

Deployment of Electronic Stability Program (ESP) in Morocco, It is the convenient choice? What is the predictable impact on road accidents' statistics?

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Abstract— In this article we will try to show the impact of widespread deployment of a driver assistance systems called: Electronic Stability Program ESP on the data of road accidents in Morocco. We will indicate the state of road safety in Morocco, then the reasons for which the choice of deploying ESP is a convenient choice in Morocco. As a result, we will conclude by evaluating the predictable impact of widespread deployment of this equipment on the statistics of road accidents in Morocco.

Keywords—Electronic Stability Program ESP, Road accidents, Morocco, Impact, Deployment, Driver Assistance Systems.

I. Introduction

Every year more than 4,000 people die on Moroccan roads, and more than 11,000 people end up handicapped for life [1], a real catastrophe which does not reflect the efforts made by the authorities responsible for road safety, which remain minimal against the growing human suffering that results.

The statistics are just as eloquent as disastrous when we take into account the number of cars in circulation in the Moroccan roads network, which does not exceed 3 million vehicles in 2011. Beyond the human drama that barely thousands of families each year in Morocco, the traffic accidents are also weighing on the national economy and hinder growth. The World Health Organization (WHO) considers the socio-economic costs of accidents in Morocco is about 1.42 billion \$ per year, or 2% of GDP (Gross Domestic Product). [2]

Authorities and organizations concerned with road safety in Morocco have been implicated in the decline of accidents number and fatalities on the roads, through strategies based on traditional measures of prevention, which in its component for driver is based on legislation, control, and punishment as principal axes of these strategies. However, these conventional measures are reaching limits beyond which, these measures, just by themselves, cannot provide an improvement in the balance sheet of accidents, and statistics have shown the inability of these actions to satisfactory results for this major problem which costs Morocco thousands of people and more than billion \$ every year.

However, other avenues of progress subsist, such as Driver Assistance Systems, which are designed to compensate for the driver's cognitive and perceptual system failures, such as drowsiness, inattention, poor visibility, etc. This can lead to reducing risks of road accidents.

In this article we will aim to estimate the predictable impact of one of these systems which is the Electronic Stability Program, or ESP, on the road accidents in Morocco. To do this, and based on official road accidents' statistics issued by the Ministry of

Equipment, Transport and Logistics, we will first show the state of road safety in Morocco, then we will present the reasons for which the choice of deploying ESP proves to be an adequate choice for Morocco. As a result we will complete the assessment of the expected impact of the widespread deployment of this equipment on the data of accidents in Morocco based on research efforts that have addressed this issue.

II. Road Safety situation in Morocco

Concerning the state of road safety in Morocco, we took 2012 as a reference year because the definitive accident statistics of 2013 are not yet published by the Ministry of Equipment, Transport and Logistics.

To get a general idea about the criticality of the problem, the table below presents the different indicators of road accidents in Morocco, year 2012 [3]:

Indicators	Year 2012
Length of asphalted road network	42 882
Vehicle fleet	3 000 000
Traffic (AADT)	88,42 million veh.km/d
Vehicle ownership rates	88 vehicles per 1000 inhabitant
Deaths per Day	11.41, 4167 per year
Number of deaths per million inhabitants	141
Number of deaths per million vehicles	1455.8
Socio-economic cost	1.42 Billion \$, 2% of GDP (Gross Domestic Product)

Table 1: indicators of traffic accidents in Morocco, year 2012

AADT: Average Annual Daily Traffic which is equal to the total traffic of the year throughout the national road network divided by 365 and its unit is: million veh.km / day.

The next graph will show the evolution of deaths, accidents, injuries, and vehicle fleet during the period 2002 to 2012, where we will notice that despite the experience of actors responsible for road safety, the trend of rising number of casualties and accidents is always present.

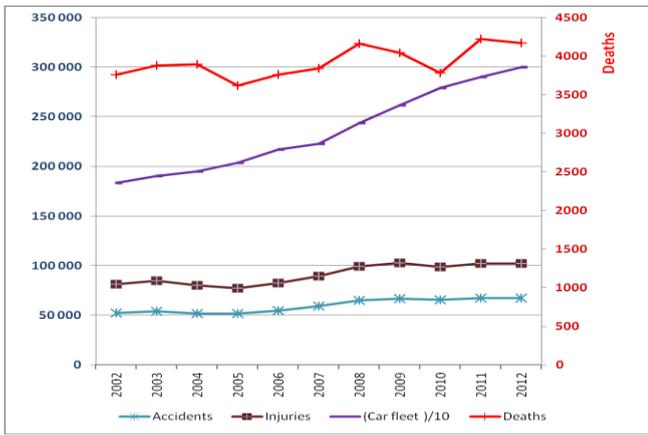


Fig 1: accidents, casualties and vehicle fleet in Morocco from 2002 to 2012 [1] & [3]

Accidents: The graph above shows that in this period the number of accidents did not decrease until 2004 by 4% and 0.2% in 2005. Then a trend of increase was recorded in 2007 especially with +8.13% and +9.8% in 2008.

Deaths: The graph also shows that for the first time in the history of road safety in Morocco, the number of deaths exceeded the threshold of 4,000 deaths in 2008, then with a slight decrease in 2009 but still above 4000 dead. The year 2010 saw a significant reduction in the number of killed from 4042 to 3778 deaths which correspond to a decrease of 6.5%. But the trend of rising came back in 2011 with an increase of 10.5% compared to 2010, then a slight decrease of 1.3% in 2012 compared to 2011.

Injured: In term of injuries, the years 2004 and 2005 experienced declines in the order of 5.45% and 3.73% respectively. In addition to that, the trend of increase was maintained until 2009, reaching more than 100,000 injured. The year 2010 saw a decrease of 4.3%, but just after 2011, the rise once again resumed.

Vehicle fleet: Moroccan vehicle fleet is continuously increasing; the Directorate of Road Transport and Road Safety count about 3 million vehicles on the Moroccan road network in 2012. It's important to notice that the Moroccan vehicle fleet continues to increase up to 3.72% to 7.47% annually over the past decade. But despite that, the figure of 88 vehicles per 1000 population remains very low compared to other countries, especially the European countries.

As a conclusion of the first part, the strategies of authorities and organizations responsible for road safety in Morocco, which is based on legislation, control, and punishment, showed very limited results to this major problem. So the fact of thinking now to more paths of progress proves to be a necessary choice, especially the use of new technologies such as Intelligent Transport Systems (ITS) and more specifically the driver assistance systems which are an essential component of ITS.

In this paper we will present one of these systems, which is the Electronic Stability Program ESP, then we will show the reasons for which the widespread deployment of this system in Morocco can cause a positive influence on the balance sheet of accidents in Morocco. Finally, we will estimate the predictable impact of this system on accident statistics in Morocco in light of research that evaluated the potential effect of ESP on reducing the severity and risk of traffic accidents.

III. Presentation of Electronic Stability Program ESP

The ESP is a driver assistance system designed to help the driver to take intended path, it intervenes to prevent the vehicle from skidding in an avoidance maneuver, understeer (when front wheels lose traction) or oversteer (when the rear of the vehicle skids). It is also expected that the ESP is useful to drivers on degraded adhesion conditions (Examples: wet road, snowy, or icy), or even in combination of two or three of these situations [4]. ESP detects a potential skid, by analyzing the speed of rotation of wheels and the rotation of the vehicle with a yaw rate sensor. If the detected behavior of the car is not according to the steering wheel angle, the ESP will act individually on the braking of the four wheels and the engine torque in order to correct a path which deviates from the path desired by the driver. This braking is therefore no longer produced by the driver but by the ESP itself, (usually a warning light or a beep indicates that the system is in action), so that braking will keep a better stability of the vehicle in avoidance maneuvers, understeers or oversteers.

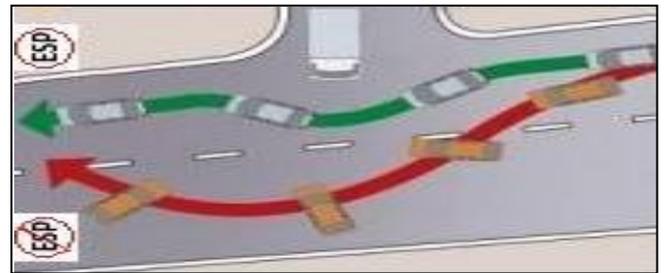


Fig 2: Example of ESP intervention in avoidance maneuver

IV. The reasons why the deployment of ESP in Morocco can improve road safety:

A. Loss of control is considered as the main cause of fatalities in MOROCCO:

The two graphs below show the distribution of accidents and casualties by type of collision in Morocco in 2011:

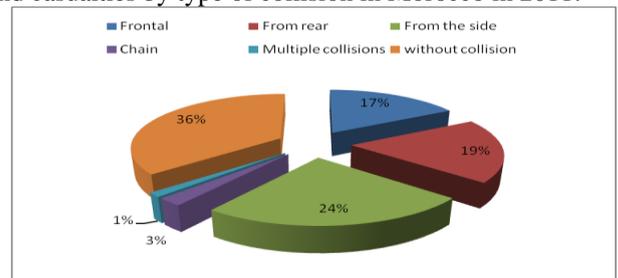


Fig 3: Distribution of victims by type of collision in Morocco in 2011

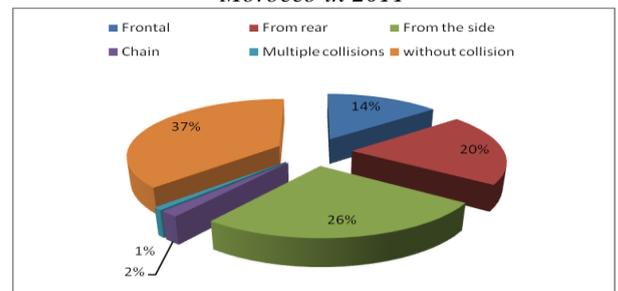


Fig 4: Distribution of accidents by type of collision in Morocco in 2011

Loss of control is often referred to road departures and side collisions [5]:

Road departures accidents occur without collision and can be divided into two types of accidents: the problems of orientation in which the vehicle exits the road without dynamic problems and remains controllable. And loss of control accidents where we find that the transverse acceleration of the vehicle is inconsistent with the handling and the vehicle becomes uncontrollable. This type of accident constituted 37% of all accidents in 2011 (Figure 4), and was behind 36% of all victims (Figure 3).

Side collisions are considered as a main result of the loss of control [6], where we generally found a car from a sense that slides on the opposite side of the road, causing a lateral crash with another car coming from the opposite direction. In 2011 and among the accidents that have been subject of specification, 26% of accidents are caused by lateral crashes (Figure 4), this type of accidents was behind 24% of all victims (Figure 3).

According to statistics of the Ministry of Equipment, Transport and Logistics, "41.80% of deaths in and outside urban areas resulting from loss of vehicle control". [7] This corresponds, for example in 2011, to 1766 lives lost resulting directly or indirectly from the loss of control. So measures around which we must focus should be applied in areas where the greatest benefit can be provided, in other words it must target the priority cause behind traffic accidents, which is the loss of control. And the main reason of the design of the ESP is the loss of control, so the deployment of this system will undoubtedly have a major positive impact on the balance sheet of accident in Morocco.

B. Vehicles not equipped with a driver assistance system cause more accidents [8]:

The graph below shows that 51% of the cars involved in traffic accidents in Morocco are older than 11 years [1]:

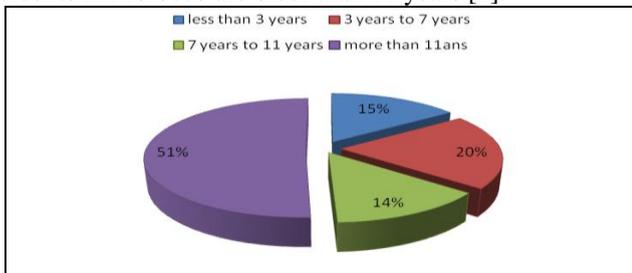


Fig 5: Distribution of cars involved in accidents by age group, 2011

To get to prove that cars equipped with a driver assistance system are less involved in accidents than non-equipped cars in Morocco, it was therefore necessary to consider the ages of vehicles involved, because of the lack of statistics concerning presence of Driver Assistance Systems in the Moroccan fleet, and obviously a lack of data on the presence of these systems in cars involved in accidents.

The graph above shows that 51% of vehicles involved in road accidents are older than 11 years. And when we see that the driver assistance systems have been widespread after the 2000s, from where we can say that half of the vehicles involved in traffic accidents recorded in 2011, did not contain, surely, any onboard driver assistance system. And there will be, certainly, a large percentage which we cannot estimate in the rest of the cars (aged under 11years) involved in road

accidents and which are not equipped with any driver assistance system.

Despite the paucity of data concerning the details of accidents in Morocco, it has been demonstrated that non-equipped cars with a driver assistance system, certainly including ESP, cause more accidents. But the driver must be careful of the effect of the concept of risk-homeostasis [9], or the feeling of absolute safety by driving a well equipped car. This causes a change in the conduct by taking more risk, especially by increasing the speed, which can remove the gain of safety offered by the system.

C. ESP a high potential in reducing accidents:

Since its appearance in Europe around 1995, ESP has attracted considerable interest, because the loss of control is a contributing factor in a large percentage of traffic accidents, for that numerous researches have attempted to evaluate the effect of ESP on the severity and risk of accidents. Initially, the effect of ESP on accidents was estimated indirectly by first calculating the percentage of accidents involving factors related to loss of control, and then applying various reductions estimated to these accidents. In Morocco, according to the Ministry of Equipment, Transport and Logistics, 41.8% of deaths caused by traffic accidents, in and outside urban areas, are resulting from loss of vehicle control [7], or in other words, the deaths caused by such accidents can be positively influenced by ESP.

Many researchers around the world have attempted to evaluate the impact of ESP on the risk of accidents resulting from loss of control. In 2006, a three-step analysis of accidents in France shows that vehicles equipped with ESP have a 44% reduction in risk of being involved in an accident of loss of control compared with vehicles not equipped with ESP [11]. In 2001, Sferco et al. used correctly detailed data to estimate the potential impact of ESP, the results of this study suggests that if the root cause of an accident is the loss of control, ESP can prevent or reduce the severity of 42% of injury crashes and 67% of fatal accidents [4]. These data are identical to the estimates provided by Tingvall et al. (2003) [10] and those reported by Aga and Okada (2003) [12] Langwieder et al. (2003) [6], and Unselt al. (2004) [13] and Becker et al. (2004) [14].

To conclude this part, we showed the reasons why the choice of deploying ESP in Morocco proves to be a reasonable choice to improve the balance sheet of road accidents. The first reason is the loss of control which is the first cause of mortality on Moroccan roads. The second reason is that vehicles not equipped with a driver assistance system, ESP is one, cause more accidents, Thirdly, the potential of ESP in reducing the risk and severity of loss of control accidents. Moreover, this equipment has even more advantages because it does not require other intelligent systems related to infrastructure for implementation, and also because of its reasonable cost which is around 490\$, and it is appropriate to the geography of Moroccan roads (many turns).

V. Predictable impact of the deployment of ESP on road accidents in Morocco:

ESP is useful to drivers, during bad negotiations of turns, for example the driver passes through a turn with a speed of 80 Km / h instead of 60 km / h causing the risk of under or

oversteers. ESP is also useful during abrupt situations where the driver turns the steering wheel sharply during avoidance maneuvers of an obstacle for example. It is also designed to be useful to drivers in degraded adhesion conditions such as wet road, snow, or ice or even when the combination of two or three situations mentioned above [4].

A review of existing studies that evaluated the impact of ESP on the number of accidents has led us to develop a table (table 2 in the end of the paper) containing a range of studies, each study is characterized by its authors, its type, the target of accidents study, the country where the study was conducted, the percentage of reduction and this percentage applied to Morocco. This will allow us to have an idea about the impact of ESP on road accidents in Morocco in light of these researches.

During our review, we noted that studies are often based either on the analysis of accidents in real driving situations or studies based on unreal driving situations. Concerning the type of studies that is based on the accident analysis in real driving conditions, there are two types of studies: studies "case control", which are conducted on one or more vehicle models marketed without ESP at first, then was equipped with ESP, and studies "before and after", which compares the number of accidents before the introduction of ESP on the market and after its implementation. Concerning the studies that are not based on real driving situations; there are studies on test tracks, or on simulators or simply by estimations. We are focused on studies based on real driving conditions, because we think it is nearer to reality.

As previously mentioned the loss of control cause 41.8% of deaths on Moroccan roads which corresponds, for example in 2011, to 1764 life lost, so if we did a brief calculation, we have firstly accident severity in 2011 was 6.5 fatalities per 100 accidents [1], from where the 1764 deaths due to loss of control are caused by 27139 accidents, which are the targets of accidents where ESP can offer a considerable reductions.

Note: To calculate the corresponding percentage reductions in Morocco, we took the year 2011 as a reference year, because we could not get the details of final accident statistics for 2012 issued by the Ministry of Equipment, Transport and Logistics.

The revision of studies that evaluated the potential effect of the ESP on road accidents, including the studies mentioned in the table 2, shows that independently of types of accidents, ESP reduces the number of accidents by 19% to 67%, of course accidents involving a single vehicle are most affected by the influence of ESP than multiple-vehicle crashes, and this because the single-vehicle accidents are primarily due to loss of control. Consequently, loss of control and accidents arising are reduced by 25-70% with the use of ESP, but there are significant differences between the results of each study this variation is mainly due to the methodology used, and the relevance of statistics. But the main thing which it cannot be doubted is that ESP alone can prevent from many accidents and save many lives. And this should be more than enough for Morocco to take the initiative and ensure that the obligation of this essential equipment on all registered vehicles, including light vehicles on which the ESP showed great efficiency.

VI. Conclusion:

At first we have shown the state of road safety in Morocco and the criticality of the situation, after we introduced the system in question which is ESP, and then we mentioned the reasons why

the choice of deployment of ESP is an adequate and optimal choice for Morocco. And to get an idea of the potential impact of ESP deployment on the number and severity of accidents in Morocco, we reviewed studies that have addressed this issue. It was found that generally and independently of the types of accidents, ESP reduces accidents by 19% to 67%, loss of control and accidents arising are reduced by 25-70% with the use of this equipment.

Concerning Morocco, ESP can reduce between 5970 and 18997 accidents, and if we proceed in terms of accidents severity, we can say that ESP can save between 388 and 1234 lives each year. And this should be more than enough to ensure the requirement of this equipment and its introduction as standard equipment on all new or certified vehicles in Morocco, to make a significant step forward in improving road safety and reducing human suffering affecting thousands of families each year.

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Study and Country	Type of study	Particular conditions	Percentage reduction	Impact applied to Morocco
Farmer (2006) [15] United States	Accident analysis, study "before after"	Off-road vehicle	32% -37% of accidents involving multiple vehicles	Reduction between 11725 and 13557 accidents involving multiple vehicles
Aga & Okada [12] (2003) Japan	Accident analysis, study "case control"		35% of accidents involving a single vehicle	Reduction of 8687 accidents involving a single vehicle
Green & Woodrooffe [16] (2006) United States	Accident analysis, study "case control"	Off-road vehicle	70% of accidents involving loss of control	Reduction of 18997 accidents involving loss of control
		differences between men & women	No significant differences	
Tingvall et al. [10] (2003) Sweden	Accident analysis, study "before after"		22% of target accidents of ESP	Reduction of 5970 accidents involving loss of control
Kreiss et al. [17] (2006) Germany	Accident analysis, study "case control"	Using a new methodology	54% of target accidents of ESP 78% of fatal accidents targets for ESP	Reduction of 14655 accidents. Reduction of 1184 fatalities

Table 2: Studies that have evaluated the effect of ESP on accident and the expected effect applied to the case of Morocco