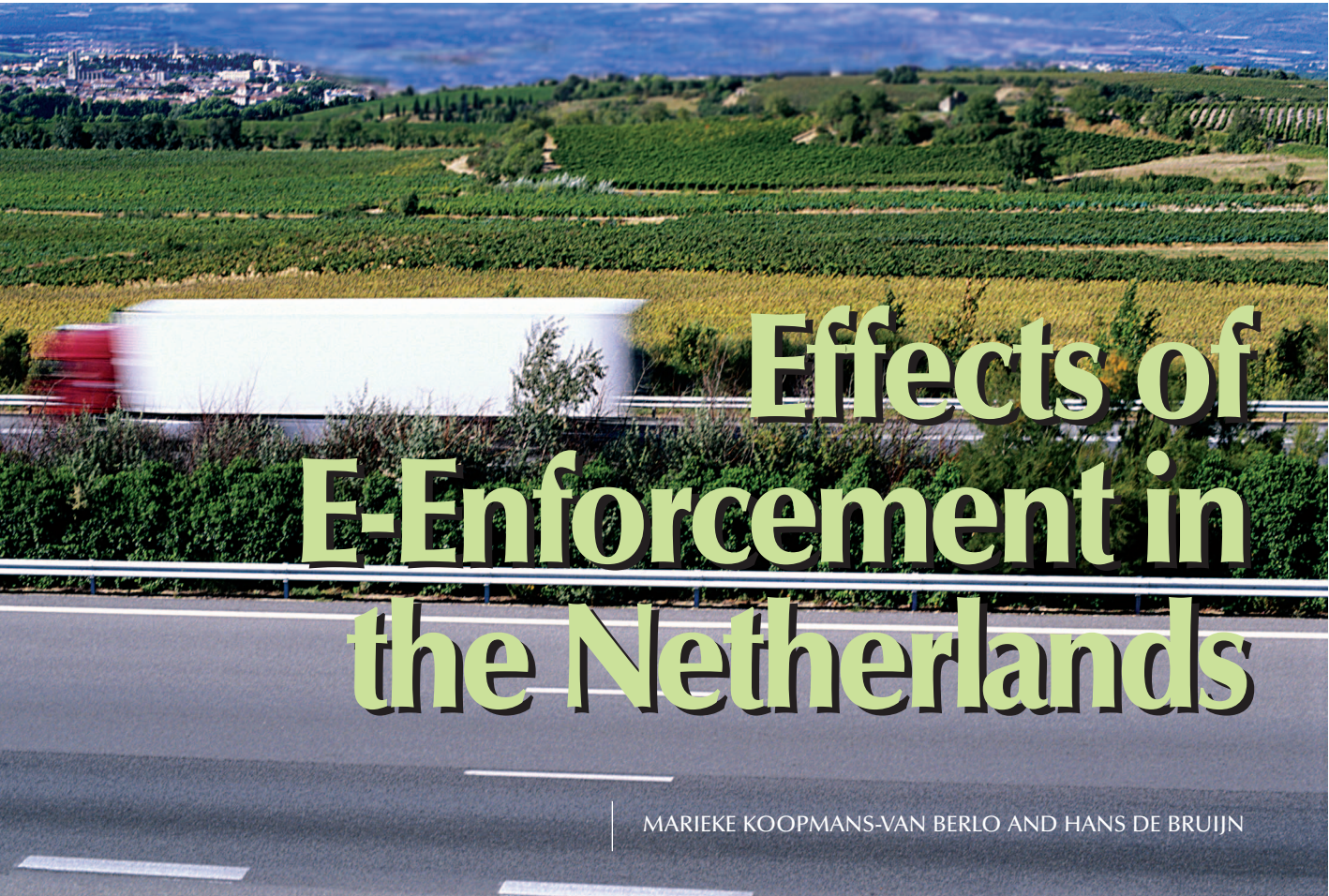




Effects of E-Enforcement in the Netherlands

MARIEKE KOOPMANS-VAN BERLO AND HANS DE BRUIJN

©PHOTODISC

Recent decades have seen the emergence of “e-enforcement” – the use of electronic tools in law enforcement. In some sectors, such tools have been common for some time, as in the use of cameras to prevent red light running and speed violations.

These traditional forms of e-enforcement (“automated enforcement,” “photo enforcement”) have a limited function: to produce photographic evidence of relatively simple offenses. Recently, however, several new initiatives have been developed, which we shall term “second generation e-enforcement.” The prime characteristic of these new measures is that they go further than merely recording the offense, and can be used to address more complex violations.

It seems likely that governments worldwide will increasingly adopt forms of e-enforcement. Accordingly, we considered research that centers on the impact and effects of such measures to be of great importance. Much is already known about the functioning of the first generation of e-enforcement. Various studies conclude that, while there is some opposition on the part of motorists, the e-enforcement measures have generally been well received and are considered successful. However, little is yet known about second generation e-enforcement. Therefore we focus here on e-enforcement’s functioning and effects. In particular, we address the question of how e-enforcement affects the relationship between the regulating authority (i.e., the enforcement official) and the regulatee.

This article is based on our research into the effects of two forms of second generation e-enforcement: the digital tachograph and ‘Weigh in Motion’ (WIM). The digital tachograph replaces the analog tachograph in all heavy goods vehicles within the European Union. The equipment registers drivers’ driving and rest times. Weigh in Motion with Video (WIM-Vid) is a system involving sensors in the road and cameras, which detect and register overloading of heavy goods vehicles. The WIM-Vid system was developed and implemented in the Netherlands and is currently attracting international attention. We shall compare the situation prior to the introduction of these e-enforcement measures to the situation after the introduction of e-enforcement.

E-Enforcement: First and Second Generations

E-enforcement, or electronic enforcement, is the use of electronic tools in law enforcement [19]. We shall distinguish between the first and second generations of e-enforcement.

The first generation of e-enforcement tools provided means of “automated enforcement.” The three most common forms of automated enforcement [10] involve the use of cameras to enforce existing laws against red light running [8], [10], [16], [17], [19], [22] [24], speed violations [10], [23], and entering railway crossings when the gates are down [10], [15]. Other examples of e-enforcement mentioned only briefly in the literature involve the enforcement of laws against failure to pay tolls, high-occupancy vehicle lane violations, tailgating and aggressive driving, electronic toll collection systems, and remote sensing of vehicle emissions [4], [5], [10], [21].

Automated enforcement is now in large-scale use throughout the world. Bochner [5] reports that automated enforcement is in place in over 75 countries. The literature on automated traffic enforcement, mainly concerning red light running and speeding, shows a positive picture for enforcement possibilities. Automated traffic enforcement has proven very effective in reducing violations and accidents [8], [15], [16], [17], [19], [24]. When Wissinger, Hummer et al. [24] asked focus groups to name positive aspects of automated camera enforcement, responses included personnel savings, constant monitoring, and the ability to help control crime and violations. Red light cameras are strongly supported by public opinion [24]. However, there are exceptions. Some authors state that motorists oppose the introduction of automated traffic enforcement and have attempted to influence politicians [4], [21]. Various web sites exist on which opponents

explain how to avoid prosecution resulting from an offense detected by automated enforcement measures. The sites also publish the current locations of mobile automated enforcement units and advertise devices that claim to prevent a camera from clearly photographing a license plate [10]. E-enforcement has the potential to allow a “zero tolerance” approach to be adopted [24]. In the words of Bovens and Zouridis [6]: “Information and Communication Technology makes it possible to perfect the legality of the execution in the extreme.”

Notable Characteristics

What are the main characteristics of the first generation of e-enforcement, and what differences are to be found in the second generation? Table I presents the most significant differences. (The table and its subsequent notes are based on the two forms of second generation e-enforcement measures examined during the current research.)

The first notable characteristic of the first generation is that enforcement takes place on the basis of a single behavioral variable: has the regulatee jumped a red light or not? Has the regulatee exceeded the speed limit or not? The conclusion automatically follows from the measurement. The second generation concerns a combination of behavioral variables, whereupon a conclusion can be drawn only after analysis and calculations. The situations are more complex.

In the case of Weigh in Motion, for example, not only the weight of the total load, but also the load on

each of the vehicle’s axles should be considered. The axle load is a complicated measurement, affected by the speed of the vehicle. The method of calculating whether an offense has been committed differs according to the type of goods vehicle and the applicable regulations. In the case of driving times regulations, the calculation relies on the combination of driving time, rest time, and the type of activities conducted when stationary. This calculation is a complex one: various configurations of driving and rest times can constitute a violation, while a deficit of rest time within a certain period can be compensated in another.

A second characteristic of first generation e-enforcement is that the systems record incidental violations, at one moment in time at one particular location. Second generation e-enforcement is concerned with structural, ongoing illegal behavior. The systems monitor the behavior of regulatees through time and at various locations and collate the observations.

The WIM system comprises a number of measuring points at various locations. Each is connected to the others. Readings from the various locations, taken at various moments in time, are combined to produce an integrated picture for each regulatee. Similarly, the digital tachograph is permanently installed in the vehicle, and is thus able to register the driver’s behavior on an ongoing basis.

Thirdly, the first generation records “first order information,” which serves only to record the specific violation. Enforcement is

Table I

Comparison Of First And Second Generation E-Enforcement Measures

First generation e-enforcement	Second generation e-enforcement
One dimensional	Multi-dimensional
Incidental	Structural
Geared towards individual offenses: first order information	Geared towards patterns: second order information

confined to the individual offender and the individual offense. Second generation e-enforcement tools are able to aggregate data, whereupon attention shifts from enforcement at the individual level to that at the

enforcement official and regulatee. Sometimes this process is necessary because the regulatee is ignorant of the law. Sometimes, it is necessary because the regulatee is in a position of power and the

adopt the behavior concerned, avoiding controls, complying with the letter but not with the spirit of the law and so on [9], [13].

As stated earlier, research into the first generation of e-enforcement measures reveals a degree of opposition. Regulatees develop strategies to elude prosecution; they avoid known locations of automated enforcement units, or use devices to prevent a camera clearly photographing their vehicle's license plate. Nevertheless, the first generation of e-enforcement is regarded as having been successful and effective. To our knowledge, current research has not yet explored the success of second generation e-enforcement. We address the specific question of what influence second generation e-enforcement measures have on regulatees' strategic behavior.

The method adopted in this research is that of qualitative case study. We opted for this method for two main reasons. Firstly, scientific research into e-enforcement is still in its infancy. Secondly, because empirical research provides a matter-of-fact picture of the actual pros and cons of e-enforcement. We confined our research to only two case studies because the number of available case studies that satisfied the selection criteria was limited. These criteria were: the presence of empiric material, the scope of technology in the enforcement process, and societal relevance. Moreover, we wished to obtain a full and detailed picture of each case study. The focus of our research is the second generation of e-enforcement. We do not set out to compare the first and second generations with each other. Rather, we compare the situation with the second generation in place to that before the introduction of e-enforcement.

The case studies were conducted between January and August 2003 with the assistance of the Dutch Transport and Water Management Enforcement agency. The method entailed an average of ten semi-

Automated enforcement is now in large-scale use throughout the world.

collective level. The "second order information" can be used to assess risks, set priorities, identify patterns, and plan capacity.

The digital tachograph links data relating to the driving and rest times to the individual driver, and records background information that will enable the relevant authority to establish, say, the context of an accident. Information such as the speed and distance traveled in the past 24 hours, all card entries, and any attempts at fraud will be recorded. The WIM system establishes connections between types of violation, types of vehicle, load, haulage operators, the country of origin of those operators, and points in time.

Theory, Research Questions, and Method

The literature frequently distinguishes between two styles of enforcement [9], [20]. The first is that of "sanction," "compulsion," "coercion," and "penalization." In this paper, we refer to this as the "sanction style." It is based on the central notion that violation of the regulations must be penalized to ensure that regulatee observes the regulations in the future. Unremitting enforcement of legislation "to the letter" is the key concern: there is less attention for the interaction with the regulatee.

The second style relies on keywords such as "compliance," "conciliation," "compromise" and "remedialism." We shall use the term "compromise style." Here, enforcement is a process of consultation and negotiation between

relationship between enforcement official and regulatee is therefore interdependent.

In the sanction style, information is crucial. Provided the enforcement official has correct information concerning the regulatee's behavior, he can take the appropriate action. E-enforcement is attractive in this situation, in that it provides more, and better, information about behavior than the traditional forms of observation.

The second generation of e-enforcement tools appear promising in this regard. They involve not only the enforcement of a single behavioral variable, with an automation and standardization of observations at the individual level as in the first generation, but the enforcement of several behavioral variables, integrated in time and place. In combination, they provide aggregated information. One interesting question is therefore whether second generation e-enforcement will provide the enforcement official with better information as the basis for better enforcement strategies.

The compromise style relies on the interaction between enforcement official and regulatee, who negotiate with each other. In the literature concerning the relationship between these two parties, we see considerable attention devoted to the strategic behavior, or "game playing" of regulatees. They attempt to defer enforcement, citing the unreasonable nature of the rules, presenting excuses and "cover stories," claiming to have had no option but to

structured in-depth interviews per case study. Respondents were representatives of the regulating authorities, regulates, and e-enforcement system developers. These interviews were complemented by a desk study of internal documents provided by the respondent organizations, the Internet, and the existing literature. A full account of the case studies and research methodology is to be found in [25].

Two Case Studies

Weigh in Motion with Video

Overloading of heavy goods vehicles can take two forms: the vehicle as a whole can be overloaded or there can be an excessive load on one of the axles. Both types of overloading cause damage to roads and dangerous situations. As overloading represents a form of unfair competition, both types of overloading are liable to penalties as an economic offense.

Original Enforcement

Before any electronic enforcement system was available, enforcement officials and police conducted incidental roadside checks. Motorcycle

squads halted heavy goods vehicles and led them to a parking space at the side of the road. The vehicles were selected by appearance: trailers with a large bulge on top or with sagging axles stood a good chance of being stopped and weighed, as did vehicles from haulage companies with a bad reputation, or vehicles carrying a specific type of freight known to have a tendency towards overloading. Once a driver had been led to the side of the road, he was required to drive his vehicle slowly onto a weighing platform and to stop at each axle. The weighing platform determined the load on the axles. If overloading was discovered, an official report was produced.

E-Enforcement

A definition of Weigh in Motion is "the process of estimating the total weight of a moving vehicle and the part of that weight carried by each wheel, each axle or axle group or a combination thereof, by measuring and analysing the dynamic tyre forces of the vehicle" [11]. Much of the technological development of the WIM system has been done at the

Center for Transportation Research, at the University of Texas at Austin (see, for example, [12], [14]). An innovative application based on the WIM system has recently been developed in the Netherlands, by linking the WIM itself with cameras (WIM-Vid, video) and registration databases (Fig. 1).

Induction loops are placed in the road to register the passage of traveling vehicles, along with sensors that record the axle configuration and the axle loads. The axle configuration indicates the type of vehicle, thereby specifying the norms that apply to it. Cameras above and beside the road photograph the registration number, time of violation, any hazardous substances sign displayed, and the vehicle as a whole. An infrared camera is also in place for night-time photographs. All passing heavy goods vehicles are monitored 24 hours a day. The measuring points are indicated by road signs.

Enforcement officers can watch images of overloaded heavy goods vehicles in real time, either on the spot or from a remote location. The data from the WIM-Vid system is automatically linked to the registra-

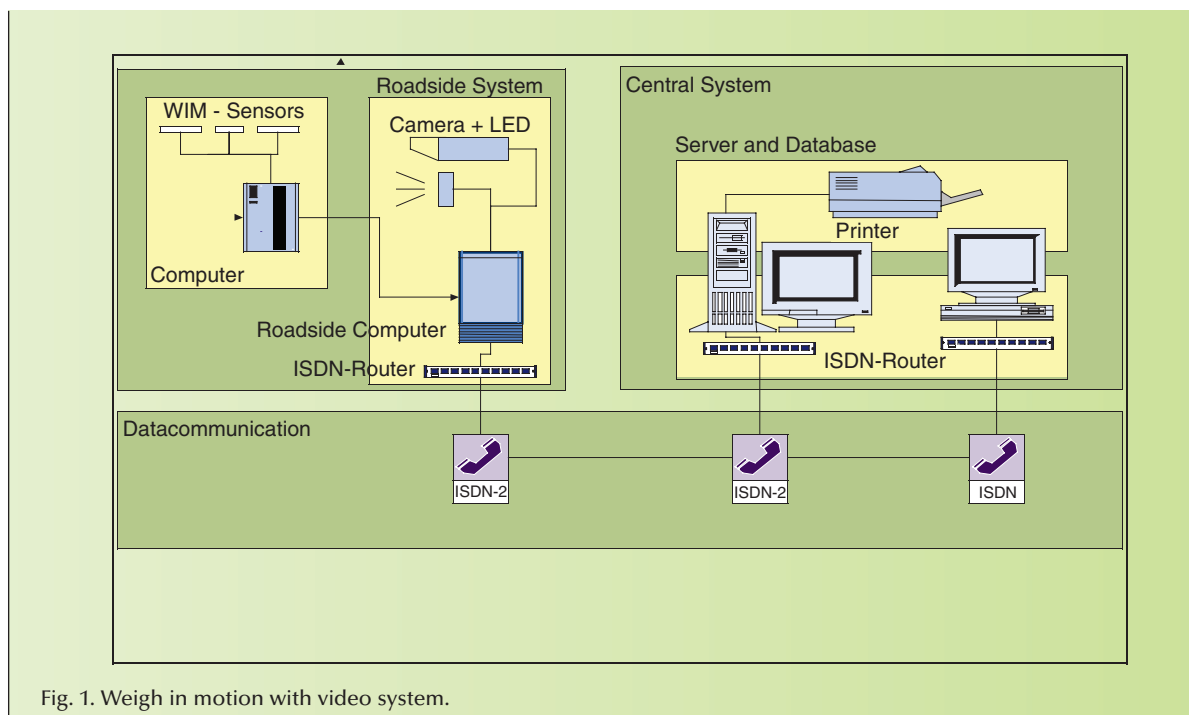


Fig. 1. Weigh in motion with video system.

tion data held by the Dutch Road Transport Directorate (RDW) Centre for Vehicle Technology and Information, thereby linking the information about the violation with the name of the company which owns or operates the offending vehicle. WIM-Vid is used to

Original Enforcement

A tachograph is a mandatory piece of equipment in heavy goods vehicles. It records the driving and rest times of the driver. From 1975 until the present day, the tachograph has been analog, i.e., mechanical. When using an analog

E-Enforcement

In 1997 the European Union Transport Council ordered the mandatory introduction of the digital tachograph. Technical specifications have been published and arrangements for enforcing with the digital tachograph have been made.

The digital tachograph is a piece of equipment that is now to be installed in every heavy goods vehicle or bus. As with the analog tachograph, the basis is a “motion sensor” in the gearbox. Like its analog counterpart, the digital tachograph registers speed and distance and links these to date and time (Fig. 2).

In order to link the data to a person, the driver carries a personal “smartcard.” When a driver changes vehicle, he takes the smartcard with him and inserts it into the tachograph of the next vehicle. The tachograph writes to the driver’s smart card and to its own memory. If a driver should operate the vehicle without inserting a smartcard, the tachograph will still register the data in its own memory, but without linking it to a name. The data is stored on the driver’s smartcard for 28 days and in the tachograph’s memory for one year. Each enforcement official also carries a smartcard. When he inserts this into the tachograph during a roadside inspection, he can download all the data from the tachograph’s memory.

The company has special company smartcards. These allow the data from all the vehicles’ hard disks to be downloaded to its computer. Companies are obliged to store all data in a central file for one year. During a company visit, the enforcement official can view the entire database. In the future, the Transport and Water Management Enforcement agency would like to see the companies submit their data on a mandatory basis. Finally, there are also workshop smartcards. Each workshop authorized to install digital tachographs has a smartcard that allows full access to the tachograph and its settings [1], [2].

E-enforcement has the potential to allow a “zero tolerance” approach to be adopted.

select violators, who are subsequently checked for overloading using a weighing platform. Violators found to be in violation of the regulations must remedy the situation on the spot and will always receive a penalty.

Legal Aspects and Privacy Concerns

National law in the Netherlands does not allow for sanctioning based on the Weigh-in-Motion data. Therefore, the system can only be used for “preventive” applications. In order to sanction overloading, enforcement officials must still operate the measuring points and direct supposedly overloaded trucks to a static weighing platform on a nearby parking lot.

The weigh-in-motion data is transported only in encrypted form. Once the WIM-vid data is linked to the company identities, the data is only accessible to the enforcement agency. Pictures of trucks are only kept in case of a violation. Because of these precautions and because of the absence of direct sanctioning, privacy concerns were limited.

Digital Tachograph

Tired drivers drive less safely; this is the reason underlying the existence of legislation governing driving and rest times for the drivers of buses and heavy goods vehicles. Violating these rules is an economic offense.

tachograph, drivers are required to insert a paper disc into the machine during their shift. A sensor in the gearbox measures the speed of the vehicle and the distance traveled, and a stylus traces these details on the wax layer of the paper disc. The driver takes his paper disc with him when he changes vehicle, and is required to carry the discs for the last eight days with him during working hours. The relevant operator company is required to keep all drivers’ discs on file for one year.

The Transport and Water Management Enforcement agency conducts inspections on the roads and at company premises. During roadside checks, the enforcing officer asks the driver to produce his tachograph discs and he reads whether that driver has taken enough breaks and sufficient rest. A company visit is only carried out if violations are suspected, for example on the basis of roadside inspections. As stated above, companies are required to store their drivers’ tachograph discs for one year. During a company visit, the enforcement official takes away with him the pile of tachograph discs from the previous year. The discs are inspected by scanning them one by one into a computer program which is able to detect violations. Companies are sometimes asked to submit their paper discs to the enforcement agency on a voluntary basis.

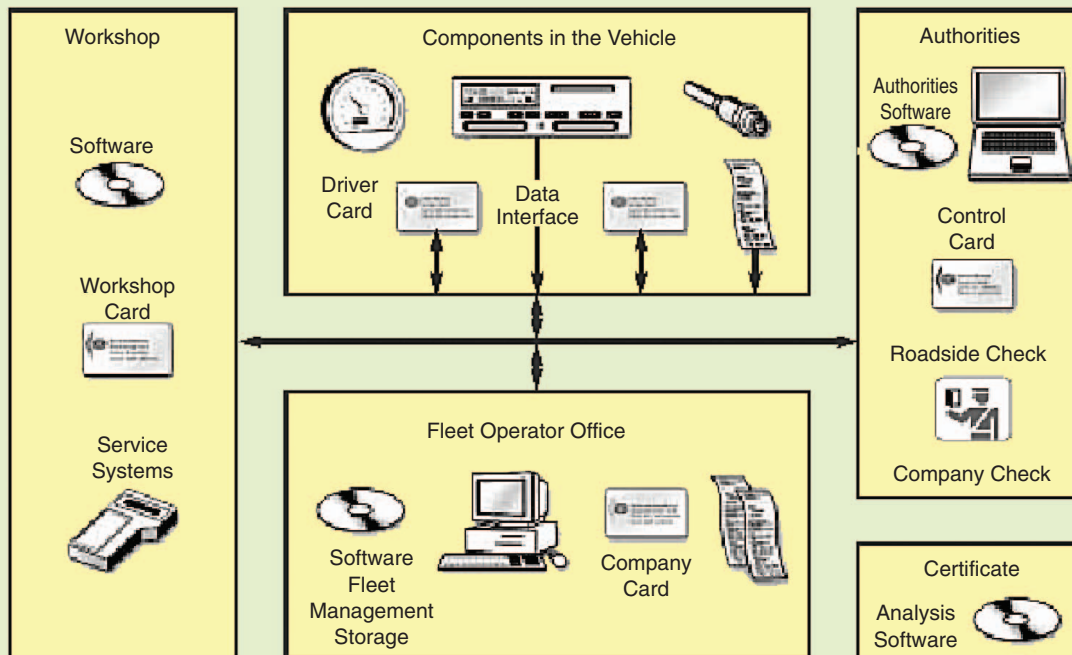


Fig. 2. Digital tachograph system [7].

Legal Aspects and Privacy Concerns

The European law that prescribes the introduction of the digital tachograph, does not provide enough conditions for effective enforcement. Mandatory downloading and storing of tachograph data on a company level is therefore prescribed additionally by Dutch national law. Privacy concerns are not a central issue, probably because the digital tachograph succeeds the analog tachograph, which in principle has quite the same impact on drivers and transport companies.

Observations

We shall present observations drawn from the case studies in line with the two research questions. First, we consider the impact of e-enforcement on the provision of information and related procedures, before going on to consider the impact on the interaction between enforcement official and regulatee, to include aspects of strategic behavior.

E-Enforcement and Information

More first-order information facilitates operational enforcement.

In both case studies, e-enforcement appears to result in a greater quantity of first order information that can be used in operational enforcement. Previously, enforcement of overloading regulations relied on incidental spot-checks. Weigh in Motion monitors 24 hours a day at six measuring points. While enforcement officials used to have information about only those vehicles that were pulled over, they now have data relating to all passing vehicles.

The discs from analog tachographs provided information about one particular driver only. The digital tachograph provides two sources of information: the driver's smart-card and the memory of the device itself. An enforcement official who downloads information from the device in the vehicle gains all information pertaining to all drivers who

have operated this vehicle in the past year. Similarly, while the driver was required to retain analog discs for eight working days, his smart-card records the data for the past 28 working days. The digital tachograph also serves to reduce the time required to conduct an inspection on company premises. Enforcement officials used to have to read a vast stack of individual discs. Now, they receive all data in one digital file. This improved efficiency enables the same number of enforcement officials to control a larger number of operators.

More second-order information and pattern recognition leads to new strategies at the collective level.

In both case studies, e-enforcement may be seen to result in a greater quantity of second-order information, more opportunities for pattern recognition, and possibilities for new enforcement strategies at the supra-individual (collective) level. It is likely that companies will

eventually be required to submit all tachograph data “on line” to the enforcement agency. The onus of responsibility therefore shifts from the enforcement official to the regulatee. The enforcement official can achieve greater efficiency in enforcement, and can extend the scope of control.

The original enforcement of overloading regulations focused on the individual vehicle. A violation would be detected and penalized, whereupon the enforcement process was at an end. The new Weigh in Motion system records license plates and hence establishes a direct link between violations and the company responsible. This enables enforcement officials to identify frequent offenders.

have led to new enforcement strategies:

■ *Targeted weight controls.*

Previously, roadside inspections were rather random in nature, and valuable manpower was wasted on inspecting vehicles that were within the prescribed limits. Weigh in Motion enables offenders to be singled out for roadside inspections. Types of vehicles that were previously not inspected because compliance was “assumed” are now subject to targeted controls.

■ *Company visits.*

Enforcement officials now visit the ten “worst offenders” and confront the management of those companies with the facts: they have hard evi-

Strategic behavior reduced at the level of the instruments.

In the original enforcement practices addressing overloading, enforcement officials experienced considerable strategic behavior or “game playing” on the part of regulatees. The earlier systems of enforcement addressing both overloading and driving/rest times gave rise to much strategic behavior. Every driver knew how to manipulate the analog tachograph. A simple paperclip attached to the essential moving parts was enough to make the device record an extended rest period. Special cables could be used to stop the device, or fuses could be removed. Other tried and tested methods included “clocking” (turning the clock and vehicle odometer back) or entering a false entry signal. Some “do-it-yourself (DIY) enthusiasts” went so far as to modify the quartz crystals of the clock in such a way as to enable time itself to be slowed down or speeded up [1], [2]. Fraud with the analog tachograph formed one of the prime reasons for introducing its digital counterpart. What opportunities for similar strategic behavior exist with WIM and the digital tachograph?

The digital tachograph has been deliberately designed to preclude tampering. Security is “state of the art.” The connections with the motion sensor in the gearbox are sealed. The device has far fewer connections than its analog predecessor. There is no means of entering information, other than from the motion sensor itself. All components are molded into the tachograph body, which cannot be disassembled. The device will record all manipulation attempts with a special code, which it then presents to the enforcement official during an inspection.

The Weigh in Motion system records every instance of overloading. Drivers can attempt to mislead the measuring points, but the design of the system automatically precludes success in doing so. Drivers

The full and unremitting application of the rules in a sanction style could lead to a loss of legitimacy.

The WIM system also enables patterns to be distilled from the violations recorded. For example, 70 percent of overloading offenses were shown to relate to the overloading of only one axle, rather than the vehicle as a whole. In most cases, the axle concerned was that at the very front of the vehicle. Enforcement officials have discovered that, in most cases, it is not the actual weight of the load that leads to a violation, but improper distribution of that load on the vehicle. Another significant new finding has been made. Some types of transport used to be subject to extremely infrequent inspection because enforcement officials believed that overloading of these types was unlikely. However, Weigh in Motion proved them to be high-risk groups.

The identification of frequent offenders and pattern recognition

dence of all offenses committed by the drivers employed by that company and demand that measures be taken. Enforcement officials are not able to impose sanctions or penalties during these visits, but can threaten more intensive roadside controls for the company concerned.

■ *Information to the industry.*

Another approach involves, consultation with selected companies regarding loading practices and technological solutions that will reduce axle load or improve the distribution of load on the vehicle.

E-Enforcement and Strategic Behavior

What influence does e-enforcement have on the strategic behavior of regulatees? How do WIM and the digital tachograph affect the interaction between enforcement official and regulatee?

who change lanes to avoid the sensors will be photographed, besides which the detection loops cover the entire breadth of the road, including lanes that may not be used by heavy goods vehicles. Tampering with license plates is similarly fruitless. Where the system cannot automatically recognize the number, it will be read from a photograph later. Driving over the sensors in groups will also prove ineffective, since cameras are positioned on both sides of the road, whereupon the license plate can never be concealed. The conclusion must be that the opportunities for “game playing” at the level of the instruments are far more limited than was previously the case. The introduction of e-enforcement has created an intensive and practically watertight system of control.

Strong incentives to strategic behavior at collective level.

The interaction between enforcement official and regulatee is very much reliant on the degree to which the regulatee regards the rules and their enforcement to be legitimate. Here, we see a remarkable phenomenon. Now that the intensity of enforcement has been greatly increased by e-enforcement methods, the legitimacy of the rules and their enforcement is more likely to be questioned by the regulatees. Two examples:

- The majority of overloading violations relate to the overloading of only one axle, due to improper distribution of the load as a whole. Regulatees are therefore not overloaded as such, since the weight of the vehicle is within the prescribed limits. They are merely too heavy on one axle. Many consider the strict enforcement of the overloading rules on the basis of just one axle as unjustified. After all, the cause of the overloading is not economic but tech-

nical: for some types of vehicle, it is simply not possible to find a technical solution to prevent single-axle overloading. Before the introduction of WIM the overloading of one axle was hardly enforced.

- Driving times and rest times are established by European legislation. Enforcement officials can penalize drivers for a violation committed some time in the past, and in another country. It appears that the manner in which enforcement officials interpret the regulations varies from country to country, as do the penalties they can, or choose to, impose. Transport companies believe that the introduction of the digital tachograph will exacerbate the problem of inequality of treatment, since it enables enforcement officials to consider driving and rest times over a very much longer period than was previously the case.

The strength of second-generation e-enforcement thus becomes its weakness. It enables full enforcement on a larger scale, but given the complexity of the behavior that enforcement must address, there could well be some loss of legitimacy. Where the legitimacy of the regulations or their enforcement is contentious, there will be major incentives to adopt strategic behavior. If there is absolutely no opportunity for such behavior at the operational level (the system is, as we have seen, watertight), then it may manifest itself at other levels. It could, for example, shift from the individual level (the driver) to the collective level of the company, or even the industry as a whole. When a company or a large section of the industry indulges in strategic behavior, the potential impact will be many times greater than that of strategic behavior at the individual level. Some examples of collective strategic behavior are:

- Companies may, for example, refuse to cooperate with on-site inspections, devising countless strategies to frustrate the enforcement officials’ work. They may refuse entry to their premises, they could withhold all but the minimum required information, they could ensure that the vehicles and drivers are all elsewhere at the time of the inspection, and so forth.

It would be a step further if companies or sections of the industry were to attempt to frustrate the use of the instruments themselves.

- A significant risk attaching to the digital tachograph is the use of the “workshop smartcard,” which enables workshop mechanics to change the settings of the device. Experience with the analog tachograph reveals instances in which workshop staff have been bribed to tamper with the equipment. Bribery or unchecked circulation of workshop smartcards could open the way to large-scale fraud with the digital tachograph. Indeed, Anderson [1], [2] predicts just this. It also seems tempting to manipulate the downloaded data for all drivers while on the company’s computer. This is the data that enforcement officials check during a company visit. Although rigid security measures are in place, we must consider the possibility that the fraudsters will eventually prove smarter than the technology. If they succeed in cracking the security, the risk of widespread fraud involving digital tachographs is even greater than that involving the analog version.
- Strategic behavior at a collective level is also visible with

regard to WIM. Thirty minutes after a measuring point is staffed, the number of overloaded vehicles falls dramatically. After two hours, there are practically no overloaded vehicles at all. The enforcement officials assume that drivers are communicating with each other and either

- Second generation e-enforcement offers opportunities for intensive, information-based controls and inspections. Strategic behavior remains in place even after the introduction of e-enforcement. These observations are in line with the familiar insights with regard to the first generation

enforcement of behaviors that are more complex than those addressed by the first generation. At the same time, the full and unremitting application of the rules in a sanction style could lead to a loss of legitimacy (see also [3]). Ideally, enforcement officials who use the second generation e-enforcement tools should enjoy greater discretion in applying the rules more flexibly. Literature on law enforcement shows that in complex and ambiguous situations law enforcement should be accompanied by discretion in order to be effective [3], [18], [20]. We argue that in our case more elements of a compromise style should be introduced. This means that second generation e-enforcement brings with it a difficult task. While it enhances the opportunities for effective and efficient enforcement, it must be used with due moderation in order to prevent loss of legitimacy and the adoption of collective strategic behavior.

This task prompts an important recommendation with regard to the introduction of second generation e-enforcement, namely that it should be accompanied by a strengthening of the professional autonomy of the enforcement official, for at least three reasons:

- The enforcement official must be able to weigh the likely effect of full enforcement against the possible loss of legitimacy. If the loss of legitimacy is seen as too great, he must be able to exercise discretion.
- The enforcement official must be able to weigh the likely effect of full enforcement against the likelihood of encouraging strategic behavior at the collective level. If the costs of counteracting strategic behavior are greater than the gains of strict enforcement, the balance will tip in favor of a more moderate approach.

In complex and ambiguous situations, law enforcement should be accompanied by discretion in order to be effective.

stop or select an alternative route when they know that a measuring point is in operation. These opportunities for strategic behavior also cast a different light on another finding: companies that have been visited by the enforcement officials do not appear in subsequent statistics. This may be because they then observe the rules. However, given the possibilities for strategic behavior, it may also be because they avoid all measuring points thereafter.

It must therefore be concluded that opportunities for strategic behavior do exist. The question of whether this behavior is being adopted in practice is more difficult to answer by means of research. After all, it is in the regulatees' own interests to ensure that strategic behavior remains invisible. Nevertheless, we may state that there are now marked incentives to adopt strategic behavior on the collective level, and that there are also various (technical) possibilities for strategic behavior at this level.

Implications

Based on the analysis of the two instruments, the following conclusions can be drawn:

of e-enforcement measures.

- Second generation e-enforcement enables pattern recognition at the supra-individual level, e.g., at that of the company or (sections of) the transport industry. The case studies show that this pattern recognition opens the way to new enforcement strategies, perhaps targeting companies that are known frequent violators of the regulations.
- Because controls can now be more intensive and are practically watertight, there can be some contention regarding the legitimacy of the rules and the manner in which they are applied.
- There are now very few opportunities for strategic behavior at the individual level. However, there are stronger incentives to adopt strategic behavior at the collective level, partly because the legitimacy of the regulations and their application is now contested.

Paradoxical Picture

A somewhat paradoxical picture therefore develops around the second generation e-enforcement measures. They offer many possibilities for more effective and efficient

- While enforcement at the individual level will no longer require the enforcement official to exercise any significant degree of discretion, the activities at collective level (e.g., company visits) will indeed do so. Enforcement at the collective level cannot be readily standardized, and therefore demands appropriate professional autonomy.

The following are examples of how discretion and professional autonomy can be exercised in our cases:

- Enforcement officials could make a distinction between overloading on one axle and overloading of the whole vehicle. As overloading on one axle is mainly a technological problem, enforcement officials could offer their expertise to transport companies, to find solutions. If a transport company is in the process of adapting the vehicles, officials could refrain from sanctioning until the problem is solved. It could be decided in general that companies are offered a transitional arrangement for a certain period of time, in order to invest in more robust vehicles.
- Concerning the digital tachograph, enforcement officials could cooperate with transport companies in order to establish an enforcement level playing field. If regulations are interpreted differently in other countries, enforcement officials could consult the transport associations about their views on the different interpretations.
- The tachograph enables enforcement officials to consider driving and rest times over a much longer period than was the case with the analog tachograph. The use of discretion could imply

that if a violation is beyond a certain point in history, officials refrain from certain forms of sanctioning.

These recommendations arise from the paradoxical situation cited above, and may be regarded as somewhat counter-intuitive. After all, second generation e-enforcement renders enforcement activities watertight, whereupon it should become a self-executing process demanding no professional autonomy whatsoever on the part of the enforcement official. However, the risk of legitimacy loss, the risk of collective strategic behavior being encouraged, and the gains to be made by shifting enforcement onto the supra-individual level render such autonomy absolutely essential.

Author Information

Marieke Koopmans-van Berlo is a Ph.D. student, and Hans de Bruijn is a full Professor, at the Department of Organization and Management at the Faculty of Technology, Policy, and Management, Delft University of Technology, P.O. Box 5015, 2600 GA, Delft, the Netherlands. Hans de Bruijn is also Program Leader and former Associate Dean at the Netherlands' School of Public Administration. Email: j.a.debruijn@tbm.tudelft.nl.

References

- [1] R. Anderson, "On the security of digital tachographs," *Computer Security ESORICS98*, vol. 1485, pp. 111-125, 1998.
- [2] R. Anderson, *Security Engineering, A Guide to Building Dependable Distributed Systems*. New York, NY: Wiley, 2001.
- [3] E. Bardach and R. A. Kagan, *Going by the Book: the Problem of Regulatory Unreasonableness*. Philadelphia, PA: Temple Univ. Press, 1982.
- [4] R. Bartoskewitz, P. Carson *et al.*, "Council report summary: Automated enforcement in transportation," *ITE J.*, vol. 69, no. 11, p. 47, 1999.
- [5] B.S. Bochner, "Automated enforcement reduces crashes," *ITE J.*, vol. 68, no. 6, p. 12, 1998.
- [6] M. Bovens and S. Zouridis, "From street-level to system-level bureaucracies; How ICT is transforming administrative discretion and constitutional control," *Public Admin. Rev.*, vol. 62, no. 2, pp. 174-184, 2002.
- [7] Ertico, *The Digital Tachograph*. Brussels,

- Belgium; Ertico, 2002; www.ertico.com.
- [8] W.D. Glauz, "Using automated enforcement to reduce speeding," *ITE J.*, vol. 68, no. 6, p. 22, 1998.
- [9] K. Hawkins, *Environment and Enforcement, Regulation and the Social Definition of Pollution*. Oxford, U.K. Clarendon, 1984.
- [10] Institute of Transportation Engineers, *Automated Enforcement in Transportation, an Informational Report of the Institute of Transportation Engineers*. Washington D.C., Institute of Transportation Engineers, 1999.
- [11] A.J. Katz and A.H. Rakha, "Weigh-in-motion evaluation; field and modeling framework and case study of truck weigh station operation," Tech Transportation Institute, Blacksburg, VA, 2002.
- [12] C.E. Lee, B. Izadmehr, and R.B. Machemehl, "Demonstration of weigh-in-motion systems for data collection and enforcement," Center for Transportation Research, University of Texas at Austin, Austin, TX, Res. Rep. 557-1F, Dec. 1985.
- [13] D. McBarnet and C. Whelan, "Challenging the regulators: Strategies for resisting control," in *Regulation and Deregulation - Policy and Practice in the Utilities and Financial Services Industries*. C. McCrudden, Ed. Oxford, U.K.: Clarendon, 1999, p. 450.
- [14] R.B. Machemehl, C.M. Walton, and C.E. Lee, "Acquiring traffic data by in-motion weighing," *Transportation Engineering J.*, vol. 101, no. 4, pp. 681-689, 1975.
- [15] L.J. Meadow, "Automated enforcement at highway grade crossings," *ITE J.*, vol. 68, no. 6, p. 24, 1998.
- [16] J.P. Perone, "Automated enforcement: An Australian perspective," *ITE J.*, vol. 68, no. 6, p. 25, 1998.
- [17] D.E. Ruby and A.G. Hobeika, "Assessment of red light running cameras in Fairfax County, Virginia," *Transportation Quart.*, vol. 57, no. 3, pp.33-48, 2003.
- [18] J.T. Scholz, "Discretion and enforcement efficiency: Problems of complexity, contingency and corruption," in *Administrative Discretion and Public Policy Implementation*, K. Hibbeln and D. Shumavon, Eds. New York, NY: Praeger, 1986, pp. 145-156.
- [19] D.M. Smith, J. McFadden, *et al.*, "Automated enforcement of red light running technology and programs - A review," *Transportation Res. Record*, vol. 1734, pp. 29-37, 2000.
- [20] M.K. Sparrow, *The Regulatory Craft, Controlling Risks, Solving Problems and Managing Compliance*. Washington DC: Brookings, 2000.
- [21] S. Turner and A.E. Polk, "Overview of automated enforcement in transportation," *ITE J.*, vol. 68, no. 1, pp. 20-29, 1998.
- [22] E.E. Walter, "The case for red light cameras," *ITE J.*, vol. 68, no. 6, p.26, 1998.
- [23] C.G. Wilmot and M. Khanal, "Effect of speed limits on speed and safety: A review," *Transport Rev.*, vol. 19, no. 4, pp. 315-329, 1999.
- [24] L.M. Wissinger, J.E. Hummer *et al.*, "Using focus groups to investigate issues of red light running," *Transportation Res. Record*, vol. 1734, pp.38-45, 2000.
- [25] M. Koopmans-van Berton, *E-Enforcement: Research on Law Enforcement and the Use of ICT at the Transport and Water Management Inspectorate*. Delft, the Netherlands: Delft Univ. Technology, 2003 (in Dutch).