Abstract—As the technical environment of the modern societies are getting more and more complex, the “relationship” between the humans and the technology should be regulated as well. There are several fields where the involvement of the legislation is necessary in order to either promote new technologies because of given economical or political issues, or quite contrary, control/regulate the application of a certain technique in order to serve the best interest of the society. There are fields where ethical problems should be addressed today even the technology is not quite state-of-the-art yet, such as in the robot-human interfacing.

This paper investigates how the terms of references of the vehicular electronic stability control (ESC) system was developed in the ECE-UN Working Party 29 domain in order to make the mandating of such systems in Europe possible. The paper discusses the special economical environment of the ESC systems, their impact on the traffic safety, especially the reduction of fatalities in road accidents. The different approaches in different business models of the truck fleet operators between Europe and USA is studied and its impact is shown on the legislative activities. Legal and moral issues are investigated as far as the role and liability of the driver in highly intelligent, and in some of the cases, in autonomous systems, as one of the most important dilemma of regulatory process: can the driver be eliminated – even only temporarily – from the vehicle control loop when his abilities are clearly not enough to provide a proper control, or he should be always in the position to overrule any kind of intelligent system?

I. INTRODUCTION

There are different ways as laws are generated. It often happens that an event occurs which we want to regulate. There are some laws which seem to be quite funny nowadays, but all of them have a reason to be created. In Danemark for example there is a law, that the driver before starting the car should check the lights, the brake and the horn. It also should be controlled that no child is hiding under the car. It sounds funny to look under your car any time you start it, but on the other hand it is reasonable, probably because of several earlier terrible accidents in that country. You will be fined according to the law in Switzerland if you forget the ignition key in the car and leave the car’s door open. In Tennessee US, you are breaking the law if you drive while sleeping. In Germany, it is illegal to stop on an autobahn (expressway). It is also illegal to run out of gas on an autobahn. [1]

On the other hand laws are created to regulate not yet existing, future systems. We may wish to exclude such solutions which would result in the wrong direction. Some new laws try to guide the development of the techniques in the right direction.

II. IMPORTANCE OF TECHNICAL NORMS IN THE LIFE OF THE HUMAN SOCIETIES

The norms are codes of conduct requiring the correct behaviour which should be followed. There are different norms such as the habits, morality, religious norms, propriety, fashion, the laws and the professional-technical standards. Their common features are the validity, which means they concern a certain circle. The norms are always general concerning to all the addressees the same way. They relate several events, they are repeated. The norms are valid under certain conditions, they direct to the future, they must be followed repeatedly. There is always a sanction which assures the validity.

Some norms are closed, determined by a particular social group such as the laws. Some norms are open, accepted in the global society. The norms can be autonomous or heteronomous depending on that the persons setting them are those who the norms are addressed or different. There are norms which are efficient, others are inefficient. Maybe earlier they were effective, but in a certain social situation they have no efficiency.

The norms have different functions. They give information about the behavior alternatives. They are the assurance of the integration and cooperation of the community. They stabilize the existence of the individual and the community. The norms are a certain measure of value as well. They help to calculate the behaviour of others in the future.

The legal norms are a special type of social norms. They are general and they are compulsory to everybody. The laws are created by the government and the state ensures the enforcement of them. The law prevails in interaction with other social norms. They can intensify or weaken the efficiency of the legal control.

The law has several functions. First of all it has a significant integrative function. It means the development and maintaining of the necessary order and security for the normal life of the society. On the other hand it has a conflict resolution function. The formation of the relation both amongst citizens and organizations, and themselves and the state and the resolution of conflicts arising from their participation effects. The laws also organize the processes of the society. Implementation researches are necessary to control the programs issued by the legislators. Many of them can’t be realized perfectly. More purposeful, more calculable, feasible laws are necessary. The careful preparation of law is essential. The participation of the scientists, researchers, practical experts is inevitable. After collecting the proposals and

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The ESC systems from several manufacturers have been already on the market in Europe for several years at the beginning of the last decade. The impacts of these systems on traffic safety have been proven by several studies (see in [5], [6], [7]): these studies reported as high as 60% reduction in the fatalities in road accidents. Even this figures are impressive, and were fully in line with the targets set in White Book of the EU targeting on the cutting of road accident fatalities by 50% within 2000 and 2010, the equipment rate for truck was very low, around 2% of the vehicle were equipped with the system. The reason was simple: the additional cost of such a system at purchasing the truck (3000-4000 Euro) impacting the business case of the fleet, thus they did not pull the system. Even the involvement of the insurance companies did not result in any improvement saying that if the accident rate will be reduced by the ESC system their product (i.e. CASCO insurance) will be more difficult to place to the market. This is somehow strange, but it was fact, none of the European insurance companies were giving any incentive on the insurance cost reduction for the ESC system which clearly reduces the probability of the occurrence of the accident. Contrary, in the USA, where the fleets have own insurance company the equipment rate jumped over 40% in 2 years, since the losses caused by the accidents will impact directly the fleet. This caused frustration both in the politics but also in the industry, since the investment to industrialize such a system is close to 3 digit billions of Euro and if not installed, no return on this investment. Since none of the approaches of the truck manufacturers and the ESC system suppliers was really successful in convincing the fleets to buy systems, they approached Brussels with the demand to mandate this system for trucks and other dangerous vehicles. It was a lucky co-incidence: 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.

III. TECHNICAL NORMS – IN THE TRIANGLE OF THE ECONOMY, NEED OF SOCIETY AND THE POLITICS

The technical regulations – as a special form of legal norms – cannot be handled independent of their economical and social environment. The case study shown in chapter V. is a typical example (depicted in Figure 1) how the politics resolved this contradiction by means of mandating the vehicular electronic stability control (further on abbreviated as ESC) system for first specific vehicle categories endangering the traffic safety in with high impact.

![Figure 1](image1.png)

Figure 1 How to resolve the contradiction between society need and industry offerings – legislation must intervene

![Figure 2](image2.png)

Figure 2 Structure of the UN-ECE legislation system

Of course, before doing so, the terms of references had to be generated for such systems and included in the UN-ECE regulation system, which is shown in Figure 2. Not going into any detail: this is a very complex, multi-level structure requiring long time to finalize a new, or amended regulation. Nevertheless, the ESC regulation was put in place after 2 years, which was a sort of “record” speed.

The UN-ECE structure shown in Figure 2 is implemented in most of the countries except for USA, where different type of technical regulations are used. The
major difference in the approval system: in the UN-ECE structure the vehicles are homologated by a governmental body (or an appropriate third party company) prior to put in service. In the US systems the manufacturers are obliged to make a self-certification, where all vehicles have to meet the related requirements “off-the production line”.

IV. SPECIAL SET OF TECHNICAL NORMS – HOW TO REGULATE AUTONOMOUS SYSTEMS

To generate the terms of reference for the ESC system was somewhat not trivial. Not going into too much of the details of the system operation (details can be found in references [8-11]) only one point is mentioned: the ESC system operation is based on measurement of the actual vehicle motion, which is compared to an “ideal” vehicle behavior, and if the difference is higher than a pre-defined threshold, the ESC system is going to operate the necessary actuators independently of the driver in order to correct the vehicle path.

The fact that the vehicle is doing something which is independent of the driver (these are called as autonomous systems) raised severe questions as far as the liability is concerned. Can the driver be made responsible for the consequences of such an intervention?

This is the question what is difficult to answer, since technical, legal and moral answers are possible. The technical answer is pretty simple: the driver gets only warning of the dangerous situation the intervention is made only by him. However, morally this answer cannot be fully accepted, since if the driver’s abilities are not good enough to intervene in the right way, and the technique could replace him, why not to do and save lives with that?

Thus, the basic conflict is between the following two points:

- the driver should not be relieved from the responsibility of controlling his vehicle
- the abilities of the driver are limited, in order to avoid an accident (and thus save lives) the control can be taken over by the appropriate ITS/IVS system (intelligent traffic control/intelligent vehicle control).

This conflict can be resolved by the following “legal answers”:

- either the intervention can be made by the ITS/IVS system only if it is proven that the driver is not able control the situation anymore
- when the driver is obviously in place (not sleeping, paying attention, etc.) when he intervenes it overrules any other system and takes over fully the control.

In order to have a clarity on this situation, the legislation defined for levels of the ITS/IVS systems:

<table>
<thead>
<tr>
<th>Level</th>
<th>All 4 levels (sensing, decision, action, feedback) is made by the driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 0</td>
<td></td>
</tr>
<tr>
<td>Level 1</td>
<td>the sensing is taken over by the ITS/IVS system (most of the accidents is caused by failure here). Example: the systems send a message to the driver that “an object is approaching”</td>
</tr>
</tbody>
</table>

Level 2 sensing and decision is made by the ITS/IVS system, but action is conducted by the driver. Example – the message is as follows: “an object is approaching, steer right 90 degrees”.

Level 3 all for actions are made by the ITS/IVS, this is practically the autonomous drive system (similar to the Google pilot project).

![Figure 3 Classification of intelligent vehicle systems – level of intervention](image)

This is obvious to see that to develop a clear regulation for the different system levels given in Figure 3 is not always possible. The Working Party 29 (see Figure 2) established a special working group for elaborating the appropriate terms of references, no final solution yet.

There are two systems where this work has gone to the advanced status: the automatic emergency brake system (AEB) and the lane departure avoiding (LDA) system. The target of the legislators is to accelerate the development and application of these two (AEBS, LDA) systems, which could reduce the occurrence of the severe traffic accidents resulting either from the rear-end collision or from unintentional lane departure, respectively.

The AEBS system uses a radar sensor (similar to the police speed measurement devices) and measures the distance to the preceding vehicle and makes a warning to the driver if the vehicle in front is getting closer (Level 1), giving additional command and makes aural or haptic signal to the driver, or takes off the throttle (Level 2) and if the driver does not react, and the system judges the collision otherwise unavoidable, applies the brakes to decelerate the vehicle automatically without intervention from the driver (Level 3). These systems are already on the market for passenger cars (not for trucks yet), but the Level 3 intervention will be solved differently. Although the radar sensor is precise enough to avoid the collision totally, but to have a legally clear case a prove is needed that the situation was really unavoidable and driver cannot question the necessity of the intervention later (e.g. in case of another accident as a result of the emergency braking). Some companies took the simplest way to have this prove: do not avoid the crash totally, only reduces the vehicle velocity before the impact to the level, that the collision will happen, but no severe injury will be made. This solution might sound strange, but results in a clear situation, and acceptable by the legislation.

The control of the LDA system’s operation is even more complicated, since here the vehicle will tend (unintentionally, because the driver is fallen asleep or not paying enough attention) to the other lane, and its return is more complicated than just “simply” brake as in case of...
the AEBS system. The technical legislation favors a system which gives first a warning (audio – Level 1), second gives also the direction by haptic signal (slightly rotating the steering wheel in a direction where it is decided to go (Level 2), and if the driver does not overrule the steering wheel rotation, apply a higher torque and bring the vehicle back to the lane (Level 3). Unlike in case of AEBS, in case of LDA still there is no agreement how to proceed with the regulation, since different countries would follow different rules based on their local traffic conditions.

Thus, it is shown here that even a problem technically could be solved, and even the goodwill of the legislators is given to accelerate the process, the legal frames should be appropriately defined and in difficult situations, like in case of the autonomous vehicle systems, where the driver’s role and liability is not trivial to define, it is not straightforward.

V. CASE STUDY – DEVELOPMENT OF THE TERMS OF REFERENCES OF THE VEHICULAR ELECTRONIC STABILITY CONTROL IN THE UN-ECE REGULATIONS

As it was already mentioned in part III, the development of the regulatory framework for the ESC system development has came into effect recently. The ESC cannot be clearly categorized into the Figure 3 categories, since it can be found in all components somehow. To have a better understanding, the legislators set another definition, which is depicted in Figure 4.

![Image](Figure 4) Definition of ITS1, ITS2 and IVS

**IVS**
Intelligent Vehicle System – meaning all systems, which are installed on the vehicle, using signals only from the vehicle and all the decisions are also made by the vehicle’s on-board systems. These can be strongly safety critical, thus need special care.

**ITS1**
Intelligent Traffic Systems – systems, which are using information from the road, other participants of the traffic, transferring it to the IVS, which makes a decision and intervene. These systems can also be safety critical, but not necessarily.

**ITS2**
Intelligent Transport Systems – normally used to optimize fleet operation, cargo tracking, etc. Normally they are safety critical, thus the legislation does not really considers them.

The ESC system is clearly IVS, since all its sensors are on the vehicle, the decision is made by the electronic control unit of the system and the intervention is made by the on board systems. However, somewhat the ESC cannot be clearly categorized into the groups shown in Figure 3, since the ESP is not autonomous in the sense that it does not exclude the driver from the control loop, but supports the driver under critical conditions to maintain his/her trajectory. It means as well, if the driver wants to drive his vehicle into the ditch, the ESC will help. So, than why the regulation of the ESC was necessary? The answer is simple: the legislators intended to mandate this kind of system in order to improve the traffic safety, thus it is not enough to “put a sticker ESC” on the car, but the content (i.e. what the system should do) should be clearly given.

**What questions should have been asked and answered when developing the regulation?**

**What should be regulated?**

This is always the very first question in case of complex systems. In case of ESC the function and not a system was very precisely defined, namely the expectation what kind of effect the system should bring (avoiding roll-over, jackknifing, skidding out, etc.). Special aspect of this topic was that the towing (or single) vehicles can perform different function than the towed vehicle (trailer), which had to be considered.

**How to regulate?**

This was the most complicated question, since at the time of the legislative process the ESC systems on the market achieved a certain maturity level, but the technology is improving, other solutions are to be expected.

So, how to regulate – design or performance?

The dilemma was if the regulation is too generous as far as the design is concerned in order to accommodate future systems, it can be easily misused. Take an example: normally the unilateral brake application is the most effective tool to control the vehicle yawing motion. A manufacturer can claim, that he does not need it, since he can control the same motion by automatically opening or closing the windows on the appropriate side of the vehicle, thus modifying the air flow, which rotates the vehicle in similar way like the brake. This is theoretically right, but the effect is so small that it cannot be efficient. Thus, the regulation – at least the current version – clearly defines the application of the throttle and brake control as a mandatory part of the ESC system, but does not exclude any future solution, where the effectiveness is proven. Normally the design criteria are not elegant, since it can give benefit to companies having that already, but in this case the clear interest of the society overruled this.

Similar approach was followed for the sensory part of the system, here a sort of half design, half performance criteria was given.

Of course, as the technology develops, also the third party homologation bodies will have a cost efficient way to clearly measure the performance of the ESC systems, the design criteria will disappear and the performance criteria will be used. Here again there is a difference between the USA and UN-ECE approach. In the USA because of the self-certification the vehicle manufacturer can easily assess the required criteria, unlike in the rest of the world using UN-ECE regulations, the technical
services have to repeat a good part of the measurements already made by the vehicle and ESC system manufacturers. This was the – economical – reason that the regulation in Europe followed a different way using more the design criteria not the performance.

Where to regulate?

This is a question of practicability against strategy. The clear answer for the ESC regulation would have been to make a new regulation, and put it there. The solution, because of practical reason was that the existing UN-ECE Reg. 13 dealing with the brake system was amended and the ESC regulation was put in there. The practical reason was the time: to modify an existing regulation takes 2 years, to create a new one a decade.

VI. SUMMARY AND FURTHER RESEARCH

The paper presented the interim status of the research conducted on the topic how the technology development can be influenced by the technical legislation and visa versa, how the law follows the advancement in different technologies. Two examples were introduced from a “bird-eye-view”: first how the legislation can influence the technology development in order to better fulfill the community requirements on the regulation of the autonomous vehicle system, while the second example was dealing with an already developed regulation for ESC systems. What can be seen from both examples is that to find an appropriate regulation structure for highly complex technologies is not always trivial, needs a strong co-operation between engineers, lawyers and sometimes also politicians who are able to map the requirement of the society should be embedded in the regulations. In the further research this interface will be examined in more details on other examples.

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