MANUAL ON THE AUTOMATIC ENFORCEMENT OF COMPREHENSIVE ROAD SAFETY REGULATIONS

Ibero-American Road Safety Programme

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Contents

Introduction

1. Background

The course "Automatic Enforcement of Violations of Traffic Regulations" took place from 4 to 15 October 2021, promoted by the Technical Unit of the Ibero-American Road Safety Programme/OISEVI, within the context of the 'Intercoonecta' Programme of the Spanish Agency for International Development Cooperation (AECID), with the aim of strengthening public policy in the field of road safety, by reinforcing enforcement processes for bodies leading road safety, traffic police departments and governmental bodies connected with this issue.

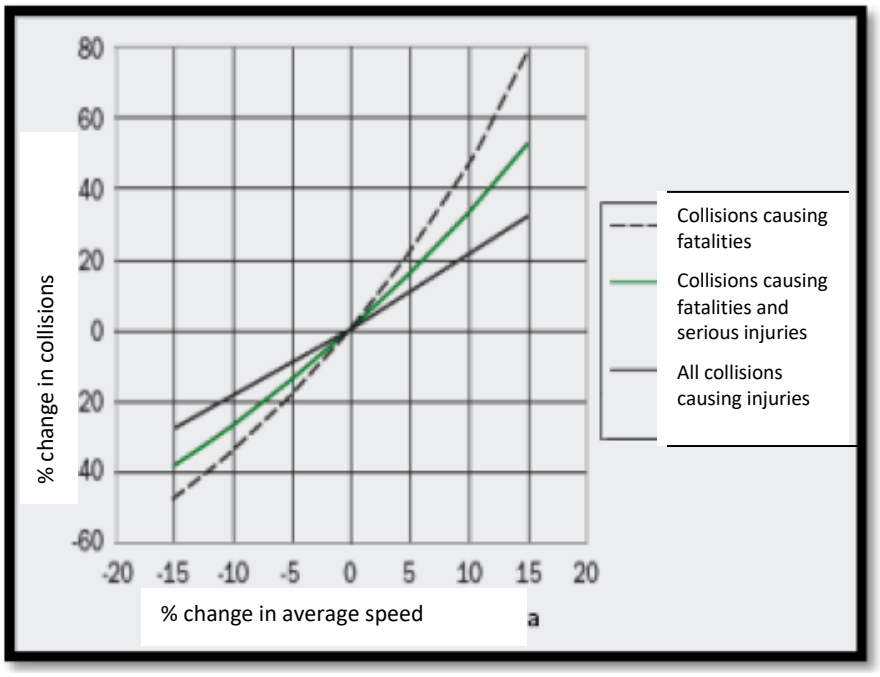
The Ibero-American Road Safety Programme/OISEVI was set up in 2019 with the support of the Ibero-American General Secretariat (SEGIB), with the aim of strengthening the network of those responsible for road safety in Ibero-American countries, to place mobility policies on the public agenda and promote safe travel by users of the road system, reducing injuries, disabilities and deaths resulting from road incidents in all the member countries.

2. Fundamentals

The new Global Plan for the Second Decade of Action for Road Safety 2021-2030 argues that there are multiple main causes behind accidents: human error when travelling, failures in the design and maintenance of transport systems, vehicles and the infrastructure system.

Along with other factors, the plan therefore suggests a series of measures and ways of applying these measures, among which we would highlight increased funding, speed management and the implementation of new technologies, all while prioritising initiatives in middle- and low-income countries. These actions are directly linked to opportunities to develop effective prevention measures by means of mechanisms to monitor improper behaviour while on the move in the majority of Ibero-American countries. This approach, combined with the substantial recent literature, suggests that one of the pillars required in safe mobility public policy efforts must focus on controlling and modifying conduct associated with risk factors. These risk factors include in particular speed as a key element in the occurrence and seriousness of road incidents, and a series of studies in various countries in fact indicate that a 1% reduction in speed achieves a reduction of approximately 4% in fatalities, as shown by Figure 1 (Job, Cliff, Fleiter, Flieger and Harman; 2020).

Figure 1: Relationship between speed, fatalities, injuries and risk of collision.



Source: Job, Cliff, Fleiter, Flieger and Harman. (2020)

Experience and good practice, which have been evaluated by supranational bodies on the basis of scientific evidence, indicate that guaranteed compliance with traffic regulations is one of the most effective ways of reducing incidents, injuries and fatalities, with those countries that have comprehensive enforcement systems in place to protect safe mobility obtaining the best results in this regard. The Police Enforcement Policy and Programmes on European Roads (PEPPERS, 2008) report in fact distinguishes more than 20 good practices for compliance with traffic regulations identified in the European Union, which have been identified as resulting in a reduction in accidents, whether fatal or not.

The human right to mobility in public spaces is governed in accordance with the regulatory framework that each society establishes for public coexistence, requiring that states guarantee that this right can be exercised through the enforcement of conduct, resulting in greater road safety (Soto Mellado, 2015). Rights and guarantees must therefore be balanced, while at all times respecting constitutionally based procedural guarantees in human terms (Losa, 2022).

3. Automatic Enforcement

Enforcement should be understood as the set of public actions guaranteeing compliance with rules within a society. Road safety enforcement involves taking public administrative, legal, technological and communication decisions in order to change cultures of road behaviour, eradicating any sensation of impunity and insecurity, and generating a perception of control to protect road users. This can be more effectively achieved through the use of automatic enforcement, which is conducted through "all forms of technology serving to detect and register an infringement of a traffic law or regulation without the direct intervention of a person" (Job et al., 2020, p. 3)

The aforementioned "Automatic Enforcement of Violations of Traffic Regulations" course arrived at various conclusions which gradually gave rise to this study, as a result of reflections based on the vast experience of the speakers and the bibliography that they provided. As a corollary to the presentations, it was established that a substantial percentage in the reduction of national road accident rates comes about through the implementation of efficient road safety enforcement systems and the automation of procedures associated with the use of new technologies.

Among the more recent evidence we could cite Job et al. (2020), who assert that "There is an irrefutable volume of international evidence demonstrating that various speed reduction measures have resulted in substantial reductions in fatalities and injuries" (p. 5). To which we could add a compilation of 45 studies (published in 14 countries) processed by PEPPER (2008), indicating as a general result that the application of speed controls has given rise on average to an 18% reduction in the number of accidents. Examples would include such cases as Austria and the Netherlands, which demonstrated an average speed reduction of 10 km/h immediately after the installation of speed control devices (PEPPER, 2008).

Experience in Latin America teaches us, through curtailed processes, that enforcement partnered with electronic resources can only prosper on a sustainable basis if it is integrated within a planned road safety system. In other words, a system devised on a comprehensive basis, incorporating not only devices consistent with the characteristics of each region, but also incorporating appropriate regulations, awareness-raising and road education campaigns, agile notification procedures, training of enforcement personnel, among other aspects.

This manual contains recommendations and an approach to the methodological procedure with application parameters and criteria, based on experiences and good practices arising from management systems in Ibero-America and globally, as to automatic enforcement and the development and implementation of such systems. This will thus serve as a guide for countries, regions or organisations aiming to design and/or evaluate a safe mobility system, highlighting the administration of enforcement of the speed factor, among other aspects which likewise affect road safety.

A long process of compilation of initiatives and research has resulted in four steps presented as part of the process required to implement an efficient enforcement system, namely: sustainable planning, technology management, efficient procedures and effective regulation. In our opinion, these actions serve as the key elements guaranteeing the right of citizens to safe mobility.

Chapter 1: Management of automatic enforcement for sustainable mobility planning

4. Vision

Mobility is an inherent right of all people, potentially found at different times and circumstances in our lives, affecting our ability to act in order to freely live our lives. Mobility is thus involved in the actions of drivers, companies, multipurpose and public transport fleets, with a range of repercussions. However, within this apparent chaos of movements there are certain rules which establish order in traffic flow, rules and resultant actions that must be planned and put into practice in a comprehensive manner so as to guarantee road safety. Such a situation will not be achieved if the measures are deployed in isolation or do not make provision for key elements such as infrastructure planning, training with regard to the means of transport, classification and qualification systems for those involved in mobility, underlying political decisions regarding this matter, and even, all other rights and human capacities.

Road safety must be integrated, as part of these guarantees, within a set of rights, regarding which "*it is vital to work towards the full implementation of human rights to ensure that the lives of men, women and children improve everywhere*", since "*all the enshrined rights are interrelated, and are all equally important*" (Bachelet, November 2018). Enforcement should likewise be included within this principle of comprehensive planning, as it is one of the road safety mechanisms for guaranteeing that this right can be fully exercised. We must therefore have a vision of the automatic enforcement system within a plan that guarantees the right to free mobility can be exercised, respecting the safety of all citizens. This process is built through the principles of responsibility and solidarity of the actors involved, following the objectives and targets described below as an operational guide.

5. Comprehensive planning of enforcement based on the Sustainable Development Goals

The main reference framework by which we should be steered is first of all the UN proposal of the Sustainable Development Goals, setting a series of goals and targets to be achieved by 2030, integrated within the renewed targets of the Decade of Action for Road Safety 2021-2030, with the aim of reducing death and injury by at least 50% by 2030, along with the comprehensive improvement of transport systems: targets 3.6 and 11.2 (United Nations, 2015).

The role of road safety promises potential benefits for citizens' lives, which extend beyond their personal safety. An efficient automatic enforcement system in line with the safe mobility needs of all should help to facilitate access to education (SDG targets 4.2 and 4.3), healthcare (target 3.8), access to food (target 2.1) in an equitable manner (target 9.1). To the extent that this network is well-planned, it furthermore helps to establish economic, social and environmental links between urban, periurban and rural areas (target 11.a).

Those countries that have achieved a satisfactory level of safety will necessarily also have resolved a major problem which is very present in Latin America, namely corruption (SDG target 16.5), through the creation of effective, transparent and accountable institutions (target 16.6), inclusive, participatory and representative decision-making in line with the needs of institutions (target 16.7), while also addressing funding-related aspects (target 17.1). They are also likely to have tackled issues such as the sustainability of cities (SDG 11), climate action (SDG 13) and gender matters (SDG 5), all of which are goals which must be considered within mobility planning to ensure that fair and sustainable solutions are found. These diverse elements help to improve road safety in an efficient and sustainable manner (Auert and Khayesi, 2021).

With regard to the specification of these targets, it may be mentioned that technological innovation applied to enforcement process automation is vital to develop actions serving to optimise processing times, manage the flow of information between the offender and the enforcement institution, reduce the use of inputs, easily save records for situations of repeat offences, professionalise the role of the human resources employed in the system, reduce the cost of energy expenditure, fuel, notifications, and the entire non-automated bureaucratic process.

Clear progress has been made in such emerging technologies as advanced driver assistance systems, including electronic stability control, lane change alerts and automatic emergency braking, which are already making a driver's task easier in many countries (2021 Global Plan). We thus anticipate the concept of Smart Mobility and Smart Cities, the proposal being that administrative tasks should be automated, to the extent that the workflow or procedural flow is well defined. The real appeal of process automation is that it serves to free up resources, offering concise results in terms of filtered information, while also facilitating reasoned and reliable decision-making, backed up by scientific evidence. This whole set of benefits has made investment in monitoring and administration systems a goal shared by numerous cities (Bouskela, Casseb, Bassi, De Luca and Facchina, 2016).

Record management in road safety regulation enforcement is a process that can feasibly be included within an established regulatory sequence of actions. It thus serves to automate subprocesses which are repeated over time, the ultimate goal being ease of composition and traceability of the administrative procedure and proper archiving upon completion. All the above will facilitate document searches, and should the case arise, the data could even be used to undertake research and data analysis projects for subsequent road safety management decision-making, as an observatory of information databases. At this point it should be clarified that a great many Latin American countries have not yet developed automatic enforcement, much less road information processing at the levels proposed above. This does not mean that it would be impossible to achieve the same development as those countries that lead the way in terms of road safety. The process is indeed feasible, but there is a long way to go before these goals are reached.

To arrive at the construction of such databases, the methods of application used by new technologies should involve some type of automatic detection. Digital sensors and cameras are better able to detect speeding, red light violations and other regulatory breaches. One of the greatest benefits of such supervision systems is their deterrent effect, making users more cautious, with a corresponding increase in safety and improvement in general road network performance. There is evidence indicating that the mere presence of such instruments, duly signposted, has achieved immediate changes in driver behaviour, by reducing average speeds, which Jobs et al. (2020) refer to as "general deterrence".

6. Enforcement in the Global Plan for the Decade of Action for Road Safety 2021-2030

> "Speeding, drink-driving, driver fatigue, distracted driving, and non-use of safety belts, child restraints and helmets are among the key behaviours contributing to road injury and death" (World Health Organization, 2021, p. 14).

The above citation allows us to assert that those administrating the design and functioning of transport systems take such conduct into account in defining laws, effectively applying them, and facilitating road safety education. Such management also takes into account that people's behaviour is heavily influenced by the safety characteristics of vehicles and road infrastructure design, which must take into consideration the needs of all, and be designed to be easy to understand, allowing for intuitive traffic flows which ensure that traffic mobility actions themselves then serve to prevent accidents. To clarify the preceding point with an example, a street with little traffic, few road signs, few elements of friction and a low speed limit (30 km/h) will prompt drivers continuously to exceed this limit, since they intuitively feel that a higher speed would not entail a risk. Meanwhile, a busy road where there are numerous pedestrians, with various elements of friction will cause drivers to reduce their speed, although the regulations allow them to drive faster, since they will feel that a higher speed results in a danger for themselves or for others.

By guaranteeing the functioning of an automated (and properly organised) system to control improper conduct, we will then do away with the sense of impunity, and generate a sense of control and safety on public roads, on the part of citizens in general, and road users in particular.

7. Enforcement within the context of road safety

Road safety enforcement should be understood as the set of public actions by the state to guarantee compliance with road safety regulations, involving the adoption of clear, feasible and evaluable public policies. In this paper we focus on four dimensions: planning of administration, legal framework, adoption of technological tools and construction of the process of governance.

In his address, the Director General of Traffic in Spain, Pere Navarro Olivella, stated that "road safety policies are defined by the essential combination of education, training and information, on the one hand, and the surveillance and control systems integrated within a mobility system, on the other" (October 2021). According to our analysis, the educational/training element refers directly to the individual responsibility of each of us within the public sphere and within the sphere of our daily lives as citizens, as the main actors in the journeys that we take on public roads to conduct our personal affairs (work, study, social life, tourism, etc.). It is within this area of mobility that we act (with all our capabilities and potential), and continually update a series of personal decisions with regard to how we conduct ourselves in public spaces. And so beyond the fact that rules can design a way in which systems function, these attitudes, which are often cultural, in fact gradually shape how they operate.

We may therefore assert that level of education and training contribute to the background of criteria internalised by each of us, defining how we will behave on public roads, in accordance with our range of values and individual circumstances, either abiding by or infringing the rules.

This furthermore presupposes that public roadways are first governed by the regulations established by society itself through its legitimate structures of self-governance. It is also socially accepted that those who breach communal regulatory requirements must be disciplined, so as to prevent such conduct from causing actual or potential harm to their fellow citizens, or to the perpetrators themselves. Regarding this aspect, both the clarity of the regulatory framework, and the reliability of control mechanisms and punitive processes, have the function of reinforcing and retrieving what we have learned as being socially valid within the context of education, through the legitimate use of coercion in order to make those users who breach the rules of the road feel particularly uncomfortable, prompting them as individuals to reconsider their misconduct by means of social opprobrium, all of which serves to improve the harmonious coexistence of citizens on public roads, protecting the lives of road users, including the offenders themselves or their family.

The culture, customs and idiosyncrasies found in each region are indeed elements to be taken into account, as mentioned by Dr Nhan Tran, Head of Safety and Mobility at the World Health Organization, in stating that all road safety systems will necessarily be different, and must be adapted to the global context (October 2021). This does not mean maintaining local malpractice, but rather acting and advancing through an understanding of these realities, as recommended by the Global Plan for the Second Decade of Action for Road Safety 2021-2030, which:

> "rejects business as usual and calls on governments and stakeholders to take a new path – one that prioritizes and implements an integrated Safe System approach that squarely positions road safety as a key driver of sustainable development."
>
> (WHO, 2021 p 6).

From the perspective of the comprehensiveness of road safety systems, it should be mentioned that the implementation of controls and enforcement of conduct on public roadways involves various elements which go hand-in-hand with the policies established in the Global Plan for the Decade of Action for Road Safety 2021-2030, or the implementation of which helps to fulfil the UN Sustainable Development Goals to be achieved by 2030. (United Nations, 2015).

8. Plan technical resources for enforcement

Latin America has a wealth of experience of cases which have seen very brief implementation, and failed mainly because they did not achieve appropriate application of a comprehensive automatic enforcement system. Hence the need to understand that before remote detection equipment is acquired, there must be an administrative system capable of handling all the information making enforcement feasible. This involves designing and developing a unified database, drawing on the information provided by the different sectors involved, to obtain a fluid relationship with the metrological body certifying the calibration of the equipment (if none exists, then a body independent of the enforcement department would need to be developed), clearly establish the administrative processes to be employed (steps to be taken from the detection of the violation, proceeding through notification and what happens when faced with the different positions adopted by those involved until the closure of the process), as well as the areas involved in the process, their function, and even the definition of the purposes and forms of resource management. All of which clearly contributes to continuous optimisation as expressed in ISO 39001 on the improvement of road traffic safety management (International Organization for Standardization, 2012).

Another aspect which must be addressed in coordination is the use of technologies ensuring the protection of drivers' rights, through the maintenance and location of the different devices, which in turn generate an atmosphere of persuasion, warning drivers of the increased danger in those areas where it was seen to be necessary to implement enforcement measures. As may be seen in Figure 2, remote detection technologies in the form of speed control cameras enjoy a high degree of effectiveness in reducing accidents.

Figure 2: Summary of the effects of speed control measures.

	Test of heterogeneity			Change of number of accidents (%)	
	Cochran's Q	df	p	Summary effect	95% confidence interval
All measures	5307.82	128	0.000	**-18**	(-23; -13)
Stationary manual	1854.17	22	0.000	**-11**	(-22; +1)
Patrolling	62.7573	10	0.000	**-6**	(-16; +4)
Radar laser US/AUS	22.3372	30	0.841	**-0**	(-3; 4)
Speed cameras (all types)	1693.9	42	0.000	**-30**	(-38; -23)
- Subgroup: Mobile speed cameras	168.476	12	0.000	**-17**	(-34; 4)
- Subgroup: Fixed speed cameras	1513.02	27	0.000	**-34**	(-42; -25)
Composite Other	454.306	20	0.000	**-18**	(-33; +1)

Source: Police Enforcement Policy and Programmes on European Roads (PEPPERS, 2008)

Meanwhile, it is advisable to structure an optimal technological layout in each region, in line with the inherent local characteristics. We would not recommend acquiring all sensors of one single type, since this would mean that drivers with a greater risk tolerance become accustomed to one single system, and it may be seen that the combination of methods (composite other) is also fairly effective (Figure 2). The standardisation of the different technologies and compliance methods will play a vital role here.

As for the equipment, it is essential that it be calibrated in accordance with three relevant factors: the measurement uncertainty of the device, specified by the manufacturer; the maximum speed on the road, as stipulated in road safety legislation; and the percentage leeway allowed above the maximum speed. In this regard, and in order to avoid suspicion, it is advisable to have a technical measurement mechanism verification department involved in the proper setting and calibration of the equipment, operating as a body independent of those implementing the system itself. The calibration conditions and the elements comprising evidence of the calibration process to demonstrate the precision of the device should also be explicitly included in the legislation (Job et al. 2020).

Another element for consideration is the group of stations, within which we may distinguish 2 types: those that are in motion and others which are static, a significant factor for the latter being the characteristics of the control cabinets, and the considerations to supply them with the basic operational services they require (electrical supply, rain-proofing, communication mechanisms, vandal-proofing, etc.). The proper design of the control cabinets is essential in order to achieve a balanced structure of effective and placebo-type sensor instruments, serving to increase efficiency as to the sensation of enforcement. The combination of instruments thus achieves diverse control which prevents perpetrators from taking advantage of the weaknesses of a known sensor.

As explained by Jorge Ordás (October 2021), Sub-Director General of Mobility and Technology at the DGT in Spain, devices must be positioned by means of a clear, pre-established procedure, prioritising those areas with the greatest number of road incidents. Once these situations have been controlled or mitigated, work will continue with those areas that have the greatest impact on unsafe mobility. The effective location of sensors is vital to ensure that they are not affected by vandalism or climate conditions, thereby making them compatible with peak mobility times, which can be achieved only through complete and correct research into the potential sectors for installation (Ordás, October 2021).

We should lastly emphasise the importance of the information system, which will be securely managed, while also offering fluidity through the data derived from the individuals and institutions responsible for the vehicle fleet. This will allow public usage statistics to be generated, highlighting the seriousness of incidents, any reduction in their occurrence, the connection with violations, etc., supported by and contributing to the Big Data environment for mobility, and in turn facilitating predictive interventions, in accordance with the tolerance towards the risk of speeding in locations with similar circumstances. This set of data, along with the corresponding indicators and the information that is built up, can then lead on to conclusions in support of future preventive measures, allowing analysis and planning on the basis of scientific knowledge (Puebla, Benítez, Leaño, García Palomares, Condeço Melhorado, Mojica, Scholl, Adler, Vera, Moya Gómez and Romanillos Arroyo, 2019).

9. The legal framework and planning of operational procedures

The implementation of automatic enforcement does not replace enforcement agents or operations out on the road, but instead serves as a tool reinforcing the traditional enforcement system, focusing on the one hand on user safety, and on the other on the deterrence of assumed conduct on roads regulated by an external agency (Losa, 2022).

The legislation to address user conduct in public mobility spaces may be introduced at the national, subnational or continental level, depending on the countries' systems of governance. Traffic regulations are an essential element in guaranteeing safe conduct by roadway users, provided that they are effectively applied, and appropriate penalties are imposed to deter violations. Strategies to ensure compliance with the legislation must be backed up by communication based on proven messages to ensure comprehension and support on the part of the public, along with the involvement of local stakeholders so as to maximise compliance (World Health Organization, 2021). Clarity and transparency throughout the process, from violation to notification and payment of the fine, will generate greater social support for the whole system. Where such support does not exist, then situations of corruption may arise in the application of road safety laws, as happens in various places in Ibero-America, an aspect which undermines public support and legislative efficacy.

This document has been developed to assist jurisdictions in applying efficient automated enforcement. Cameras are the baseline in such support, since they serve as an element common to various locations within our region, as a control/enforcement component for speed limits. Their effectiveness and proper functioning are limited by various legal and operational aspects present within the process. One example of this that we could cite would be that precise imaging of a vehicle at high speed would, in the absence of reliable driving licence and vehicle registration systems, offer little as a supervisory and disciplinary system, a situation which would have no real effect in improving road safety. It is important to emphasise that speed control is a fundamental element of the Safe Mobility Approach System (Soto Mellado, 2019), which must be considered as part of comprehensive administrative planning, along with such other aspects as road infrastructure, education as to responsible social behaviour, and further elements. With regard to building road safety governance, Roy Rojas (September 2021) states that a preventive, multi-sectoral, high-visibility, transparent approach must prevail, requiring an organisation that handles data for the purposes of enforcement so as to improve the system.

Automatic enforcement is not confined solely to speed control, but can also be applied to other punishable conduct, such as failing to respect a red light, use of mobile phones, poor lane discipline or non-use of seat belts. However, this document applies specifically to the automatic enforcement of speed limits, since this is the fundamental risk factor in all road incidents, and the administration of this aspect thus requires significant attention worldwide, playing an essential role in reducing road accident deaths and injuries.

Chapter 2: Administration of technological resources for comprehensive automatic enforcement

According to the approach of the global plan, civil society, the private sector, financial institutions and UN bodies have a key role in road safety (Global Plan, 2021), although public administration is the most significant actor in this regard.

The system must give citizens the sensation of feeling protected by the State, and this is the main focus of attention (Brunori, 2021). Success does not lie in the amount of fines registered and collected, but in making citizens aware that wherever there is a control point, there is a danger (Ordás, October 2021), and that the State is on hand to care for people. Because this is what will prompt drivers to adjust their conduct in accordance with road safety, rather than doing so to avoid punishment. Such awareness will cause drivers to adjust their behaviour in accordance with road safety, maintaining a safe driving style, thereby extending safety beyond the boundary of action. Meanwhile, if drivers adjust their behaviour only to avoid punishment, then once control is no longer present, they will resume their hazardous driving.

The process of implementing automatic enforcement requires consideration of a number of matters. The core and novel element lies in high-tech equipment, although in order to achieve the ultimate goals of lower accident rates, we must address various aspects involved in effective operations, namely the systems themselves, their location, maintenance, calibration, the large amount of information they generate, the procedure leading to the violation notice being generated, along with other elements. A number of these are addressed below.

10. Practical tools

In order to incorporate an automatic or electronic enforcement system (as mentioned in various Ibero-American countries), one must first create uniform procedures which incorporate what is already being done through non-automatic processes. The next step is not immediately to replace all the procedures, but to reinforce the prior system through the incorporation of technology, achieving development and continuous optimisation in which both systems function in coordination, making the sensor element (whether an automatic speed detector or a speed detector with an enforcement officer) independent of the rest of the procedure until the violation reaches the offender.

There are two important elements for consideration here in order to unify criteria: first of all, the cabinet and the periodic verification processes for autonomous equipment, and furthermore the training of enforcement officers in the use of the instrument, the database and the process of fines (comparing the database against the photo, colour, make, model, etc.). The recommendation here is to have an automatic complaints centre, which monitors the process from the point at which the violation is registered until it is sent to the home address, which must occur within a mandatory time limit in order to ensure (by means of adjudging) that the user is aware that they were in danger and that they endangered those around them.

It would be wrong to think that application of the automatic enforcement system reduces the need for enforcement officers, thus resulting in a cheaper system. Although, as mentioned previously, an automatic system does not require the intervention of an operator to take a measurement, autonomous systems do need trained staff for their maintenance and use. They could be the enforcement officers themselves, with training for this new function, or other different personnel, but the devices do inevitably need some type of support. The officers must continuously monitor the proper condition of the equipment and constantly rotate them in order to provide a range of oversight (with different devices) so as to maintain the overall effect of plentiful checkpoints. The officers thus begin to change their more analogical and even dangerous functions for tasks that require greater specialisation in the use of technology, with a positive impact on their training and their appraisal as key actors in road safety.

11. Unified database, Big Data and Smart City

The major challenges to be faced by Ibero-American countries are an increase in congestion, serious road incidents, pollutants and greenhouse gas emissions. A region becomes more efficient to the extent that it is capable of obtaining data from the environment, the infrastructure installed by service providers and citizens out on the street, which can then be processed and transformed into information to help in reaching decisions capable of mitigating, organising, anticipating or predicting countless urban challenges (Bouskela, et al. 2016). Automatic enforcement will form a part of this vast network of intelligently processed information.

In order to focus on road safety, firstly access is required to information regarding mobility-related incidents in public spaces, serving as the basis to identify those locations requiring control. It should be remembered that the ultimate goal of automatic enforcement is to reduce the fatality rate and the number of incidents. It is highly advisable for this unified database to be linked to others, using this complex and large-scale dataset represented by Big Data to process and analyse the substantial flow of integrated information, which can, for example, link average vehicle speed to the violations registered, and in turn link these data to accidents involving criminal proceedings.

Clearly, Ibero-America is home to a wide range of different possibilities for the application of this type of information, a matter raising the need to resolve other prior aspects in certain countries before mass use of information is possible, requiring a substantial degree of progress in terms of technologies and skills development.

12. Metrology body independent of the enforcement agency

To keep the instruments within their detection range, they must be systematically calibrated, a process which must be performed by an agent from outside the transport body, generating complete transparency in terms of equipment calibration. To this end, the agent responsible for calibration must be a State body which is not operationally dependent on revenue from violations, and must derive no benefit whatsoever from approving or rejecting the instrument.

The calibrated instruments must be registered on a website allowing any citizen to access the instrument's calibration history. This means that the person served notice of a violation will be able to see the calibration date indicated on the fine itself, and confirm it against the website. The website must include the instrument ID, the model, serial number, calibration date, values measured and the results

of the calibration (approved or rejected). Both the independence of the metrology body and the public availability of the information are essential to lend clarity and credibility to the process.

13. Installation of technological instruments

The most advisable principle according to experience in Ibero-America, where the application of automatic enforcement systems has achieved the greatest sustainability, is to use a space designed to securely and effectively house the technological instrument. This compartment is known as a control cabinet, which can house the sensor instruments, calibration apparatus (if any), the electricity converter device in the event of an electrical power supply, or energy storage device (batteries) if autonomous, along with the communication system, the vandal alarm and any other equipment needed.

Control cabinets

Although countries typically have different types of cabinet, the recommendation is to unify the space for all technological instruments that may be used. When a remote enforcement system begins, the planning of control cabinets will prove more effective, the greater the provision made for the future.

The control cabinets fulfil various functions at once. It would be wrong to consider one as more important than another, since the system works thanks to the proper integration of all its parts. It is generally thought that the main function of the cabinet is to provide support for the technological instrument, but it also fulfils a support function for the elements connected with electrics and communication. The Cabinet must therefore have enough space to house the required communication element, whether using radio, 3G or fibre-optics. However, it must at the same time have areas allowing one element to be removed and another installed simply (in case the sensor changes location). This dual functionality must also be present in the electrical service, which must be capable of receiving the power supply and transforming it in line with the needs of the equipment, but should also be capable of operating autonomously with a photovoltaic cell and the respective batteries.

Functions of the cabinets

The vandal-proofing function determines the structural conditions of the cabinet allowing it to withstand certain expected acts of sabotage according to the design scenario, with both the outer housing and any glass elements capable of withstanding impacts. The equipment does not generally suffer a high vandalism rate, as the device has no subsequent use. However, such acts may be taken by those wishing to prevent the relevant control from continuing. Depending on the area, a surveillance camera may be used in the vicinity of the cabinets as a deterrent, while a police assistance protocol is in place if an imminent act of vandalism is detected. An alarm system with internal sensors may also be used, sending a radio or telephone alarm to the central remote equipment unit if triggered. The above makes it clear that planning must not be confined simply to the aspects of the cabinet's location, but also the elements ensuring its integrity. Radar security is essential for the sustainability of road safety policies. It is enough to mention the case of France in 2019, where widespread vandalism of radar devices led to a 17% upturn in road accident figures (El Periodico.com).

The rotation function allows the technological instrument to be systematically swapped between different cabinets located in a region, with the monitoring system varying between a laser, camera or Doppler radar, so as to achieve diverse and effective enforcement, and preventing offenders from exploiting any possible weakness of the instruments.

The calibration function involves facilitating independent access to the instruments by the metrology control body, which may involve remote or wireless communication, or some standardised connection. The fundamental aspect here is to include the external audit body within the system planning process, whether in the design or the implementation. As stated by Ordás (October 2021), Spain has made progress in online or remote verifications, procedures to keep the equipment in operation (since this must not be transferred to the regulatory body), while limiting travel by skilled personnel.

The function of protection against environmental factors refers to the characteristics required of the cabinet, depending on the region, to protect it against the climate and the environment surrounding the technological measurement tool. This mainly considers such negative events as possible flooding, rain, lightning strikes, hailstorms and sunlight. As for orientation, some devices have problems when aligned with the sun, and an East-West orientation or vice versa may therefore make it difficult to perform detection at dusk or dawn. This can be resolved when installing the cabinet, by taking into account the orientation, the type of measurement instrument used and the manufacturer's recommendation.

The design of the cabinet must allow safety for the precise location where it will be installed, for example taking into account installation behind a guardrail, if possible, or an area that is safe for road users. Other aspects for consideration would include a design which ensures that the magnitude of a vehicle impact is not heightened; the requirement to avoid elements that would reflect sunlight or vehicle headlights; and the location must allow signposts to be installed sufficiently in advance as to allow drivers to adjust their speed in accordance with the relevant signage before they are registered.

Meanwhile, information signs should be installed as to the possible existence of speed control in process, taking into account reaction and deceleration times.

Initial determination of the location

As stated in previous paragraphs, the cabinets must be located in areas where there have been accidents or where these are seen as a possibility. In this case the presence (or possible presence) of a speed detector generates a real sensation of care in the minds of drivers, so as to avoid incidents causing fatalities or injuries. This determination of the location of the cabinets will be based on the databases registering road incidents, with subsequent analysis by road safety experts. Subsequent steps require in-person attendance to corroborate the feasibility of the location, checking the possibility of implementation, network communications, security against vandalism, signage, orientation, the environmental factor and any other problems which could arise.

Services required for operation

Autonomous equipment requires services in order to function. The most common for technological tools enforcing speed limits are communication, electricity and drainage.

For communication, the ideal is fibre-optic access, as this offers secure communication, although this is not a decisive factor, since basic 3G coverage is sufficient (4G being better). Communication to report violations can wait until the signal is re-established (or even work off-line), and the operating cost would likewise not be a limiting factor, since the service can be fulfilled with a minimal data tariff per month (this is not the case on other occasions, such as traffic control by streaming), although each locality will need to evaluate this specific point. If a network connection is not available, then it is also possible to use what are known as speed warnings, which could function with solar energy, a speed detector and a sign informing the driver of the speed registered, and generating the sensation of control, to prompt drivers to adjust their speed themselves.

A drainage service must be ensured, with continuous run-off throughout the duration of a storm or weather phenomenon. Servicing is also required to clean the gutters and/or unblock ducts which typically become blocked by a build-up of earth or any other circumstance.

14. Recommended devices and procedure

A speed detector is defined in the Spanish RAE dictionary as a "device to measure speed" (Asale, 2021a), a definition which would cover numerous devices used to measure speed. However, there are some which are capable of not only measuring speed, but also such other aspects as the quantity of cars, safe distance between vehicles, identifying if the driver is using a mobile phone, etc.

Separately from what can be measured, the recommendation is to use devices that do not interfere with the roadway, both during installation and when control is applied. Non-invasive technologies, which would be recommended according to experience in our region, include Doppler effect, laser and section speed detectors.

Such devices are typically referred to as speed radar, although radar is one specific type of speed detector, the term being an acronym of "radio detecting and ranging" (Asale, 2021b). The system uses electromagnetic radiation reflected by an object to determine its location or speed. This definition would cover Doppler effect speed detectors, which may be seen as genuine radar devices. However, the device known as a laser speed detector operates in a similar manner by reflecting a pulse of infrared light which is returned to the speed detector, but cannot be considered radar, as it does not use electromagnetic radiation.

The margin of error or uncertainty that each instrument may reveal must be considered as a variable when selecting the device, since this margin could prove to be inappropriate for control purposes. The legislation in each region establishes or must establish the leeway applied to the speed limit. For example, it could be mentioned that in certain locations the margin established by law is 10%. When selecting the instrument, one must take into account the range expected to be measured and the leeway for this range, since the measurement might not be valid if the instrument error is greater than the leeway allowed by law.

The speed at which the speed detector must generate a speeding alert is the result of adding the legislative leeway and the uncertainty of the instrument to the speed limit. If the speed is lower, the perpetrator could claim that the control record is unreliable and invalid. For example, if local legislation allows a leeway of 10% and the limit in the sector being monitored is 60 km/h. In this specific case, the maximum speed at which one can travel is 66 km/h, and the instrument must generate a violation alert beyond speeds above 69 km/h, since its uncertainty margin is 3 km/h. If a violation notice is served below this speed, the offender could claim that if the error of the instrument is taken into account, they were within the margin of leeway indicated by the corresponding legislation, and request that the violation be invalidated.

Doppler speed detectors

These are commonly referred to as radar devices, and use a transmitter and a receiver using a continuous wave in the microwave band, operating according to the Doppler principle. In other words, they calculate the speed of the vehicle by measuring the apparent change in frequency of a wave generated by the relative movement of the source with regard to the observer. A Doppler effect speed detector must receive product approval, installation control and calibration control at least once per year, or after each repair. Installation control must be conducted every four years (or when the cabinet is repaired).

These types of speed detector tend to be the most commonly used because they are highly reliable in operation with different types of climate, are capable of monitoring up to 6 lanes simultaneously, irrespective of the direction of travel, identifying the perpetrator and distinguishing between light and heavy vehicles. However, they have two main disadvantages: first of all, they are more expensive than other types of speed detector. Secondly, devices that detect this type of control are typically available on the market, and can be bought by drivers who like to drive at high speed. This type of speed detector may be manual (handheld gun), fixed (urban or inter-urban roads), mobile (with a tripod or fixed to a vehicle) and autonomous.

Laser technology speed detectors

These devices are wrongly referred to as radar guns, although according to a dictionary definition this is not the case, since rather than using an electromagnetic wave, they employ an infrared laser using a frequency of 33 MHz and a wavelength of 904 nm to measure speed. The laser beam reaches the vehicle, reflecting a pulse of infrared light back to the speed detector. The time that this operation takes, and the interval between pulses, determines the vehicle's speed (very similar to the Doppler system method). This type of technology is known as LIDAR, an acronym for Light Detection and Ranging or Laser Imaging Detection and Ranging.

This type of speed detector is cheaper than a Doppler effect device, and there are no detectors available for such instruments on the local market. However, they are not as stable as radar devices under adverse weather conditions.

The sweeper system can measure not only the speed of different vehicles in different lanes, but can also count the quantity of vehicles (an essential aspect to collaborate with local databases), the length of the vehicles passing by, and can also issue a violation notice to drivers who fail to respect a safe separation distance. This type of speed detector may be manual (handheld gun), fixed (urban or inter-urban roads), mobile (with a tripod or fixed to a vehicle) and autonomous.

Section detectors

This device (also known as an OCR, or Optical Character Recognition device) is wrongly referred to as a speed sensor or radar, although it is not a sensor instrument, but instead comprises two cameras separated by a known distance, and using a domain recognition system to measure how long it took for a vehicle to be recognised by the two cameras. As they are a known distance apart, the average speed of travel over the section in question can be calculated.

This type of speed detector is cheaper than a LIDAR device and cannot be detected by other technologies. However, they are not as stable under adverse weather conditions, the bolts of the plates may alter their pattern recognition and they have problems with East-West orientation (and vice versa) around dawn and dusk.

The camera system is capable not only of measuring the speed of different vehicles in different lanes, but with access to a single vehicle fleet registration database can also be used to check whether they have mandatory insurance (in countries where this is mandatory), or if the vehicle has been scrapped or stolen. Their uncertainty range is +/-3km per hour, irrespective of the speed of travel.

There are other types of speed detector, briefly characterised by Chaparro and Ferreira Mancilla (see Figure 3).

Figure 3: Classification of Speed Detectors

Technology	Description
Speed detectors with radar technology.	The emitter antenna projects radio waves which are reflected by the vehicle, while the receiver antenna captures the signal which bounces back, which is distorted by the Doppler effect, compared with the signal which was emitted.
Speed detectors with radar technology.	Laser technology speed detectors differ from radar in that they use a laser rather than radio waves. They are used both for fixed and mobile radar installations, but not radar in motion.
Induction speed detectors	Induction speed detectors use induction coils or strips positioned beneath the tarmac which serve to calculate the speed of vehicles as they pass over and activate them.
Contact speed detectors.	Contact speed detectors use two sensors embedded in the tarmac which are activated when they are crushed by the wheels of the car, serving to calculate the speed of vehicles passing over them.
Section speed detectors.	Section speed detectors comprise two video cameras separated by a fixed distance (for example 10 km), equipped with a number plate recognition system (OCR, or Optical Character Recognition), which calculate the average speed of the vehicle over a specific section, by measuring how long the vehicle takes to cover the distance.
Camera-based speed detectors.	Camera-based speed detectors are not speed detectors per se, but video surveillance or video monitoring systems, as they comprise a camouflaged police vehicle fitted with a video recording system. The police vehicle is thus positioned behind the perpetrator, and records the violation with videographic evidence.

Source: Chaparro and Ferreira Mancilla, 2016

15. Recommended layout for electronic detection of traffic violations

As previously stated, each device has its advantages and shortcomings in terms of control. To benefit from the advantages of all the devices, the recommendation is to use a proportion of each type of device, and periodically to rotate them around the control points. If this is performed systematically, reckless drivers do not become accustomed to one specific type of control. Each locality will need to manage a different proportion in line with its specificities, which will gradually be defined on the basis of actual use. To begin with, then, the recommendation is not to buy sensors of only one type, but to

begin by using a variety of the three types of device. The recommended proportion to begin with is: 25% with Lidar technology speed detectors, another 25% with Doppler technology, and 50% with section detectors (Ordás, October 2021). An additional 50% to 100% of devices with empty cabinets should be added to this amount. This means that two thirds of the cabinets installed on the roadway have a control device, which gives drivers the sensation that they are being monitored.

16. Types of station

There are different ways of categorising measurement devices, none of which refers to the measurement principle of the device itself, but rather to the use that can be made of it. Hence the fact that the first group to be categorised is the "in motion" type, where the device is used for measurement in motion. For example, it is installed on board a control vehicle, such as a patrol car or helicopter. For this type of device, the apparatus indirectly calculates the perpetrator's speed, since it must take into account the speed of the control vehicle. This speed of the control vehicle should be indicated on the device record.

If, meanwhile, the device is not in motion when the measurement is taken, it is categorised as "static" or "stationary". They are positioned within control cabinets, gantries, tripods or stationary vehicles, and typically measure the offender's speed directly. They are subdivided into fixed and mobile devices. Fixed devices are stationary and have a fixed location, requiring several services to be disconnected and then reconnected simultaneously to relocate them. Meanwhile, mobile devices are stationary, but can be easily relocated by moving them to a different position. The latter do not have fixed power or LAN connections, some of them being portable with a tripod (or other support system), while others have the form of a trailer containing all their services.

Information system

The development of an information system covers the existing intercommunication among different databases, providing fluid interaction and access among them, along with swift and straightforward updates. As for usage of the system, particular emphasis must be placed on the users, who will need different levels and hierarchies with separate access permissions for each rank. It is furthermore important to have records of any changes made by the different users, to lend greater transparency to the processes.

Beyond the significance of the information system to generate data for statistical purposes, it is important to highlight their importance for use in temporal analysis, traceability and their predictive capability, working with variables such as those linked to devices, users, dates and times when information is generated. The system is thus not confined simply to operation in isolation (which is unquestionably useful), but also serves as a continuous planning tool.

17. Communication and validation protocol

As stated previously, the ideal approach for communication is to use fibre-optic access, given the security of communication. However, this is not a decisive factor, since basic 3G coverage could be sufficient. In such cases, where the signal could be intercepted, then given the sensitivity of the personal information handled, the recommendation is to use encryption system protocols for this communication, to guarantee the validation and confidentiality of the data communicated.

18. Procedure for electronic enforcement

Fines must be issued with the data as to calibration of the instrument by the metrology body, to avoid the instrument being questioned. Particular emphasis must be placed on false positives, since they generate unease and discontent which may cause the system to lose credibility. It is advisable here to discard fines in the event of the slightest doubt, to avoid claims or appeals which undermine the credibility of such systems. A properly handled fine with appropriate information gives rise to no doubts in the mind of the offender.

19. Vehicle, driver and equipment data

As previously stated, the fine contains the data for the instrument and the vehicle, so that the person fined can first check that the details of the fine itself tally, while the enforcement officers can check for false positives, with access to the data, furthermore allowing the instrument calibration to be checked, as well as the colour, make and model of the vehicle against the image that is included. This requires one single database containing the vehicle data and the record of pending fines to check for repeat offences, likewise including drivers in the database of driving licences issued, and the control devices. The staff handling these databases require training both in the use of the technical tool and in information management security. There should also be a database listing the make and model of a vehicle with a standard blueprint or photo type image, to be used by the enforcement agent as a reference for the model of vehicle, for comparison when checking the vehicle indicated by the database against the image obtained through automatic enforcement.

20. Statistics and data observatory.

The expected end result of this process is not the collection of a fine, but a reduction in accidents (in principle with fatalities), or the road fatality rate. All violations must therefore be recorded and compared against the rate so as to amend or maintain the automatic enforcement strategy. The data analysis could thus lead to a change to the position of enforcement devices, an increase in their number, or a switch to new devices. This closes the positive feedback loop to improve the quality of life of all road users.

Chapter 3: Management of operational automatic enforcement procedures based on good practice

The Spanish Road Safety Foundation defines good practice as:

> "Action or set of actions resulting from the identification of a need or problem and performed by members of an organisation, with the support of its management and participatory bodies, generating a satisfactory response to the need or problem raised. They entail a clear improvement, at all times in accordance with certain ethical and moral criteria within the context in which they are developed." (FESVIAL, 2020 p 6.)

Such good practices must be documented to serve as a point of reference for others and facilitate process improvements. There are countless manuals of good practices in this regard, both for road safety in general and for risk factors in particular, although unfortunately in Ibero-America, compendiums dealing with automatic enforcement or speed control are less abundant. In Spain, meanwhile, initiatives aiming to compile good practices in this sphere have arisen at the General Directorate for Traffic, and national and municipal initiatives in Latin America are typically instigated through the actions of some international body (IADB, CAF, ECLAC and PAHO).

A great many good practice initiatives have also notably been generated not only by public bodies (lead agencies), as traditionally occurs, but also by private institutions (Mapfre Foundation, 2015; Gasnova, 2019). Note should also be taken of the quantity of material concerning road safety, in particular in the occupational sphere (Cenifer and Tesicnor; DGT, 2018; Fesvial, 2020; Fraternidad Muprespa, 2008; Umivale, 2015), revealing the concern on the part of employers, who to a great extent bear the economic cost of roadway incidents at work and when commuting, as indicated by the bulk of the regulations in force. In this respect, it is worth highlighting standard ISO 39002 (ISO 39002 ISO-39001.es) with regard to good practice models to implement safety management during travel.

The question that then arises is: What is the criterion applied to consider that a practice represents good practice? In studying investments made in infrastructure to improve road safety, Yannis, Papadimitriou, Evgenikos and Dragomanovits reached the conclusion that good practice is any practice that would be desirable in terms of cost effectiveness. Meanwhile, the WHO (2010) considers that while the introduction of good practice in the sphere of road safety today enjoys a consensus, the same does not occur with certain practical aspects, which would include the processes of data gathering and the creation of an information system.

Although explicit mention is often not made of good practice when talking of road safety, the fact is that global authorities in this sphere are well aware of the need to identify and implement such practices. In fact, both the Global Plan for the First Decade of Action for Road Safety and for the Second Decade (2011-2020; 2021-2030) contain a complete survey of those practices which, in strictly methodological terms, improve road safety in the areas where they are applied.

In this regard, the aim in this chapter of describing Ibero-American experiences with positive results is based on the idea that they could be rethought for similar contexts, without overlooking the principle that road safety strategies always involve a wide range of people required to share one single space. Hence the major need for an understanding of good practices on the part of the entire community using the public space, as the most appropriate instrument to achieve safe road travel by all actors, through their internalisation of these principles. Nor can this apparently be achieved without allowing the community to participate in building and reproducing the system.

Despite the great many different perspectives as to formulating and implementing road safety strategies (Wong, Hung and Lo, 2002), there is a widespread consensus that they must take into account the different realities in which they are implemented. In this regard, it should be remembered that high-income countries have a long history of endemic traffic accidents which have been successfully reduced thanks to the identification and application of good practices (Asian Development Bank, 2013). This is a path which developing countries need not necessarily follow, although they can (and must) consider applying such methods.

21. Compendium of good practices in Ibero-America

Following a comprehensive review of a series of practical speed enforcement case studies in the region of Latin America, we have been able to identify a set of practices which have proved successful in those locations where they were applied. They are presented below, distinguished by geographical location. We will first consider those ventures corresponding to the cases of Uruguay, Mexico and Chile, before then addressing ventures funded by international bodies in Brazil, Colombia and Argentina.

Uruguay

For the authorities of the National Road Safety Unit (UNASEV), enforcement is one of the four pillars for safe mobility, alongside education, decentralisation, coordination and management. The effectiveness of the electronic enforcement conducted in the country can be analysed in three different areas: in the capital (Montevideo), in the east of the country (Maldonado) and at the national level (Ministry of Transport). Analyses are set out immediately below for the three aforementioned cases.

A national radar plan is currently being developed by the Ministry of Transport and Public Works, for which the UNASEV will provide information as to "blackspots" with a high level of road accidents, in order to prioritise control of these areas. The data department worked on this project, providing highly valuable information. Meanwhile, an 80% match rate was found between the spots identified by the Ministry and those provided by the UNASEV. With regard to enforcement: 177 radar control posts were covered, with 100 traffic enforcement devices rotated among them, covering the entire country. This marked a turning point in Uruguayan road safety. In this enforcement proposal, users are given advance notice that they are entering a zone with radar detectors, by means of road signs. The authorities see it as fundamental to publicise and alert users as to the radar devices. The expected results are: greater compliance with traffic regulations and a drop in road accident rates. One of the matters of greatest concern is maintaining appropriate calibration of the devices. To this end, Uruguay has a body which provides guarantees and backs up the accuracy of the verification results: the Technological Laboratory of Uruguay.

Montevideo

Speed is monitored via the Mobility Management Centre, belonging to the Departmental Government. The Mobility Management Centre is defined for the authorities as "*the launch of various smart transport systems, applied in real time to the administration, management and control of traffic and transport in the city*" (Draper Praderio, October 2021). This management centre was installed in different phases: systems were first of all installed on the main city avenues and on the Rambla (from Carrasco to Ciudad Vieja). This item in particular was of significant importance in reducing road accident rates from the perspective of the technical staff, as it is one of the city's main traffic hubs. These interventions are overseen through a technological equipment network (centralised traffic light controllers, traffic survey cameras, closed-circuit television cameras and variable message signs). The contribution made by electronic enforcement is highly significant, in the opinion of the specialists. They first of all generate data to improve traffic flow and reduce travel times, and can furthermore define scenarios to improve road safety and reduce accident rates, increasing control capacity. Meanwhile, a monitoring centre can optimise usage of the road network, providing citizens with real-time information about the traffic situation, while also allowing policymakers to plan and model traffic, by permanently gathering field data. There are traffic monitoring cameras in place (146 devices at 119 points around the city, comprising a closed circuit). 525 centralised traffic light-controlled junctions have so far been installed, along with 296 vehicle counting sensors and 147 traffic monitoring cameras. The following have specifically been installed: 46 speed control and red light points, 12 variable message signs, 44 wireless sensors to measure travel times by section, 28 junctions with centralised pedestrian demand. The results in Montevideo are very good in terms of planning and procedural aspects. The city would seem to have blazed a trail that other cities should now copy. In this regard, the improvement in quality of life in the area of Mobility goes hand-in-hand with real-time information allowing improvements to be made to citizen traffic flow dynamics.

Maldonado

Located in the South of the country, the region includes the seaside resort of Punta del Este (a global sun and sand tourism destination), and a total population of more than 160 thousand people, along with a very substantial inflow of tourists during the summer season. As for electronic enforcement, a tender process is currently being conducted for 28 speed control points in both directions of traffic flow (7 of which lie within national jurisdiction). 5 mobile speed enforcement devices are also being tendered. There are plans for 25 red traffic light junction enforcement points, to detect forbidden turns, encroachment on pedestrian crossings and traffic speed (at least in one direction of flow). There will be a total of three stages to be fulfilled, with deadlines 60, 90 and 120 days after the contract is awarded. As for the fines, they would be of the order of USD 150-460. This case is at the tendering stage, making it important to monitor its evolution for a future study of the processes undertaken.

In the case of Uruguay we see the need and the application of automated monitoring policies for improvements in terms of road safety. Both at the country level and at the level of the localities named, there are application plans or projects covering joint work with different bodies. The results of these efforts are expected in the future in terms of reduced accident rates.

Mexico

Mexico City has designed a novel proposal in the region in response to the major challenge of managing the flow of motorcycle traffic and reducing deaths among motorcyclists (at present the accident and fatality rates have increased), while at the same time needing to deal with the whole issue triggered by the pandemic. The "Fotocívicas" programme (based on camera technology and radar) is hugely innovative. This is a programme launched in 2019, based on cameras which record the speeds of private vehicles, public transport and freight trucks, helping to reduce deaths and injuries. When the current administration took office in Mexico City, these cameras and radar systems already existed. No additional investment was made, as they instead reused the infrastructure already in place. There was a review of this technology and the administrative processes, including the supplier handling the technology, and they observed a skewed incentive: the company was taking a percentage of the fines applied. And so they started analysing where the cameras and radar devices were located, and found that they were not necessarily where the most lives were being lost, but where the most violations occurred. Therefore, firstly the cameras and radar devices were relocated, and then their location was made public. The aim here was not to penalise people, but to prevent them from suffering accidents in the most dangerous places. The locations were publicised and properly signposted.

The next step was to change the form of penalty, and so there was a switch from an economic fine to one based on "civic fines", which involved an obligation to undertake a series of activities: some are online, and others in person. It was hard to measure the impact of this programme, because of the pandemic that lasted a year and a half, and so it proved impossible to undertake 100% of the in-person activities that had been carried out. One positive aspect that the authorities saw was the fact that people exceeded the speed limits far less than before. And so whereas fines were previously applied to those driving on average 17 km/h faster than the maximum limit, they are now applied at 7.5 km/h above the limit, revealing a drop in speed where the limit is both 50 km/h and 80 km/h (the two limits in place in the city). The number of violations per number plate also dropped from 3.5-4 to 2.3. Violations analysed by day of the week and time remained unchanged. Most violations take place between Fridays and Mondays. With this new civic penalty, the repeat offence rate has dropped from 1.6 to 1.3 per plate. What they have seen is that 80%-90% of plates with up to 2 violations no longer have any. When the programme began, they saw normal behaviour in traffic occurrences in terms of the number of people killed and injured, but then began to note improvements (despite the difficulties in measuring this because of the pandemic). The "Fotocívicas" programme has 3 important components:

- Education→ this component was not previously included in the penalty model.
- Awareness-raising → also not previously included.
- Responsibility → the person behind the wheel must take responsibility.

How does the programme work? For the first two violations, a warning is simply given, with those receiving the warning being required to enter a microsite and acknowledge receipt of the warning, as a disciplinary reminder. For the third warning, a basic online course is applied and must be completed (Traffic Regulation, Rights and Obligations, Civic Roadway Use Systems). For the fourth violation there is an intermediate course (information, module on people who have suffered a traffic accident or lost a relative in a traffic incident, with the aim of raising people's awareness of the consequences of traffic incidents). By the stage of the fourth violation there is an in-person workshop (the Cycle School proved the most successful) delivered over one and a half hours, comprising 40 minutes of theory and then another part with practical activities. All these penalties were well received by the offenders. The topics focused above all on cycling infrastructure and the lack of respect for/knowledge of this infrastructure on the part of other road users. From the sixth violation onwards, they must perform two hours of community service: helping on the metrobus, in the carriages exclusively for women, issuing mobility cards, at car parks, community tasks (cleaning of open spaces), programmes in the historic centre (cleaning), taking care of exhibition rooms at the Natural History Museum. It is important to point out that for each violation, points are deducted from the number plate (violations are attributed to the plate, not the individual's licence). Meanwhile, drivers must undergo a mandatory vehicle check 1 or 2 times per year, and those with unpaid violations cannot complete this check. One of the factors behind the programme's success is attributable to the microsite, serving as one single platform where citizens can access all aspects regarding the programme.

Given all the above, the programme is seen as forming part of a paradigm shift, in that it moves away from a situation which involved little more than collecting fines, to enforcement which aims patiently to generate a positive change in driver behaviour. Within this change, those responsible for the programme assert that if they could, they would like to have the offenders undertaking in-person activities from the first violation onwards, but the large number of offenders (more than 1.5 million) makes this goal hard to achieve. They are nonetheless working to pursue options to increase the city's capacity.

The programme managers have reached the conclusion that offenders are much more bothered by spending their time on these activities as a result of the violations, than the monetary value of the fines. What is more, it was found in many cases that families already allowed for the cost of fines in their household budgets.

The case of Mexico City tallies with the recommendations made by Pere Navarro (October 2021) as to penalties that serve to convey the message rather than fines of a high monetary value, which are rarely paid.

Chile

In the case of Chile, there are major problems linked to electronic speed enforcement. First of all, users do not believe that the system is employed to generate awareness, or feel they are not sensibly positioned (Perillo, October 2021). Meanwhile, as in other federal countries, municipalities do not show good judgement in deciding which areas to monitor. There is likewise a clear lack of regulation, and failures in the system to notify offenders of their fines (many are informed that they have a fine when they undergo their vehicle's VTV inspection). Meanwhile, there is also a lack of judgement in terms of the appropriate installation of radar devices, for example cases of trucks taking violations in prohibited locations. Furthermore, evidence may be seen of a lack of transparency in terms of information about the radar installations (which do not have proper standardisation), and the protocols to serve notice of

violations. All the above increases the perception of the system on the part of citizens as one intended purely to collect fines.

In several of the previous subsections we saw that radar devices proved highly effective if appropriate criteria followed. However, in order to reinforce a positive view of the system, citizens must see its benefits, and its impact on social safety. By showing the good results generated by implementation (in terms of accidents and fatalities, as the best argument in support of installing the devices).

What are the main solutions to this problem that users would see, according to the International Automobile Federation (FIA)? For Perillo (October 2021), according to the data from various surveys, the options are linked to the following actions: establish a road awareness programme, switch from a system of fines to one of education, apply a new system of penalties (scaled by % speed, for example), introduce driving licences with points, apply road safety criteria in installing radar devices, create funds to finance road safety and mobility projects.

In Chile, the services conducted by the Chilean Automobile Club have established that 60% of drivers exceed the 50 km/h speed limit, and that drivers in the country are furthermore not prepared to change their habits. The need in this regard is to seek cooperation from other institutions to modify such conduct.

The groups to consider when proposing electronic enforcement include Automobile Clubs and Touring Clubs. These institutions date back almost a hundred years and enjoy great credibility, not only in representing users but also in terms of their perspective, allowing them to deliver training, generate proposed improvements based on foreign experiences, and even providing governments with human resources (instructors, traffic agents, etc.).

They represent an ally worth considering when conducting surveys, behaviour/speeding studies, in the promotion of public policies (specialists working in government and transport committees), or simply at the point of supporting and publicising measures (social media), or in drawing up points recovery courses.

These institutions could therefore support electronic speed enforcement through awareness-raising campaigns, social media, surveys, public policy actions, technical studies. This is in fact what happened in Chile, where the Automobile Clubs and Touring Clubs served as collaborative agents in awareness-raising. The case presented with regard to Chile demonstrates that as the Global Plan declares, good practices, and road safety actions in themselves, can have one main authority responsible, namely the State, but there are other actors that can make significant contributions towards this goal. A consideration of these contributions likewise serves to establish a good, comprehensive road safety policy.

Cases of speed management projects financed by the UN Road Safety Fund

Over recent years, projects have been presented involving comprehensive speed management processes for funding by the UN's global fund. Many of them have already been implemented, and focused on addressing practical cases in Latin America.

In each case, the policies for efficient management recommend that the intervention approaches should not be isolated, but integrated across a suite of actions which should be based on clear information measures at all levels, aiming at all times to establish an overview and a comprehensive approach. There must be arguments as to the reasons why to intervene, establish regulations and credible limits which are logical and easy to comply with, seeking support from expert communication sectors, academics and others. Speed control also involves the element of technology, logical multi-focal and multi-sectoral measures, with a systemic perspective. Clearly, the development of planned actions within the stated context makes it much more feasible to put in place efficient automatic enforcement systems.

State of Pará, Brazil

The project is entitled *Strengthening Road Traffic Enforcement in Brazil*, with the support of the UN Road Safety Fund, and with two goals: first of all, to underpin the technical and operational capacity of traffic agents through appropriate academic training, and furthermore to implement better evidence-based traffic enforcement practices. Work is being performed on the preparation of a National Traffic Enforcement Protocol, aiming to standardise procedures for the application of traffic rules, adapt identification and include the risk factors proposed by the WHO. Automatic speed enforcement may use fixed and mobile/portable radar devices, the latter having greater restrictions (only on urban roads if the specified speed limit is 60 km/h or higher, and on highways where 80 km/h or higher).

For this project, all speeding violations have a fine, divided into three categories: up to 20% above the speed limit, between 20% and 50% above the speed limit, and 50% or more above the maximum permitted speed. Another strategy used in the state was automatic enforcement by means of station monitoring, since the regulatory code makes no provision for violations detected by technological means. Following the restrictions and difficulties linked to the pandemic, certain preliminary results were obtained, such as training of agents, creation of a data analysis committee and citizen participation. Automatic enforcement is undergoing incipient implementation throughout the State of Pará, covering 88 municipalities after 3 months of work in 2021. This is an interesting case, as it provides a reference point in the region for those that have a similar governmental organisation system, of federal states with autonomous regulations, which need to be reconciled by means of governance-building.

The case of Pará once again reveals efforts to implement automatic enforcement, but at an initial stage of the optimal development of procedures.

Medellín, Colombia

The municipality of Medellín has now spent more than 20 years working on Road Safety. As early as the first decade of the 21st century, they undertook practical initiatives with radar, with the aim of finding a solution for an expressway in the city: the 64C (Northern Motorway), with its respective internal and external connections. The results obtained were not particularly auspicious, however, since by 2019 the number of fatalities on this road remained high (19 deaths in that year alone), most of them (95%) being pedestrians, motorcyclists and cyclists. The first goal proposed by the authorities was to reduce the speed in the urban zone to the recommended limits: 50 km/h. In parallel, actions were taken with the population groups using this route. They furthermore drew up a media and dissemination plan, and workshops intended for the community, with different actors of interest. The measures managed to achieve a reduction of up to 80% in fatalities, 30% in injuries, and 15% in road incidents overall. The decision was therefore taken to apply the measure to a further 10 roads.

Nonetheless, there is a degree of uncertainty on the part of the authorities with regard to this type of measure, focused mainly on how long the positive effects of the measures last. It should, however, be clarified that in Colombia automated speed control is not applied, since there is a major regulatory problem with regard to serving notice of fines, and the solution to this now lies with the Senate.

Colombia: highways in Quindío

As mentioned previously, the country reveals a serious problem which prevents the use of automatic enforcement. The authorities cannot apply technological systems throughout the territory, because of legal impediments. Nonetheless, the National Road Safety Agency of Colombia has successfully developed a safe system in one area of the country with high mobility: Quindío. They identified numerous roads there with high accident levels, roads with extremely high levels of mobility which connect Bogotá to popular tourist areas, with considerable speeding (65.1% of vehicles were exceeding the speed limit). During the months of December, January and February, many families head to the Caribbean for the festive period, which is when these highways see a great influx of vehicle traffic, leading to an increase in accident rates in general, and a 47% rise in fatalities. The routes are challenging, since they pass through mountain areas with inclines and bends requiring lower speeds, which cars and motorcycles often fail to respect, increasing accident rates. The agency decided to apply a simple practice: reviewing speed limits in sections with the highest accident rates, reducing speed limits to a viable level and providing information through signposts/radar devices indicating vehicle speed (educational radar). The aim was to persuade drivers not to exceed the limit, thereby achieving a 55% reduction in fatalities in December 2020 alone in the target area, whereas the level increased by 19% over the course of the year in other municipalities.

Speed fell in Quindío by more than 10%, mostly trucks, then motorcycles, and lastly cars. The agency took a positive view of this initiative, although as in the previous case, doubts again focused on the sustainability of the results and consolidation of the initiative over time. Questions were also raised as to the persistence of driver behaviour when other measures are applied instead of penalties, which do make an impression on the driver. If this were achieved, there would furthermore be the question of whether or not effort or investment was saved. Beyond these dilemmas, this case is presented as another among many in which the authorities are managing to reduce speed and fatalities in Latin America.

Buenos Aires, Argentina

2 transport transfer hubs were identified in this city: Sáenz and Flores, with high accident rates, essentially involving pedestrians. The reasons behind incidents there vary: speeding, buses jumping red lights, and pedestrians crossing at inappropriate locations. The actions undertaken were accordingly also diverse in nature: safe infrastructure (speed bumps, rumble strips, elevated crossings for pedestrians, signposts), increased monitoring and relevant legislation (traffic officers, speed and red light controls, and penalties resulting in licences being seized or fines applied directly), education and awareness-raising (meetings with elderly local residents, training sessions for bus drivers) and civic commitment (meetings with companies, CSR to help operate the system). There was a very significant effect, resulting in a clear reduction in fatalities of 86%, and a 72% drop in speed. Here we also see official action with a direct effect, although action was likewise taken with infrastructure.

Resulting recommendations for the effective implementation of automatic enforcement

Based on the experiences identified above, a series of recommendations may be drawn for the consideration of successful automatic enforcement in Latin America, taking into account the diverse circumstances and specificities of the region. They are detailed below:

- The successful initiatives reveal the need to build Latin American solutions inherent to our regions, our contexts and our people, in other words "grounded initiatives". It is of vital importance in this regard to somehow involve the local community in enforcement programmes (from planning to implementation), based on the principle that only if road safety measures are internalised can positive results be achieved across society in a meaningful and lasting manner. The Chilean case indicates one possible initial approach or point of entry to raise social awareness of road safety policies.
- Any measure must be backed up by data which genuinely support it. It should be borne in mind in this regard that data is now being continuously generated, covering a host of measurements, which at present are not used in an optimal manner. The generation of data left, right and centre is extremely costly, while the low level of usage represents a waste of resources. The definition of appropriate and relevant metrics serves first of all to apply controls, observe trends, and predict future results so as to act accordingly. Meanwhile, empirically backed decision-making minimises errors. Lastly, the gathering and appropriate analysis of empirical data serves to defend measures against potential detractors. The role of observatories is vital here as centres to gather, process and distribute information.
- Enforcement proposals must be genuinely innovative, to the extent that they need to be able to convince road users of the necessity and desirability of driving within the established speed limits. Regarding this aspect, initiatives such as those in Mexico City, which switched from a monetary fine system to a civic approach, reveal the substantial power of innovation. Aside from their ability to surprise the population, non-monetary measures reduce inequality within the community, since irrespective of economic resources, all those committing the same fault have the same capacity to "pay", as the fine takes the form of time rather than money.

- Communication and transparency are fundamental. Prior to implementing an automatic enforcement system, then, the authorities must reliably communicate this to the population, simply and directly explaining the goals, and granting a reasonable period of time to allow citizens to internalise it. They must also signpost the different checkpoints. This is the only way of clearly establishing that the primary goal is to address conduct which is harmful to health.
- Understand the role of civil society within the measures. On occasion, road safety measures are decided unilaterally by the authorities, which are often unaware of movements at a corner, a city block or neighbourhood. Organising workshops, inviting different types of road users, serves to provide an extensive understanding of the situation, and better and broader acceptance of the future measures.

A compilation of the stated experiences and practices allows us to assert the need and the very considerable predisposition on the part of authorities to improve road safety through speed control. Clearly, these initiatives reveal different possibilities for application and levels of development, which suggest that the introduction of appropriate automatic enforcement systems in Latin America will vary widely.

We thus find cases such as those of Mexico and Uruguay, revealing integrated and extensive efforts, with very substantial planning of speed control policies, executed with positive, large-scale results. In other cases, we have seen more recent and sectoral policies, generating evidence of positive (although recent) results, and uncertainty as to their sustainability. At the very other end of the scale we have countries or regions with no experience of good practice, where automatic enforcement would seem to be a pipe dream.

Chapter 4: Management of a regulatory framework for efficient automatic enforcement

An automatic technology system serving as a tool to monitor speed and other factors in road accidents, known as automatic enforcement, is an instrument which aims to transform the way in which control is applied, so as to reduce the rate of such accidents worldwide. This goal entails a social paradigm shift, while the incorporation of technologies provides greater effectiveness and efficiency in determining the causal relationship of a road incident.

This novel context demands legislation to develop this aspect and guarantee implementation of the process. Contrary to popular belief, the legal sphere covers not only due process, but also guarantees as to the conditions of reliability demanded of the system. Legislation thus has responsibility covering not only the technological regulations applicable to the electronic inputs (guaranteed by precise technical standards established on an ad hoc basis), but also the validation of the processes for the incorporation of enforcement elements within public spaces, as well as establishing regulatory guarantees for the process from the point at which the alleged offender commits the traffic irregularity.

To achieve this goal, general regulations are required, governing three aspects:

- The first of these is to bring in a law responsible for explaining and authorising the use of automatic systems for vehicle traffic enforcement, giving the community the chance to understand the basic aspects of automatic enforcement (such as the technical and automatic technological road control system), the governing principles, the goal of reducing road accidents, accompanying road education and disciplinary regulations.
- Once this first aspect has been resolved, specific regulations need to be issued, serving to establish the technical, technological, professional, human and other terms required to determine the quality, efficacy and efficiency of the automatic elements that will be used, and of the entire enforcement system, including the parameters to resolve location, the type of IT and technological systems to be used for automation, and the whole framework concerning the form and enforcement technique itself.
- This process lastly includes the punitive procedure applied to those in breach of traffic rules, with the ultimate goal of educating the general public so as to develop a better culture and changes in traffic and transport habits. This is brought about by reprimanding citizens in the event of a breach of traffic rules, through various procedures. All while ensuring that the process does not remain confined to systems of fines, instead facilitating the emergence of a road use culture which will help to reduce accident rates.

22. Automatic enforcement

An overview of the bibliography concerning regulations in terms of automatic enforcement allows us to assert that few Latin American countries have embarked on the path towards automatic enforcement. In countries such as Colombia and Argentina, their governments have taken the initial steps to regulate automatic support systems for road accident control. Nonetheless, there are still gaps in terms of coverage and a change in road culture, since Latin America still has a very considerable number of victims as a result of road incidents.

Various organisations corresponding to Ibero-American countries, both public and private, have focused their attention and concern on the human factor as the cause of most traffic accidents. The aim is accordingly to enable the implementation of measures within their regions that would tend to bring down the rate of road accidents, mainly efficient automatic enforcement systems derived from internationally consolidated initiatives. Initial advances have been made in Latin America in terms of enforcement regulations, as in the case of Chile, Costa Rica and Uruguay, where the first debates are being conducted as to the implementation of an automatic enforcement system. In others, meanwhile, we find an absence of information as to processes being undertaken for this purpose. These regulatory gaps, together with the major road accident pandemic, have prompted the need to turn to the experience of nations across the rest of the world, and of course, as seen in the previous chapter, certain good practices from our region of Ibero-America, to offer a general guide as to an efficient enforcement process. Despite these gaps or grey areas in legislation, there are some regulatory elements associated with road safety providing us with an insight as to the starting point on the way towards automatic enforcement.

In order to identify certain rules linked or potentially opening the way to automatic enforcement, we summarise below those regulations in each country that concern certain elements governing traffic or penalty proceedings:

1. ARGENTINA

a) Law 19511: this is the law responsible for determining the Argentinian legal metric system (SIMELA), establishing the units, prefixes and symbols which are accepted for measurement within Argentinian territory, as the only metric system accepted for measurement devices in Argentina, while furthermore establishing that measurement devices must be periodically inspected and calibrated to ensure that the measurement taken complies with appropriate measurement parameters.
b) Law 24449: establishment of the National Traffic and Road Safety Law, specifically creating the Federal Road Safety Council, the main role of which is to perform all relevant actions to avoid road accidents, and generate road safety education. The same law sets up the National Traffic Offence Records Register, as a means of monitoring alleged offenders, fugitives from justice, disqualified individuals, penalties, and all other information of relevance for road safety administration.
c) Law 26353: this law governs the structural links between the National agency and the Provincial agencies, to implement the points system as a guide to traffic behaviour, standardising criteria with regard to traffic licences, control of alcohol levels and authorisation for use throughout national territory of a radar- and photo-based speed control system, establishing that the purpose of such measures is not to collect fines, but to achieve road safety.

d) Law 26363: this law elevates to the rank of a national law the provisions of Decree 1232 of 2007, specifically creating the National Road Safety Agency, and in general the issuance of driving licences, control of alcohol levels, speed, and the establishment of the points system.
e) Law 25650: this law establishes the ban on using the radar system for vehicle control, unless it complies with metrological or technological regulations.
f) Decree 1232/07: this decree establishes an agreement between the regional provinces and the national state in order to "establish the national driving licence register", an agency at the national level, operating as a federal organisational system, responsible for matters including the control, issuance, registration, certification and cancellation of driving licences throughout national territory; to implement the points system as a guide to traffic behaviour, standardising criteria with regard to traffic licences, control of alcohol levels and authorisation for use throughout national territory of a radar- and photo-based speed control system, establishing that the purpose of such measures is not to collect fines, but to achieve road safety.
g) Resolution 753 of 1998: this is the regulation issued for the purpose of establishing the technical and metrological parameters that must be fulfilled by radar and speed detector devices[1].
h) Decree 829/94: this regulation provides one of the initial approaches to technical metrology device controls[2].
i) Decree 1157/72: this decree serves to set up the National Metrology Commission, as the body responsible for the following: update systems for measurement, regulation of the technical parameters of metrology systems, and perform all activities to standardise and guarantee an effective measurement system.

2. CHILE

a) Decree-Law 557/74: creation of the Ministry of Transport (now known as the Ministry of Transport and Telecommunications); this same regulation determines the organisation and source of the funds available to this ministry.
b) Law 18059: following creation of the ministry, this law determines its functions, which include the following: present the national authorities with traffic-related plans and programmes, propose legal regulations for traffic and transport policies, and issue any rules required in accordance with land traffic provisions.
c) Law 18290 (Traffic Law): this law establishes not only general regulations and the vocabulary employed in the sphere of traffic, but also the rules to be adopted for the issuance of driving

[1] Establishing the information that manufacturers must include with each speed detector, the speed indicator device, together with the units of measurement used for this purpose. The technical specifications include all manufacturing requirements and the tests and checks to which the speed detectors must be subject in order to achieve optimal guarantees and assurance of the measurement of vehicle speeds, eliminating the possibility of the vehicle being measured, irrespective of the existing climatic, electrical or magnetic conditions.

[2] Determining that while the national government draws up all regulations and rectifications for the certification of metrology systems, supported by factory technical self-certification, but determining the minimum requirements of the products sold to ensure that this self-certification is correct, and in accordance with the technical requirements for use and legal control requirements, so as to ensure a reliable metrology system.

licences[3]. It further indicates certain maximum speeds dependent on the type of vehicle, and the ban on traffic below the minimum permitted speed. It establishes those acts which constitute offences and infringements, as well as indicating the requirements for the authorisation of driving schools. Particular mention should be made of the authorisation granted by the Chilean State to such enforcement agencies as the national police force and tax and municipal inspectors, in performing their function of oversight of compliance with traffic law and any resultant violations, assisted by violation detection and registration equipment, which will be of the cinematic or photographic film type, or any other type allowing the reproduction of images, sound, or confirmation of a breach of traffic law.

d) DFL 1 of 2007: this decree with legislative force serves to modernise Law 18290. With regard to the use of recording equipment in image and sound format as tools for the supervision of compliance with traffic legislation, it brings in the requirement that such devices must be duly signposted in accordance with the signposting manual, furthermore indicating the obligation that such equipment must fulfil a minimum standard for the elements recorded thereby to be reliable and accurate, given the evidential use of such information as the basis for reports of violations or infringements that will be conducted by the competent local police courts, with a particular emphasis on the fact that this equipment must guarantee protection of and respect for private life, with such limitations as: the individual identification of the occupants of the alleged offending vehicle, except in those cases established in traffic legislation.
e) Supreme Decree No. 196: regulating technical and usage standards for equipment recording and detecting traffic violations[4].
f) Supreme Decree No. 60 of 2013: this decree is intended as an update to Decree 86 of 2001, establishing certain basic requirements for instruments to measure and register violations in the zones in question, in particular those with high impact, establishing certain minimum measurement parameters[5].
g) CATI Law (in process): the CATI Law (or Automated Traffic Violations Centre) is being introduced by the Ministry of Transport to establish this centre, which aims to prevent road accidents, while giving rise to a behavioural change, through automatic enforcement technology serving to

[3] Depending on the type of vehicle, since there are public, private, freight and passenger vehicles, which may or may not require a professional licence;

[4] Once authorisation had been granted for the use of equipment to register and detect violations, this legislation was drawn up to determine the technical conditions of such equipment, the way in which it was to be used, and how to handle the information acquired by the devices, specifically clarifying that the devices governed by this law are solely for the registration and detection of traffic violations, and do not correspond to the devices for speeding and red light violations, which are already governed by separate regulations. The technical requirements of the devices governed by this law include the demand that equipment intended to capture information as a visual record, the number plate of the vehicle, location of the violation and date and time, must register vehicles travelling at a maximum of 250 km/h.

[5] Basic information that must be registered about the vehicle (the number plate, speed, two images with a difference of 0.5 and 1 second between them to ensure the fault when jumping a red light), while also imposing the requirement that it should be impossible to identify the vehicle's occupants individually. It meanwhile indicates that when the image or video is captured, this must clearly indicate the date and time when the recording was made, the place where the violation occurred, the speed permitted at that location and the vehicle speed. With regard to the technical requirements for registration instruments, it was indicated that they must be capable of registering speeds between 20 and 250 km/hour, and withstanding temperatures between -5 and 60 degrees, with capacity to store the record for at least one month, all of this applying to equipment which must be certified and calibrated every two years to ensure that the devices do not commit errors of more than 3% in judging the speed.

detect speeding violations. This technology will be positioned in accordance with certain objective and public parameters, with due signposting.

3. COLOMBIA

a) Law 769: this law constitutes the national land transport code, the guiding principles of which are: user safety, mobility, quality, suitability, coverage, free access, full identification, free transit, education and decentralisation. It sets out in general terms the terminology used for traffic in Colombia, such as the definition of streets, different types of sign, together with how they must be interpreted and located, different elements comprising traffic penalties, together with the elements that facilitate such incidents and the means of evidence, for example through alcohol tests (reference is also made to tests for other hallucinogenic substances). The most significant points to be noted include road safety training in general, a task entrusted to legally recognised authorities, such as mayors, police bodies, inspectors, and even the army and traffic and transport bodies, which are given the task of determining temporary rules to improve road safety[6]. As in other nations, drivers in the country are required to undergo a course and certain tests to declare them fit to drive vehicles, whether or not they have any type of physical limitation. Once the driving licence is granted, it must be renewed at certain periods, which depend on the type of vehicle and age, the minimum being each year if the driver is aged over 80, and the maximum every 10 years for drivers of private vehicles aged under 60[7]. It also establishes the organisation of technical and mechanical inspection centres, which serve to verify the optimal condition of the vehicles[8]. As for the application of penalties, this law makes only a basic indication that instruments capturing image and sound will be presented as evidence, which may be disputed by the offender. The same law establishes the minimum and maximum speeds that vehicles must abide by both in cities and on highways.

b) LAW 1383 of 2010: this regulation constitutes an update to the national transport code with regard to the granting and validity of driving licences, the suspension and cancellation of licences, traffic requirements, the requirement and form of control of pollutant emissions. It furthermore extends the type of violation and penalty depending on the law that has been violated, and determines the disciplinary process, which involves a summons served on the offender, indicating that they must appear before the competent authority. This summons is drawn up by a traffic officer in person, although the same law also allows the authority to hire technical and technological agents serving to obtain evidence of the occurrence of infringements.

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[6] In the more specific case of the police and inspectors, the gathering of evidence and issuance of reports presented to the sanctioning authorities in cases of breaches of this traffic law.

[7] Together with the driving licence, the driver must have their vehicle licence to hand, containing general information about the vehicle, and as a result any penalties may be applied either to the driving licence, either suspending or cancelling its validity, or may otherwise be applied to the vehicle licence, immobilising the vehicle, another of the elements governed by the law, aside from the requirements to establish traffic academies and road safety education in schools.

[8] This inspection is periodic and is compiled in a database accessible to the transport authorities (the transport information held by the authorities comprises driver identification, home address, type of licence, vehicles owned, violations, penalties and other elements).

c) Law 1843 of 2017: this is the law responsible for regulating and authorising the manner and use of automatic and semi-automatic violation and traffic monitoring devices. This furthermore includes monitoring of speed, red lights at junctions and technical/mechanical inspections. The same law indicates that notification must be served on the owner of the vehicle, in due form, allowing the offender to benefit from a conditional reduction in the penalty. Information about the vehicle and its owner will be drawn from the single national traffic register.

4. COSTA RICA

a) Law 9078: this law constitutes the general standard governing national traffic, and as with all general traffic regulations, it begins by giving definitions used within the roadway system, and likewise establishing the requirements in order to be entitled to drive an automotive vehicle[9]. The law also indicates how the Technical Vehicle Inspection ('IVE') certificate is obtained[10]. The legislation likewise establishes the parameters for collection of payment for traffic accident insurance, and the form of issuance of driving licences, determining the medical parameters and the required knowledge, requirements which will depend on the type of vehicle driven. With regard to speed, this law establishes the maximum permitted speeds, which may be monitored by the competent authorities by means of electronic vehicle measurement devices, which the drivers may be aware of and may dispute[11]. Costa Rica is another country which has introduced a points system as a means of permanent driver evaluation. If a certain number of points is reached, the licence may ultimately be suspended.

b) Executive Decree No. 39946: this is the text approving the metrology regulation for speed measurement, whether by automatic or non-automatic laser or Doppler-type speed detectors, determining as general requirements the need for a user manual, which must indicate how the equipment functions, with instructions and conditions for use, among other usage information. Costa Rica only accepts as speed detection instruments that may be used as evidence in penalty proceedings those which have a memory and photographic or video camera, which must record not only the vehicle, but also the date and time of the violation and the speed of the vehicle, with the capacity to measure between 20 and 150 km/h. Such equipment must be protected, and cannot have a margin of error greater than 5%, in accordance with maintenance procedures. The legislation likewise regulates all other technical aspects that the speed measurement instruments must fulfil, to ensure their efficiency and the quality of the information gathered.

[9] A title of ownership, driving entitlement certificate and valid insurance are required, with this information being registered in the national register.

[10] It establishes the periodic vehicle inspection to conduct mechanical, electrical and electronic checks, certified by means of a sticker.

[11] Speed monitoring may be performed both semi-automatically, as used by traffic officers, or automatically. In the latter case, once the violation is generated, a notice must be served within 10 days on the owner of the vehicle, who will be liable for payment of all fines applied to the vehicle, unless they can prove that they did not cause the violation. One interesting feature of this regulation is that it forbids the use of technologies and instruments on board vehicles that would serve to evade or override public surveillance equipment, such as radar wave detection devices.

5. CUBA

a) Law 109: this is the regulation comprising the road safety code, governing aspects including the issuance of driving licences, the obligation to maintain vehicles with due technical certification, speed limits in accordance with the type of road being driven on and the type of vehicle, establishing all forms of traffic signal, and the signals that must be used in the event of any change in the form of vehicle traffic, if the vehicle does not have indicator lights. The law furthermore establishes the inclusion of a road safety teaching position at schools, and creates the national road safety commission, as the body responsible for implementing policies intended to ensure safe traffic conditions. However, with regard to breaches of traffic rules, where they do not constitute a criminal offence, the law has established fines as the penalty instrument, issued only by a traffic officer in person. In the case of Cuba, it may be seen that there is no legal development for the implementation of automatic enforcement systems.

6. ECUADOR

a) Organic law on land traffic, transport and road safety: this constitutes the general land traffic regulation, indicating the requirements to obtain a driving licence, and the need for the vehicle to have due technical certification qualifying it as a vehicle authorised for use on the road. As in the previous cases, there is an explanation of traffic signs, determination of maximum driving speeds in accordance with the type of road and vehicle. As for penalties for breaches of the traffic law, it was found that although no clear indication is given as to the use of automatic or semi-automatic speed monitoring systems, explicit authorisation is given for the alleged offender to prove their innocence with recordings from any cameras that might be positioned at the location where the violation occurred.
b) Technical Recommendation INEN-OIML R 91: although no Ecuadorian regulation was found to govern and authorise the use of technological instruments for speed monitoring, it was found that the Ecuadorian standardisation institute presented a technical recommendation with regard to the required conditions of radar equipment to measure vehicle speed. This same document indicates the technical information that the manuals of such devices must contain, the required measurement capacity and other additional characteristics as to how to properly position such devices, in order to ensure optimal use.

7. GUATEMALA

a) Decree 132-96: general traffic regulation, which in very general terms assigns responsibility to the general directorate of police, as the authority responsible for planning, directing and implementing plans for roadway organisation, road safety and disciplinary matters in the event of traffic violations. The regulation in turn indicates that in the specific case of enforcement, private organisations may be contracted to provide support. As in every country, drivers must hold a licence qualifying them as authorised to drive an automotive vehicle, which must hold authorisation for use on the road, be insured, and hold technical environmental and noise pollution control certification. It furthermore indicates the different types of sign which road agents must understand and respect, and the permitted speeds, along with the penalty process in the event of a breach of speed limits.

b) Technical standard “NTG/OIML R-91": This regulation was drawn up specifically to develop all technical and complementary matters for the acquisition, verification, calibration and commissioning of Doppler radar devices, and the instrument to measure speed more precisely, and also to control vehicle speed limits in certain sectors. Among other usage aspects, it indicates that the radar device must be located in an angle of between 15° and 30°, since this is the only way to obtain the margin of error permitted by the law, namely +/-2%. For Guatemala, the speed range that radar devices must register is between 30 and 150 km/h, being capable of withstanding temperatures between -25° and 75° C when not in service, and between 0° and 50° C in service. Bearing in mind that the information gathered by the radar devices must give the operator certainty as to the events, the devices must be subject to various climate tests and other environmental elements which could affect their operation.

8. PARAGUAY

a) Law 5016 of 2014: Paraguayan law comprising the traffic and road safety regulation, containing the general framework for the granting and control of licences, technical/mechanical certification, the speed limits by which drivers must abide, and penalty systems in the event of a violation. Violations include the use of devices to avoid speed measurement or anti-radar devices, with authorisation given for the use of radar equipment and other technological elements as tools to gather evidence in the event of an infringement.

9. PORTUGAL

a) Código da Estrada pe la Portaria 1542/2007: in the case of Portugal, this regulation specifically sets out the use of speed detectors (authorising the use of different types of speed detector irrespective of the measurement system they use), or other types of technological speed measurement equipment, indicating how the models presented to them are to be approved. They must be accompanied by the user manual and documented information as to components and functionality, along with a separate device to be used as a test subject. Bearing in mind the importance of speed detectors, they must be periodically checked to guarantee the accuracy of the information measured, while indicating the permitted margins of error.

10. DOMINICAN REPUBLIC

a) Law 63-17: the regulation in question serves not only as the general text governing land traffic, transport and road safety, defining the elements comprising transport and road safety, and establishing the requirements to obtain a traffic licence, while also determining the permitted speed limits, among other aspects (signage, penalties for breaches of traffic regulations, road safety education), but also establishes the national land traffic and transport institute, which will have the task of authorising and determining usage parameters, as well as the technological elements to be used in order to achieve better control of speed, as one of the main causes of road accidents. The aim is thus that such equipment should be recognised for their accuracy, and this regulation in fact addresses the use and implementation of technologies as a support tool for traffic control and safety as a cross-cutting issue. It is Articles 264 to 270 which specifically stipulated the use of technologies for speed control.

11. URUGUAY

a) Law 18191: the general traffic and road safety regulatory law, establishing minimum requirements in order to drive an automotive vehicle, such as a duly issued driving licence, which will be subject to the points system in accordance with the violations committed by the driver, traffic permit, technical/mechanical certification and vehicle registration certification. It likewise establishes the speed limits by which drivers must abide to avoid committing a violation, which may give rise to a fine, establishing the proviso that even if a violation is declared and a fine imposed, the driver is entitled to present any evidence deemed relevant to demonstrate that it did not occur.
b) Law 19824: among other aspects, this law focuses on emphasising and specifying the elements of safety and technology required of human-powered and automotive vehicles in order to promote road traffic safety and protect the physical safety of road users, briefly establishing that the road authorities may use technological systems to verify compliance with road regulations, without exploring the matter any further.

The comprehensive analysis set out above allows us to establish that in Ibero-America there are differing levels in terms of the regulations in place which could impact on speed control by means of automated methods. We thus find that European countries are the most advanced in terms of road regulations, with appropriate, developed content addressing not only speed control, but also automated enforcement. They unquestionably serve as a guide and example for other countries that are less developed in this matter, and their regulations have in fact been, and could be, replicated in Latin American countries.

Countries such as Argentina, Mexico, Chile and Uruguay may be seen to be in a process of evolution, since they already have extensive and robust road use legislation, with substantial references to speed control, and recent inclusions as to the use of appropriate technologies for this purpose. Without reaching European standards, this group present broad prospects of appropriate implementation of automatic enforcement, since their regulations have progressed to cover the gaps resulting from the emergence of this type of enforcement.

At a lower tier we find a rather diverse group of countries which, aside from other shortcomings, present basic regulations in terms of road safety, with little or no provision for speed control, whether analogue or automated. For this group, greater efforts will be required to achieve the ultimate goals of reducing road accident rates through speed enforcement, covering a wider range of elements conducive to road safety. As for regulations, they must inevitably first extend road safety provisions in order to allow for more specific aspects such as those raised in this document.

The results of the surveys conducted with the technical staff from various countries involved on the course "Automatic Enforcement of Violations of Traffic Regulations", promoted by the OISEVI (Ibero-American Road Safety Observatory) through its Technical Unit, within the context provided by the 'Intercoonecta' Programme of the AECID (Spanish Agency for International Development Cooperation), serve to provide evidence in line with the text of the preceding paragraphs (Table 1).

Table 1: Characterisation of the automatic enforcement process in the countries of Ibero-America

Country	Regulatory aspect		Planning	Technology	
	Laws exist	Enforcement official required	Planned	Technical standard	Certification body
Portugal	Yes	Yes	Yes	Yes	Yes
Spain*	Yes	Yes	Yes	Yes	Yes
Argentina	Yes	Yes	In progress	Yes	Yes
Mexico*	Yes	Inconclusive	Yes	No	DK/NA
Uruguay	Yes	Inconclusive	No	Inconclusive	Yes
Chile	Inconclusive	Inconclusive	In progress	Inconclusive	Inconclusive
Cuba	Yes	No	Yes	Yes	Yes
Colombia	Yes	No	Yes	No	Yes
Costa Rica	Yes	Inconclusive	Yes	Inconclusive	Yes
Guatemala.	In progress	No	Yes	In progress	Yes
Paraguay	Yes	No	DK/NA	No	Yes
Brazil*	Yes	Inconclusive	DK/NA	DK/NA	DK/NA
El Salvador	In progress	Inconclusive	DK/NA	No	No
Honduras	Yes	No	No	No	No
Dominican Republic	Yes	No	No	DK/NA	DK/NA
Ecuador	Inconclusive	No	DK/NA	Inconclusive	Inconclusive
Bolivia*	DK/NA	DK/NA	DK/NA	DK/NA	DK/NA
Peru*	DK/NA	DK/NA	DK/NA	No	DK/NA
Panama*	DK/NA	DK/NA	DK/NA	No	DK/NA
Nicaragua*	DK/NA	DK/NA	DK/NA	No	DK/NA
Andorra*	DK/NA	DK/NA	DK/NA	DK/NA	DK/NA
Venezuela*	DK/NA	DK/NA	DK/NA	DK/NA	DK/NA

Source: OISEVI, 2021

Note: If 'Inconclusive' is indicated, this is because different responses were found, or application covers only some regions or some specific aspects in a country.

23.Towards enforcement regulations

States, and the public officials acting as their representatives, can only act in accordance with the legal specifications. This is important to understand, because even if a government wishes to impose penalties on offenders who cause traffic accidents in some way, and have reason to do so, they cannot unless there is an appropriate procedure which in turn guarantees citizens' rights, such as freedom, equality and the right of defence, and protection of the rights and defence of the accused. This is what is known as the principle of legality, and is the most important principle to take into account in enforcement matters, since the State must first of all establish the speed limits and the required safety elements according to the vehicle, sector and population, along with proper maintenance of the roadway network and adequate signposting, as fundamental elements to mitigate those external elements which could cause traffic accidents. It is easiest for the authorities to address technical and human aspects, as they aim to control speed limits and other factors involved in accidents. It is in this sphere that autonomous technological tools can facilitate control. As indicated previously, however, this can only be determined by legislation with a series of principles allowing greater efficacy.

24.Technical regulatory framework

The technical regulatory framework requiring implementation includes the parameters that must be established by law with regard to the sensor devices that need to be used for vehicle control, and the parameters for installation on public roads, in addition to the system of calibration, maintenance and certification of the sensors that are to be used. These elements are vital, to avoid technical failings that would be counter-productive when penalising those who breach road safety laws, and generating the required road use culture to reduce the number of road incidents.

Aside from the sensors, another technical aspect requiring regulation corresponds to the information-processing systems, as it must be recalled that the information handled comprises sensitive data which the State must scrutinise in accordance with the law, and user protection.

25.Need for a procedural regulatory framework

The disciplinary process in Colombia, employing autonomous traffic systems, began with what were known as "photo-fines", using sensors to measure speed and other transport aspects, in order to oversee compliance with general safety regulations. Where a breach of traffic regulations was detected, a fine was sent to the home address of the owner of the vehicle, on the basis of the possible breach caused. However, the Colombian Constitutional Court ruled that photo-fines were unlawful, as they violated the right of defence of the owner of the vehicle, and as a result the sensors could not directly instigate the penalty, but instead give rise to the initial step in the administrative disciplinary process. In Argentina, where the concept of photo-fine also exists, we would highlight the case of the municipality

of La Plata, where an attempt was made to declare this concept null and void, it being argued that there had been a failure in educating the local population regarding this matter.

These amendments to the concept of photo-fines demonstrate the need for a better-established procedure, allowing the use of automatic technological control tools, while at the same time, in accordance with the principle of legality, allowing possible offenders to present evidence which could ultimately demonstrate their innocence, or some factor exempting them from the penalty.

26.Recommendations for efficient enforcement regulations

On the basis of the experience of Spain, the recommendation is to take into account the following points:

- Human conduct is the main factor causing road accidents, indicating that the greatest efforts must focus on achieving control of such activity, by means of penalties or by means of education.
- This requires that an efficient enforcement system be devised: including reasonable penalties, in other words, fines that are not too high, that can feasibly be paid, and in a swift process. In other words, ideally no more than a few days would pass between the violation being committed and the fine being collected.
- Simple and straightforward procedure: with regard to penalty proceedings, which means beginning a penalty process while respecting the right of defence of the possible offender, by means that are easily understandable and accessible to the general population.
- Punishment of the offender: once the penalty process has ended and the offender has been identified, the penalty must be effectively imposed as the initial tool to generate awareness.
- This punishment of the offender must give rise to a sensation of control allowing a change in road culture, as it has been demonstrated that the greater the sensation of control, the greater the respect shown for traffic regulations, and the lower the number of traffic accidents.
- Regulatory procedure: to achieve the above, while respecting the principle of legality, the procedure for the use of automatic systems, and the penalty process, must be duly regulated in the legislation of each country.
- As a result, the regulatory procedure must be accompanied by strict control of the procedural steps, to allow and facilitate the development of due process.
- Points system: bearing in mind that not all violations have the same impact, nor do they represent the same risk, the recommendation is to apply the points system, since this establishes a hierarchy of violations, assisting in the control and classification of offenders.
- Easy payment system: monetary collection must employ all available technological tools, allowing users to settle their fines in the simplest manner possible, the penalty in itself constituting a more than sufficient levy with regard to the violation.
- Notifications: notice must be given of violations, granting the driver or owner the chance to defend themselves, and to be informed of the violation giving rise to the penalty process.
- Technology serves as the support tool throughout the enforcement process, and must therefore be present not only in the cameras and sensors, but also throughout an information management system via a platform.
- Electronic complaints: as technology is an instrument in daily use, and citizens also form part of the traffic regulation control and compliance process, they must be provided with a platform easily accessible from any device, allowing them to submit the relevant complaints.

- Processing centre: all the information must be administered by an information-processing centre, which keeps the control systems calibrated, ensures compliance with notification deadlines, and effective penalty proceedings.

27.Conclusions

Across such a diverse group of countries as Ibero-America, we find one aspect common to all regions: the need for policies that provide the general public with safe traffic conditions. We refer here not only to such isolated measures as control, but also a comprehensive concept of road safety, from the ideas behind regulations and planning, to the implementation of measures, enforcement and notification of violations, among other aspects. These efforts are coordinated among different State agents, above all requiring the participation of other actors to achieve agreements with the community and an effective change in behaviour on the road.

The pre-eminent goal here is to control speed, given the swift effect of such measures in reducing road accident rates, as amply demonstrated worldwide, and as we have reflected in this report. Moving away from a fine-focused approach which has already proved unfruitful, we see speed control as vital in rapidly reducing accidents and fatalities both in countries with high rates and in zones or sectors of various cities that need to combat this problem. Here we agree with global recommendations and with the experts we featured in the first chapter of this paper.

The new technologies which already have a significant presence in our daily lives, emerge as key instruments in achieving proper control. Clearly, each technology has its own specificities, strengths and weaknesses, which must be considered when applying them in such diverse regions and situations as can be found in our countries. It is clear that technology in itself requires a great many processes and contexts to facilitate its incorporation, in terms of qualified personnel, maintenance, installation processes, appropriate management, cabinets, political decisions to apply and maintain such devices, as well as, of course, regulations to back up its usage.

In terms of laws connected with road safety, we find a very broad spectrum in Ibero-America, ranging from countries with robust, diverse, comprehensive and constantly updated legislation, to countries with basic, old-fashioned road safety laws with limited potential for application. More precisely, in terms of automatic enforcement it would be fair to say that the differences become more extreme, although we do find a group of countries which have made regulatory progress, with their respective difficulties, in approaching a standard closer to the regulations of those countries that already have automatic enforcement in place as a robust road safety policy instrument.

Good practices are processes which stand out for their achievements in terms of road safety. A number of them are featured in this paper, presented in the main by their own administrators, and they are of huge significance, in that they serve as processes working towards the ideals intended by every jurisdiction to protect citizens on the move. They furthermore provide a means of comparison among different administrative systems, and clearly offer an example of progress in this sphere for those administrators seeking similar results.

The gathering on Automatic Enforcement of Violations of Traffic Regulations, organised by the Spanish Ministry of the Interior, served as a forum to discuss these matters, allowing not only the pooling of experiences regarding road safety, but also recognition of the forms of progress being made in this regard by each country or jurisdiction. This made it possible to refresh content, generate ideas and strengthen ties of cooperation, which are fundamental in achieving advancements in road safety policy.

Lastly, we would like to bring this report to a close with what we modestly believe to be good recommendations that jurisdictions should follow to arrive at appropriate implementation of automatic enforcement.

1. Road safety policies must be included within a larger ambit, namely comprehensive mobility planning.
2. A strategic road safety action plan can then be set out on this basis, presented in harmony with other aspects of urban mobility.
3. Manage speed systemically, understanding its role as the primary risk factor.
4. Information is now the key to any type of policy or action, and the integrated use of technology and data therefore offers greater potential in handling and selecting tools for automatic speed enforcement.
5. Identify and agree the application of the most appropriate road prevention instruments for each jurisdiction, taking the community into account and informing them that the ultimate goal is to protect citizens' lives.
6. Strengthen the different institutions (and their practices) which form part of safe mobility, as necessary elements for the system to achieve its preventive function.
7. Build processes that guarantee the right to mobility through a legal framework linking up the institutions involved in the process in terms of safety.

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