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# The Influence of Modern Technical Systems in Vehicles on Road Safety

**Ljubo Glamočić**
Graduate Mechanical Engineer, Pan- European University Apeiron, Faculty of Traffic Engineering, 13 Vojvode Pere Krece Street, 78000 Banja Luka, Republic of Srpska, e-mail: ljubo.v.glamocic@apeiron-edu.eu

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**Abstract:** A vehicle is a very complex technical system with several aspects. The basic purpose of each motor vehicle, is its primary goal to ensure the safety of the vehicle and, therefore, the safety of all traffic users. In order to achieve the basic goal, in the latest motor vehicle engineer development, during the development itself to the ultimate serial production, considerable attention is paid to the development and improvement of technical systems that help and improve vehicle management, and improve the control of the dynamic movement of vehicles. The ABS system (Anti-lock Braking System) is a precursor to the development of these systems, based on which a whole spectrum of active management systems has been developed. There is an overview of positive impacts of some system on the vehicle safety. Influence of the system of the active safety of traffic is presented through the correlative interaction between the number of traffic accidents with light bodily injuries, number of the light injured persons and number of vehicles possessing ABS and/or ESP system and number of traffic accidents and their consequences in the Republic of Srpska. The results showed that there is a strong correlation between the number of traffic accidents with light bodily injuries, number of light bodily injuries and number of vehicles possessing ABS and/or ESP system. Furthermore, the results showed that the increase of number of the registered vehicles increases the percentage of vehicles possessing the mentioned systems. Safety of vehicles is a very important factor of the traffic safety. Decrease of the average age of the fleet contributes to the great extent to the decrease of a number of the traffic accidents and their consequences.

**Keywords:** road safety, systems of active and passive road safety, modern devices for controlling of dynamic movement of vehicles, ABS, ESP.

## INTRODUCTION

The vehicle is one of the basic factor of the road safety. The importance of the vehicle as an important factor of the road safety is becoming more and more prominent due to the increase of number of vehicles. At the same time, this fact implies the obligation that this factor given even more attention. There are basic measures for improvement of safety in terms of movement of motor vehicles on the roads. Drivers and other persons responsible for proper operation of the vehicles on the road must neither manage the vehicles nor order any other person to do it, which is not in a technically proper condition or which does not meet the requirements prescribed for participation in the traffic.

There has been a sudden increase of number and complexity of the electronic systems in vehicles for the last four decades. Share of electronics in the today's vehicles is even 25% of the total generation price. Analysts estimate that more than 80% of innovations in the vehicle industry are based on the electronic systems (DEKRA, 2017). However, for the purposes of systematic survey of the traffic safety, it is most important to find understanding of complex interactions between man, vehicle and road (lanes, namely surrounding). Interactions of man-road-lane (surrounding) are very important both for safety and traffic management as well as for the design of traffic roads and vehicles. Threat to the traffic safety and occurrence of traffic accidents result from the false behavior of the users, namely, the sub-system of traffic, as a complex social-technical system. The ideas of the information technologies were joined with the method of traffic safety control on the vehicle (sensors, mechanical elements, sets,) and central processing units which regulate the correction of mistakes caused due to different reasons during the vehicle movement. ((Tešić i dr. 2012).

The surveys (Elvik and Vaa, 2004; WHO, 2004; WHO, 2009) point out the importance of the constructive characteristics of vehicles, as one of segments for improvement of the traffic safety condition. Namely, that is the reason to have the procedures for assessment of the vehicle safety characteristics introduced worldwide, in a form of a so-called NCAP tests (New Car Assessment Program), known as the "crash" tests. The surveys

showed that vehicles which have better grade at the Euro NCAP tests lead to 30% less deaths and severe injuries ( (Lie and Tingvall, 2000). Technically proper condition of vehicles has an important role in the system of the traffic safety. Considerable influence on this segment of the traffic safety can be carried out through the reinforced inspection control of work of the stations in charge of technical examination of vehicles. The surveys (Hakkert et al., 2007) show that the death risk in vehicles which are more than 30 years old is more than ten times compared to new vehicles. The reasons for these results are actually in the protection equipment systems of vehicles. Pešić (2012) analyzed the average age of the fleet of the USA. The regression analysis showed that indicators of "average age of the fleet" and "number of the persons who died in the traffic accidents are in so-called "negatively strong relation" (r= -.851, r= 0.01). This dependence is not expected with the increase of the average age of the fleet, the number of traffic accidents is reduced, but if the term "compensation of the risk" is taken into account, then, on the other side, the results are more than realistic.

### Active safety of vehicles

Active safety of vehicles is, first of all, related to all prevention measures, which the constructor of the vehicle should include even in the vehicle design phase, and which are related to the system of driver – vehicle – road – surrounding, in order to avoid the conflict situations. The measures which belong to this group are: finding possibilities for timely noticing and reacting in relation to other traffic users (pedestrians, traffic structures, other vehicles) and limit of information which the driver can timely and concurrently *receive*, everything from the aspects to remove the risks of traffic accidents. Electronic elements in the vehicle, contributing to avoidance of the conflict situations are, inter alia:

- efficiency and reliability of the braking and controlling system of the vehicle;
- decrease and removal of inappropriate conditions in the vehicle (driving comfort, noise, oscillations, winding and air-conditioning, inappropriate layout of the control panel and ergometric factors);
- automatic communication between vehicles (*Vehicle to Vehicle – V2V*) and communication between the vehicle and traffic infrastructure (*Vehicle to Infrastructure- V2I*).

Active safety of vehicles is defined through possibilities to manage, reliably and with as much control as possible, the motor vehicle and accordingly avoid conflict situations on the road. Systems for automatic regulation of the vehicles' movement contain the devices which, with the minimized actions of drivers, enable proper maintenance and stability of the vehicles' movement, regardless of the road conditions. The intense technological development is obvious when it is about these systems, but the influence of drivers is still not possible to be eliminated. Accordingly, the basic function of such systems is actually the support for the driver, which provides him with a possibility to anticipate but also relatively later to react whereby maintaining the stable movement of vehicles.

Passive traffic safety aims at reducing consequences of the traffic accidents. When the traffic accident happens, it is reasonable to ask questions how to reduce the consequences, how to reduce the number of those injured, how to reduce the weight of suffering and reduce material damage. Today, in the world, there are a lot of generators of vehicles. With each of those generators, the element abundance of active and passive safety is different, being conditioned by the regulations and standards of the generator's country, level of development of generation, tradition of generation, etc.

### Brakes

One of the basic systems on the vehicle which considerably affects the safety of the traffic users and which belong to the scope of active safety is the braking system. The role of this system is to provide, in a controlled and stable way, the vehicle with fulfillment of the following conditions such as: 1) deceleration in order to reduce the speed; 2) prevention of the movement when parking; 3) braking when moving along the slope. The braking system in a physical sense is achieved by friction, which transforms the vehicle movement energy to the heat energy. The method of exploitation and safe realization of great exploitation speeds depends on capability of the efficient, safe and stable deceleration of the motor vehicle. For the above mentioned reasons, the braking characteristics are considered to be very important element of dynamic features of the vehicle. The braking process itself is realized through the braking system and other systems of the motor vehicle actively participate in it, first of all the cycles with pneumatics as well as the support system. The braking system has a great impact on the whole traffic safety and that is why the braking system is one of the first and most detailed standardized systems with the motor vehicles, within the international framework. All systems of active, as well as of passive safety are mutually amended and added. Each of them is made with the aim to save as many people as possible. Looking from different aspects, without modern technology and new systems, the safety level in traffic would be significantly less and it is necessary to further pay attention to development and improvement of active systems for the vehicle safety in order to achieve as good communication between the vehicle-driver-surrounding as possible.

### Contemporary electronic systems for control of the dynamic behavior of the vehicle

Increase of the traffic safety is ensured by applying the systems which increase the braking efficiency and

contribute to better stability of the vehicle, such as ABS, BAS, ESP and ASR systems. With sudden development of the information technologies, the serial generation of electronic system for control of the vehicle stability when braking, was initiated. The first such system, based on which the whole range of products was developed, within the vehicle behavior control is the Anti-lock Braking System – ABS, often called the Anti-block system. The system itself was previously applied in the aviation especially on big planes. Further development of the information technologies and decrease of prices, the whole range of other systems which improve dynamic behavior of vehicles, based on the ABS system, was achieved, such as:

- control of ETS operation,
- slipping control with acceleration ASR,
- stability control ESC, ESP
- automatic blockage of differential ALD and
- electronic division of the braking force EBD;

In the next part of the document, there will be basic characteristics and method of functioning of the most applied contemporary systems, and it is about ABS and ESP systems.

***Anti-lock Braking System ABS***

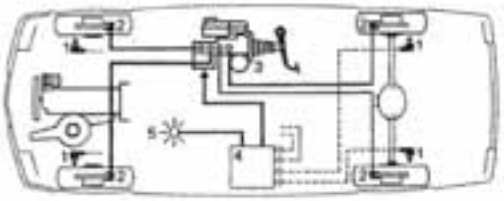
The basic idea, on which functioning and operation of the anti-lock braking system is based, for application with the motor vehicles was the intention to develop the system which will be adapted to the driver' behavior while braking. In some situations in the traffic, it often happens that even very experienced drivers urgently and in a panic brake because of other traffic users. Such reaction is particularly expressed with the non-experienced drivers, which normally, results in blockage of cycles and loss of the control over the vehicle.

The main goal, while developing this system, was to prevent the blockage of cycles and keep the possibility of realization of the side forces on the cycles, which would enable the control also in cases when the braking control has been activated by the excessive force, accordingly resulting in a higher level of safety. It comes out from this that the basic advantage of the vehicle with ABS system is that it can, even apart from the maximum braking avoid unfavorable contacts with maneuver and can also strongly brake even with the too fast turning. The results obtained testing and assessing confirm the assumption that ABS is particularly efficient and useful on the bases with the reduced adhesion. So, for example, when testing on the wet concrete, when the vehicle moves at the speed of 140 km/h, the vehicle without ABS has the braking path of 181 m, while the braking path of the same vehicle, equipped with the ABS, under the same conditions, is 112 m which is for about 40% shorter path of stopping. The speed of the vehicle movement which does not possess ABS, in the moment when the vehicle with ABS stopped, is 86 km/h (www.dekra.de).

From the mentioned results, considerable significance of this system with the motor vehicles is visible as well as its possibility to correct the human mistakes, but it can help in no way if the driver does not take care of the conditions of the road and traffic. Unlike the standard braking system where the braking forces are regulated according to the previously defined law, anti-lock braking systems operate in a way that they follow and detect deceleration of each cycle separately, immediately turn its brake off and turn them on again when the cycle starts turning. With the last generation of these systems, the brakes release before the complete cycle blockage, regulating the pressure at the turning on again in order to provide for maximum utilization of the cohesion coefficient.

Basic elements of ABS are:

- sensors for the turning speed of cycles;
- control device (computer) and
- electric magnetic valves;



1. Sensor of number of turns
2. Braking cylinder on cycles
3. Hydro generator with the main braking cylinder
4. EUJ- (CPU)
5. Signal lamp

**Figure 1.** Anti-block braking system (ABS)

***System for control of stability - ESP***

This system permanently analyzes behavior of vehicles according to the estimated intentions of driver, in order to immediately react and correct each behavior which deviates from the desired and which might cause the loss of control over the vehicle. The system selectively applies, precisely and independently, the controlled braking pressure on each cycle of the front and/or back axis, and if necessary, electronically reduces the engine motor. EPS system was developed on the basis of ABS, whereby there was extension with sensors which detects 150 times in a second, information about the turning angle of the controlling cycles, vehicle turning around the vertical axis as well as about the side acceleration and based on those data, it determines deviation from the desired optimum path and defines the required correction. The correction is carried out through the ABS subsystem, system for control of ETS operation and system for electronic division of EBD braking forces. Apart from maneuverability of ESP, it automatically stables the vehicle in different situations in driving, particularly in a badly estimated curve, at the sudden local changes of adhesion and during sudden maneuvers of avoidance.

## METHODOLOGY

According to the available data (taken from the database of the Ministry of Interior of the Republic of Srpska, Ministry of traffic and communications and Audiotex – ltd.) on the registered motor vehicles in the Republic of Srpska for the period from 2012 to 2017, there was a permanent increase of a number of the registered vehicles (this term is meant by the vehicles which passed the regular technical examination of vehicles). So in 2012, total number of the registered vehicles in the Republic of Srpska was 298,270 vehicles and in 2017 it was 366,890 vehicles which is the increase of about 23%. In this number of totally registered vehicles, the group of motor vehicles M1, M2, M3 is dominant, thenH1, H2, H3 lorries, as well as the terminal vehicle O4 equipped with ABS and ESP systems (Table 1.).

**Table 1.** Structure of the fleet in the Republic of Srpska from the aspect of the registered vehicles and vehicles which possess ABS and/or ESP in the period from 2012 to 2016

| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|
| Total number of the registered vehicles in the Republic of Srpska | 298.270 | 312.361 | 320.889 | 328.271 | 342.884 | 377.076 |
| Number of vehicles with ABS and/or ESP systems | 108.010 | 130.473 | 151.956 | 171.781 | 194.738 | 239.256 |
| % vehicles with ABS and/or ESP systems compared to the total number of the registered vehicles | 36.21 % | 41.76% | 47.35% | 52.32% | 56.79% | 63.45% |

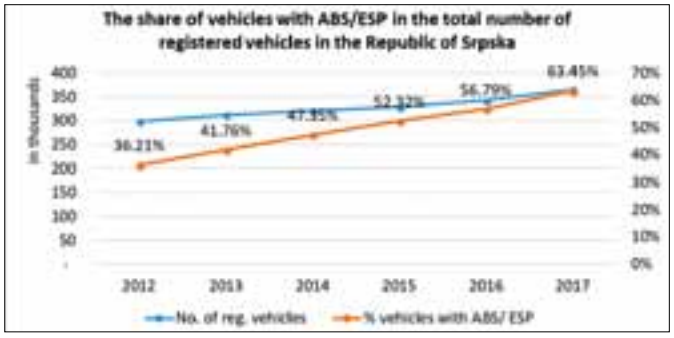



**Figure 2.** Trend of increase of vehicles with ABS and/or ESP systems (in %) and number of the registered vehicles in the Republic of Srpska

In the Figure 2, trend of increase of number of the registered vehicles in the Republic of Srpska for the period of five years can be noticed. However, it is interesting to notice that a share of vehicles which are equipped with ABS or/or ESP has been constantly growing for about 5 and more % annually which considerably affects the traffic safety in the Republic of Srpska (63.45% in 2017). This is particularly important to mention when it is known that the factor Vehicle affects with 13% in occurrence of the traffic accidents (Figure 3).

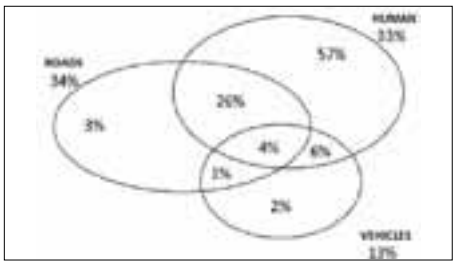



**Figure 3.** Traffic safety factors as causes of the traffic accidents (PIARC, 2003)

In the Table 2, there is a structure of the traffic accidents and their consequences in the Republic of Srpska in the period from 2011 to 2017. Analyzing these data, it is clear that at the national level there is no firmly established system of the traffic safety.

**Table 2.** Structure of the traffic accidents and their consequences in the Republic of Srpska in the period from 2011 to 2017

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|
| Number of traffic accidents | 9378 | 8441 | 8589 | 8581 | 9295 | 9783 | 9637 |
| a) with killed persons | 150 | 130 | 146 | 123 | 135 | 121 | 103 |
| b) with heavily injured persons | 577 | 541 | 498 | 534 | 599 | 577 | 550 |
| c) with lightly injured persons | 1526 | 1312 | 1470 | 1505 | 1662 | 1741 | 1591 |
| d) with material damage | 7125 | 6458 | 6475 | 6419 | 6899 | 7344 | 7393 |
| Persons affected | 3382 | 2961 | 3093 | 3155 | 3631 | 3711 | 3301 |
| a) Killed persons | 163 | 140 | 153 | 131 | 150 | 130 | 115 |
| b) Severely injured persons | 702 | 651 | 607 | 632 | 745 | 703 | 646 |
| c) Lightly injured persons | 2517 | 2169 | 2333 | 2392 | 2736 | 2878 | 2540 |

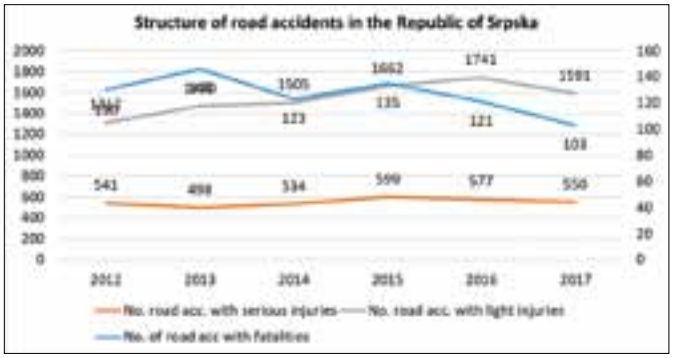



**Figure 4.** Structure of the traffic accidents in the Republic of Srpska in the period from 2012 to 2017

In the Figure 4 it can be noticed that number of the traffic accidents with the killed persons "varies" and there is no clear trend of decrease of these traffic accidents. Additionally, in the Figure 5, there is a structure of those affected in the traffic accidents. There is a similar situation as it is with number of the traffic accidents. Number of those killed in the past period has no constant trend. It can be concluded that at the national level there is no firm and independent system of defense against the traffic accidents established.

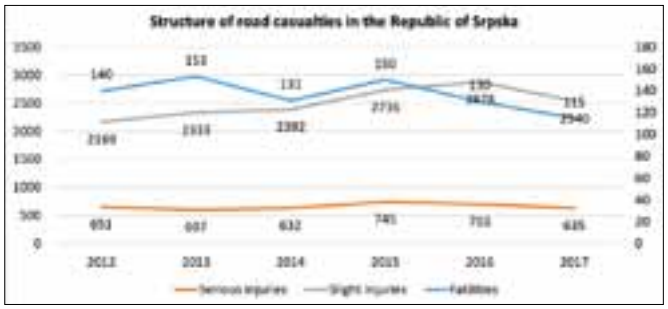



**Figure 5.** Structure of those affected in the traffic accidents in the Republic of Srpska in the period from 2012 t0 2017

The method which was used for analyses of the relations between previously stated indicators is Spearman's correlation. The data presented include the whole territory of the Republic of Srpska and five-year's period from 2012 to 2017.

## RESULTS

Spearman's correlation showed that there is a strong correlation between the number of traffic accidents, their consequences and representation of the braking systems with ABS and ESP in the fleet of the Republic of Srpska for the period from 2012 to 2017 (Table 3)

**Table 3.** Intensity of the correlation between the number of vehicles with ABS and/or ESP systems in the fleet in the Republic of Srpska and the number of the traffic accidents and their consequences in the period from 2012 to 2017

| Correlations | | | | | | | |
|---|---|---|---|---|---|---|---|
| | $SN_{pog}$ | $SN_{ttp}$ | $SN_{ltp}$ | $SN_{mat}$ | POG | TTP | LTP |
| Correlation Coefficient | - .714 | .600 | .829** | .829** | - .714 | .314 | .829** |
| Sig. (2-tailed) | 0.111 | 0.208 | 0.042 | 0.042 | 0.111 | 0.544 | 0.042 |
| N | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | | | |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | | |
| $SN_{kill}$ | number of traffic accidents with the killed persons | | | | | | |
| $SN_{htp}$ | number of traffic accidents with the severely injured persons | | | | | | |
| $SN_{ltp}$ | number of traffic accidents with light injured persons | | | | | | |
| $SN_{mat}$ | number of traffic accidents with material damage | | | | | | |
| POG | number of the killed persons in the traffic accidents | | | | | | |
| TTP | number of the severely injured persons in the traffic accidents | | | | | | |
| LTP | number of light injured persons in the traffic accidents | | | | | | |

Pursuant to the Table 1, it can be concluded that there is a strong correlation (r= .829, p= .01) between the number of traffic accidents with lightly injured bodies and number of vehicles in the fleet of the Republic of Srpska which possess the braking systems with ABS and/ or ESP (hydraulic + ABS, air + ABS, combined ABS, hydraulic + ESP, air + ESP, combined + ESP). Also, there is a strong correlation between the number of traffic accidents with light injured persons and number of light injured persons with number of vehicles in the fleet which possess the previously mentioned braking systems (r= .829, p= .01). In the Figure 6 and Figure 7, there are graphs indicating the dependence between the number of traffic accidents with light injured persons and number of light injured persons with the number of vehicles in the Republic of Srpska which possess the braking systems with ABS and ESP.

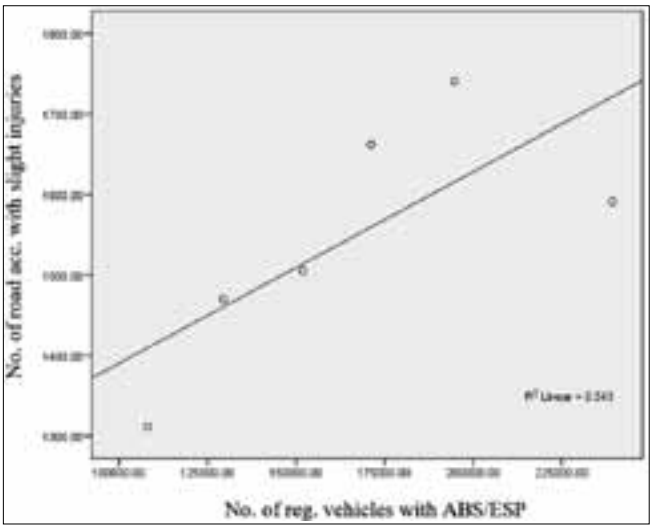



**Figure 6.** Dependence between the number of traffic accidents with lightly injured persons and number of vehicles in the fleet which possess the braking systems with ABS and/or ESP

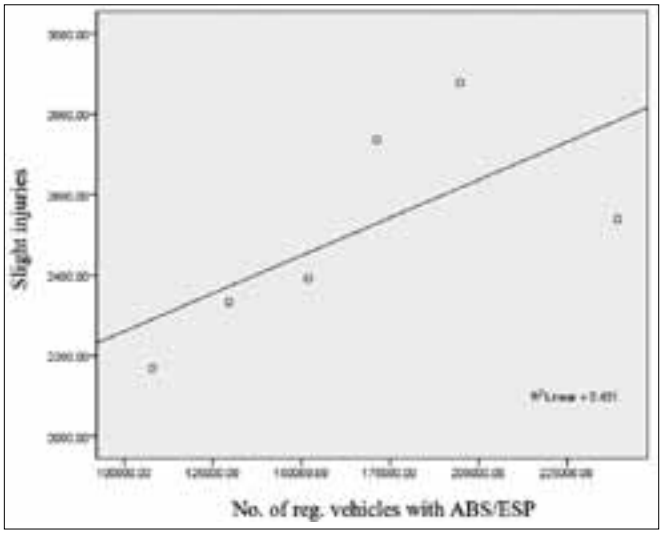



**Figure 7.** Dependence between the number of lightly injured persons and number of vehicles in the fleet which possess the braking systems with ABS and/or ESP

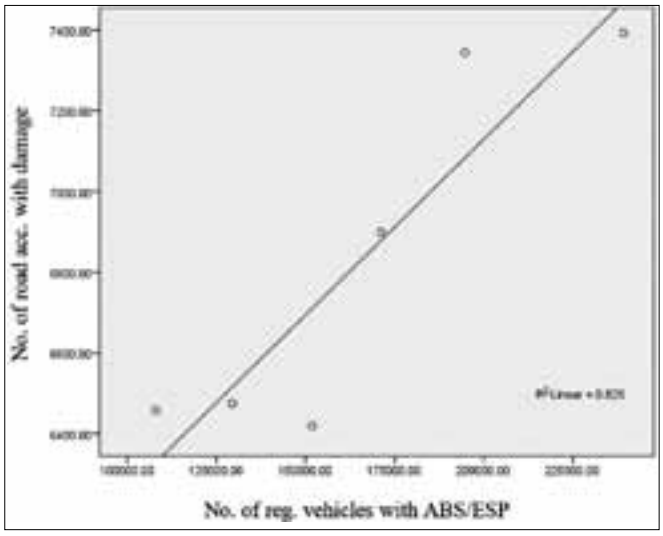



**Figure 8.** Dependence between the number SN with material damage and number of vehicles in the fleet which possess the braking systems with ABS and/or ESP

## DISCUSSION

The obtained results may be explained with the fact that additional systems in the vehicles (ABS and ESP) have contributed to reduction of consequences of the traffic accidents in the respective period in the region of the Republic of Srpska. Namely, there is a statistical importance between the number of traffic accidents with lightly injured persons, number of lightly injured persons, number of traffic accidents with material damage and number of vehicles which have the braking systems with ABS and ESP and which passed the regular technical examination of the vehicle. Actually, the traffic accidents "have overflown", i.e. number of traffic accidents with the killed persons and severely injured persons have decreased, while the number of traffic accidents with lightly injured persons and material damage have increased. Normally, apart from this factor, consequences of the traffic accidents have reduced due to preventive and repressive actions of all structures of the traffic safety system in the Republic of Srpska in the spheres of the most significant factors of risk (speed, alcohol, use of the safety belt, etc).\

## CONCLUDING REMARKS

Elements of active and passive safety of the traffic in vehicles considerably contribute to decrease of number of traffic accidents and their consequences. Application of the electronic systems in vehicles has been expanding and present vehicles have got dozens of these systems in order to provide for predictability of situations, accelerate reactions and minimize mistakes of drivers. The driver as a human being has certain performances and being like that he cannot follow the traffic which is rapidly carried out today. In that case, the risk of occurrence of the traffic accidents is very high. That is why the automobile industry tends to develop electronic systems in order to increase the performances of man, namely of the vehicle, because the man and vehicle makes a compact unity participating in the traffic. Communication with the environment (sensors detect vulnerable traffic users, traffic signs and other structures, vehicles) is achieved by development of the advanced systems, providing a driver with a possibility to have as much information as possible.

Having in mind that man tends to mistakes, electronic systems try to minimize the mistakes (e.g. detection of vehicles in the traffic course which brake earlier, detection of monitoring of the appropriate traffic lane, detection of sudden obstacles, etc). Huge representation of these systems resulted in commencement of using these systems with mechanical systems of reliance, detection of bumps on the road and similar, everything for the purposes of increase of comfort while driving.

Representation of these and similar systems in the Republic of Srpska has a growth trend caused by a level of export of vehicles with minimum prescribed EUR 4 norm, which involve, minimum, the following systems: ABS, ESP, ASR, AIRBAG and similar). Apart from that, a share of vehicles equipped with these systems annually is increased for about 5% which considerably contributes to reduction of traffic accidents with deaths and severe consequences. Of course, the increase of vehicles with contemporary systems is the result of type-approval of vehicles at the Bosnia and Herzegovina level, because it ensures a level of interchangeability of the fleet in the Republic of Srpska and reduction of the average age of the fleet from 18.5 years in 2012 to 16.5 years in 2017.

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