Intelligent Vehicle Systems in the Light of the Technical Regulations

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Abstract— Nowadays more and more technical systems will directly interfere with the everyday life of people, sometimes this can cause conflicts, which is caused by the intelligence given to the machine. The humans will not give only command to the machine but also the machine can decide itself how to handle a given situation. What is important that in this relationship the intelligent machine will not cause uncertain or dangerous situations. A very important field, where this problem is thoroughly investigated is the field of intelligent vehicle system.

This paper gives an insight to the legislation process of the electronic stability control system and other, similar intelligent vehicle systems. Particularly, how the international legislation bodies (primarily the ECE-UN working party 29) approach this problem on example of the mentioned systems.

I. INTRODUCTION

Legal processes have different ways to occur. Sometimes an event happens which forces regulation. In other cases laws are formulated to adjust not yet existing, future systems. We may wish to eliminate such solutions which would result in the inaccurate direction. Some new laws try to direct the improvements of the techniques in the right way.

The technical standards as a judicial norm are in the form of law, but the substance of it is mainly a technical norm. They can be technological designations, arrangements brought out by ministeries and they order mandatory practice.

Technical norms aren’t like moral norms and aesthetic norms, which are usually based on or derived from larger systems of thought and tradition. Technical norms are generally based on concrete experience and empirical studies. They are evaluated in terms of their consequences in action. [12]

There are diverse controversies in this field which should be absolved, for example the borderlines of the judical regulations, the entities and their assignments, the acknowledgement of the patterns of technical laws. [2]

II. TECHNICAL NORMS – MAP ECONOMICAL, POLITICAL AND SOCIAL DEMANDS

The development of complex system, like the transportation follows a specific scheme as shown in Figure 1. The demand of the society will rise, in this specific case, for increased mobility (business and leisure travel, more goods should be transported, etc.). The vehicle industry can react to this demand and will produce vehicles with higher load and passenger capability, stronger engine, in average higher velocity. The vehicle industry is also very “diligent” as far as the volume is concerned, and can produce cars in high amount. Of coarse, these vehicles will load the environment in greater extent.

Figure 1
Development of the transportation systems (Michelberger)
The development of the road and traffic infrastructure cannot keep the pace with the vehicle industry; mainly due to its inflexibility as far as the stakeholder structure is concerned. Thus, the rapidly growing car population on the unchanged infrastructure will lead to conflicts and irregularities among the participants of the road traffic, the number and severity of the accidents will increase, pollution emitted by the cars will also cause problems.

The only way to react to this conflict is via the legislation, the society will force its authorities to intervene and make laws and regulations which will resolve, or at least mitigate the consequences of the conflict described above. Some examples:

- Emission regulations – as the traffic density was increased, the demand for cleaner vehicles has increased. A Euro VI engine emits virtually nothing, especially in comparison to vehicles not long time ago.
- As the increased static wheel load (which is crucial in utilization of the cargo capacity of trucks, especially in Europe) destroys the road surface and leads to quick deterioration of the pavement, the maximum axle load can only utilized when the vehicle’s suspension complies with the requirements of the “road friendliness”.

After setting the technical norms, the loop starts again, the industry will develop new systems, which will comply with the regulation.

The Electronic Stability Control systems are one of the best examples how the society demand can influence via the legislation the industry to fulfill demand, which might not economically attractive, but serves a social interest.

III. REGULATION OF THE ELECTRONIC STABILITY CONTROL – A SUCCESSFUL PROJECT OF THE EU

The ESC systems from diverse producers have been already available on the market in Europe for many years in the 2000s.

The affects of these systems on traffic safety have evidences shown by several studies (see in [5], [6], [7]). These reviews described about 60% decrease in the fatalities in road accidents. These data are really notable and are absolutely in line with the goals set in White Book of the EU targeting on the decreasing of road accident fatalities by 50% within 2000 and 2010. The installation rate for heavy vehicles was really low, about 2% of the vehicle were installed with the system (Figure 2 shows a summary of the European traffic accident history with fatalities). The explanation for that is very simple: the extra cost of such a system at buying the truck (3000-4000 Euro) influences the cash flow of the fleet, tat is why they did not chose the system. Even the insurance companies did not help in the further steps saying that if the accident rate will be decreased by the ESC system less companies or people will buy their product (i.e. CASCO insurance). It is quite strange, but it was true that no European insurance company paid attention to the insurance cost deduction for the ESC system which inevitably decreases the frequency of the occurrence of the accidents. In the other hand, in the United States of America, where the fleets have own insurance companies the equipment rate increased over 40% in 2 years, since the casualties caused by the accidents will influence immediately the fleet. Therefore it made disappointment both in the politics and in the industry, since the introduction of this system in the industry costs close to 3 digit millions of Euros and if it is not incorporated into the vehicles, it will not return the investment. Unfortunately none of the attempts of the truck producers and the ESC system suppliers had any success in convincing the fleets to purchase their systems, they proposed Brussels an intercession to instruct the fleets to use this system for trucks and other dangerous vehicles. Fortunately both the politics and the industry had the same interest and European Union mandated the application of the ESC systems from 2013 for all heavy vehicles.

The first step before the introduction of this regulation was to generate the terms of references for this kind of systems and include it in the UN-ECE regulation system, which is presented in Figure 2. This is a very complex, multi-level structure and it requires very long time to have a new, or modified regulation. Even so this ESC regulation went through all the processes in 2 years, which was a kind of “record” rapidity.

![Figure 2 Traffic accident development in Europe](image)
IV. SPECIAL TECHNICAL STANDARDS - HOW TO CONTROL THE AUTONOMOUS SYSTEMS

It was not easy to find out the way of establishment for the terms of reference for the ESC system. At this point I do not wish to go too much into the details of the system in references [8-11] I want to mention just one point. The operation of the ESC system is based on the measurement of the actual vehicle motion. It is compared to an “ideal” vehicle behavior, and if the difference is higher than a pre-defined value, the ESC system starts to operate the necessary actuators autonomously of the driver in order to correct the vehicle’s track.

There is an often discussed issue in the fact that the vehicle is doing something independently of the driver. The liability raised severe questions. Can the driver be responsible for the consequences of an intervention made by an autonomous system?

It is a very difficult question, which can not be answered easily, because of the fact that technical, legal and moral answers must be taken into consideration. The technical answer is quite easy: the chauffeur gets only an alert of the critical circumstances and the decision is made only by the driver. On the other hand there is a strong moral dissent. It says, if the chauffeur’s abilities are not good enough to decide in the right way, and the technique could substitute him, why not to do so and save lives this way?

The basic difference is between the next two views is the following:

- the chauffeur can not be absolved from the accountability of controlling his truck
- the capabilities of the chauffeur are limited, to be able to avoid an accident and at the same time save lives, the control can be taken over by the appropriate intelligent traffic and vehicle control system.

This contradiction can be solved by using the next legal answers:

- the ITS/IVS system makes an arbitration only if it is absolutely manifested that the chauffeur is not able to handle the situation or
- in case the chauffeur is apparently in place (not sleeping and paying attention) when he acts it has a priority to take over the control from the system.

For levels of the ITS/IVS systems were determined by the ECE-UN working party to make this situation clear:

Level 0 all 4 levels (perception, conclusion, action, replay) is made by the chauffeur
Level 1 the perception is done by the ITS/IVS system. Pe. the systems send a note to the chauffeur that “something is getting close”.
Level 2 perception and conclusion is made by the ITS/IVS system, but action is done by the chauffeur. Example – the note is the next: “something is getting close, steer left 90 degrees”.
Level 3 all for actions are made by the ITS/IVS, this is the so called autonomous drive system.

In fact, to develop clear rules that meets all three specified levels is not always possible. The ECE-UN working group set up a special working group to identify the correct task, but it has not met a permanent solution yet.

The automatic emergency brake system (AEBS) and the lane departure avoiding (LDA) system were the main target of the ECE-UN working group. They wanted to speed up the development and practice of these two (AEBS, LDA) systems. This would have a very good effect on the traffic and reduce the severe accidents caused either by the rear-end collision or by unplanned lane departure.
Let’s have a look at the AEBS system. It has been used in passenger cars for a while, but not in trucks. It uses a radar sensor, which is similar to the police speed measuring device. The sensor measures the distance between the vehicle A and B and makes a notice to the chauffeur of the vehicle A if the vehicle B is getting closer (Level 1). It gives an extra warning and makes a significant sign to the chauffeur, or takes off the gas pedal (Level 2) and if the chauffeur does not do anything, the system makes a decision that the bump is otherwise unavoidable, it uses the brakes to slow down the vehicle automatically without the driver doing anything (Level 3). There is also a legal aspect built in the system, which is for proving that the collision was unavoidable, whereas the radar sensor would be precise enough to avoid the collision totally. Despite this fact, the truck companies don’t use a system which avoids the collision, just reduces the severity of the accident. This way can be proven that the accident was unavoidable. The vehicle velocity is reduced before the collision to exclude any injuries, but it doesn’t eliminates the bumping totally. This sounds maybe a little bit strange, but legally it is necessary to have a clear situation in case of any other casualties for example some damage happens in the goods.

The LDA system operation management is even more complicated, because the car leaves the track (this happens maybe because the chauffeur fell asleep or was not paying enough attention), and the return is more complicated than just braking as with the usage of the AEBS system. The technical legislation supports a system that first creates a warning (Level 1), after it also gives a tactile for the direction (slightly turns the steering wheel in a direction where they decided to go (Level 2), and in case the chauffeur does not make a different decision than the system, and it uses a higher torsion and puts back the track to the lane (Level 3). In the case of the LDA the regulation process did not get to a final decision of a common regulation. The reason of the difficulties is that different countries use different rules, which originate from the different local traffic circumstances.

So you can see, if there is a problem, which can be solved technically, and even the goodwill of the legislators is given to speed up the process, the legal framework should be established. The case of the autonomous vehicle systems is a difficult situation where the chauffeur’s roles and responsibilities are non-trivial to determine.

V. THE DEVELOPMENT OF ROAD ESC UN-ECE REGULATIONS

The regulations mentioned in the title were developed lately.

The ESC system is a real intelligent vehicle system, as all its sensors are on the truck, the electronic control unit of the system makes the conclusion and the on board systems make the intervention. On the other hand it is not autonomous in case if we look at the fact that the chauffeur is in the control loop. The system helps the chauffeur in case of critical conditions to maintain his/her track.

If we want to categorize the ESC into the earlier mentioned 4 level system, it belongs somewhat to each as shown in Figure 4. Although this is goes beyond the scope of this paper, but it is worth to be mentioned the way how this “legal” requirement (i.e. the ESC can only support the driver in his job maintain the required trajectory, but not intervening instead of him) is technically realized. In the system theory this type of control is called as virtual, or reference model following control, whose scheme is shown in Figure 5.

The in Figure 5 shown control works as follows: the vehicle on-board electronics runs the so-called virtual model, which receives the same inputs which are measured on the vehicle (steering wheel angle, vehicle speed and some others). The virtual model is determined based on some optimality criteria, and generates those state variables which are characterizing the vehicles’ motion. In the usual application this is the yaw rate of the vehicle, which is also measured.

![Figure 4 Grouping of the intelligent vehicle systems](image-url)
The control intends to minimize the difference between the real (measured) and the reference model generated value, and when the difference exceeds a certain level, intervenes into the vehicle behavior through the existing actuators: steering, unilateral brake control, or throttle.

So, when the regulation was developed, several questions were asked in order to deploy the above described control logic into legal and simple technical terms.

VI: SUMMARY AND FURTHER RESEARCH

This paper gave an insight of some of the crucial points of the ongoing research work when technical and legal terms have to be handled together. The interference between the technology development and the legislation structure’s reaction is continuous and on-going process, when one of them is changing it will cause reaction on the other side. The results of this continuous interaction will appear in the technical norms and regulations. As the technology is getting more complex the legal background should also develop.

In the paper the example of the ESC regulation development was introduced as one of the latest, most complicated, but absolutely needed new terms of references, where a technical conflict was described in absolutely legal terms.

This research will continue and other problematic areas will be investigated. One of them is the conflict of the application of alternative fuels in order to improve the CO2 balance of some transportation systems.

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REFERENCES