:	:	:	:	3000	:	:
Maximal payload	Wagon with end section	[t]	Standard 42	53.7	48.5	2 x 38	44		:	:	:	:	60	55,5	67.5	56.88
	Wagon with no end section		44	55												
Maximal axle load		[t/axle]	8,25	7.5	6	18.5–22.5–18.5	22.5		22.5	22.5	22.5	:	23.38	21.5	23.5	:
Distance between running gears		[mm]	13700	12730	15900	2 x 14400	:		17800	17800	14000	17800	18500	15500	15230	:
Wheelbase		[mm]	750-700-750	4 x 700	2200	2000-1800-2000	:		:	:	:	:	:	:	:	:
Height of floor above top of the rail, empty		[mm]	Standard 410/450 High tare 430/470 Ultralow 310/450	480	:	200	:		820	820	820	968	1200	1100	1133	:
Height of floor above top of rail, with 13 t payload (empty lorry)		[mm]	475	465	410	:	:		:	:	:	:	:	:	:	:
Wheel diameter	New wheel	[mm]	360 / 380	380	360	840-920-840	:		920	920	920	:		:	:	:
	Worn wheel		355	335	325	:			:	:	:			:	:	:
Minimal negotiable radius as individual wagon		[m]	80	120	:	150	:		:	:	:	:		:	:	:
Minimal negotiable curve radius in a train		[m]	150	150	150	150	:		:	:	:	:		:	:	:
Maximal speed		[Km/h]	120	120	120	120	140		140	140		120	120	120	120	Loaded: 65 Empty: 75
Vehicle gauge			UIC IRS 505-1	UIC IRS 505-1	UIC IRS 505–1	UIC GB1 and GI3	UIC GC		UIC GC	UIC GC	UIC GC	0–V-M	0–V-M	1 – T	1 – T	Konkan Railways
Maintenance cost		[€/km]	0.08 – 0.15	0.08 – 0.15	:	0.062	:		:	:		:		:		:
Price		[€/pcs]	150000	150000	:	350000-457000	:		400000			45000 - 55000				:

The Eurotunnel company operates 18 trainsets, having in their composition 2 locomotives, one passenger car, 3 special loader wagons and 30 or 32 wagons which could carry the same number of lorries. From the 18 trainsets, 6 use BREDA FIAT wagons (1st generation), 9 are composed by ARBEL wagons (2nd generation) and 3 employ WBW wagons (3rd generation). The last ones were purchased in 2017 for 40 million euro, meaning that the price for a such wagon is approximatively 400000 euro [9].

Several models of wagons are designed for the area with track gauge of 1520 mm [11-13]:

1.Model 13-4095, produced by Ukrainian company Dneprovagonmash, which adapted a type of flat port-container wagon for the truck carriage. This wagon is designed with normal wheels, a platform located at normal height above the rails, platforms allowing the passage of the road vehicles to other wagons and devices for secure the lorries during the transport. Loading and unloading is performed in a serial manner, at one of the edges, using a mobile ramp made in metal. At the same time, such wagons could be attached in trains together with port-container wagons. They have been used in the following services:

a) Yaroslav trains, which ran between Lugansk / Kiev (Ukraine) to Slawkow (Poland) or vice versa. These trains included in their composition 30 wagons of model 13-4095 and 2 sleeping cars for the drivers.
b) Viking trains, still running from Draugyste / Klaipeda (Lithuania) to Chornomorsk (Ukraine) and vice versa. These trains include in their composition both port-container wagons and wagons of model 13-4095. A report indicates a train was made up of 24 Ro-La wagons, 12 port-container wagons and 2 sleeping cars.

2.Model 13-9009, produced by the Abakanvagonmash Company (Russia) and able to carry both containers and road trains;

3.Model 13-9961, developed by the Uralvagonzavod Company (Russia) and homologated in 2017. This wagon could carry all kind of heavy road vehicles (lorries, tractor trucks, articulated vehicles, trailers and semitrailers. Their loading and unloading are possible both at one of the edges and on a lateral side of the wagon. Passage from one wagon to another one is possible, too.

4.Model 13-5205, also produced by the Uralvagonzavod Company (Russia) and used in an experimental transport of an articulated vehicle, between Moscow and Novosibirsk, in 2019.

In India, where the track gauge is 1676 mm, a flat wagon that was initially used for the carriage of rails and steel products has been modified so that it could carry lorries. Trains includes up from 29/30 wagons, each one being able to carry two trucks of 2 axles or one truck of 4 axles. There are restrictions regarding the truck height (maximum 3.4 m) and gross tonnage (25 tonnes for 2-axle trucks and 40 tonnes for 4-axle trucks). Loading and unloading of a truck are performed in 10 – 15 minutes, in a sequential manner, at one edge of the train, with the help of a platform and a fixed ramp. Portable ramps are usually used for unloading, respectively and for loading and unloading of the tankers [3, 14].

3. Trends, issues, learnings

In Europe, since 1960', Ro-La trains have run on 53 relations, of which 13 were being domestic and 40 internationals [1]. Table no. 2 depicts the evolutions in the last decade.

***Table 2**: Ro-La routes in Europe [6, 18, 19, 20, 21, 22]*

Year	Total number of routes	Number of domestic routes	Number of international routes
2010	14	4	10
2018	9	2	7
2021	7	1	6

During the last decade, Austria has been the country operating the greatest number of rolling highways. Here, train composition includes 8 axle wagons in the series Saadkms. As shown in the figure no. 1, the traffic volume has recorded a descending trend.

In 2010, the Ro-La trains were serving 7 relations, of which only 3 are operational today [19, 21].

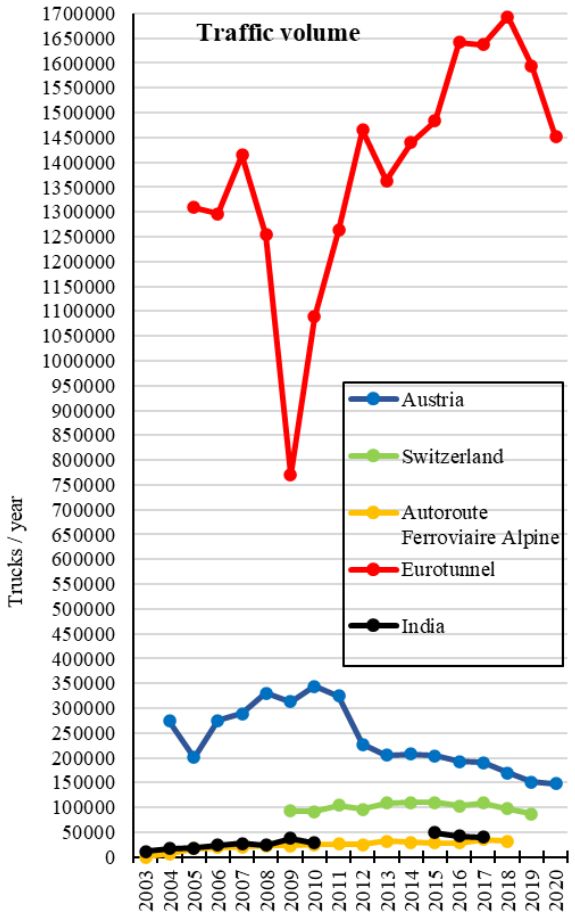

***Figure 1:** Traffic volumes on rolling highways in Europe [3, 14, 18, 19, 20, 21, 23]*

The trains were cancelled on 4 relations, due to:

- Cease of subsidization by the Hungarian Government on the relation Wels–Szeged (Hungary) and the by the authorities in the region Fiuli-Venezia Giulia, on the relation Trieste– Salzburg;
- Traffic restructuring made by the national rail operator in Austria, Rail Cargo Austria.

However, the demand is kept because the Austrian Government has implemented a policy of environment protection, supposing support measures such as state aids, traffic bans during the night or in specific periods, high tolls, fiscal facilities for the vehicles using the Ro-La services, strict limitation of the transit permits for trucks registered in countries which are not members of the European Union and free travel on 70 km around the terminals for the users of the Ro-La services [23-25].

The need for subsidies and other support measures derives from the high difference of the costs recorded in the case of the Ro-La transport and the cost of the road transport. The respective costs and the subsidies are presented in the tables no. 3 and 4.

***Tabele 3:** Road and Ro-la costs in Austria [24]*

Traffic type	**Road [euro / 1000 tkm]**	**Ro-La [euro / 1000 tkm]**	**Ratio of Road cost in Ro-La cost [%]**
Domestic	56	119.8	46.74%
Import - export	56	81.8	68.46%
Transit	56	103.5	54.11%
average	56	102.5	54.63%

Measurements and calculations performed by the Austrian Railways (OBB Holding) and the Austrian Federal Environmental Agency (UBA) confirmed the positive effects the traffic shift from road to the Ro-La trains. As examples, the specific CO_2 savings for every relation are depicted in figure no. 2.

Table 4: *Subsidies granted to the Ro-La trains [20, 25, 26, 27]*

Relation	Km in Austria / Km Total	Subsidies 2010 [€/vehicle]		Subsidies 2018 [€/vehicle]		Subsidies 2020 [€/vehicle]	
Brenner-Worgl	94	Day	90	Day	77	Day	76
	94	Night	45	Night	33	Night	33
Wörgl – Rocanfort (Trento)	96	90		Day	77	Day	76
	233			Night	33	Night	33
				Italy	33	Italy	33
Rocanfort (Trento) - Regensburg	73	90		Day	94	Day	94
	463			Night	47	Night	47
				Cancelled		Cancelled	
Wels - Maribor	325	75		77		77	
	341						
Salzburg – Fernetti (Trieste)	212	80		81		Cancelled	
	382	Italy	33	Italy	33		
Salzburg - Villach	180	70		Cancelled			
	180						
Wels - Szeged	293	70		Cancelled			
	648	Hungary 6 € / train-km, Max. 2500 €/train					
Basel - Lugano	312	3200 CHF/train + 170 CHF/truck		313 CHF/truck		Cancelled	
Novara - Freiburg	482			314 CHF/truck		227 CHF/truck (2019)	
Aiton - Orbassano	175	415.51		237		n/a	

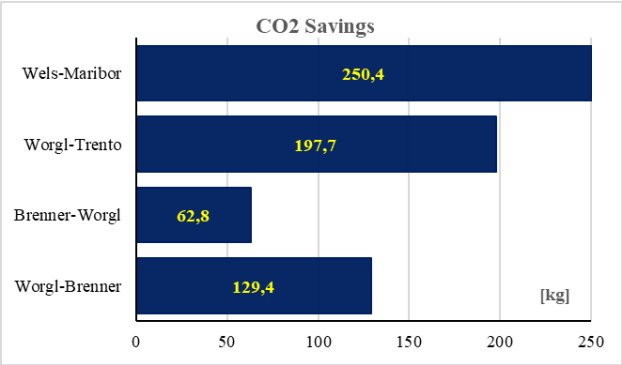

Figure 2: *CO_2 savings due to the Ro-La trains in Austria [21]*

Calculations based on information on a report published Swiss transport authorities indicates that, in 2016, the average cost of the Ro-La services was 836 CHF/truck. This means that the intensity of the state aid has been higher than 40% from the service cost [28].

According to the certificates issued by the intermodal transport operator Ralpin AG (organiser the Ro-La transports in Switzerland), to the interested customers, 'every trip on the rolling highway on the Freiburg – Novara relation results in the following savings: 299 kg of CO2, 0.8 kg of nitrogen oxide and 0.01 kg of fine dust'. As a consequence, every year, 30000 tonnes of CO_2 are saved [20].

On the Alpine Rolling Highway (Aiton–Orbassano), inaugurated in 2003, the traffic figures depict positive evolutions, as in the figure no. 1, but far from the expectations. The best clients for these services are the heavy lorries carrying dangerous goods for which the French Authorities forbid the passage through the Mont Blanc and Frejus Tunnel and have as alternatives longer road routes, on more than 700 km, via Vintimille.

Information in reports published by the General Inspectorate of Finances in 2005 and by the French Court of Accounts in 2018 allowed to calculate the service costs indicated below [3, 26, 27]:

- 1003,50 euro/truck, in 2005;
- 585,90 euro/truck, in 2015.

As these costs are related to only 175 km, the demand has been kept only through important subsidies (table no. 4), granted in equal parts by the French and Italian governments. At the start of the operations, the state aid intensities reached 85% from the total cost, then they decreased to 50 - 55% [3, 24, 26, 27].

On the other hand. estimations from 2015 and 2018 indicate that the traffic shift from road to rail would reduce the emissions of CO_2 with 5000 tonnes/year, respectively with 6400 tonnes/year [24]

The truck shuttle services through the Channel seem to be most successful example of rolling highway. In this case, the geographical conditions constitute a real driving force. Their competitors are the ferry lines that and slow and offer longer Channel crossing times and are influenced by the weather conditions. In September 2008, a fire seriously jeopardized the trust of the clients in truck shuttle services, fact reflected by the important traffic losses in the period 2008–2009, that were accentuated by the economic and financial crisis. However, in 2010, a remarkable recovery occurred. At the same time, the traffic seems to be not affected by the Brexit. In this case, neither French authorities nor British Government grant subsidies [9].

In the '1520 mm area', the performances are rather poor:

- 'Yaroslav' trains running from Lugansk / Kiev (Ukraine) to Slawkow (Poland) or vice versa carried, between 2003 and 2005, carried only 3200 trucks [22,29]. The service stopped in 2005, then it was restarted, in 2009, with 2 trains / week, for a short period.
- 'Viking' trains connecting Klapeida/Draugyste (Lithuania) and Illycevsk/Odessa (Ukraine) seem to be more oriented to the containers than to the trucks. In the period 2003 – 2008, they carried only 535 road vehicles.

In Russia, experiments were performed on several relations, but they were unsuccessful [30]. For the relation Moscow – Helsinki, estimations in 2013 indicate the following service costs [15]:

- For the accompanied combined transport (including the road legs, the terminal operations and the rail leg): 1340-1560 euro/truck;
- For road transport with Finnish driver: 1200–1400 euro/truck;
- For road transport with Russian driver: 800–1150 Euro/truck.

In India, the alternative name of Ro-Ro service is used. The first trains started to run over Konkan Railways in January 1999. Services are currently operated on the relations Kolad – Verna (415 km, covered in 12 hours), Kolad - Surathkal (712 km, covered in 20 hours), Verna -Surathkal (305 km, covered in 5 hours) and Ankola-Surathkal [14].

The Indian Ro-Ro services seem to be popular, because they really bring benefits to the truckers. Rail prices are lower than the road costs and transport times are much reduced in comparison with those specific to the pure road transport, allowing quicker delivery and better turnround cycles for the road vehicles.

The main findings and the learnings from the experience gained in more than 50 years by the companies involved in the rolling highways transport are [1, 5, 23, 31]:

1.Attractiveness could be increased only if the services provide real benefits to the potential customers. From this perspective:

a) Price is the most important criterion for choosing or rejecting the Ro-La service and must be lower than the cost of the road transport;
b) Transit time must be as lower as possible and cannot overcame the transit time specific to the road transport;
c) Quality (especially the punctuality) and the flexibility (especially regarding the check-in procedures) are also appreciated.

2.Without the support of the public authorities and implementation of appropriate policies and measures, the rolling highways cannot exist. Cease of the public subsidies and aids led to the cancellation of the services. Best examples are the trains running in domestic traffic in Germany, the trains between Lovosice (Czech Republic) and Dresden (Germany) and the trains Wels (Austria) – Szeged (Hungary).

3.Subsidies are not a warranty for the success and implementation of the rolling highways. A good example is the RoMoNet aiming to organize Ro-La trains between Regensburg (Germany) and Bucharest (Romania), which got financing of

2326132 euro for three years, through the European Marco Polo Programme, but no train ran.

4.In Western and Central Europe, as well as in India, the Ro-La services are organized according to the principles specific to the "shuttle" production system [18, 19, 20, 21]. On the other hand, the 'liner train' production system could be observed in the cases of the 'Yaroslav' and 'Viking' trains [22, 32].

5.Natural and geographical factors could influence in a positive way the traffic development.

6.Political factors always have important influences. Thus, in the case of the international services, services were cancelled in the years when new members joined the European Union This happened because the truck companies in these countries take benefits from the removal of the custom procedures at the borders with old members and from the liberalization of the road transport in the union, the transit permits becoming not necessary. Examples are the trains Lovosice–Dresden, Glogovăţ (Romania)–Wels (Austria) or Szeged (Hungary)– Ljubljana (Slovenia).

7.In the period of the economic and financial crisis started in 2008, many services were cancelled, or the train frequencies were reduced, due to the decrease of the trade volume. As example, we could mention the trains Szeged (Hungary)-Ljubljana (Slovenia).

8.Optimal distance for Ro-la trains seems to be 300-400 km. Distances longer than 1000 km corroborated with travel times of 18-20 hours are not attractive for the truck drivers.

9. Rolling highway could develop when the loading profile of the railway lines allows trucks with the height of 4 m.

10. On the successful routes in Austria and Switzerland, the average train capacity use has been 85 - 90%.

11. The road transport companies have to cope with the risk to see experimented drivers migrating to their competitors, if they impose the use of the Ro-la services. This happens when drivers' revenues are based on performances measured in kilometres recorded in driving processes.

12. Statistics reveals that the truckers from the new EU member countries are no more interested in accompanied combined transport, the actual users being from Western countries, respectively from Turkey and other non-EU states.

An important issue is that, in the countries members of the European Union, the subsidization programmes need, previously, the approval of the European Commission [24]. This one checks and analyses the compliance with the provisions in the European treaties, in the competition regulations and in the 'Community guidelines on State aid for railway undertakings', a communication imposing the maximal values for the aid intensities, as below [24]:

- 'for aid for rail infrastructure use, 30 % of the total cost of rail transport, up to 100 % of the eligible costs'. The notion of 'aid for rail infrastructure use' has an ambiguous definition and the Commission practice is to take into consideration the rail infrastructure use charges and the terminal fees.
- 'for aid for reducing external costs, 30 % of the total cost of rail transport, up to 50 % of the eligible costs';
- Higher intensities than those above, if the interested national or local authorities come with further justifications and after longer procedures.

The Austrian Government and Italian authorities in the regions Trento and Friuli-Venezia Giulia have kept the aid intensities at levels compliant with the standard intensities, even though the differences between the cost of the Ro-La services and the cost of the road transports are higher. On the other hand, the French and Italian Governments got approvals for intensities overcoming 30% from the total cost for the Alpine Rolling Highway [24].

Austria also provides an example for the fact that it is not possible to adopt any measure for the protection of the environment and supporting the rolling highways. A decision of the European Court of Justice that followed an infringement procedure initiated by the European Commission forced the authorities in this state to remove the bans imposed on the A12 motorway, in the Inn Valley (Tirol) for heavy vehicles carrying waste, stones, earth, logs, cork, ores, steel, marble, and ceramics.

All these facts indicate that the European competition rules could delay, break or jeopardise the programmes having the aim to shift the traffic from roads to other less polluting transport modes, including the Ro-La transport.

5. Ro-La services in Romania

In 1993, Romanian Railways organised in cooperation with the Bulgarian Railways the first rolling highway services, between the Romanian terminal Bucureşti Progresu and the Bulgarian one in Kapichan, using Bulgarian flat wagons in the series Rgs, modified in order to accommodate trucks. The respective Ro-La trains took benefit from the problems encountered at that time by the trucks at the passage of the Romanian – Bulgarian border. When these ones were solved, the interest for such services disappeared and the services were abandoned. Later, the two railways had a new attempt to organise Ro-la trains from Bradu de Sus to Kaspichan and vice versa, but the services were also cancelled after a short period [23].

Traffic volumes recorded in the relation Bucuresti Progresu-Kaspichan are presented in table no. 5.

Table 5: *Bucureşti Progresu – Kaspichan traffic volumes [23]*

Parameter	1993	1994
Number of trucks	1945	4515
Tonnes carried	73910	171000

In 1998, trains were put in circulation from Sopron (Hungary) to Glogovăţ. The project was unsuccessful, only 87 trucks being carried on this route.

Despite the wrong experience, but having as arguments the growth registered by the Ro-La services in Central European countries in the period 1995–2000, the limited number of transit permits given by the old members of the European Union to the Romanian road companies and the custom procedures at the Romanian-Hungarian border, the national freight railway operator purchased 160 Saadkkms wagons, representing an investment of USD 31.2 million, of which USD 12 million came from a loan given by European Bank for Reconstruction and Development. Services were organised as in the table no. 6 below.

Table 6: *Ro-La trains in Romania, in the period 2002–2006 [23]*

Relation	Distance [km]	Composition	Frequency [trains / week and direction]	Transit times
Glogovăţ - Wels	732	21/22 Saadkkms 1 cuchette car	initially 3 Maximum 12	18 h 41 min. –20 h 2 min.
Episcopia Bihor - Wels	713	21/22 Saadkkms 1 cuchette car	6	20 h

In time, the services recorded the performances in figure 3 [5, 23].

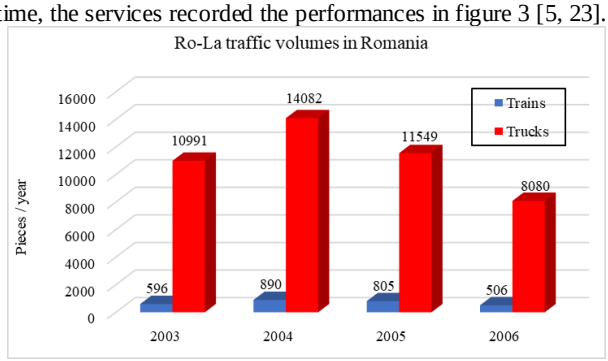

Figure 3: *Ro-La traffic volumes, in Romania*

Trains running from Glogovăţ to Wels had serious competitors in the services from Szeged to Wels, because the Szeged terminal is located at only 70 km from Romanian - Hungarian border and both services served the same market formed from Romanian, Bulgarian and Turkish trucks This fact lead, for a period, to the cancelation of the Szeged–Wels trains and to the provision by the Hungarian railway operator of traction services having poor quality for the trains from / to Romanian terminals.

Unfortunately, in 2007, after the accession of Romania and Bulgaria to the European Union, the phenomenon observed in the case of the Lovosice – Dresden trains also occurred in the case of the Ro–La trains from and to Glogovăț or Episcopia Bihor. Movement liberalisation for Romanian and Bulgarian trucks within the European Union, as well as the disappearance of the custom procedures at the Romanian – Hungarian border made the Ro-la services totally unattractive.

In fact, according to the statements in different publications, the Romanian road companies did not appreciate the Ro-la services. Romanian users of the services organised both in Romania and Hungary claimed that:

- Services were being inflexible, because the organisers had imposed the presence of the truck with 2 – 5 hours before the train departure and an eventual delay on the route or at loading was leading to the loss of the place in train and penalties;
- Transport duration were being very high in comparison with those recorded on roads and highways;
- Ro-La trains have registered important delays in comparison with the official timetable, producing losses to the road carriers;
- The restrictions imposed to the trucks have not brought benefits for the road companies, this fact also characterising the drivers' programme;
- On the Szeged – Wels route, taking into account the Diesel fuel consumption, the road transport was being even cheaper that the rolling road system by 50 – 75 euro /truck;
- Drivers have not appreciating the Ro-La system, because their revenues were depending on the distance covered on roads (minimal salary plus a supplement depending on their performances). This aspect generated, especially before the economic and financial crisis, the risk of migration of the experienced workforce to the competitors, having negative effects in services and performances of the road transport firms.

The national railway operator in Romania made efforts to revive the Ro-la traffic in Romania and performed experiments on 2 relations: Bucureşti Progresu – Glogovăț, in 2008, respectively Dornești – Episcopia Bihor, in 2018.

Taking into account the legal limit of 150 km imposed to the initial and final road legs, the Ro-la trains running between Bucureşti Progresu and Glogovăț could traffic from the relations:

- Bucharest to Arad region or vice versa ;
- Bucharest to Timişoara region or vice versa;
- Bucharest to Oradea region or vice versa;
- Giurgiu to Năd lac or vice versa, representing transit traffic.

For these trains, the figure no. 4 presents the comparison between the total costs specific to the accompanied combined transport and those related to the road transport. This costs have the status of "business secret", so that they could not be revealed.

In both cases, the analysis reveals the following aspects:

- There is a real demand that could be attracted by the Ro-La services if they come with real benefits for the truck companies.
- The infrastructure status in Romania generates transit times much greater than those on roads. For this reason, the possible customers claimed that the services did not bring them real benefits.
- Romanian authorities have developed un unfair policy materialised in a huge discrepancy between the rail infrastructure use charges and the tolls (price of the vignettes of 1200 euro/year, kept unchanged). For comparison, in Austria, the tolls related for the normal roads (not for Brenner motorway) are 41 times greater than the tolls in Romania (0.01 euro/km in Romania versus 0.41818 euro/km in 2021), while the Romanian rail infrastructure charge is higher than on Austrian railways (3.16 euro/train-km in Romania versus 2.44 euro/train-km, in Austria [33], in 2018, for trains with gross tonnage of 1000 tonnes).
- The operation of the Ro-La trains needs subsidies with intensities much higher than those in the European regulations.
- A hilarious fact is that the price of the Diesel Fuel paid by the rail carriers includes an excise that is partially used to finance the road maintenance.

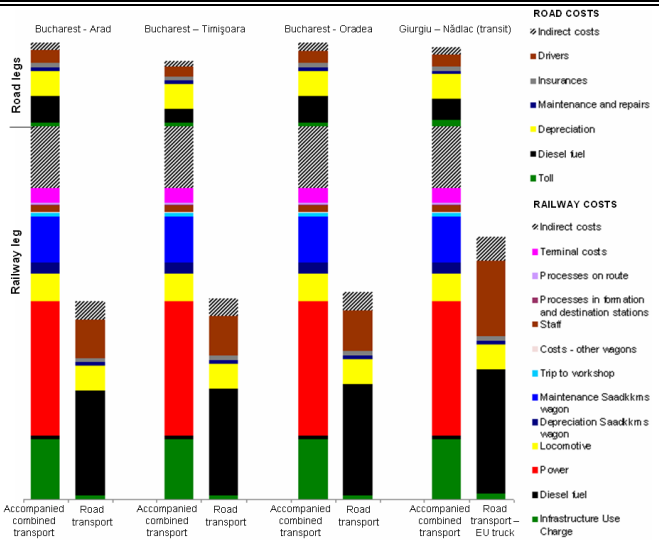

Fig. 4: *Comparison between the total costs in accompanied combined transport and road transport*

- The total deadweight generated by the tares of the road vehicles increase the operating cost of the Ro-La services.
- There is no exception or reduction from the full payment of the vignette price for the use of the rolling highway.
- There is no tax payment exception or reduction for road vehicles used in combined transport;
- There were limited ways to decrease the different railway cost articles. Thus:
  - Rail Infrastructure charges need political will for a structural change. According to the legislation into force, they must cover the maintenance and periodical repairs, as well as the cost for train planning and monitoring. A favourable approach could be the taxation at the level of the social marginal costs.
  - Fuel and power cost could be decreased if the locomotives in the fleet would be replaced with new ones, characterized by lower consumptions. Unfortunately, the market price of a modern locomotive is about 2.5 – 4 million euro, generating higher depreciations costs.
  - Wagon depreciation cost could be reduced to the half of the value included into the total cost only if their turnround cycle would be significantly improved through go and back trips in the same day. Taking into consideration the times spent in departure and arrival terminals (at least 3 hours), the goal will be achieved if the trains will be able to cover both distances in less than 9 hours. This also means that the commercial speed should increase from the actual value of 35 km/h to 70 km/h. Unfortunately, this cannot happen in the next years, because modernisation works are planned and performed only on the itinerary of the Bucuresti Progresu – Glogovaț trains, between Simeria and Arad.
  - Human resources are characterised by a high and costly specialisation, by different formation requirements for the different positions and by different salaries. At the same time, as proved in other countries and in the private sector, the same person could perform more tasks than in the actual job description specific for his / her position. Therefore, it is necessary to review the railway specialisations and the requirements for them, respectively to develop formation programmes according to the actual requirements on the transport market, so that the railway staff could be used in a more efficient manner.
- The development of the rolling highways is not sustained through traffic bans, as in Austria. Restrictions are imposed only on a limited number of road segments and for limited periods of time.

While the first experiment tested merely the technical and operational issues, the second one was also focused on the effects of different regulations on the market demand. Thus, the Ro-La train from Dornesti to Russe was organised in a context in which the

Environment Fund Administration initiated and launched, in 2017, a programme granting subsidies with the intensity of 60% from the total costs for rolling highways [34]. The respective programme came with a requirement imposing to the rail carriers to calculate, invoice and perceive from the road transport companies the value-added tax (VAT) at the level corresponding to the unsubsidised price. Obviously, the potential customers had negative reactions. Therefore, the Dornesti–Russe relation was seen as having potential to attract demand excepted from the payment of the VAT (VAT rate of 0%), respectively trucks running between countries that are not member of the European Union, in transit through Romania.

Initially, the intention was to load and unload the lorries on the wagons in the area of the Ukrainian border station Vadu Siret, but this idea was abandoned due to the legal framework for the performance of custom procedures at a EU border.

Consequently, in the final solution, the trucks entered in Romania through the road border point in Siret, ran on a distance of 16 km and rolled on the wagons in Dornești station. The trip between the border point and the loading station was not excepted from the payment of the toll, because the Romanian legislation does not allow this. In Bulgaria, the lorries rolled off in a terminal in the Port of Russe, then they had to go to the Road Border Point for checks, weighting and recording in the computer system of the Bulgarian Road administration.

The main finding from the experiment is that the implementation of support measures must always come with a strong coordination with all entities that could have influences in the customers' behaviour and with amendments favourable to the rolling highways in the regulations related to the fiscality, road use charging and custom procedures.

On the other hand, Ro-La trains generate savings of the emissions of air pollutants, reductions of the external costs and decrease of the road congestion. The savings of the emissions of greenhouse gases are results of the analyses done on a Tank-to-Wheels (TTW) and Well-to-Wheels (WTW) basis, with the EcoTransIT software tool (compliant with the European Standard EN 16258:2012). On the other hand, the reductions of the external costs were calculated using the methodology developed for the EU Marco Polo Programme.

The values of the different parameters specific the the experimental trains are presented in the Table no. 7.

Table 7: *Parameters specifics to the experimental trains [23, 34]*

Parameter	**București Progresu - Glogovăț**	**Dornești - Giurgiu Nord fr. (Russse)**
Experiment Date	28/07/2008	27/07/2018
Route	București Progresu - Chiajna-Craiova-Filiași -Livezeni-Simeria Triaj-Glogovăț	Dornești-Suceava-Adjud-Buzău-Ploiești Est-Chitila-Chiajna-Videle-Giurgiu Nord Fr.
Alternative road route	București-Pitești-Ramnicu Vâlcea-Sibiu-Deva-Arad	Siret-Suceava-Adjud-Bacau-Buzău-Urziceni-București-Jilava-Giurgiu
Distance on Diesel traction	23 km	103 km
Distance on electrical traction	588 km	482 km
Total Distance	611 km	585 km (RO) + 12 km (BG)
Distance on alternative road route	545 km	565 km (RO)
Train composition	21 Saadkkms + 1 couchette car	20 Saadkkms + 1 couchette car
No. of trucks	19	19
Transit time on rail	16 hours and 40 minutes	16 hours
Transit time on alternative road route	10-12 hours	10-11 hours
Rail infrastructure use charge	113 €/truck	97 €/truck
Road toll	6.05 euro/km 11 euro/day	11 euro/day
Deadweight	247 tonnes	247 tonnes
Increase of the infrastructure use charge due to the deadweight	+2.5%	+1.9%
Increase of the Diesel fuel consumption due to the deadweght	+18,5%	+12.63%
Increase of the power consumption due to the deadweght	+11.2%	+12.76%
Neccesary State aid intensity	50-55%	60%
Reduction of CO_2	WTW	6570 t/year	7734.3 t/year
	TTW	8395 t/year	7373.00 t/year
Reduction of emissions of NO_x	WTW	20440 kg/year	18490.90 kg/year
	TTW	19710 kg/year	15914.00 kg/year
Reduction of emissions of SO_2	WTW	-9490 kg/year	-3759.50 kg/year
	TTW	55,48 kg/year	54.02 kg/year
Reduction of emissions of Non-methane hydro carbons	WTW	2920 kg/year	2365.20 kg/year
	TTW	0 kg/year	-175.20 kg/year
Reduction of emissions of particulate matters	WTW	-803 kg/year	-206.59 kg/year
	TTW	219 kg/year	109.50 kg/year
Reduction of the external cost, of which		4007575.90 €/year	3812965.20 €/year
• Air pollution		2322662.90 €/year	2145470.00 €/year
• Climate changes		1147268.00 €/year	1260038.40 €/year
• Noise		208619.40 €/year	123282.40 €/year
• Accidents		-65189.00 €/year	-228724.60 €/year
• Traffic congestion		394214.60 €/year	512898.00 €/year

6. Conclusions

The best characterisation of the rolling highway system is given in the prestigious Encyclopaedia Britannica, respectively a "costly intermodal technology". If the trends and evolutions in Central and Eastern Europe or on the Alpine Rolling Highway are taken into account, the Ro-La services prove to be controversial solutions, being simultaneous:

a) Very attractive for the environmental activists and for the large public not involved in transport;
b) Popular for many public authorities;
c) Costly and inefficient for the traditional railway operators;
d) Not interesting for the new entrants on the rail freight transport market;
e) At least indifferent for the road transport firms;
f) Unpopular for the truck drivers.

Despite that the rolling highways come with interesting technical solutions that could contribute to the sustainable development of the society, their commercialization and progress are possible only if the road transport companies would really benefit from their implementation. Otherwise, it is utopic to think that the road carriers would prove civic attitude, taking into consideration the scarf competition on the transport market.

Attractiveness of the Ro-la services could be increase through:

- Financial support (direct grants) for operations;
- Financial support for construction for construction or / and

development of terminals and for purchasing of equipment (specialised wagons, trucks, computer systems, etc.);

- Fiscal measures (excepting from the payment or reducing the different taxes and charges);
- Policy regarding the charging for the use of the rail infrastructure, respectively for the use of roads;
- Introduction of circulation bans for heavy road vehicles;
- Severe limiting the number of the transit permits for heavy road vehicles registered in countries that are not members of the European Union;
- Bonuses for the use of the Ro-la services;
- Recognition of the time spent in Ro-la trains as rest time for the drivers;
- Internalization of the external costs.

Consequently, actions for amending and updating the provision of the European regulations (especially those in 'Community guidelines on State aid for railway undertakings') and national legislation in many countries become a necessity.

Moreover, a 'must' seem to be a debate in connection with the competition principles and rules, so that these one would not embarrass or delay the implementation of different policies and programmes of sustainable development, for which the rolling highway represent a real solution.

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Laser Induced Breakdown Spectroscopy technique for detection of trace elements in Particulate Matter emitted from in-use Diesel engine passenger vehicles

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Abstract: *The particulate matter (PM) and soot emissions generated from Diesel combustion engine driven vehicles are forming significant sources of toxic and metallic nanoparticles into the air and surrounding atmosphere in heavily traffic areas or locations. Previously, we reported that particulate matter from in-use Diesel engine passenger vehicles are chemically composed of major and minor chemical elements with different concentration. Here, we apply laser induced breakdown spectroscopy (LIBS) technique for qualitative comparative study of trace chemical elements adsorbed in different PM and soot matrices. The adsorption of these chemical elements in generated PM exhaust emissions occurs due to the complex combustion processes. The main responsible sources are: injected fuel type (Diesel, Biodiesel), fuel quality, fuel additives, engine lubricants, engine combustion process, incomplete catalytic reaction, inefficient PM filtering devices, engine failure or polluted intake air. All these factors as well as current engine state alter final chemical composition of particulate matter generated from in-use Diesel engine passenger vehicles -exhaust emissions.*

Keywords*: PARTICULATE MATTER; DIESEL EXHAUST PARTICLES; SOOT; CARBON EMISSIONS; CARBON; POLLUTANT EMISSIONS; IN-USE VEHICLES; VEHICLE EMISSIONS; EXHAUST EMISSIONS; EMISSION STANDARDS; METALLIC NANOPARTICLES; TRACE METALS; TRACE ELEMENTS; TRACE EMISSION*

1. Introduction

The vehicle's exhaust emissions are forming major sources of toxic gases as well as particulate matter (PM) including metallic nanoparticles and pollutants into the environment and surrounding air atmosphere [1,2]. Most of these emissions are from Diesel engine driven vehicles either passengers, light-duty or heavy-duty Diesel engines. For human being and his health it is extremely important to inhale pure, non-polluted air. Non-contaminated air is consequential for proper function of our lung, respiratory function or cardio-vascular system, as well as for the brain and central nervous system [3,4]. After regular and long term exposure to Particulate Matter emissions, accumulation of nanoparticles in our body can cause the pulmonary disease, lung infection, pneumonia, asthma, cardiovascular diseases as well as neurological and mental diseases [5,6].

Current existing European emission standards [7] for diesel-engine driven vehicles specify the maximum allowable values for hydrocarbons, carbon monoxide, nitrogen oxides, Particulate Matter (PM) with certain diameter ($PM_{2.5}$ and PM_{10} sizes in μm) and Particulate Number (PN) from exhaust emissions. However, these emission standards do not concern any additional compounds or chemical elements contain in PM or in the soot emissions formed by in-use Diesel engine vehicles. Nevertheless, chemical elements adsorbed by carbonous particles present significant fraction of Diesel Particulate Matter (DPM) or soot emission contents. Since PM emissions from vehicles are considered as dominant source of air pollution in urban areas and in the cities with heavy traffic; therefore accurate in-situ technique for on-line / off-line measurement of PM / DPM and its chemical composition from automotive exhaust emissions would be desirable [8].

From our previous research, where we apply Laser Induced Breakdown Spectroscopy (LIBS) method to investigated DPM from in-use Diesel engine passenger vehicles, strong optical emission were observed from major spectral lines, mainly from Carbon, Iron, Magnesium, Aluminium, Chromium, Zinc, Sodium, Calcium and others. These elements were identified as major components of Diesel Particulate Matter [9]. Beside the major elements of DPM, in Diesel Particulate Matter are also present minor chemical elements, particularly: Silicon, Nickel, Titan, Potassium, Strontium, Molybdenium and others. Different concentrations of detected minor elements were measured with respect to the type of complex particulate matter, this topic is further discussed in [10]. The main goal of this research is to spectrochemically by means of LIBS method analyse and identify trace chemical elements adsorbed in Diesel Particulate matrix.

2. Methodology

Laser induced breakdown spectroscopy (LIBS) technique [11-13] is an analytical spectrochemical measurement technique [14] which can be use for rapid qualitative [15] as well as for sensitive quantitative [16] compositional characterisation of different forms of materials: solids [17], liquids [18], gases [19], powders [20] or nanoparticles [21]. In LIBS technique, high power laser radiation, with nanosecond or shorter pulse duration, is interacting with the investigating material. Short pulse laser radiation is focused into the studied material and generate the plasma. Optical emission spectrum from plasma is collected by the optical spectrometer into the ICCD detector and processed by PC. From LIBS spectra, it is possible to obtain chemical composition of the examined sample. In this research we apply laser - plasma spectroscopy technique for the measurement of trace chemical elements in PM emitted from exhaust emissions generated from in-use Diesel engine passenger vehicles. We use the high resolution LIBS technique for diagnostics of soot and Particulate Matter (PM). Here we analysed soot and PM, extracted from exhaust manifold part, from different passenger vehicles, that are use in daily life environment. The main aim of this study is to qualitatively analyse trace chemical elements in different PM matrices.

3. Experimental procedure

Laser induced breakdown (plasma) was generated by the Nd:YAG (Neodymium doped Yttrium Aluminum Garnet) solid state laser, model Yasmin, from Quantel, France. This laser is emitting laser radiation at fundamental wavelength 1064 nm with 8.5 ns pulse duration. In this research we apply laser pulses with 300 mJ energy per single pulse. The emerging laser radiation has been focused with 10 cm focusing lens into the plane solid target surface to create a laser plasma. Optical emission from plasma has been collected perpendicularly via optical telescope into the high resolution Echelle spectrograph model Aryelle Butterfly from LTB Berlin, Germany. Spectrograph is equipped with sensitive Intensified Charge Coupled Device (ICCD) detector PI-Max 4 from Princeton Instruments, USA. A layout of experimental Laser Induced breakdown Spectroscopy - LIBS setup for DPM measurement is shown in Fig. 1. This spectrometer consists of two separate spectrographs, one part for UV spectrum and second part for VIS spectrum of electromagnetic radiation. The UV part is from 190 nm to 440 nm and the VIS part is for the optical spectrum from 440 nm to 800 nm. Spectral resolution is from 3 picometres to 7

picometres (pm) for VUV part and from 4 pm to 8 pm for VIS part. Thus this Echelle spectrograph provide spectral information in broad spectral range and with very high spectral resolution. Optical emission from laser - plasma has been collected from VUV as well as from VIS parts, therefore the total spectral window from 190 nm to 800 nm wavelength has been recorded. The delay time of 1 μs after the trigger signal and gate width of 2 μs was used. The LIBS emission was measured in open air atmosphere at atmospheric pressure and at room temperature.

Sample preparation and collection

Different PM samples from in-use Diesel engine passenger vehicles of major brand car producers in Europe have been analysed by LIBS. Particulate matter has been collected from the tail pipe at the end of the exhaust manifold, while selections of in-use vehicles were performed randomly. More than seventy different samples from vehicles were collected and analysed by LIBS. The collected particulate matter from Diesel engine passenger vehicles - exhaust manifold has been mechanically pressed into small pellets with flat disc shape profile. Laser induced breakdown spectroscopy signal from DPM shows spectral lines that are characteristic in ultraviolet and visible spectral region. Each measured spectrum has been accumulated from twelve laser shots and averaged on ICCD detector.

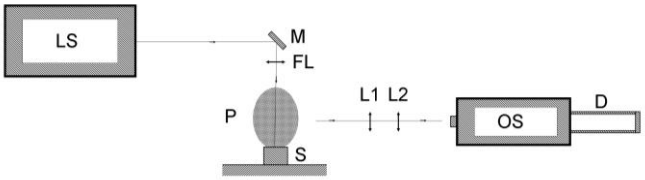

Fig. 1 *Layout of the Laser Induced Breakdown Spectroscopy experimental setup. LS - laser source (Nd:YAG laser, Yasmin, Quantel, France), M - Mirror, P - plasma, S - sample, FL - focusing lens, L1 and L2 - optical telescope, OS - optical spectrometer (Aryelle Butterfly, Echelle spectrograph, LTB Berlin, Germany), D - ICCD detector (PI-Max 4, Princeton Instruments, USA).*

4. Results and discussion

Characteristic Laser Induced Breakdown Spectroscopy signal obtained from Diesel Particulate Matter matrix is shown in Fig. 2. LIBS spectra measured from Diesel particulate matter collected from in-use Diesel engine passenger vehicles exhibits characteristic peaks, optical spectral lines with specific atomic, ionic and molecular transitions in the signal. Strong optical emission signal is appearing from major spectral lines, particularly from Carbon, Iron, Magnesium, Aluminium, Chromium, Zinc, Sodium and Calcium. However, also minor chemical elements like Silicon, Nickel, Titan, Potassium, Strontium, Molybdenium lines are present. In this research we focus our attention to identification of trace chemical elements in the Diesel Particulate Matter from in-use Diesel powered engine vehicles.

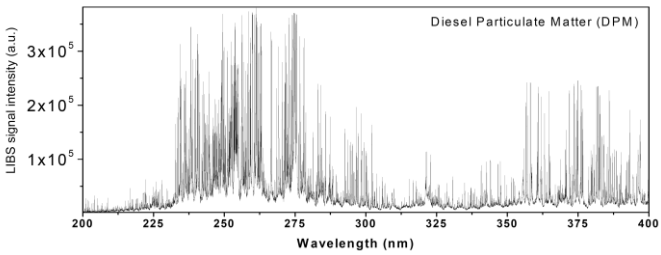

Fig. 2 *Optical emission LIBS spectra from Diesel particulate matter sample. Spectrum contains major, minor and trace elements spectra patterns. Intense spectral lines are from major components: Carbon, Iron, Magnesium, Aluminium, Chromium, Zinc, Sodium and Calcium.*

Trace elements of Diesel Particulate Matter

To identify the trace elements in various DPM matrices the LIBS setup was optimised for optical detection, to obtain high quality spectral data. Acquired LIBS signals show optical emissions from trace elements like: Barium, Boron, Cobalt, Copper, Phosphorus, Manganese and Platinum with high resolution. From LIBS spectra it is possible to obtain the analyte signal emitted at certain wavelength, with specific line peak intensity, line peak shape, and line peak width, different for each DPM sample. The intensity strength and profile of particular atomic or ionic line is basically proportional to the concentration of analyte in the studied material. To obtain qualitative comparison of DPM samples we numerically calculated the responded LIBS spectral line signal, the integral value of peak area for each spectral line of interest, using background correction and spectral line fitting procedure. In this way we could obtained the peak area information related to individual atomic / ionic spectral emission from corresponding chemical elements adsorbed in different types of Diesel particulate matter matrix. Results from LIBS measurements are shown in Fig. 3 (a-g), while results from numerical calculations are shown in Fig. 4 (a-g).

Identification of trace elements in various DPM matrices:

Ionic emission from Barium spectral line (Ba II @ 455.40 nm) is shown in the Fig. 3(a). In this figure a raw, not filtered spectral data from LIBS measurements are shown. Here we select only six different Diesel particulate matter samples with most pronounced Barium signal. Selected samples with Barium ionic line are samples with number # 61, 4, 51, 26, 41 and 60. Barium signal have been measured in 26 samples, from 67 different DPM, see Fig. 4(a).

In Fig. 3(b) measured atomic emission from Boron doublet spectra line (B I @ 208.88 nm and B I @ 208.95 nm) are shown. Here we selected six different samples with line emission from Boron, where the LIBS signal is clearly visible. The comparison of calculated integral peak values is shown in Fig. 4(b). Samples with high content of Boron are #4, 2, 22, 30, 15 and 64. Boron is in DPM present as trace element in 27 different samples.

Optical emission from Cobalt spectral line (Co II @ 228.61 nm) is shown in Fig. 3(c). Here, the relatively higher content of Cobalt were measured in samples #54, 12, 57, 56, 65, 64, 67 and 55. From numerical calculation of Co II spectral line, signal from cobalt emission was measured in 14 different DPM matrices, as shown in Fig. 4(c).

Copper is shown in Fig. 3(d), as ionic spectral line (Cu II @ 224.70 nm) in ultraviolet spectral range. High content were measured in sample #44, 12, 59, 20, 5, 41, 37 and 28. The comparison of calculated integral values are shown in Fig. 4(d). Copper is present in 62 different samples.

Signal from Phosphorus spectral line measured from six DPM samples are shown in Fig. 3(e). Phosphorus ionic line (P II @ 221.03 nm), is present in UV spectral range. Compared results from numerical calculation are shown in Fig. 4(e). Phosphorus trace element has been measured in 26 different DPM samples. Relatively strong LIBS signal from phosphorus trace element is in sample #44, 12, 4, 5, 34 and 20.

Atomic emission from Manganese triplet (Mn I @ 403.07 nm, Mn I @ 403.30 nm and Mn I @ 403.44 nm) is shown in Fig. 3(f). From this spectral graph it is possible to observe content of manganese in samples #12, 4, 55, 59, 34 and 67. Manganese trace element has been measured in 18 different DPM and comparison of integral values are shown in Fig. 4(f).

Atomic emission from Platinum spectral line is shown in Fig. 3(g). Here, the spectral line (Pt I @ 203.24 nm) from eight different DPM samples is clearly visible. Platinum as the trace element were measured in 30 different samples. While most intense signal were recorded from samples # 12, 55, 59, 58, 34, 20, 27, 64.

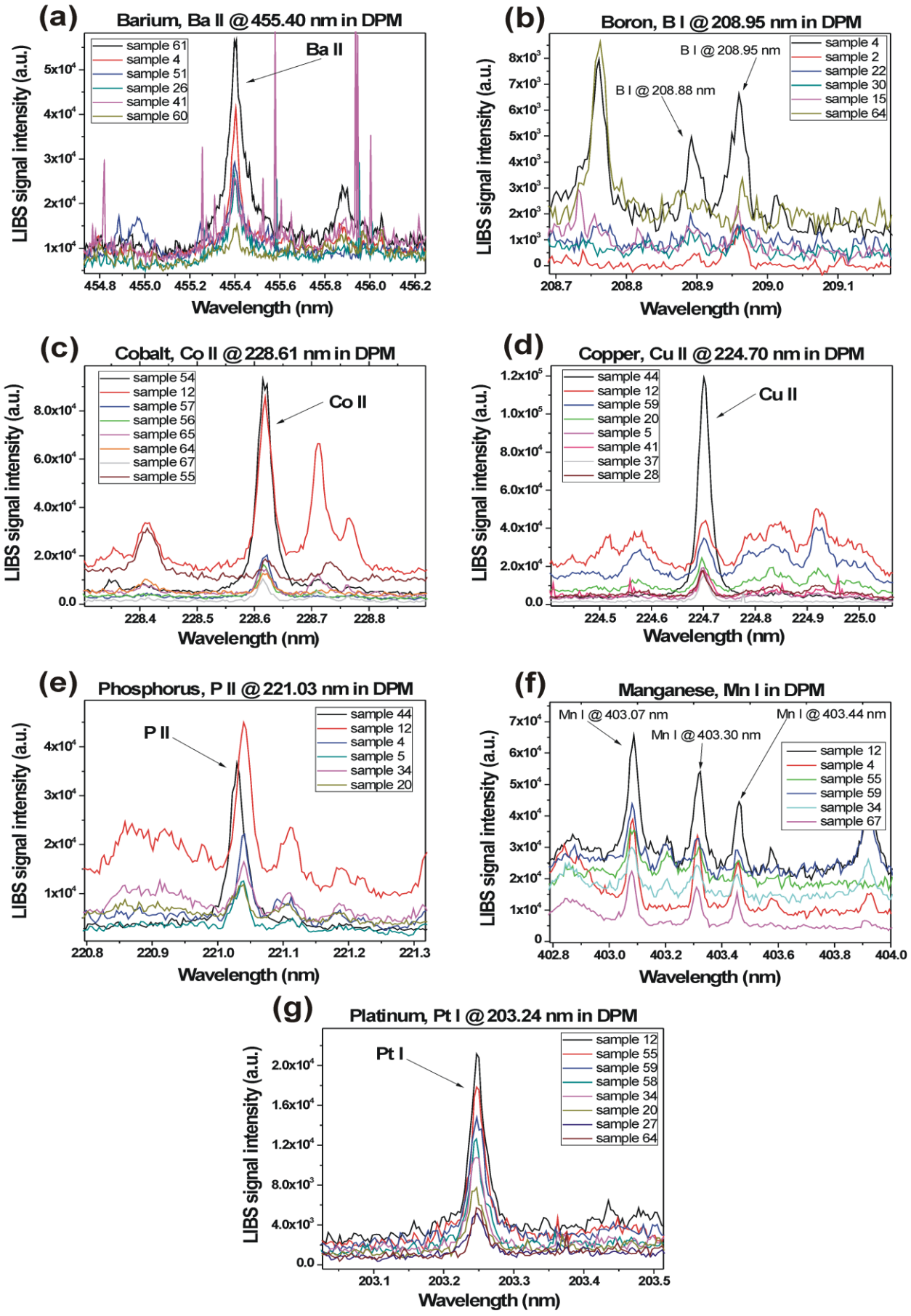

Fig. 3 *Optical emission spectra from: Barium (a), Boron (b), Cobalt (c), Copper (d), Phosphorus (e), Manganese (f) and Platinum (g), measured by high resolution LIBS technique from Diesel particulate matter collected from in-use Diesel engine passenger vehicles.*

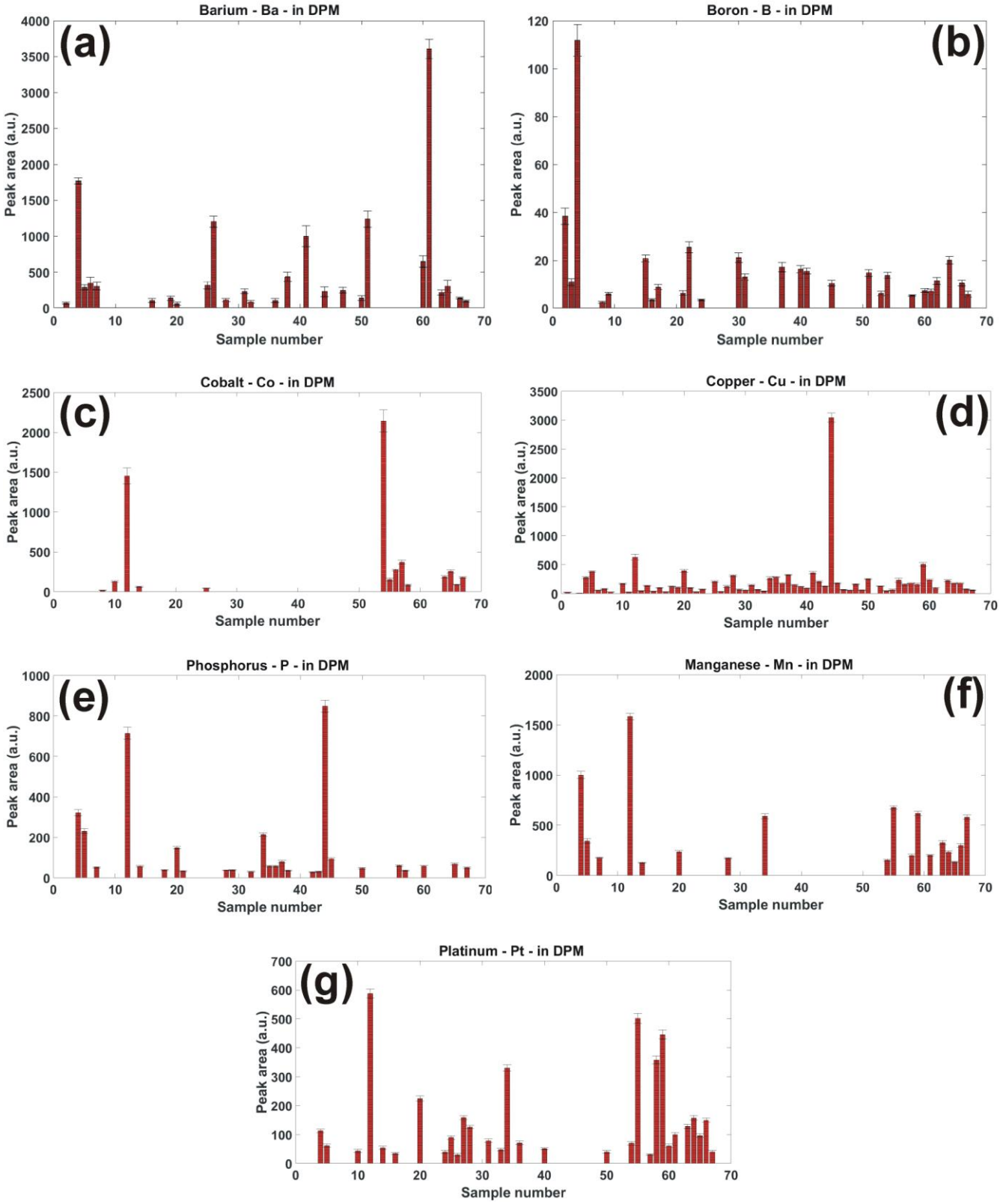

Fig. 4 *Comparison of calculated integral values from LIBS optical emissions spectrum of : Barium (a), Boron (b), Cobalt (c), Copper (d), Phosphorus (e), Manganese (f) and Platinum (g) trace chemical elements in Diesel Particulate Matter.*

In Table 1 are summarised measured analytes, the spectral atomic or ionic lines used for analytical LIBS measurements and number of samples where the trace chemical element has been successfully detected.

Table 1: *Spectral lines used for analytical measurements and number of samples with detected trace element.*

Analyte	Spectral line	Wavelength (nm)	Detected in / total number of samples
Ba	Ba II	455.40	26 / 67
B	B I	208.95	27 / 67
Co	Co II	226.61	14 / 67
Cu	Cu II	224.70	62 / 67
P	P II	221.03	26 / 67
Mn	Mn I	403.07	18 / 67
Pt	Pt I	203.24	30 / 67

5. Conclusions

In this research, we have investigated the trace chemical elements agglomerated in Diesel Particulate Matter. Different particulate matter samples were collected from in-use Diesel engine passenger vehicles randomly, from different models. Particulate Matter has been analysed spectrochemicaly by means of a high resolution laser induced breakdown spectroscopy - LIBS analytical technique. The qualitative LIBS measurements revealed the presence of trace chemical elements, in particular: Barium, Boron, Cobalt, Copper, Phosphorus, Manganese and Platinum. These elements are in DPM adsorbed with different concentration. From these analytical measurements we can conclude that laser induced breakdown spectroscopy technique is very powerful method for qualitative characterisation of DPM. It can almost instantly measure major, minor as well as trace chemical elements adsorbed in DPM. LIBS technique is capable to examine Diesel Particulate Matter with high sensitivity and spectral resolution and thus obtain spectrochemical information about the chemical composition of different DPM matrices.

In the previous research we have characterised DPM by means of LIBS technique, where we qualitatively and quantitatively analysed major chemical elements contained in the DPM matrices. Major elements were identified as C, Fe, Mg, Al, Cr, Zn, Na, Ca and others [9] and minor chemical elements as: Si, Ni, Ti, K, Sr, Mo and others [10]. We have find out, that all these chemical elements are forming significant content of Diesel particulate matter composition. All these major, minor and trace chemical elements adsorbed in particulate matter are contributing to overall composition of exhaust emissions from in-use Diesel engine passenger vehicles.

The agglomeration of these chemical elements in PM exhaust emissions occurs due to the complex combustion processes. Mainly responsible sources of these chemical elements are: injected fuel type (Diesel, Biodiesel), fuel quality, fuel additives, engine lubricants, engine combustion process, incomplete catalytic reaction, inefficient PM filtering devices, engine failure or contaminated intake air. All these processes as well as current engine state modify the actual exhaust emissions and final chemical composition of particulate matter from in-use Diesel engine passenger vehicles. Up to now, it is not distinct which of these sources are mostly influencing the actual composition of DPM. Therefore in the future, it would be important to identify these sources for precise monitoring of major, minor and trace chemical elements in Diesel particulate matter. This knowledge would serve to better understand the chemical composition and processes behind the formation of Diesel Particulate Matter and Diesel exhaust emissions. And finally, it can contribute to minimise unwanted pollutants from in-use Diesel engine vehicles.

Acknowledgements

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Analysis of the freight transport interport construction inTirana-Durrës region (FTITD).

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Abstract: *The crowning of the historic aspirations of European integration, means that the Tirana-Durrës region should be able to compete as equal with other regions in Europe. So, on the one hand, the opportunities for its economic development will increase, but on the other hand, competition will intensify with other regions. This will require economic sophistication in the Tirana - Durres area, which will also be a challenge for the next decade. On the road to becoming one of the Balkans Hub, among the main objectives remain: improving infrastructure and mobility in the Region, increased competition, improving the quality of life, protection and rational utilization of natural resources. Although competitive advantage at national level has been enormous compared to other regions, at the Balkan and European levels, this advantage is lesser and controversial. Consequently, it is necessary to create a platform on which it is based development and increase the competitiveness with the regions around our country. Seeing that road networks have heavy traffic, other modes of transport and their coordination need to take on a growing role. An efficient policy in this regard would be the construction of a Freight Transport Interport, with a contemporary logistics and integrated with Intelligent Transport Systems[1]. This would be a new junction in the supply chain and would provide a solution to transport systems, developing in full harmony the interaction of Road, Rail and Maritime Transport infrastructure. In addition to the study of the respective legal framework that would support the planned interventions for the realization of ITMTD, this paper presents the results of the SWOT analysis as a recognized way of identifying, comparing and evaluating the advantages, weaknesses, opportunities and risks of a project.*
Keywords*: INTERPORT, HUB, SUPPLY CHAIN, INTELLIGENT TRANSPORT SYSTEMS, SWOT ANALYSIS.*

1. Introduction

Building an Interport is a wide-ranging operation with significant socio-economic effects in the life of a Region[2]. Especially when it comes to the Tirana-Durrës region, which represents nearly one third of the number of businesses operating in Albania and the residency of about 34% of the population. Among other advantages, its construction will avoid:

- Increasing the number of blockages in road transport,
- Increasing environmental pollution;
- Increasing overall transport costs;
- Increasing the total costs of industrial production;
- Increasing the de-industrialization process;
- Reducing the competitiveness of the industrial sector.

From this point of view, ITMTD would be a very good opportunity to connect to Corridor X, VIII and the EGNATIA Highway, which would further establish a link with the entire European Transport Network, (Fig. 1).



Fig.1 *General structure of the design algorithm of the traffic light regulation*

The Durrës, Vlora and Shengjin Cities Development Plans (WB Project) have developed the idea of building miniInterports, to increase the efficiency of using existing ports.
Therefore, based on these development plans, it may be recommended to build an FTI [3], (according to the European concept of "Industrial Intermodal Transport Freight Parks").

As we will see below, this could be in an area of the Region (near "Mother Teresa" International Airport) near Kamza. It could be incorporated into the Master Plan of Albanian Governments for Albania's return to the Hub for Transport in the Balkans and Southeast Europe (Fig. 2).

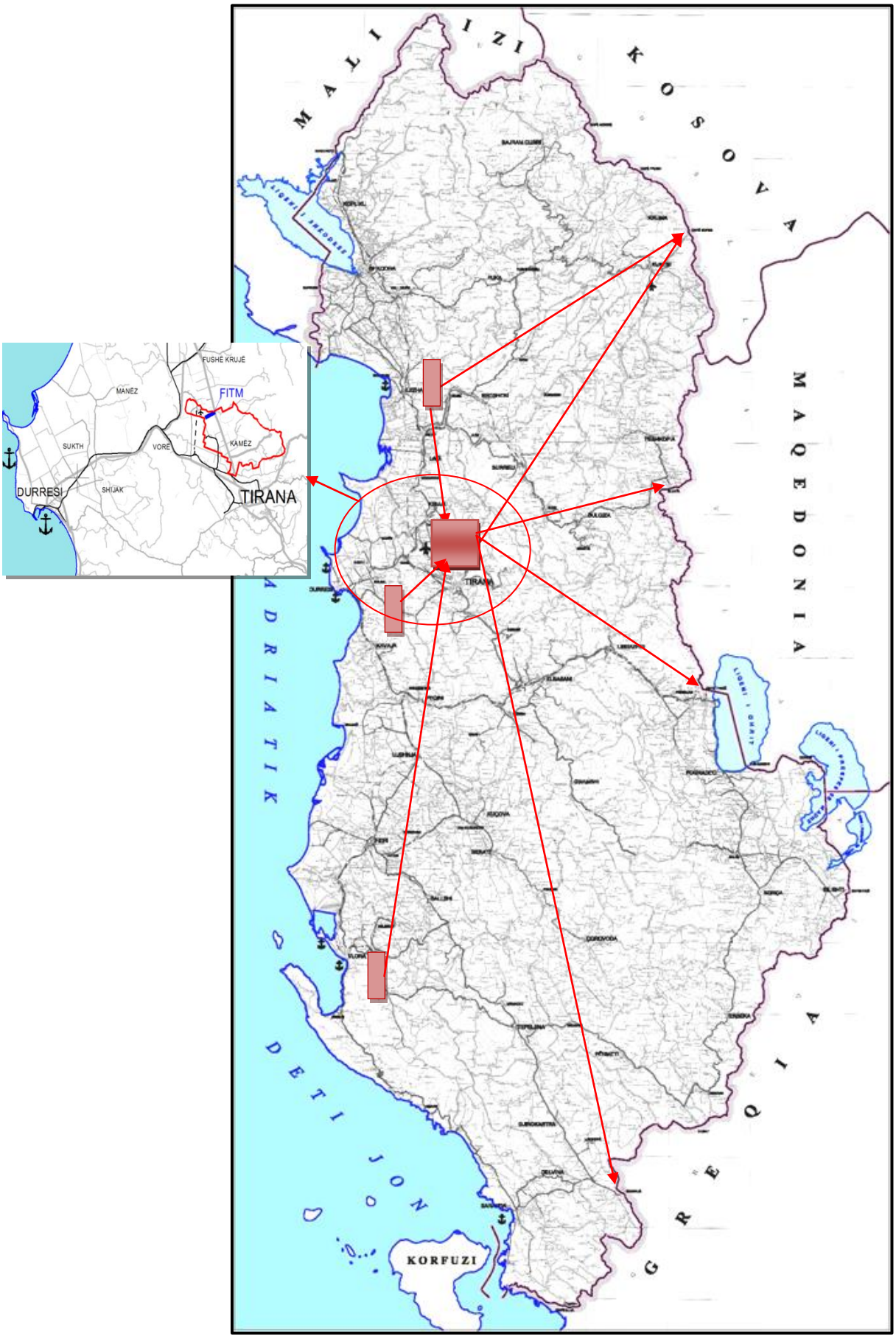

Fig.2*MiniInterports connection with FTI*

2. *Advantages of FTITD as a logistical*

Located in an area near the airport, in the northern part of Kamza (Figures 3, 4), Interport would have the ability to connect quickly and easily to:

- The central road network of Albania through "Kamza Ring";
- North-South corridor (Hani i Hotit- Kakavijë);
- Kosovo, through the Durrës-Kukës-Morinë corridor;
- "Arber Street" with North Macedonia;
- National Rail Network;
- "Mother Teresa" airport;
- The Kamza ring, and via Tirana ring road, will connect to Tirana - Elbasan road as part of Corridor VIII.

On the other hand, the construction of this FTI would serve as an intermodal logistic platform and it:

- Will increase storage capacity (containers) of Durrës port and improve the possibilities of transporting freights from and to Tirana;
- will improve the local economy and generate employment in the area;
- will be a logistic platform in the metropolitan area of Tirana and along Corridor VIII, including intermodal infrastructure to increase cross-border cooperation;
- will develop freight transport by rail lines thereby reducing the blocking of roads;
- will promote initiatives for the transport of freights without causing environmental pollution;
- will support the development of logistics initiatives for the urban distribution of goods;
- will integrate and optimize the use of infrastructure for the carriage of goods and passengers, including the development of innovative technologies such as Intelligent Transport Systems, to increase safety and efficiency.

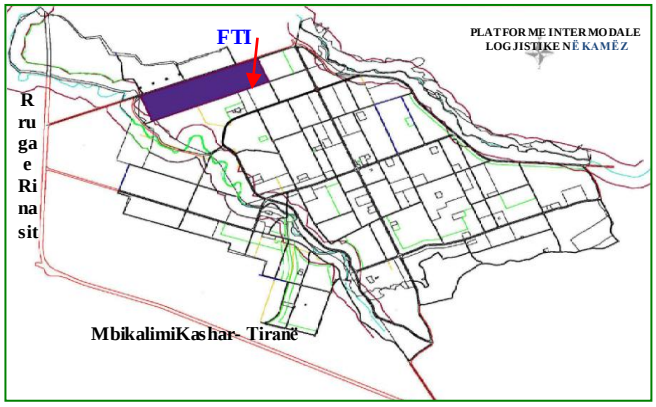

Fig.3 *FTIPlanning*

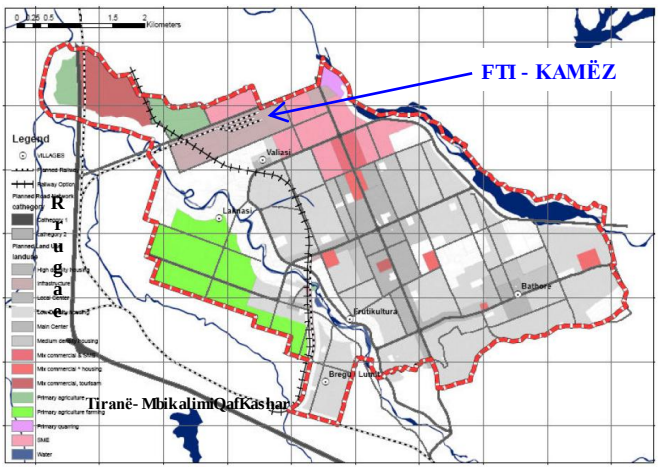

Fig.4 *FTIconnection map with the rail line*

3. *FTI Infrastructure and Services*

Freight Transport Interport, as a large-scale enterprise, will have a complex infrastructure and will provide a wide range of services[4].

Infrastructure:

- Warehouses for road-rail exchange (Fig. 5);
- Large and medium warehouses for handling, packaging and classification of goods;
- Special warehouses for storing frozen and fresh food;
- Creation of a modern ITS control center with the use of modern technologies to provide, control and monitor containers and goods via satellite GPS devices;

Services:

- District Customs along with veterinary laboratories and services for inspection and health control;
- ITS along with Post Office / Public Telephony / Bus Service;
- Parking areas (beside this platform is predicted a "Parc and ride" area);
- Loading and unloading technologic equipment;
- Supply Station and Washing Equipment for Vehicles.
- All the necessary services for the comfortable stay of the operators, (bar, restaurant, internet, etc).

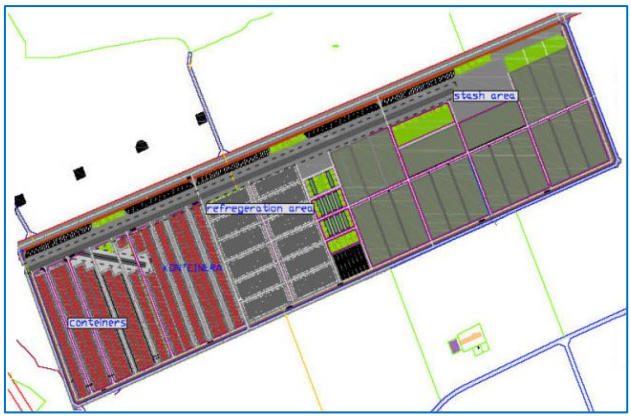

Fig.5*FTI-s infrastructure*

4. *FTI Infrastructure and Services*

Logistic centers in which operations of transferring goods are carried out in planned interventions should be supported by the respective legal framework and financial means. They are intended to realize the interoperability and freedom of movement in Europe throughout its network.

In our country there is generally no legal framework in this area. Over the last 20 years, the National Transport Plan has been drafted and upgraded twice, with International Assistance, but almost nothing is provided in this plan for the Industrial Freight Interportions.

For this reason, it is imperative that, taking advantage of the best European experience, work on the drafting of Albanian legislation in this field, by accepting European norms as reference norms.

5. *FTI Infrastructure and Services*

At the end of this paper, let's look at the results of the SWOT analysis (Strengths, Weaknesses, Opportunity and Threats Analysis), a known way of identifying, comparing and evaluating the advantages, weaknesses, opportunities and risks of a project [5].

Strengths

- There is a National Transport Plan;
- Development of the Tirana-Durres Region is a national priority;
- All classic modes of transport are carried out in the region: road, sea, rail, air;
- There is basic transport infrastructure: the most important port of Albania-Durres, Rinas International Airport, Tirana-Durres railway, good road network;
- Increase processing capacity and quality of services at Rinas Airport and Port of Durres;
- The intersection of the two most important national corridors: North-South and East-West;
- Connecting of these corridors to Pan-European transport corridors;
- Increasing Mobility in the Region;
- Increase private sector participation in all modes of transport;
- Expanding interurban and urban bus lines;
- Large number of shipping and land transport companies.

Weaknesses

- Lack of a Regional Transport Plan and Authority to implement;
- The unsatisfactory management of urban traffic and signaling;
- The poor state of rural and urban roads and their maintenance;
- Lack of parking spaces in the second row;
- Partial absence of pedestrian and bicycle routes for bikers;
- The inefficiency of cargo carriers with trucks, vans and trucks;
- Low standards of road safety, relatively large number of accidents, medium level pedestrian running skills, pedestrians in vehicle passageways;
- Limited access of rural areas to public transport;
- Education at low levels with the rules of road traffic;
- Small number of modes of transport exchanges;
- High degree of environmental pollution from old and heavy vehicles;
- High and unnecessary heavy equipment in urban areas.

Opportunitys

- Better combination of types of transport (road, sea, rail, air);
- Improvement of links between the main elements of transport: port-rail, airport-highway;
- Improve traffic management at all levels;
- Introducing transport plans into new urban plans;
- Realization of high-speed public transport between Tirana and Durres and between them of the Rinas Airport;
- Improve public transport at all levels;
- Removal of unnecessary heavy equipment from urban areas;
- Motor vehicle insurance policies to consider the extent of environmental pollution and the encouragement of more ecological means and ways;
- Trainings on traffic management and road safety;
- Better combination of modes of transport;
- Improvement of financial management of public transport (price-subsidization);
- Increase private business participation in transport investments;
- Use of Intelligent Transport Systems to coordinate different modes of transport.

Threats

- Increasing the number of traffic jams;
- Lack of plans and their implementation;
- increase the number of vehicles by about 30% per year;
- Insufficient parking;
- Failure to improve safety, reduce accidents, fuel quality, pollution levels (health costs);
- Failure to improve the road network;
- Failure to improve public transport (in quantity and quality), abandonment of rail transport;
- Investments in transport may not be in line with development plans;
- Increase the number of unnecessary heavy vehicles in urban areas.

6. Conclusions.

Based on the above, in conclusion, we can list some of the key factors for successful transport development in the Region:

- Improving public transport between cities and municipalities, particularly the high-speed lines Tirana-Durres-Aeroport.
- Discouraging the use of heavy vehicles that increase environmental pollution.
- Reducing the road network by shortening the main internal and external lines and relocating heavy vehicles traffic outside urban areas.
- Better integration of traffic management by improving the utilization of existing transport networks by introducing Intelligent Transport Systems technologies.
- Improving road safety and community education related to it.
- Improvement of urban parking.
- Improving road maintenance.
- Improving the links between different modes of transport.
- Improvement of rural roads.

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Prospects for utilizng natural gas as fuel in small-capacity maritime transport assets

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Abstract: *Normally, maritime, air and surface transport assets powered by internal combustion engines are the major sources of chemical, biological and physical pollution of the environment. In the meantime, oil shortage and world oil prices are rising every year, which raises questions on the use of alternative energy sources that are not fossil fuels.*
At the present time, natural gas as one of the types of fuel is widely and successfully used in surface transport owing to the availability of their sufficient reserves and good thermophysical characteristics. The article deals with the prospects for natural gas production in the sea and the possibilities of utilizing its energy source in small-capacity marine and river transport equipment in both diesel-cycle and directly converted to natural gas-powered diesel engines.
KEY WORDS: *DIESEL ENJINE, HIDROGEN SYLFIDE, METHANE, MEMBRANE TECHNOLOGY.*

1. Introduction

At the present time, the energy-environmental parameters of the internal combustion engines of vehicles depend to a great extent on fuel type used, because the maritime, air and surface transport assets that are the consumers of oil obtained from oil processing are the major sources of chemical, biological and physical pollution of the environment. In the meantime, oil shortage and world oil prices are rising every year, which raises questions on the use of alternative energy sources that are not fuels obtained from oil processing.

An important direction for the development of maritime transport is increasing fuel efficiency, energy efficiency and environmental safety of its energy equipment. Typically, these parameters in internal combustion engines are determined by the organization of the work process and the type and composition of fuel used. Therefore, it is important to convert the energy equipment of small-capacity naval vessels to the gas-diesel cycle or directly to the natural gas cycle.

1. Preconditions and means for resolving the problem

Depending on primary raw materials, alternative fuels are of various types, of which at the present stage natural gas, as one of the forms of fuel, is widely and successfully used in road transport, which is due to its reserves and good thermophysical characteristics. In particular, the use of this type of fuel has the following advantages:

- High-octane rating allows to increase the degree of compression, which increases the capacity and saves fuel;
- Toxicity and acoustic performance of combustion products are reduced, which significantly improves the state of the environment;
- It is possible to use the principle of quality regulation, which allows us to increase fuel efficiency;

The significant amount of methane in the deep waters of the Black Sea leads to an increase in the percentage of its use as an alternative energy source in transport power equipment, since natural gas (CHn) is more environmentally friendly than traditional fuel, because carbon mass fraction is 74 ÷ 75%, while the same indicator for gasoline is 85,6% and for diesel fuel - 86%, which leads to a decrease in the CO and CO_2 concentrations in combustion products.

The question arises: how can methane be obtained from the deep-sea waters? To solve this problem, we used the method of membrane separation of the gaseous mixtures based on the use of porous, non-porous and composite selective-penetrating membranes. The advantages of the membrane separation processes are continuity, low energy consumption, process control, and compatibility with other separation processes. At present, importance among the various methods of cleaning the gaseous systems, the adsorption methods are becoming increasingly important, as they provide practically complete capture of waste and cleaning of several components simultaneously.

- High-octane rating ensures efficient and fault-free performance of gas diesel at high compression degree. It should be noted that in this case smoke opacity is reduced by 2-3 times (which is typical for diesels) and almost no soot particles are formed;
- It is possible to convert diesel directly to compressed natural gas. From an environmental perspective, such an engine is more efficient than the base diesel and gas diesel variants, because no solid particles are produced in the form of soot and the smoke opacity is reduced to zero;
- The degree of wear of the piston cylinder parts decreases and the service life of the oil increases.

Thus, natural gas as an energy source can be successfully used in small-capacity maritime and river transport, as well as in gas-diesel cycle power equipment and diesel converted directly to natural gas.

The question is: why have we brought this problem to the forefront and conducted studies?

Georgia is known to be a country with limited reserves of fuel and energy resources, but the energy potential of the Black Sea can be widely used in transport energy equipment and primarily in low-capacity maritime transport.

Hydrogen sulfide and methane existing in the deep waters of the Black Sea attracted the attention of scientists immediately after their discovery as a virtually inexhaustible raw material for the production of alternative energy and with a view to addressing the lack of fuel and energy raw materials.

One of the main problems in determining the environmental status of the Black Sea today is the presence of methane and hydrogen sulfide in the lower water layers, the content of which is increasing every year due to pollution. Studies conducted at the end of the last century revealed that the main source of methane dissolved in water (75%) is the shallow (700 m) sedimentary volcanic layers, where the existing thermobaric conditions are favorable for the formation of solid methane carbohydrates, which decompose with an increase in sea-water with emission of large quantities of methane.

To extract a mixture of hydrogen sulfide, methane and other components from the deep waters of the Black Sea, a technological scheme of the device was developed, which is designed to ensure the processes of separation the gaseous mixtures extracted from the depths of the sea, as well as their decomposition through the use of the membrane technologies and sorption methods. In particular, in our case, the membrane-zeolite module for methane adsorption was studied.

The study revealed that methane practically does not adsorb on undried zeolites, but the study of methane adsorption was carried out on locally produced pre-dried natural clinoptilolite and synthetic zeolites of Khekordzula (CaA, cationite KY-2-8) modified with Ni. The experiment studied the adsorption rate of CH_4 on zeolites with

dependence on the delay time (Fig. 1).

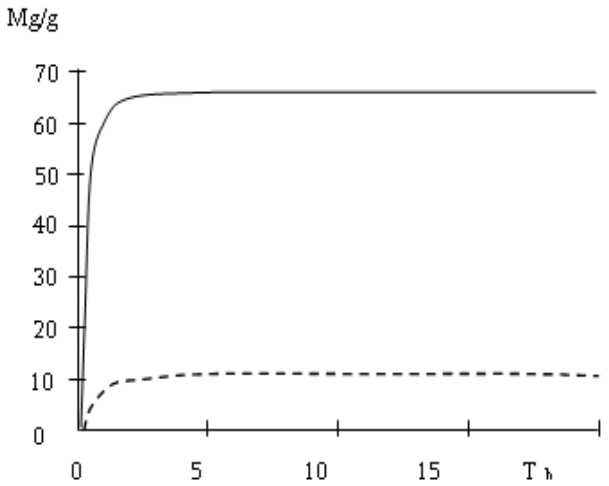

Fig. 1. *The adsorption rate of CH_4 on zeolites.*
---------- CaA
- - - - modified with Ni.

The study revealed that synthetic zeolite CaA is characterized by high adsorption capacity towards methane. Productivity of Khekordzula's zeolite modified with Ni is much smaller, while methane KY-2-8 is not adsorbed at all on cationite, although the rate of adsorption in both cases is almost not dependent on the delay time, that is, natural zeolites and synthetic CaA can be used as highly-efficient adsorbents towards CH_4 in the deep waters of the Black Sea.

In the case of gas diesel, it differs from the base engine in terms of both the mixture production and mixture ignition. In particular, in this type of engine, the mixture of air and fuel gas is compressed, the self-ignition of which at the end of the compression is not carried out due to the high self-heating temperature of natural gas (680-750 ^{0}C) and the so-called "ignition dose" of diesel fuel (the diesel fuel self-ignition temperature – 320^0 – 380 ^{0}C) is used to generate a combustion source at the end of the compression. In modern engines, the value of the ignition dose is 15-20% of fuel cyclic supply of the base diesel engine and depends on the load mode. In this type of engines, the fuel mixture is prepared and delivered to the cylinder in the fuel supply system of gas-powered vehicle, while the ignition dose of diesel fuel is injected at the end of the compression from the base diesel nozzle. In our case, the study covers a four-stroke two-cylinder diesel engine (9.5 / 11) with combustion chamber in the piston. The data of the pilot studies for both base diesel and gas-diesel cycle engines in nominal conditions are given in Table 1, while Figure 1 illustrates the external service indicators.

Table 1. *Characteristics of the diesel and gas-diesel engines operating cycle*

Characteristics	Type of engine	
	Gas-diesel	Diesel
Effective power, kW	9,78	10,1
Mean effective pressure, MPa	0,486	0,502
Effective torque, n.m.	58,6	60,2
Diesel fuel consumption per hour, kg/h	0,651	2,322
Gaseous fuel consumption per hour, kg/h	0,409	-
Diesel fuel effective consumption, g/kWh	0,74	225
Gaseous fuel effective consumption, g/kWh	46,5	-

2. Conclusion

Studies have demonstrated that the effective power and torque of the gas-diesel and its base diesel engines are practically are substantially the same. However, in the case of diesel engine, the cost-effectiveness of diesel fuel is reduced by almost 3 times. It should be also noted that the gasoline-diesel engine has better environmental performance than the base engine. In particular, smokiness of combustion products decreases by 2-3 times and the noise level - by 3-8 dB. At the same time the reduction in carbon oxides and hydrocarbons is observed in the combustion products, but nitrogen oxides are increased. Studies in this direction are ongoing on the engine operating in load mode. Work is underway to convert the diesel engine directly to natural compressed gas. This type of engine is an engine operating by carburation and forced ignition that is more economically and environmentally efficient than the base diesel and gas-diesel engines.

The next stage of the research involves exploring the possibilities of using methane as an energy source in the low-power gas-diesel-cycle engines, as well as in the diesel engines directly converted to natural gas.

Based on the results of the conducted studies, we can implement in practice the conversion of the small-power diesel engines to natural gas, which will allow us to successfully use methane extracted from the Black Sea basin as fuel in small cargo ships. This will contribute to the creation of small-capacity ports within the country's territorial sea and further intensification of small and medium-sized businesses.

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