Implications of innovative technology for traffic law enforcement.  
A conclusion from the 6th FP project PEPPER (Police Enforcement Policy and Programs on European Roads).

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ABSTRACT.
This paper presents the work that has been completed in the PEPPER project. The aim of this task has been to assess implications of innovative technologies for the EU defined key areas in traffic safety: speed, drink driving, and use of restraint systems. The paper gives an overview of the most relevant enforcement technologies and systems used today and the potentialities envisaged for those to be deployed in the near future. Enforcement technologies have demonstrated to have a positive effect on safety but the legal/jurisdictional requirements and socio-political contexts often constitute a significant refrain to their deployment.

Key Words.  

INTRODUCTION.
A serious effort has to be made by EU and national authorities to provide a clear and stable legal framework, plus clear type approval guidelines in which the development, implementation, and operation of new enforcement technologies can be swift and efficient in all Member States. The organisation and cooperation of all actors involved and the needed interaction and synergy between automated enforcement and other ITS systems, like control and traffic information systems, together with commercial value added services, might contribute highly to their put in operation.

ACTIVE AND PASSIVE ENFORCEMENT.
The systems described are divided in two parts, differentiating between active, and passive enforcement. Additional technology of relevance and interest is presented briefly. Main findings and implications are documented and certification procedures in accordance with EU type approval have been considered. Matrix variables, developed by TØI, have been used to concretise implications of systems and technologies [1].
ACTIVE ENFORCEMENT.

Active enforcement covers and is defined as the strategies used by the public administrations and state-sanctioned private enforcement agents, of repressive and punitive nature, laid down on a motorist beyond his control. This domain is strictly governed by laws, laying down strict rules on type approval and certification where necessary and applicable concerning technical devices that have to measure values in relation to the violation like speeding, red light crossing, distance travelled, weight, tailgating, illegal use of bus lanes, etc.

SECTION CONTROL.

In the mid 90s, the Dutch Ministry of Transport (RWS) evaluated vehicle-matching technology for section speed control. A pilot started on the A-2 motorway between Utrecht and Amsterdam at the end of 1997. The entire system was integrated in the existing roadside architecture, using the gantries for the Traffic management system and the data communication infrastructure integrated along the motorways. An interface was built for the Central Processing Unit of the National Police, complying with police specific conditions, like type approval and certification. The pilot was put in operation after first having jurisprudence on this new technology and methodology and the results proved that the technology worked in a reliable manner; also effects on traffic behaviour and speed harmonisation are clearly visible. The High Court of the Netherlands has approved this new methodology and digital imaging enforcement.

Section control, the technology.

A complete digital image capture sub-system for up to $n$ cameras is mounted on gantries at the beginning and the end of each section. A camera is provided for each lane and all cameras are cross-referenced enabling tracking of vehicles that change lanes in the section. The system has Interfaces to a wide variety of vehicle detectors and a serial interface to communicate with up to $n$ lane controllers. GPS receivers are checking the time continuously and ensure the proper functioning of the system as well. At each side on top of the gantry, a light detector is in place, adjusting the cameras for the varying light conditions. At night, a near infrared flash is used, hardly visible for the motorists. The captured images are stored temporarily for calculation and initial processing (fingerprinting) in roadside cabinets.

Detecting speeding, using vehicle image matching.

The entry & exit stations capture and store image of vehicles; for each vehicle a fingerprint is generated for each image and date, time and location are stamped, as well as the system parameters. A communications link transmits fingerprints (1kB each) to a central office and each exit fingerprint is compared against the sub-set of entry fingerprints. Matching fingerprints identifying a speed violator are stored if the calculated speed is above the set threshold. All other images and fingerprints are rejected if no speed violation has been detected.
The batch file with the recorded violators are transmitted to the processing office of the Police for further processing and automatic license plate recognition.

**Implications of section control.**

The Netherlands and France have achieved about 30% less traffic deaths and lower degrees of speed violations over the past years shear by speed enforcement. Upon the introduction of section control in the Netherlands, the number of violations dropped under 1% of the total 24 hrs traffic volume. Traffic flow improved and the number of accidents decreased. Large scale implementation of section control in the EU27 would have a significant impact on accidents, traffic deaths, and pollution. However, the deployment of these systems is very slow due to the lack of an efficient EU type approval mechanism. Another implication, found in the Netherlands but also in Austria concerns cost-benefit. In the Netherlands, the positive cost-benefit issue was the fact that the system did not need extra human processing resources. A Norwegian pilot study found obstacles like driver vs. owner/keeper responsibility in multiple EU member states, as well as obstacles regarding protection of privacy (Norway and Switzerland). This does however not affect the efficiency of the section control system itself. These secondary problems need to be addressed urgently on the EU level and on the national level.

**COMBINED RED LIGHT AND SPEED ENFORCEMENT.**

Traditionally, automated enforcement systems to record red light violations have been applied for many years. Traditionally wet film was used for decades and the only function was detecting violation of the red light phase. This required additional equipment like loops to detect that a vehicle had crossed the stopping bar after the traffic light switched to the red phase and a triggering mechanism to record the violation.
Statistics on this specific traffic violation are not easy to obtain from Europe. In the United States it has been recorded that jumping the red light increases in occurrence and severity. The US National Highway Traffic Safety Administration (NHTSA) reports that about 6.4 million crashes occurred on America’s roadways in 2000. Red-light-running, which results in roughly 950 deaths and 90,000 injuries a year, is estimated to be the cause in 92,000 annual crashes, about 1.4% of the 6.4 M total, making it one of the leading problems at urban intersections with traffic signals [3]. Fatal motor vehicle crashes at traffic signals increased 18 percent nationally between 1992 and 1998. By comparison, a six percent increase occurred at all other collision location types with fatalities [4]. Occupant injuries occurred in 45 percent of the red light running crashes, compared to 30 percent for other crash types. 63 percent of Americans witness a red-light-running incident more than once a week. One in three Americans knows someone who has been injured or killed because of a red-light-runner.

**Implications of combined red light/speed enforcement.**

Crashes may be prevented or mitigated through the use of Intelligent Transportation System (ITS) technologies that attempt to overcome human and vehicle limitations. The shift from wet film to digital images opens up new possibilities to enhance the functionality of red light violation in a way that this could be expanded to cover speed measurements during all phases as well. As studies have shown, the severity of red-light running crashes is partly caused by increasing a vehicle’s speed prior to jumping the red light in order to either to try to pass at the green/yellow phase or to avoid jumping the red light. Speed enforcement at all phases would be a strong deterrent to speeding-up when approaching a signalised intersection. This combined enforcement technology should be applied at a large scale globally. The barriers here are institutional and organisational; traffic lights are traffic management domain and basically not meant nor designed as enforcement equipment. This means that if one wants to enforce ignoring the red light and speed, additional enforcement equipment has to be installed and connected to the red light installation, which is something traffic managers do not always like.

**TAILGATING.**

Discouraging tailgating has long been a key concern for the Traffic Divisions of the Police, particularly on motorways, it is a common violation throughout the EU. Apart from being a major cause of road accidents, it ranks highly on traffic nuisances lists and is a serious contributory factor to bad driver behaviour, road rage, and accidents. Against a background of steadily rising traffic levels it has become increasingly difficult to deter violations using the conventional method in which patrol cars travel alongside suspected offenders and attempt to collect evidence using their speedometers and portable video cameras. To overcome the problem, new digital imaging technology has been introduced. It has been type approved and certified by the German National Physikalisch Technische Bundesanstalt and by the Dutch national standards organisation NMI for tailgating enforcement.

- **Tailgating technology.**

Traffic is filmed by a video camera located above the roadway on a convenient over bridge or road sign gantry. The image range covers 300m of a clearly-defined road section on which white lane-dividing lines are marked with short transverse lines at distances of 300, 150 and 50 meter from an 0m point of origin. 300 meter is the longest range at which it is technically
possible to overcome the effects of perspective and produce usable images. The full 300m section allows confirmatory observation of driver activity over distances of the kind which the police use for conventionally tracking suspects. Watching the video on monitors, operators can spot evidence of possible tailgating from an initial distance of up to 1km. At the same time, using the time coding, the system measures the time elapsing between the two sets of measurements and the distance travelled to calculate the vehicles’ average speed. If the system shows a car maintaining a distance of less than the applicable legal distance in combination with the measured speed there is evidence of an offence. A second video camera records vehicles’ license plates and drivers’ faces, (when allowed, this may vary in the member states as well) for traffic violation enforcement purposes, the results are linked to the record of the offence through the system’s time coding. This technology has already proved to be effective in discouraging trucks - among the worst offenders - from tailgating.

**Implications of tailgating enforcement technology.**

The technology, described above, is undergoing further development to make it applicable for other types of infractions that can be recorded by the same system concept. The potential of this technology is that it will be able to capture legible vehicle data to acquire unlawful behaviour by digital information assessment. Applications, eligible for this enhanced tailgating enforcement technology will be: Distance/tailgating enhanced - Noise abatement - Improper Vehicle lighting - Driving in the wrong lane/contra flow - License plate related infractions - Overtaking prohibition, multiple categories of vehicles - Dedicated lanes, multiple categories of vehicles - Closed lanes, related to time and/or categories of vehicles - Compliance with safety belts regulations - Monitoring of transports subjected to special licensing (Height, width, length). Barriers that may hamper further deployment and operation are privacy regulations and again, the lack of a Pan European Type approval mechanism.

**DRINK DRIVING.**

The members of the European Union all use screening and evidence devices for the determination of the BAC. These devices are adapted or adaptable for the various BAC limits in the EU and have to be type approved for each Member States and calibrated before they can be used in operational traffic policing. Technology developments are applicable to these devices as well, but innovation started already over 15 year ago. Back in the 80ties and 90ties of the previous century the technology to detect alcohol in a person’s blood improved drastically. Initially, chemical devices were used, those devices were costly, difficult to handle, unreliable, and difficult to interpret; they were used as a first indication that had to be followed by a blood test to deliver lawful proof. The new generation of electronic devices are far more reliable and better to handle. Nowadays the results are accepted as lawful proof and electronic devices for roadside alcohol screening and detection are used widespread. The most far reaching implication is operational by nature. The easy-to-use systems and low costs of this equipment prompted police more and more to exercise random breath testing. Barriers are that random breath testing is not allowed in some member states (UK) and the fact that there is no EU BAC limit.

**SEAT BELT ENFORCEMENT.**

Seat belt and other restraint devices (children’s seats) enforcement is still based on physical observation only by an enforcement officer. In terms of efficiency this does not provide good
results in terms of raising awareness that the proper wearing of seat belts contributes in a major way to prevent being gravely harmed or worse in case of a traffic accident. Next to this, continuous physical observation would require too many human resources in order to be effective.

**Seat belt enforcement technology.**

Digital imaging technology can be used as has been proven in a Finnish pilot [5]. When the seat belt use is visible to the eye it is very likely that it can also be detected automatically by means of digital imaging technology. It has been proved that when the seat belt is visible, the mean grey values of it and background differ more than about 15 units in a scale of 0 to 255 in a gamma corrected grey level map. For achieving good average visibility to the seat belt area with different windshield constructions, a rather shallow angle for the camera, about 15 degrees with respect to the ground level should be used. An extra light from the side of the car was found to improve the visibility in such cases where there is a dark background for the dark seat belt.

**Implications of seat belt detection system.**

It would be possible to introduce an interlock with the ignition system but this meets (strangely enough) resistance by the car manufacturers, claiming that their customers would not accept it. Manufacturers rather invest in warning systems than in interlock systems when it comes to the safety belt aspect. A technology solution for 24/7 enforcement on wearing your seat belt mainly on urban roads would push safety belt compliance considerably and would relieve human staff.

**PASSIVE ENFORCEMENT.**

Passive enforcement can be regarded as an off-spin of the technology that is being developed and brought to the market by the industry with the aim to enhance road safety. This can be integrated in the road infrastructure or installed as an intelligent tool in ‘smart vehicles’. Information and warning technologies can be considered to be the basis for this kind of enforcement. This technology does not address enforcement in the first place but has the potential to inform and/or support the motorist to drive safely and in compliance with the traffic regulations. It has not punitive impacts and is voluntarily in nature. This supporting role can take many different shapes, as was said before, either being integrated in the infrastructure or in the vehicle, or taking a different approach to its study, being oriented to actively support the driver or just to make roads safer. A prominent part of passive enforcement can be derived from in-vehicle technology which is under full development. To name but a few: ISA – ALCOLOCK - ADAS – CVIS – CALM - V2V – V2i. These systems that either interact with the vehicle or with the vehicle, the driver and the direct environment (other vehicles and the infrastructure) have a huge potential to be applied to passive enforcement without any repression. Problem is that it is not being recognised as such, not by the manufacturers, not by the authorities and not by the driver him/herself.

Enforcement agencies have acquired this vision during the PEPPER project. It will be their task to present this to other stakeholders in the Road Safety area and to find ways to support and promote this on a larger scale.

**INTELLIGENT SPEED ADAPTATION (ISA).**
Intelligent Speed Adaptation (ISA) systems is the assembly name of a various type of functions which have been seriously and comprehensive evaluated in a number of field operational tests in several countries around the world. The ISA concept brings speed limit information into the vehicle. Navigation devices in the vehicle (commonly by GPS) provide a precise location and heading, whilst an on-board map database compares the vehicle speed with the location’s known speed limit. In the future, this technology will however also be able to indicate at any moment the optimum speed within the legal limit adapted to traffic conditions, road features and weather conditions as well as temporary restrictions such as those for road works. The safety effects that current ISA technology can deliver are already impressive. Research has shown that advisory ISA can achieve an 18% reduction, and non-overridable intervening ISA a 37% reduction in fatal accidents. In other EU countries, up to 50% of traffic deaths could be avoided if all cars were equipped with supportive ISA.

The results from a number of pilots on ISA in the EU demonstrate that there is a majority support for ISA technologies. ISA will reduce the need for traditional police enforcement of speed limits and can replace costly physical measures currently used to obtain speed compliance. Another advantage with ISA is that it is much cheaper than any other means to enforce existing speed limits. There are some obstacles that has to be forced before implementation of system like costs of in-car and infrastructure equipment, the lack of accurate speed limit databases. In the short term, ISA could be one of the most successful passive enforcement applications and a forerunner for further development of passive enforcement.

ALCOLOCK.

One in three traffic fatalities in Europe is alcohol related and around 3,000 people in the UK are killed or seriously injured each year in drink drive collisions. Alcohol interlocks could form part of a solution to reduce the problem of drink driving. An alcolock is fitted to a car’s ignition to prevent a driver from starting the vehicle if he’s over the drink-driving limit. The alcohol inter-lock can also be set at different levels depending on the particular alcohol limit suited to the different drivers. Alcolocks are currently used in driver rehabilitation programmes as well as some commercial transport companies in Sweden and the U.K.

Alcolock is seen as a way to stop people who have been convicted of driving under the influence from offending again. Trials have been taking place in recent years in the US, Australia, Canada, and Sweden, though not always under this name. Experiences in the US and Canada have shown that alcohol inter-locks can lead to 40-95% reductions in the rate of drink driving repeat offences. Field trials have shown that there is a 28- 65% lower conviction rate if there is an inter-lock installed in the vehicle, where the 65% lower rate is reached during the first year after installation. Alcohol inter-locks have been used in Sweden to rehabilitate voluntary drivers that had broken the law by driving with a blood alcohol content over the threshold level (0.2%).

MAIN FINDINGS AND IMPLICATIONS.

Member states that are at the forefront of efficient traffic law enforcement like Sweden, United Kingdom, France, and the Netherlands have achieved an average of about 30% less people killed in traffic over the past years. The mid-term review of the EU’s White Paper on Transport, which did not address Traffic Law Enforcement at all, showed a percentage of 17,5% less people killed in
traffic only. Simple mathematics show that in total a 47.5\% reduction on traffic deaths will be possible and achievable by 2010 (White Paper measures + Traffic Law Enforcement = 47.5\%). This strong potential has to be reached by an efficient and effective combination, implementation, and deployment of active and passive enforcement systems and technology, preceded by removing the barriers described as soon as possible. The latter issue, removing those barriers, has been adopted by the EU Council of Ministers of Transport and has been laid down in its resolution on Inland Road Transport Safety (Luxembourg, 2000). This was in fact to be regarded as a cornerstone document, addressing the right items. Fact is however that this document never saw a proper follow-up by the EU and its member states as it had insufficient momentum, positioned as it was in an administrative context.

Section control has been tested most extensively of all the systems presented, they are operational in some member states as has been described with impressive results. The findings and implications related to these systems are therefore considered to be the most interesting; section control has matured and should be implemented and deployed at a large scale throughout the European Union. Barriers that are hampering this, mainly type approval and privacy issues should be addressed and removed as soon as possible, starting at and being pushed from the EU policy level and lawgiving chain, down to all member states. Member States should address this as well, the initiative has to spark a both levels, and cooperation on this should be pursued with the European Commission, making it a really joint effort. At large, these same barriers (type approval and privacy issues) should be addressed and removed as soon as possible in the same manner in the spirit of the afore mentioned resolution.

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