LABORATÓRIO NACIONAL
DE ENGENHARIA CIVIL

TECHNICAL AND SCIENTIFIC FOUNDATIONS FOR THE 2021-2030 ROAD SAFETY STRATEGY

Methodology for the preparation of biennial action plans

REPORT 448/**2021 – DT/NPTS**

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Study for the Autoridade Nacional de Segurança Rodoviária

Lisbon • June 2021

R&D TRANSPORTATION

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Report 448/2021

File no. 0703/1201/22737

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Methodology for the preparation of biennial action plans

Abstract

The Portuguese Road Safety Authority (*Autoridade Nacional de Segurança Rodoviária – ANSR*) is developing for the Portuguese Government the country's road safety strategy for the coming period of 2021-2030. The activity comprises three steps: Stage 1, laying out the guiding principles of the National Road Safety Strategy: Vision Zero 2030; Stage 2, consisting in the preparation of technical-scientific reports for the new strategy, including the diagnosis of the current situation and the identification of emerging challenges, the building up of the framework for the new strategy, and the development of a methodology for preparing biennial action plans; and Stage 3, laying out the strategic vision and establishing the Action Plan 2021-2022.

Within the scope of these activities, ANSR requested the National Laboratory for Civil Engineering (*Laboratório Nacional de Engenharia Civil – LNEC*) to provide scientific and technical support to the development of Stage 2, to be delivered jointly with Prof Fred Wegman, from the Delft University of Technology. This report refers to the third activity of Stage 2.

The elements to consider while preparing biennial action plans are provided, which follow the Deming Cycle approach and integrate SMART targeted interventions consistent with the framework developed in the second activity. Two examples of the application of this approach are detailed, one regarding speed management in urban areas, through 30 km/h Zone and Home-Zone area-wide infrastructure interventions; and the other covering speed management in interurban roads.

Keywords: Road Safety / Strategy / Planning / Statistics

FUNDAMENTOS TÉCNICO-CIENTÍFICOS PARA A ESTRATÉGIA DE SEGURANÇA RODOVIÁRIA 2021-2030

Metodologia para elaboração de planos bienais de ação

Resumo

A Autoridade Nacional de Segurança Rodoviária (ANSR) está a desenvolver para o Governo português a estratégia de segurança rodoviária do país para a próxima década de 2021-2030. A atividade compreende três etapas: Fase 1, na qual se estabelecem os princípios orientadores da Estratégia Nacional de Segurança Rodoviária: Visão Zero 2030; Fase 2, que consiste na preparação de relatórios técnico-científicos para apoio à preparação da nova estratégia, incluindo o diagnóstico da situação atual e a identificação dos desafios emergentes, a elaboração do quadro metodológico para a nova estratégia e o desenvolvimento de uma metodologia para a preparação de planos de ação bienais; e Fase 3, na qual se estabelecerá a visão estratégica e se elaborará o Plano de Ação 2021-2022.

No âmbito destas atividades, a ANSR solicitou ao Laboratório Nacional de Engenharia Civil (LNEC) que prestasse apoio científico e técnico ao desenvolvimento da Fase 2, a ser realizado conjuntamente com o Prof. Fred Wegman, da Universidade de Tecnologia de Delft. Este relatório refere-se à terceira atividade da Fase 2.

São descritos os elementos a considerar durante a preparação dos planos de acção bienais, os quais se preconiza que sigam a abordagem do ciclo Deming e que integrem intervenções dotadas de objetivos SMART coerentes com o quadro metodológico desenvolvido na segunda actividade. São pormenorizados dois exemplos da aplicação desta abordagem, um dos quais relativo à gestão da velocidade em áreas urbanas através de intervenções na infra-estruturas para criação de Zonas de 30 km/h e de Zonas de Coexistência em áreas residenciais ou comerciais; e o outro abrangendo a gestão da velocidade nas estradas interurbanas.

Palavras-chave: Segurança rodoviária / Estratégia / Planeamento / Estatísticas

Executive summary

The Portuguese Road Safety Authority (*Autoridade Nacional de Segurança Rodoviária – ANSR*) is developing for the Portuguese Government the country's road safety strategy for the upcoming period 2021-2030. This achievement comprises three stages: Stage 1, laying out the guiding principles of the National Road Safety Strategy: Vision Zero 2030 (Cardoso *et al.*, 2021a); Stage 2, preparing technical-scientific reports for the new strategy, including the diagnosis of the current situation and the identification of emerging challenges, the building up of the framework for the new strategy and the development of a methodology for preparing biennial action plans (Cardoso *et al.*, 2021b); Stage 3, laying out the strategic vision and establishing the first Action Plan 2021-2022.

This report addresses the third activity of Stage 2, the development of a methodology for preparing biennial action plans for the new strategy, which was performed by LNEC and Prof Fred Wegman, from the Delft University of Technology.

In this report, the elements to consider while preparing biennial action plans are provided, which should follow the Deming cycle approach and integrate SMART targeted interventions consistent with the institutional and the 12 operational key intervention areas of the framework developed in the second activity (Cardoso *et al.*, 2021b). The following operational level intervention areas were selected: distraction; alcohol and drugs; post-crash care; fatigue; speeding, car occupants and motorcyclists, in rural roads; and speeding, pedestrians, PTW and cyclists in urban areas.

Two examples of the application of this approach are detailed, one regarding speed management in urban areas, through *30 km/h Zone* and *Home-Zone* area-wide infrastructure interventions; and the other covering speed management in interurban roads.

Scenarios for managing speeds in urban areas are discussed in Chapter 3, involving two components: the implementation of the Portuguese design guidelines for *Home Zones*; and the execution of urban renewal plans according to the Portuguese design guidelines for 30 km/h Zones. Both to be applied in residential precincts of carefully selected urban areas, initially within the framework of demonstration projects.

Assuming that 80 % of the urban municipal road network is amenable for installation of 30 km/h Zones and that one fifth (20 %) of these roads can be configured as Home-Zones, in due course the installation of Home-Zones will impact a total of 6000 km of carriageway and 30 km/h Zones will impact a total of 24000 km. Assuming that fatalities are evenly distributed along the urban non-NRN roads, a total of 55 fatalities per year are expected to be prevented with both interventions.

Scenarios for speed management in rural roads are presented in Chapter 4. This involves five components: changing the perceived severity of slight speeding offenses; fostering general deterrence of speeding by increased stationary manual speed enforcement; enlarging the coverage of automatic speed enforcement; matching speed limits to safe speed criteria on municipal undivided interurban links; developing road user speeding information campaigns. Eventually, at latter stages of the

implementation of the VisãoZero2030, a revision of the manual on speed limits may be needed, in order to improve its alignment with safe and credible speed criteria.

According to the assumptions taken in the scenarios, changing the perceived severity of speeding by a slight margin may prevent between 27 and 53 yearly fatalities, while adopting safe speed limits on municipal interurban roads may result in 94 to 172 less fatalities; the effect of the enforcement scenarios (30 % to 55 % fewer fatalities) depends on the geographical scope of their application. The targeted road safety problems for these components are partially common, meaning that if they are all implemented their combined effect will most likely be different from the sum of their individual effects.

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1 | Introduction

The current development of the Portuguese road safety strategy 2021-2030 by the Portuguese Road Safety Authority (ANSR) comprises three steps: Stage 1, laying out the guiding principles of the National Road Safety Strategy (Vision Zero 2030); Stage 2, preparing “technical-scientific" reports for the new strategy, including the diagnosis of the current situation and the identification of emerging challenges, the building up of the framework for the new strategy, and the development of a methodology for preparing biennial action plans; and Stage 3, laying out the strategic vision and establishing the Action Plan 2021-2022.

Within the scope of these activities, ANSR requested LNEC to provide scientific and technical support to the development of Stage 2, to be delivered jointly with Prof Fred Wegman, from the Delft University of Technology.

As mentioned, Stage 2 consists of three activities:

- The assessment of the current road safety situation, providing a clear view of the most relevant safety issues in Portugal, the status of Safe System principles in the existing road traffic, as well as a discussion of future aspects, that will most likely need to be addressed in the upcoming decade.
- The establishment of the founding principles framing the advance of road safety policies for the next ten years and of the scientific guidelines for the development of the new road safety strategy, including an overview of good practice in strategic goal and operational target setting and of cost-effective Safe System interventions, as well as the proposal of prospective key result areas for 2021-2030 and viable enabling road safety interventions.
- The development of a methodology for the implementation of the envisioned biennial action plans according to the ‘Plan-Do-Study-Act’ framework, including the procedures for their development, budgeting approval and execution monitoring. A pilot measure demonstration is also envisaged.

This report addresses the third activity of Stage 2. Specific road safety interventions have to be identified, developed and carried out, for implementation of VisãoZero 2030. These interventions are the building blocks for implementing a Safe System approach and they ought to be developed at the institutional level (providing the enabling conditions for focused evidence-based and data-driven road safety management) and at the operational level – this one comprising 12 key areas: speeding, pedestrians, PTW and cyclists in urban areas; speeding, car occupants and motorcyclists in rural roads; distraction; alcohol and drugs; fatigue; and post-crash care (Cardoso *et al.*, 2021b).

In Chapter 2, the elements to consider while preparing biennial action plans are provided, which should follow the Deming cycle approach (Plan-Do-Study-Act) and integrate SMART targeted interventions consistent with the framework developed in the second activity. General terms of reference for interventions are provided, as well. Two examples of the application of this approach are detailed in chapters 3 and 4. One example concerns speed management in urban areas (Chapter 3), specifically by means of demonstrating projects for integrated area-wide infrastructure interventions intended to create proper 30 km/h Zones and Home-Zones, in line with the recently developed design guidelines. In the other example (Chapter 4), a combination of six elements is proposed for delivering speed management on interurban roads. Final remarks on VisãoZero2030 implementation and the preparation of the first biennial action plan are provided in Chapter 5.

2 | Proposed methodology for the preparation of biennial action plans

The elimination of all deaths and serious injuries is the long-term goal of a Safe System Approach. This can be obtained by diminishing opportunities for human[1] failure leading to crashes and by ensuring that in the event of a crash, the associated impact energies and their rate of transfer remain below the thresholds likely to produce either death or serious injury in the involved human partners. It is further recognized that these thresholds vary from crash scenario to crash scenario and depend on the level of protection offered to the road users involved.

An effective strategy to achieve this vision can be built up from an effective human tolerance based speed limit setting and founded on four elements (ITF, 2008, Koornstra *et al.*, 1992, and Wegman & Aarts, 2006): an understanding of the crash injury risks and their trends; compliance with the prevailing road and traffic rules; effective education of the road user; effective regulatory organization for vehicle and driver's admittance into and exit from the system. These are the five building blocks for VisãoZero 2030, graphically depicted in Figure 2.1 (ITF, 2008); to which requirements for post-crash support are added, in the interim period while such a system is not reached.

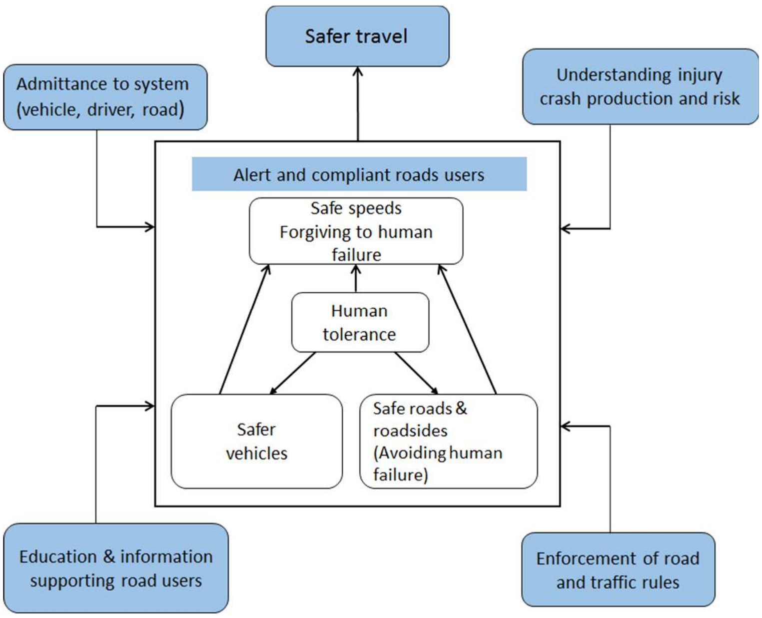

Figure 2.1 – The Safe Systems model (adapted from ITF, 2008)

[1] Active human operator – vehicle driver or pedestrian

The arrangement of these blocks in the design and operation of the road transport system, as well as the interactions between the various layers, actors, activities and components of a Safe System are shown in Figure 2.2 (ITF, 2016), which highlights the vital role of using data and evidence to inform a management by objectives approach, needed for supporting collaboration for shared responsibility.

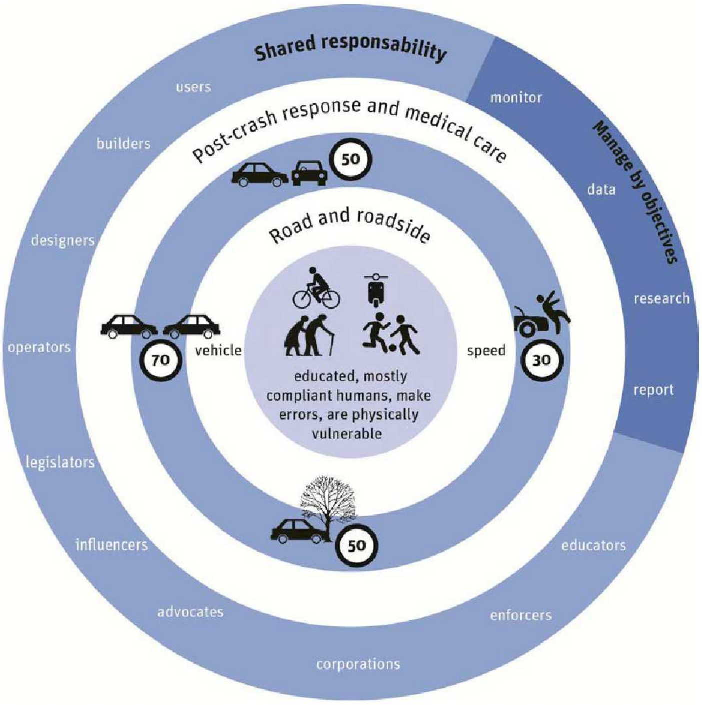

Figure 2.2 – Conceptualisation of the Safe System (ITF, 2016)

As shown by fruitful international experience (e.g., the Netherlands, the United Kingdom, Sweden, Norway and Australia) effective and systematic road safety management implies continuing investment into establishing and managing the organisational structures and procedures to meet the current and coming demands of the road transport system, as well as successfully nurturing the political decision makers, in order to keep road safety on the political agenda.

Building capacity in road safety management and successfully delivering a comprehensive road safety strategy is a process that takes time and involves developing a qualitative and long term investment plan for road safety improvements across all sectors, covering the three traditional product development stages for each element – establishment, growth and consolidation phases, as shown in Figure 2.3, from Mulder & Wegman (2009).

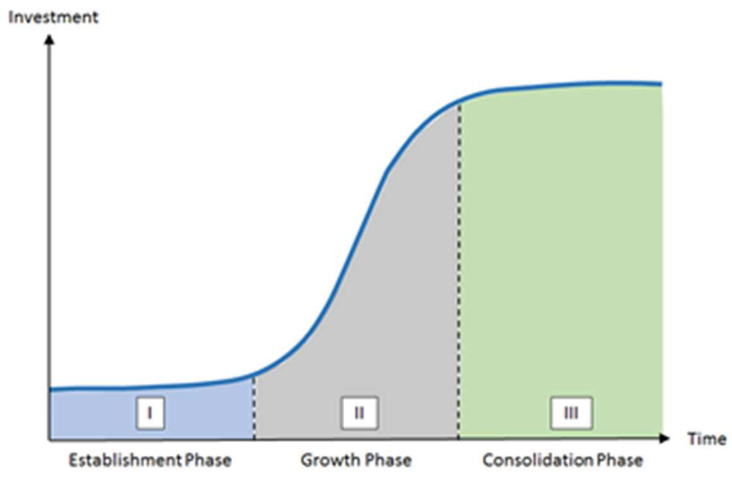

Figure 2.3 – Road safety investment strategy (Mulder & Wegman, 1999)

As in other countries, Portuguese road safety sectors are not all at the same stage of development, as evidenced in the VisãoZero 2030 safety diagnosis (Cardoso *et al.*, 2021a). Overall, Portugal is positioned in the Growth Phase, and improvements can be achieved by working with road safety targets, a stronger emphasis on evidence-based and data driven selection and evaluation of interventions, better integrated, reliable and sustainably funded remedial programmes, and more accountable stakeholder responsibilities, in order to reinstate the level of diminishing trends for road crash injury numbers reached by the turn of the century.

It is recommended that the strategic action plan be delivered through action plans (2 to 3 years) organized in a logical progression, such that priorities in one interim plan become the building blocks in the following plan. In this way it can be ensured that all the vital components necessary for each road safety intervention area are in place at the right time.

In order to build technical capacity and gain public support, it is also recommended that in selected areas demonstration projects (of proven interventions) be implemented on a small scale, before initiating large scale intervention programmes and associated investments. Such stepwise approach will also facilitate reaching political backing, by gradually building confidence on the merit of the interventions and allowing for a more conservative management of decision risks. It is also recommended that pilot studies be undertaken and their results analysed, before national scale-up of innovative interventions is initiated; the same applies for those good practice interventions for which there are reasonable concerns about their transferability to the Portuguese road system.

As mentioned in the previous document (Cardoso *et al.*, 2021b) road safety interventions are envisioned at the institutional level, directed at providing enabling conditions for the efficient management and delivery of VisãoZero 2030, and interventions at the operational level.

Usually, there are no direct effectiveness measures for interventions of the former type, apart from the acknowledgement that they deliver institutional framework components needed for performing Safe System approach functions. That is the case, for example, of interventions for providing good road safety information (registration of fatal and serious injury crashes, exposure data, as well as safety performance and policy output indicators) which is a fundamental requirement for effective management of results. It is also the case of interventions aiming at strengthening the structures and procedures to support coordination of road safety activities within government structures and across local authorities, and at building proper conditions for road safety related research, development, monitoring and evaluation.

Interventions at the operational level consist in activities performed to correct road safety problems originating system failures, related to vehicles, roads, road users and post-crash care. They address issues such as road and vehicle standards consistent with safe speed limits (Figure 2.1), ensuring that roads and vehicles remain compliant to standards and regulations, that road users comply with traffic rules, and that vulnerable road users are dully protected; as well as the conditions for the active contribution of post-crash care to limit the severity of crash outcomes. In most cases, measures of effectiveness are available for interventions of this type, at least obtained from international experience (Elvik *et al*., 2009; and https://www.roadsafety-dss.eu/#/), but amenable to transferability analysis (Meta *et al*., 2019).

Advancing road safety interventions through demonstration projects is consistent with the Deming Cycle approach (or PDSA cycle – see Figure 2.4), which is a framework to address problems and implement solutions in a rigorous, methodical way, mimicking the application of the scientific method to the management of practical problems. It is described as a circular sequence of four steps continuously applied in order to implement new procedures or improve existing ones.

The first step – **Plan** – consists in fully exploring the information available and understanding the problem to address or the opportunity to take, in order to develop a robust intervention implementation plan, establish success criteria and delineate measurable indicators.

While planning each road safety intervention the SMART framework for crafting goals is a widely used approach for clearly setting its boundaries, defining the steps to take, identifying the necessary resources, and earmarking the milestones that indicate progress along the process, thus facilitating achieving success efficiently. In this framework (Figure 2.5), intervention goals are Specific, Measurable, Achievable, Relevant and Time-based. This means that targets are clearly described, assisting in recognizing and detailing the steps needed for their achievement; that progress toward the final goal is quantifiable, through a measurable scale correlated with the objectives; that the goals are realistic, practically possible based on available resources, therefore likely to be achieved; that the issues addressed are focused on the most immediate and impactful application of available resources (both in the short- and long-term); and that the time allocated for their achievement is sufficient and does not degrade their usefulness.

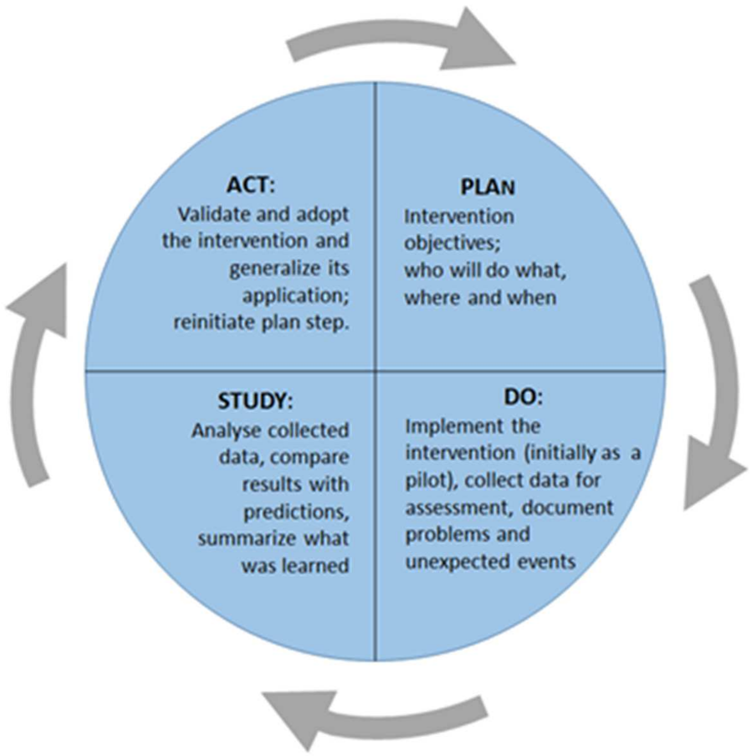

Figure 2.4 – The Plan-Do-Study-Act cycle (Deming cycle)

In the next step – **Do** – the devised intervention is applied while gathering data on the previously established indicators, to be used in the succeeding stage. Frequently, it is prudent to test the intervention on a small-scale pilot project, which allows verifying whether the proposed changes achieve the desired outcome, while minimizing the disruption of the system or the required investment. Depending on the intervention, pilot (demonstration) projects can have a limited geographical scope (e.g., small area-wide interventions in urban areas, or corridor interventions in interurban roads).

In the following step – **Study** – the applied intervention results are analysed and compared with the expectations and objectives defined in the first step, to assess whether it was fully successful.

In the last (or rather pre-reinitialize) step – **Act** – the intervention is standardized and generalized, if successful; and failures and issues of unsuccessful interventions are learned, to be carried to a next round of the circle. As knowledge is built, predictions will improve, on the effect of interventions under the different conditions that may exist in the future.

The PDSA framework can be used to improve complex processes, by breaking them down into elementary development stages, and exploring ways to improve each one. It is particularly helpful for implementing Total Quality Management and road safety problems. Usually, applying the PDSA cycle is a slow process, not being the most appropriate approach for dealing with urgent problems; also, it requires significant collaboration from active stakeholders, and is not suitable for radical innovation. However, none of these limitations apply to road safety interventions.

The mentioned approach is consistent with the World Bank guidelines (Bliss & Breen, 2009) for the preparation and delivery of Safe System projects, which comprises eight steps:

- Set project objectives (main and auxiliary);
- Determine scale of project investment (including budget);
- Identify project partnerships (e.g., central government and local administration partners, community groups and NGOs, private sector and relevant individuals);
- Specify project components (e.g., institutional policy reforms, targeted high-risk corridors or areas);
- Decide upon project management arrangements, namely regarding the role of the Lead agency and coordination requirements;
- Specify project monitoring and evaluation procedures, and reporting arrangements;
- Prepare detailed project design;
- Address project implementation priorities, namely regarding needs for technical assistance, knowledge transfer and roll-out program, and communication and promotion.

International experience with the application of World Bank's road safety management capacity review procedure revealed that road safety management is a complex process. Its problems cannot be always addressed effectively in the short term, which means that gaining initial political and public support has to be complemented by efforts for its maintenance until initial results are obtained, and by countering complacency when convergence towards the selected targets starts to be achieved. Gaining support for road safety policies is difficult, as the costs of interventions (once accepted) are immediate, certain and easily singled out; while the burden of inaction is uncertain, future and anonymous. The slow tempo of road safety interventions adds the further difficulty of embedding these processes in shorter budget cycles. Coordinated stakeholder cooperation is an important element, and leadership has to exhibit willingness to redress the road safety problem. Developing and implementing visible and high impact projects in which all relevant road safety players and stakeholders have an active role is an effective way to demonstrate the benefits of an integrated approach to dealing with complex road safety problems. Success in these projects usually helps to broaden their application.

Therefore, while preparing the envisioned biennial plans care must be exercised in order to reconcile the short-term goals with the long term objectives, preferably by matching VisãoZero 2030 intervention milestones with biennial action plan goals. It is expected that short term goals will be stated in terms of safety performance indicators (SPIs) and, in some cases, using policy outputs.

Intervention objectives should be well-defined and clear to all participating institutions and stakeholders, providing details on what is the action to be done, who is responsible for carrying out each step in the action, and what is the intended impact (Figure 2.5). This must be described in terms of desired level of performance, and guidelines should be provided, on how to measure the obtained level of success in reaching the desired impacts, expressing the progress towards the outcome that is being done. Current knowledge and available resources should be considered, to propose realistic goals that are achievable in the two-year time-frame, thus avoiding both demotivation (goals too ambitious) and procrastination (too conservative goals).

SPECIFIC	Specify what is to be accomplished, by how much, and by when
MEASURABLE	Identify which relevant data is available to measure progress and ensure they will be available for the duration of the intervention
ACHIEVABLE	Set objectives that are feasible
RELEVANT	Align intervention objectives with the road safety goal
TIME-ORIENTED	Establish a realistic timeframe for achieving the objective

Figure 2.5 – SMART intervention objectives

Relevance of each intervention can be appraised by considering the following aspects:

- either an evaluation of its integration in the institutional progress established by the road safety plan (VisãoZero 2030 enabling intervention) or an assessment of its contribution to desired overall strategy targets (in the case of operational level interventions), calculated using the procedure recommended in Cardoso *et al.* (2021) – see *equation 2*, in section *2.4.2*;
- cost acceptability, in view of the overall biennial budget;
- priority precedence (for enabling interventions) or cost-effectiveness ratio (in case of operational interventions).

Descriptions of the planned biennial interventions should contain the objectives and scope (general and particular) of the intervention, a detailed list of its components and their contribution to the strategy objectives, an appraisal of the human resources required and an estimate of the preliminary budget, an outline the management process, with the identification of the relevant partnerships and funding sources, an identification of preconditions for success, regarding the legal framework and technical warrants, as well as the specification of procedures envisioned for monitoring implementation progress and assessing the effects obtained with the intervention.

The methodology for preparing the biennial action plans mirrors, at a more limited scale and at a more disaggregated level, the method used for developing VisãoZero2030. It is based on the performed diagnosis, with problem analyses and statement (see Cardoso *et al.*, 2021b), and involves selecting from the list of promising evidence based and data driven road safety interventions, identified within the literature review, on-going road interventions (from the finishing road safety plan) and contributions from the stakeholders (see Cardoso *et al.*, 2021b). Prioritizing the interventions, encompasses checking political and public support on potential interventions, designing packages of interventions addressing the stated problems, developing implementation scenarios for each package, calculating estimates on their effectiveness and impacts (costs when possible) and checking that the envisioned packages allow to reach the stated targets.

In the following two chapters examples of intervention terms of reference description are provided, for speed management in urban areas (Chapter 3) and in rural roads (Chapter 4).

3 | Speed management in urban areas

3.1 Background

Speeds and excessive motorized road traffic volumes have long been a concern to transportation planners, due to the burden of road crashes and the environmental problems raised by air emissions, particularly in urban areas. Traffic calming solutions have been successfully applied as one way to tackle such problems effectively, either in a wider sense within policies to enhance public space fruition and motorized traffic demand management, reducing traffic volumes and promoting walking and bicycle transportation in addition to vehicle speeds appeasement; or in a more restricted sense, reducing vehicle speeds, and therefore crashes and their consequences, as well as noise and air pollution.

Road safety research shows a direct relation between traffic speed and the frequency and the severity of crashes, and the resulting permanent trauma, both in individual terms (the crash risk as explained by the speed of each vehicle, as compared to the one of the remainder traffic) and for traffic as a whole (i.e. the aggregated traffic stream risk as explained by the characteristics of its speed distribution). See, for example, TRB (1998), Aarts & van Schagen (2006), Cardoso (1996 and 2012), Jurewicz *et al.* (2016) and Castillo-Manzano *et al.* (2019); as well as ITF (2018) and Nilsson (2004), who first developed the power model for estimating the variation in numbers of fatalities and injuries resulting from changes in the average traffic speed.

Experience has shown that, as a rule, the most effective way to tackle speeding is to apply "speed management”, which can be defined as an integrated set of interventions at different levels, including legislation, infrastructure, enforcement, communication campaigns and ITS, such as ISA – intelligent speed adaptation (OECD, 2006 and EC, 2018).

Speed management is based on a functional classification of the road network (hierarchy), assigning to each road stretch a function (attending to its characteristics of place and movement – fruition of place, access, distribution or mobility) and a corresponding Safe Speed (see, for example, Aarts *et al.*, 2009). The configuration of the road environment (the road geometric design and its roadside) must be set to facilitate the correct perception of the appropriate speed by drivers and other road users, by means of the application of self-explaining and forgiving roads concepts, and the systematic application of consistent marking systems specific to each class of road, in order to foster an almost automatically recognition and adoption of the appropriate speed on each road (see Cardoso, 2010). Issues such as land use, public transport, area wide traffic calming, and transition zones are key aspects to consider in streets (e.g., Greibe *et al.*, 1999).

The concept of a safe speed is an important principle of the Safe System approach and directly related to the biomechanical tolerance of humans to prevalent injuries in typical crashes on likely traffic interactions. These tolerances depend on the affected human organ and the direction, intensity and duration of the impact forces, these being related to change in velocity and/or acceleration, principal directions of impact and type of vehicle and object involved. Typical criteria for setting safe speeds correspond to the impact speed where the chance of death is less than 10 %; alternatively the point on fatality risk curves where this changes from shallow to steep can be used. Table 3.1 shows commonly survivable impact speeds referenced by OECD (2006) and SWOV (2018a).

Table 3.1 – Safe street impact speeds according to type of potential road user interaction

Potential conflict	Safe speed (km/h)
No separation between vulnerable road users and cars (e.g., home zones and *woonerven*), no footpaths	15
No separation of cars and vulnerable users, in time or space	30
Lateral conflicts between cars	50

The values in Table 3.1 are based on fatality and MAIS3+ risk curves (e.g., Figure 3.1), which were established from results of in-depth accident investigation, and reflect vehicle occupant crashworthiness and third party forgivingness (e.g. pedestrian protection) developments in the car industry.

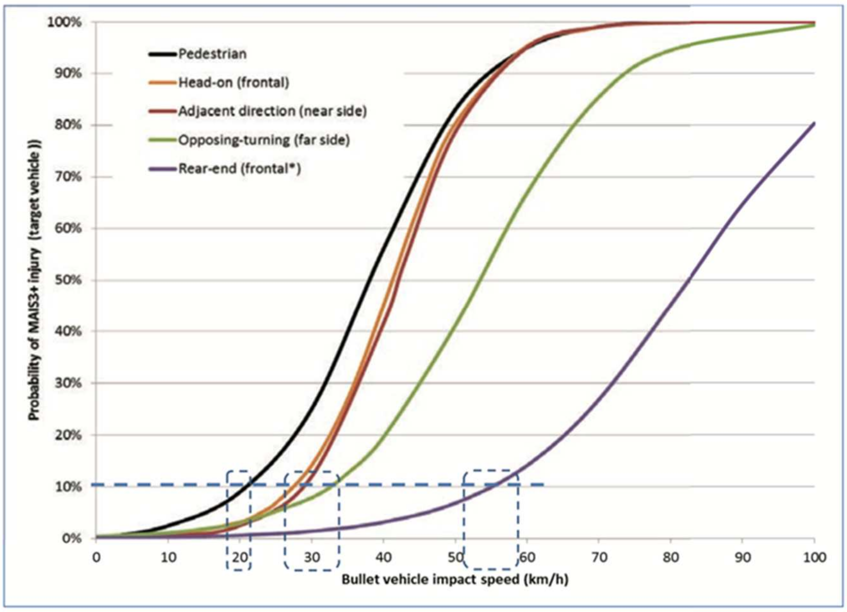

Figure 3.1 – MAIS3+ injury risk curves for various types of traffic conflict (Jurewicz, *et al.*, 2016)

Speed management involves interventions on all Safe System elements: safe roads, safe speeds, safe vehicles and safe road use. A proper configuration of the road environment is fundamental for drivers to select appropriate speeds; however, the starting point for this role of the infrastructure is a credible definition of the speed limits, a feature that has to be complemented by appropriate enforcement, rehabilitation courses for speeding recidivists, suitable public communication and education efforts, as well (OECD, 2006).

Experience has shown that in urban areas it is possible to nudge drivers to select appropriately low speeds through the careful installation of infrastructure provisions that provide intuitive perception of the traffic space characteristics and physically inhibit the choice of high travel speeds. These physical traffic calming interventions have been successfully implemented in cities throughout the world, aiming to alter driver behaviour and resulting in improved safety and life quality conditions for pedestrians and vulnerable road users.

Traffic-calming interventions are best applied through area-wide schemes commonly implemented in residential neighbourhoods, usually having as a starting point a clear definition of the road hierarchy, in order to direct through-traffic away from selected residential streets. Speeds in these streets are preferably limited to a maximum of 30 km/h – these schemes correspond to the so called 30 km/h Zones. In some cases, they may even be transformed into motorized traffic *cul-de-sacs*, to limit traffic to house or commercial local access and further protect residents in their outdoor activities; these solutions correspond to urban play streets or *woonerven*.

Table 3.2 contains the extent of carriageway in the road networks per road category (NRN[2] vs. non-NRN), in Portugal Mainland urban areas, as well as the corresponding number of crashes and fatalities in the period 2017-2019.

Table 3.2 – Urban area road safety indicators (Mainland, 2017-2019)

Street category	Carriageway length (km)	Number of crashes	Fatalities	Crashes/km	Fatalities/km
Municipal	37527	71991	816	1.918	0.022
National Road Network	5107	9175	199	1.797	0.039
Total	42634	81166	1015	1.904	0.024

Figure 3.2 presents the distribution of the number of municipalities by fatality density on non-NRN urban street bins (each bin corresponding to a 0.01 fatality/km interval). For example, there are 62 municipalities with a fatality density between 0.01 and 0.02 fatalities per kilometre of non-NRN urban street. On non-NRN roads, the maximum observed value was 0.092 fatalities per kilometre, and the 95th percentile was 0.055 fatalities per kilometre. These values are considerably lower than on NRN roads, where 2.533 and 0.287 fatalities per kilometre were the maximum and the 95th percentile, respectively (Figure 3.3). These are indicators aggregated at the municipal level, which allow to compare the overall fatality density in each municipality with the other municipalities.

[2] NRN – Portuguese National Road Network

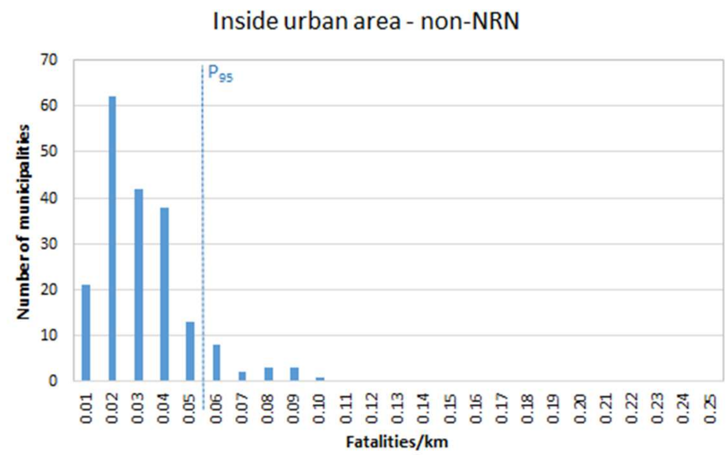

Figure 3.2 – Number of municipalities per 0.01 fatalities/km bin, inside urban areas, on non-NRN roads (Mainland, 2017-2019)

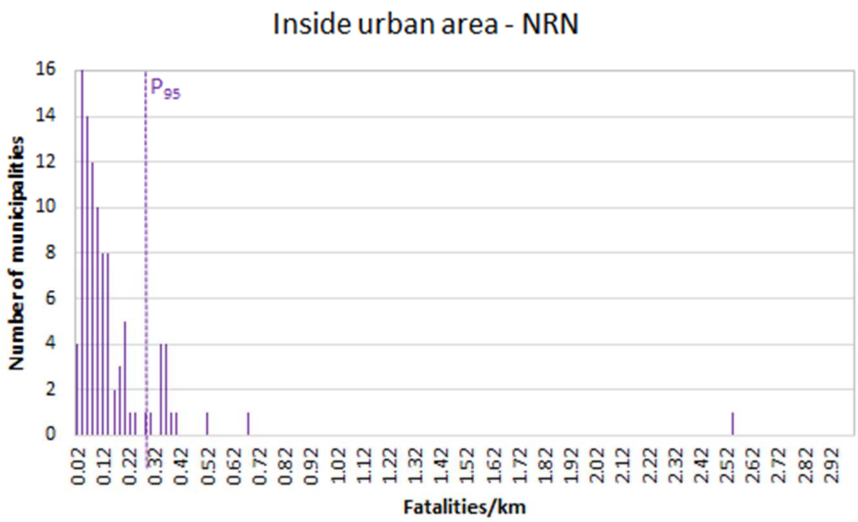

Figure 3.3 – Number of municipalities per 0.02 fatalities/km bin, inside urban areas, on NRN roads (Mainland, 2017-2019)

The aggregated linear density of fatalities in each municipality is a safety indicator which can be used for prioritizing municipalities for interventions. However, other indicators are equally important for prioritizing municipalities for speed management interventions in urban areas within VisãoZero2030, such as their willingness to participate, budget allowance for their contribution, specific budget, and the interest in involving as many municipalities as possible in this type of program.

3.2 Objectives and scope of the intervention

It is intended with the set of measures included in this intervention to reduce the safety consequences of excessive speed on urban roads operated by municipalities, with a special focus on residential and commercial areas, as well as school zones.

3.3 Components of the intervention and their contribution to the objectives

Two types of measures were selected as effective and viable on the Portuguese traffic system: adapting the urban and street design in selected areas to comply either with home zone or with 30 km/h zone guidelines (Vieira *et al.*, 2019). These measures are described in the following sections.

3.3.1 Component USM01 – Urban play street / Home zone / *Woonerf*

3.3.1.1 Objectives

Urban play streets, home zones and *woonerven (in Dutch*) belong to a similar concept of urban space allowing only a very restricted vehicle access environment:

- Urban play streets have a design which encourages recreation and outdoor play and has vehicle traffic and parking limitations;
- *Woonerven* are areas designed to meet the needs of pedestrians and cyclists, and encourage slow speeds from motorised vehicles, making it a safe and pleasant place to be (Quigley, 2017).

Urban play streets and *woonerf* solutions (also referred to as home zones) have been applied in several countries, mostly integrated in comprehensive area-wide traffic calming schemes. They affect road safety in a positive way, by encouraging motor vehicle drivers to slow down. The speed reduction is particularly effective due to planning and design arrangements – e.g., short travel distances, undefined carriageway, winding and narrow pathways – that discourage high speeds and remove their benefits, as well as empowering pedestrians and other urban space users. A resulting outcome of this solution relates to lower crash frequencies and also less severe crashes.

This intervention intends to reduce the frequency and severity of speed related crash occurrence in selected residential and commercial areas, through the modification of the infrastructure physical characteristics, in such a way that they may be signed as home zones (signs *H46* and *H47*).

3.3.1.2 Method

Urban play streets allow for mixed traffic at walking speed and may be one of a number of measures used in area-wide traffic calming for a specific area. The environment in these streets should include trees and shrubs, sandpits, play equipment, tables and benches. The road shouldn’t be rectilinear or include vertical misalignments between the road and other areas, except for entering and exiting (for instance with kerbstones). Parking places must be clearly marked.

In Norway, urban play streets can only be established if the area does not have through traffic, no building within the urban play street is more than 300 m driving distance along the most appropriate road out of the zone, the division between road and pavement is removed, speed-reducing devices are introduced (all vehicles that are permitted to drive within the area must be able to negotiate the speed-reducing devices), parking places for cars are specially marked and if kerbstones are used to mark vehicle entrances and exits to the area (Elvik *et al.*, 2009).

Design characteristics for *woonerven* is similar to urban play streets, as they should meet the needs of pedestrians and cyclists and be used as a social space for people to meet and where children can safely play. Integration of these areas in the remaining road network should include a vehicle entrance area (gate) which alerts drivers for the different environment they are about to enter.

Desired characteristics for these roads in Portugal are laid out in the technical guidelines for urban streets, prepared in the scope of PENSE2020 (Vieira Gomes *et al.*, 2019 and Vieira Gomes *et al.*, 2020a, 2020b, 2020c). These documents are intended to improve the municipal road network, through the adoption of nationally harmonized criteria in the planning of the urban street environment and in the geometric design of street infrastructure. These are essential aspects to obtain self-explanatory roads necessary for the intended Safe System. The technical guidelines are organised into four volumes, covering the fundamentals of road users and the road network (Vieira Gomes *et al.*, 2019), the geometric characteristics for motorized (Vieira Gomes *et al.*, 2020a) and non-motorized roads (Vieira Gomes *et al.*, 2020b), and traffic calming provisions applicable to each street type (Vieira Gomes *et al.*, 2020c). Volume III presents details for designing "*woonerf*" areas.

The redesign of home zones will involve variable levels of resources depending on the initial characteristics of the selected streets. It is expected to involve the planning, approval, design and construction of physical changes in the road environment, including changes in the geometric design and in pavement characteristics, as well as installing urban furniture and planting vegetation and trees. Ensuring community participation in the establishment of this type of solutions is paramount, as they are the focus of the intervention and in some cases elderly pedestrians and parents are not happy with removing sidewalks.

In view of the considerable amount of investments, a dedicated program is advisable, for which two phases are envisioned. In the first phase, the program starts with a few (three to five) pilot (demonstration) applications in selected areas of medium sized cities. *Montemor-o-Velho* and *Vila Nova de Poiares* (both on the Coimbra district), *Sobral de Monte Agraço* and *Arruda dos Vinhos* (both on Lisboa), *Mesão Frio* and *Peso da Régua* (both on Vila Real) and Armamar (in Viseu) are candidate municipalities, all having more than 0.07 fatalities per kilometre on non-NRN urban street carriageway (2017-2019). Due to the relevance of community participation and acceptance as well as local budget availability, criteria not related to safety performance are also relevant for selecting the demonstration areas.

It is advisable that these demonstration projects (possibly combining EU, national and local financing resources), include a robust assessment of impacts on intermediate road safety outputs as well as other urban quality indicators – a controlled before-after study approach being recommended.

Results from the pilot projects assessments will be used to prepare the terms of reference for the second phase, a national-wide program for remodelling residential areas throughout the Country.

3.3.1.3 Resources

The implementation of these interventions will involve different levels of resources depending on the initial characteristics of the selected streets, as it will include the planning, approval, design and construction of physical changes in the road environment, including changes in the geometric design and in pavement characteristics, as well as installing urban furniture and planting vegetation and trees.

3.3.1.4 Estimated effects

The introduction of urban play streets has been found to reduce injury accidents by 25 % and property-damage-only accidents by 20 % (Elvik *et al.*, 2009). They also have an impact on the mobility, with reductions for car occupants, and increased output for pedestrians and cyclists.

This solution was applied in Norway, were a significant reduction in car traffic was observed, and speed was reduced to 15–25 km/h. The percentage of pedestrians who relax outdoors, as opposed to walking, in the streets, increased in urban play streets. The average time spent outdoors increased by 10 to 30 %: in streets with comparable potential but without urban play street configuration yet, a recreation time was found to be 10–30 % lower. However, urban play streets can create delays and reduce access for emergency and maintenance vehicles, as referred in Elvik *et al.* (2009).

A study performed in England in 12 home zone sites revealed a reduction of 3.41 on the annual average number of accidents after implementation (Quigley, 2017b).

From research, it can be inferred that traffic speed is a mediator variable in the causal explanation of this intervention effect, and that its reduction is a foremost mechanism in casualty reductions. Therefore, it can be anticipated that the magnitude of the effect will depend on the initial speed distribution, as the resulting traffic speed distribution is independent of the intervention location, assuming it is well implemented. This reasoning and the international comparison of Portuguese and International speed traffic data (see Cardoso *et al.*, 2021b) support the opinion that the effect of this measure will be higher than reported from other European countries, and that the results from calculations presented below are conservative.

Assuming that 80 % of the municipal urban road network is amenable for installation of 30 km/h Zones and that one fifth (20 %) of these roads can be configured as Home-Zones, in due course this measure will impact a total of 37527*0.8*0.2=6000 km (see Table 3.2). Assuming that fatalities are evenly distributed along the urban non-NRN roads, a total of {0.80*0.20*(816/3)}*0.25 = 11 fatalities per year will be prevented.

3.3.1.5 Participants

Key participants in this intervention include ANSR and IMT as supervising agencies, the relevant municipalities as implementing institutions, and the residents of the intervention affected areas, as key stakeholders.

3.3.1.6 External dependencies and level of priority

The intervention is dependent on funding availability, the willingness of municipalities to participate in such program and the residents' acceptance of the interventions key elements.

3.3.1.7 Monitoring and evaluation

Intervention monitoring of intermediate results will involve the continuous assessment of the intervention's effect on a KPI related to speeds in residential areas.

As mentioned in section 3.3.1.2, two phases are envisaged, which have impact on the selected policy output monitoring: in the first phase, milestones relate to selection of testing areas, and planning, public consultation, design, construction procurement, execution, and effect evaluation of the actual interventions in each selected area; while in the second phase, milestones related to the prioritizing of areas should be included.

3.3.2 Component USM02 – Implementation of 30 km/h zones

3.3.2.1 Objectives

30 km/h zones are defined as areas where 30 km/h speed limits are used to restrict vehicle speeds, with the aim of increasing safety for all road users, but particularly pedestrians and cyclists (ROSPA, 2017). Quality of urban life and lower aerial emissions (noise and pollution), are additional positive effects of 30 km/h zones in urban areas (SWOV, 2018b).

In these areas motor vehicle drivers are encouraged to slow down, particularly through physical speed reducing measures in the area. Slower speeds inherently lead to safer roads as drivers are able to control their vehicles better, avoiding more easily potential collisions, and collisions that might occur are less severe than would have occurred at higher speeds.

This intervention aims at reducing the frequency and severity of speed related crash occurrence in those portions of urban areas where the *place functions*[3] of road space are important (resulting in a heightened risk for vulnerable road users), by providing the infrastructure with high speed incompatible characteristics easily recognizable and self-enforcing motorized drivers to a maximum speed of 30 km/h speed (delimited by signs *G4a* and *G10*).

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[3] See Viera Gomes *et al.* (2019), for details on the movement and place approach to managing roadway space.

3.3.2.2 Method

Research indicates that speed reductions achieved with the use of 30 km/h signs alone are likely to be small (Mackie, 1998 and DfT, 2007). This means that 30 km/h zoning by signs alone is most appropriate where 85^{th} percentile speeds are already low (around 35 km/h) and further traffic calming measures are not needed; therefore, in these locations 30 km/h zones are relatively inexpensive to implement. However, in areas with initial 85^{th} percentile speeds higher than the previous values, the 30 km/h speed limits have to be accompanied by a comprehensive set of self-enforcing infrastructure provisions. In both cases, a minimum set of physical interventions is always needed for providing a recognizable collection of features, consistent with the concept of "self-explaining" roads and streets.

Therefore, the 30 km/h speed limit is usually combined with other physical speed-reducing measures, such as speed humps, chicanes or others, used to increase the likelihood of drivers adhering to the speed limit. Additionally, proper perception of the specificity of the area may be enhanced by provision of gate-like enhancements at the entrance to these zones. 30km/h zones are best located in residential and intensive commercial urban areas, but also in rural villages locations, often near schools. Equally important is that the selected speed limit and the road design match and do not require unreasonable levels of enforcement by the police.

Desired characteristics for these roads in Portugal are laid out in the technical guidelines for urban streets, prepared in the scope of PENSE2020 (Vieira Gomes *et al.*, 2019 and Vieira Gomes *et al.*, 2020a, 2020b, 2020c). These documents are intended to the improvement of the municipal road network, through the adoption of nationally harmonized criteria in the planning of the urban street environment and in the geometric design of street infrastructure. These are essential aspects to obtain self-explanatory roads necessary for the intended Safe System. The technical guidelines are organised into four volumes, covering the fundamentals of road users and the road network (Vieira Gomes *et al.*, 2019), the geometric characteristics for motorized (Vieira Gomes *et al.*, 2020a) and non-motorized roads (Vieira Gomes *et al.*, 2020b), and traffic calming provisions applicable to each street type (Vieira Gomes *et al.*, 2020c). Volume III presents details for designing 30 km/h zones.

The redesign of 30 km/h zones will involve variable levels of resources depending on the initial characteristics of the selected streets. It is expected to involve the planning, approval, design and construction of physical changes in the road environment, including changes in the geometric design and in pavement characteristics, as well as installing urban furniture and planting vegetation and trees.

In view of the considerable amount of investment, a dedicated program is advisable (as for home zones), for which two phases are envisioned. In the first phase, the program would start with a few (three to five) pilot applications of proven interventions in medium sized cities. It is advisable that these demonstration projects (possibly combining EU, national and local financing resources), include a robust assessment of impacts on intermediate road safety outputs as well as other urban quality indicators – a controlled before-after study approach being recommended.

Results from the demonstration projects assessments will be used to prepare the terms of reference for the second phase, a national-wide program for remodelling residential areas throughout the Country.

3.3.2.3 Resources

The implementation of these interventions may involve different resources depending on the initial characteristics of the streets. Nevertheless it will include physical changes in the road environment, road realignment, pavement surface changes, installing urban furniture and new signs, planting vegetation and trees, etc. According to the Dutch experience, the cost of measures needed for implementing a proper 30 km/h Zone amounted to over 29350 €/km, at 2016 price level (SWOV, 2018b).

3.3.2.4 Estimated effects

Results from before-after studies performed in London showed that the implementation of 30km/h zones reduced the occurrence of accidents and injuries and also vehicle speeds (Webster and Layfield, 2007). The study considered a before period of 5 years and an after period of 3 years (1989 – 2003), and the achieved results are presented in Table 3.3. Vehicle speeds were found to be significantly reduced in the 30 km/h Zones when physical measures were implemented alongside the installation of the speed limit sign, even in sites where the 'before' speed was above 39 km/h.

Table 3.3 – Main outcomes of the implementation of 30 km/h zones (Webster and Layfield, 2007)

Type of crash/casualty	Effect	Confidence interval
All crashes	-43 %	99 %
KSI crashes	-56 %	95 %
All casualties	-46 %	99 %
KSI casualties	-60 %	95 %
Pedestrian casualties	-40 %	95 %
Child pedestrian casualties	-40 %	95 %
Cyclist casualties	-33 %	95 %
Child cyclist casualties	-59 %	95 %
Powered to wheeler casualties	-41 %	95 %
Car occupant casualties	-57 %	95 %
Child car occupant casualties	-51 %	95 %
HGV occupant casualties	-33 %	95 %
Bus/coach occupant casualties	-24 %	95 %

The estimates in Table 3.3 are high when compared to the meta-analysis results obtained by Elvik, *et al.* (2009). However, Webster and Layfield's results relate to areas where infrastructure physical measures were constructed, which does not seem to be the case in the meta-analysis. Furthermore, they relate to a restricted geographical area, with a prevailing initial median speed that may be different from the median speeds in the studies analysed in the meta-analysis. According to the Power Model, reductions in the numbers of crashes and victims are related to the amount of speed reduction effectively obtained, which in this case depend on the value of the prevailing speeds before intervention.

Experience from The Netherlands shows that there are large differences in the effect between zones, depending on the zone size, degree and characteristics of its urbanization, nature and lay-out of the speed-reducing provisions implemented, and level of success in changing traffic volume in the zone (SWOV, 2018b).

Assuming that 80 % of the municipal urban road network is amenable for installation of 30 km/h Zones (and that Home Zone – measure 3.3.1 – is applied in 20 % of these streets), in due course this measure will impact a total of 37527*0.8*0.8=24000 km (see Table 3.2). Assuming that fatalities are evenly distributed along the urban non-NRN roads, a total of {0.80*0.80*(816/3)}*0.25 = 44 fatalities per year will be prevented. Similar to the estimations for component USM01, and for the reasons mentioned in section 3.3.1.4, it is expected that the results from this calculation are conservative, and that higher numbers of prevented fatalities may be obtained in the Portuguese case.

3.3.2.5 Participants

Key participants in this intervention include ANSR and IMT as supervising agencies, the relevant municipalities as implementing institutions, and the residents of the areas affected by the interventions, as key stakeholders.

3.3.2.6 External dependencies and level of priority

The intervention is dependent on funding availability, the willingness of municipalities to participate in such program and the residents' acceptance of the intervention key elements.

3.3.2.7 Monitoring and evaluation

Monitoring interventions' intermediate results will involve the periodic (e.g., yearly) assessment of their effect on a KPI related to speeds in residential areas.

As mentioned in section 3.3.2.2, two phases are envisaged, which have impact on the selected policy output monitoring: in the first phase (demonstration projects), milestones relate to selection of testing areas, and to conclusion of the planning, public consultation, design, construction procurement and execution stages of each intervention, as well as the evaluation of the actual interventions in each selected area; while in the second phase (ramping-up country-wide application), milestones related to the prioritizing of areas should be included.

4 | Speed management on rural roads

4.1 Background

Public roads in Mainland Portugal are organized in the National Road Network (NRN), managed by the central Government (directly through IMT or indirectly through IP), and the municipal networks (local roads), managed by each municipality. The NRN comprises the IP and IC roads (usually with modern road design), EN and ER roads. These latter road categories and IC roads are the Complimentary NRN; IPs are the Main NRN. Table 4.1 contains the total road length in Mainland Portugal, as registered by INE (Cardoso *et al.*, 2021a).

Table 4.1 – Length of Mainland Portuguese roads in kilometres (Source: INE, IMT and IP)

Supervising body	National Road Network (NRN)				Non-NRN
	Motorway & Dual carriageway	IP / IC	EN	ER	
IMT / IP	3122	710	5291	4791	
Municipalities	-	-		-	80000

IP and IC roads descriptions from navigator maps allow inferring that 12 % of the ENs and ERs carriageway length is inside urban areas; and that rural non-NRN account for 69 % of that networks' carriageway length.

The distribution of travelled distance per road category is presented in Figure 4.1.

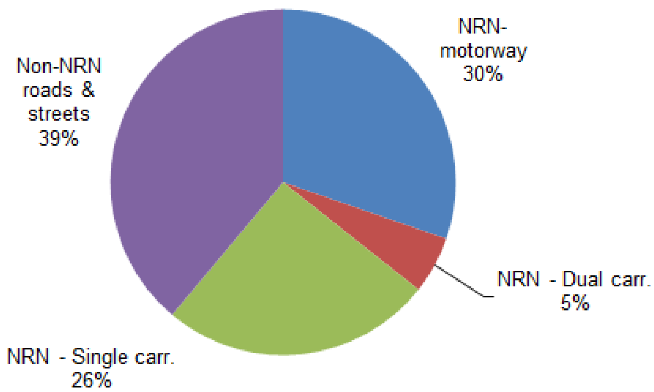
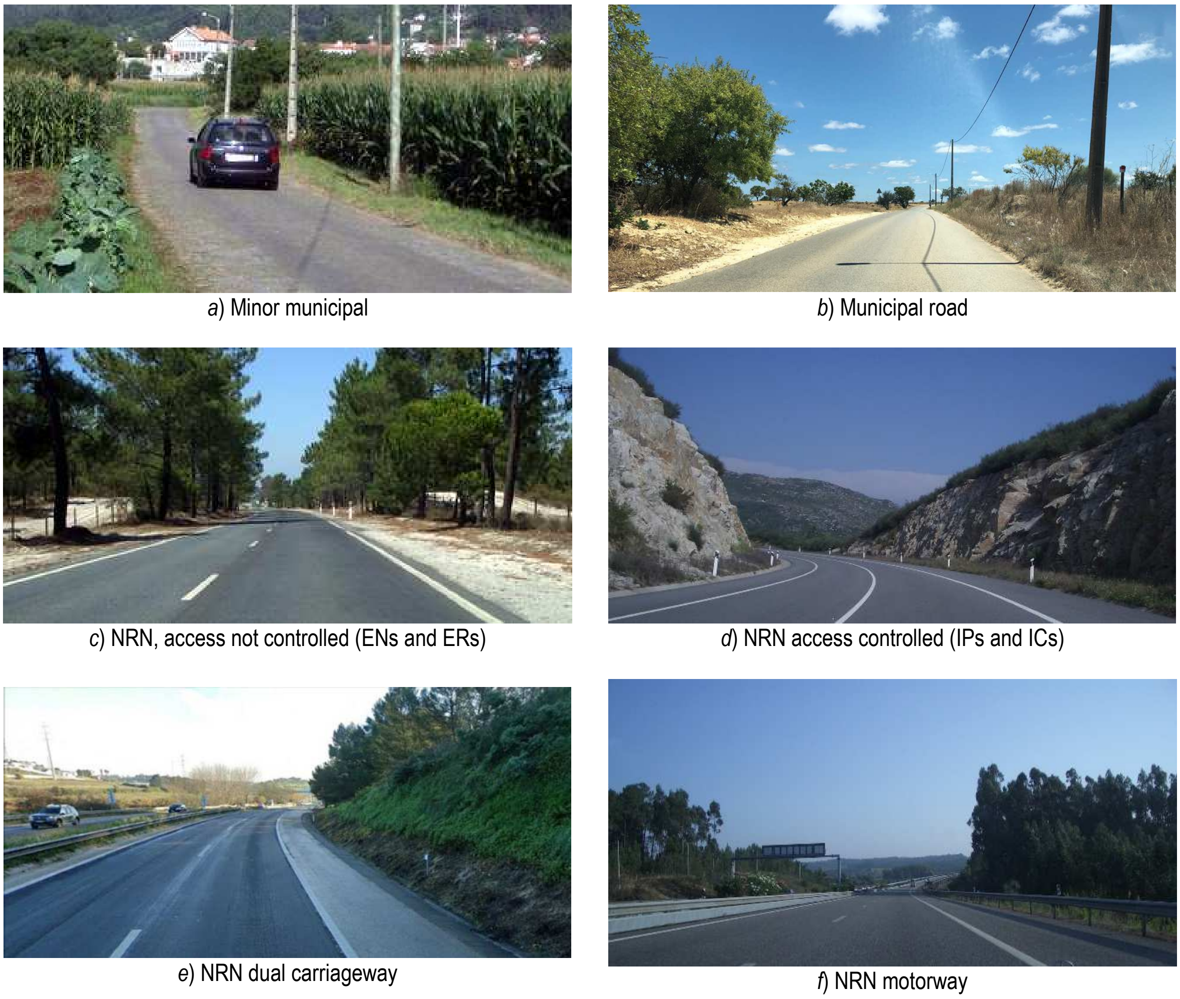


Figure 4.1 – Distribution of annual travelled distance per road category (Mainland Portugal, 2017-2019)

Non-NRN roads and streets and single carriageway NRN roads account for 65 % of the travelled distance; there are no data allowing to estimate the share of rural traffic.

Overall, IPs and ICs have full access control; most ENs, EMs and non-NRN roads have no access control.

Figure 4.2 shows typical examples of rural non-NRN roads (*a* and *b*), and NRN roads (*c* to *f*).



a) Minor municipal

b) Municipal road

c) NRN, access not controlled (ENs and ERs)

d) NRN access controlled (IPs and ICs)

e) NRN dual carriageway

f) NRN motorway

Figure 4.2 – Examples of rural roads (Source: Cardoso, 2010)

According to the Highway Code, roads outside urban areas have a general speed limit of 90 km/h, except where signed as motorways (where the general speed limit is 120 km/h) or roads reserved for cars, heavy vehicles and motorcycles (where the speed limit is 100 km/h). Pedestrians and cyclists are not allowed on the latter two road categories. Bicycle and moped traffic is absent in most rural roads, and very low during most of the year.

The general 90 km/h speed limit applies to roads *a)* to *e)*, unless site specific speed limits are mandated by the *C13-maximum permitted speed* signs. Specific criteria for differentiated speed limits on interurban roads, attending to their environment characteristics and better aligned with Safe

System principles are recommended in a specifically developed guideline (Cardoso, 2010), but not applied yet, despite a dedicated PENSE20202 action.

Motorways, IPs and ICs are designed with wide (2.5 m) paved shoulders, allowing for performing controlled emergency manoeuvres and parking stranded vehicles fully outside of the carriageway. That is not the case for most ENs and ERs, which frequently have narrow or non-paved shoulders, and non-NRN rural roads, which seldom have shoulders and often lack roadside obstacle free areas. As shown in Figure 4.3, absence of shoulders is a road characteristic most frequently found in fatal on non-NRN interurban roads, differently from what happens on ENs.

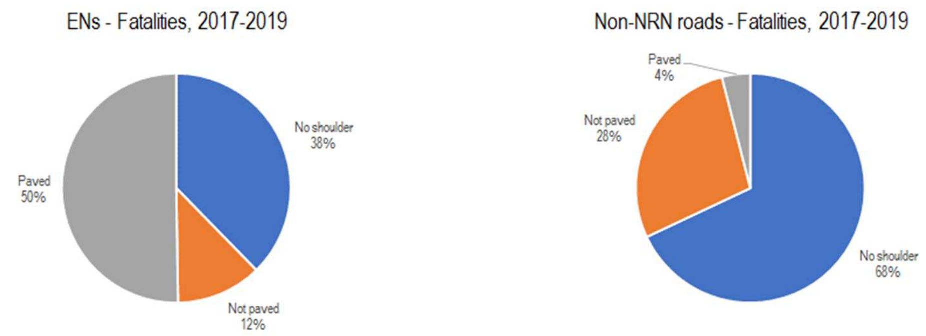


Figure 4.3 – Distribution of collision fatalities by shoulder characteristics, on interurban single carriageway NRN roads and non-NRN roads

Road safety research results show a direct relation between traffic speed and the frequency and the severity of crashes, and the resulting permanent trauma, both in individual terms (the crash risk as explained by the speed of each vehicle, as compared to the remainder traffic) and for traffic as a whole (i.e. the aggregated traffic stream risk as explained by the characteristics of its speed distribution). See, for example, TRB (1998), Aarts & van Schagen (2006), Cardoso (1996 and 2012), Jurewicz *et al.* (2016) and Castillo-Manzano *et al.* (2019); and Nilsson (2004), who developed the power model for estimating the change in fatalities and injuries resulting from changes in the average traffic speed.

Relations between changes in the average speed as a result of changing the speed limit were studied using meta-analysis by Elvik (2012), who reported a reduction of 3 km/h (with some variability), following a 10 km/h decrease in the speed limit.

Furthermore, by analysing the whole speed distribution, it can also be shown that in some cases considerable decreases in fatality numbers may be obtained by reducing the speed of a limited percentage of speeding drivers, and these are not necessarily the highly excessive speeders (Kloeden, *et al.*, 2002). Research shows that in France speeding by less than 10 km/h is perceived by drivers as not dangerous, while it has been found that this type of violation has an important role in French road fatalities (CEREMA, 2020). Depending on the shape of the speed distribution, on some single carriageway rural roads decreasing the speeds of mild violators (less than 10 km/h above the speed limit) may originate a sizeable portion of the theoretical potential fatality reduction due to speed limit compliance. This is because the contribution of each group to the total number of casualties is the product of the number of drivers in each group by the corresponding risk; and there are few drivers travelling at very high speeds and many more drivers speeding moderately.

Experience has shown that, as a rule, the most effective way to tackle speeding is to apply "speed management", which can be defined as an integrated set of interventions at different levels, including legislation, infrastructure, enforcement, communication campaigns and ITS, such as ISA – intelligent speed adaptation (OECD, 2006 and EC, 2018).

Speed management is based on a functional classification of the road network (hierarchy), assigning to each road stretch a function (attending to its characteristics of place and movement – fruition of place, access, distribution or mobility) and a corresponding Safe Speed (see, for example, Aarts *et al.*, 2009). The configuration of the road environment (the road geometric design and its roadside) must be set to facilitate the correct perception of the appropriate speed by drivers (and the general public), by means of the application of self-explaining and forgiving road concepts, and the systematic application of consistent marking systems specific to each class of road, in order to foster an almost automatically recognition and adoption of the appropriate speed on each road (see Cardoso, 2010). Issues such as design consistency, visibility, approach speed at intersections and obstacle free zones are important for rural roads (see for example MASTER, 1998, SUPREME, 2007b and Aarts *et al.*, 2010).

The concept of a Safe Speed is directly related to the biomechanical tolerance of humans to prevalent impacts in typical crashes on likely traffic interactions. These tolerances depend on the affected human organ and the direction, intensity and duration of the impact forces, these being related to change in velocity and/or acceleration, principal directions of impact and type of vehicle and object involved. Typical criteria for setting safe speeds correspond to the impact speed where the chance of death is less than 10 %; alternatively the point on fatality risk curves where this changes from shallow to steep can be used. Table 4.2 shows commonly survivable impact speeds estimated from fatality risk curves, as referenced by OECD (2006) and SWOV (2018a).

Table 4.2 – Safe impact speeds (fatality) according to type of potential car or pedestrian interaction

Potential conflict	Safe Speed (km/h)
No separation between vulnerable road users and cars (e.g., home zones and *woonerven*), no footpaths	15
No separation of cars and vulnerable users, in time or space	30
Lateral conflicts between cars	50
Frontal conflicts between cars (no physical driving direction separation)	70
No frontal conflict between cars (physical separation of driving directions), and safe roadside width	120

Fatality and MAIS3+ risk curves (e.g., Figure 3.1) are established from results of in-depth accident investigation, and reflect vehicle occupant crashworthiness and third party forgivingness (e.g. pedestrian protection) developments.

Speed management involves interventions on all Safe System elements: safe roads, safe speeds, safe vehicles and safe road use. A proper configuration of the road environment is fundamental for drivers to select appropriate speeds; however, the starting point for this role of the infrastructure is a credible definition of the speed limits, a feature that has to be complemented by appropriate enforcement, rehabilitation courses for speeding recidivists, as well as suitable public communication and education efforts (OECD, 2006). Furthermore, on sensitive areas, infrastructure may be equipped with dynamic advisory and mandatory local speed limit devices, and penetration of ISA equipped vehicles in the fleet can be accelerated by fiscal incentives applicable to new and imported vehicles, and by retrofitting repeating speeding drivers. In The Netherlands the practice of marking no-passing zones in selected single carriageway rural road sections has been effective in changing the expectation of drivers towards travel speeds. This approach was used on a hilly section in IP4, a Portuguese trunk road in mountainous area, to reduce head-on collisions and run-off-the-road crashes, but no register of behavioural studies were published. Required enforcement levels and platooning in hilly areas, due to speed differential between cars and heavy vehicles, are two potential issues that would have to be addressed, for defining proper warrants and designing pilots tests, in case of intended implementation in Portugal Mainland.

4.2 Objectives and scope of the intervention

It is intended with the set of measures included in this intervention to reduce the safety consequences of inappropriate speed on rural roads, both those belonging to the National Road Network and those managed by municipalities. This objective ought to be reached by diminishing the overall prevalence of speed violations, both high and small, on all interurban roads in Portugal Mainland.

4.3 Components of the intervention and their contribution to the objectives

Six interventions were selected as effective and viable on the Portuguese traffic system, as described in the following sections.

4.3.1 Component RSM01 – Changing the perceived danger of minor speeding offenses

4.3.1.1 Objectives

Evidence from rural road speed distributions and the variation of the relative risk with speed suggests that mildly speeding offenses (less than 15 km/h over the speed limit) are responsible for a sizeable portion of increase in fatality risk, as compared to a fully speed limit compliant behaviour of this driver group. Depending on the speed distribution shape, this increase in risk may be higher than the one due to very high speeding drivers.

This intervention addresses the mentioned issue, being intended to reduce low speeding related injuries.

4.3.1.2 Method

The current penalty for exceeding the speed limits by less than 30 km/h outside urban areas does not include an increased prospect of driving license suspension. Correspondingly, this type of violation is not considered as an important threat to safety, by the average driver; a view shared by enforcement officers and their agencies, leading to small enforcement effort, low expected punishment rates and high levels of infringement.

Increasing deterrence of these violations may be achieved by changing the legislation, diminishing the 30 km/h interval between slight and serious violation or adding one demerit point to slight speeding offenses. Alternatively, speed enforcement can be strictly applied to these violations too – although the initial level of acceptance for such a change in current enforcement procedures is expected to be low. Nevertheless, past experience on the IP5 and EN125 (see section 4.3.2) showed that this latter option can be effective, when no alternative routes (with less strict enforcement criteria) are available to potential speeding drivers.

In all cases, communication campaigns on the intended changes and the reasons for their application are recommended.

4.3.1.3 Resources

The implementation of this intervention involves changes in enforcement procedures, execution of information campaigns and, eventually, changes in legislation.

4.3.1.4 Estimated effects

Three interurban road categories were considered: motorways, single carriageway roads with access control, and interurban roads with no access control. The first two categories belong to the NRN; the latter category incorporates roads from the NRN and from the municipal road networks.

Speed-related safety outcomes were evaluated using the individual risk model for high speed roads described by Doecke, *et al.* (2011) for the relation between the risk of being involved in an injury crash at a given speed, as compared to the risk at a reference speed:

$$RR_{Ic} = e^{\left(0.07039\times(V-V_{lim})+0.0008617\times(V-V_{lim})^2\right)} \tag{1}$$

Where:

RR_{Ic} – relative risk of being involved in an injury crash;

V_{lim} – speed limit (km/h);

V – actual speed (km/h).

The effects were estimated using summary statistics of the speed distributions measured by PRP on the Portuguese NRN interurban roads, in 2013, which provide the most recent data available. Measurements were performed on motorway and single carriageway roads, with and without access control, and the corresponding values for the average and the standard deviation are presented in Cardoso *et al.* (2021b). Data from single carriageway roads without access control were used in the analysis of interurban roads with no access control.

It was assumed that speeds are normally distributed, with the mentioned average and standard deviation values, and that no change in current speed limits (120 km/h on motorways and 90 km/h outside urban areas – irrespective of the type of access control) would take effect. It is further assumed that only drivers in slight violation or travelling almost at the speed limit will change their choice of speed and that their speeds are reduced in order to keep the same difference to the serious violation speed limit. This corresponds to assume that only drivers in the interval 110 - 150 km/h on motorways, and 80 – 120 km/h on other interurban roads, would be affected.

It is further hypothesized that there is no behaviour adaptation – drivers will be equally attentive, aware of traffic situations and responsive to danger, despite their travel speeds being lower – and that the standard deviation of the speed distribution will not change significantly either.

Changes in the relative risk of injury crash per road category and prescribed speed interval between slight and serious offense are presented in Table 4.3. For instance, the reduction in the gap between slight and serious offense on interurban roads, from the current 30 km/h to 25 km/h is expected to result in a 12 % reduction in the number of fatalities on motorways, and in less 28 % fatalities on interurban access-controlled single-carriageway roads.

Table 4.3 – Injury crash risk variation resulting from reduction in serious-slight offense interval

Interval between slight and serious offense (km/h)	Road category		
	Interurban no access control	Interurban access-controlled	Motorway
25	-20 %	-28 %	-12 %
20	-32 %	-33 %	-18 %
15	-40 %	-36 %	-22 %
10	-45 %	-38 %	-25 %

In the 2017-2019 period a total of 887 fatalities were registered in Portuguese interurban roads (47 % of the national total), of which 569 (30 %) occurred on interurban roads without access-control, 143 (8 %) on interurban access-controlled roads and 175 (9 %) on motorways. Combining these values with the reductions presented in Table 4.3, the variation in the national number of fatalities can be estimated, assuming equal proportional variations in the numbers of fatality and injury crash occurrences. The results are presented in Table 4.4. For instance, the reduction in the gap between slight and serious offense from the current 30 km/h to 25 km/h is expected to result in a 9 % reduction of the total number of fatalities in the country.

Table 4.4 – Estimated fatality variation, resulting from reduction in serious-slight offense

Interval between slight and serious offense (km/h)	National number of fatalities	Number of annual fatalities prevented
25	-9 %	27
20	-14 %	41
15	-17 %	50
10	-18 %	53

4.3.1.5 Participants

Key participants in this intervention include ANSR, the enforcement agencies (PSP and GNR) and legislators.

4.3.1.6 External dependencies and level of priority

The intervention is dependent on legislative approval, by the Government or National Assembly, on the willingness of enforcement agencies to change current procedures, and on the capacity to process the expected increase in the number of detected violations – at least in the first months immediately after changing the speed limit offense severity criteria.

As mentioned, information campaigns are recommended to foster acceptance by drivers and ensure reasonable levels of compliance since the early stages of implementation.

4.3.1.7 Monitoring and evaluation

Execution fulfilment of the intervention can be assessed by means of the legislative approval, the success of the road safety campaigns and the strictness and level of enforcement monitoring.

Intermediate results are assessed through changes in a composite speed KPI expressing the percentages of both the speeding drivers and the speeding drivers bellow the speed limit plus 30 km/h.

4.3.2 Component RSM02 – Growing speeding general deterrence by increased stationary manual speed enforcement

4.3.2.1 Objectives

Exceeding the speed limit might be the most common form of traffic violation. Many drivers would drive faster than the speed limit if they knew that the police were not enforcing speed on a particular road. Even if the risk of apprehension is low, the simple possibility that the police may check speeds influences speed choice behaviour. Stationary and manual speed enforcement is intended to ensure compliance with the speed limit, thus reducing the number and severity of accidents. Experience has shown that general deterrence is not effectively achieved by solely relying on police activities, and that information campaigns are a critical important element of this type of approach. Therefore, it is critical that component RSM05-Road user speeding information and campaigns is coordinated with this RSM02 component.

Experience shows that the full realisation of the benefits of effective enforcement of road user behaviour legislation depends largely on the definition of a set of measurable compliance targets and on the permanence of police monitoring activity. Enforcement rigor and tolerance margins are also known to impact on enforcement effectiveness (De Waard and Rooijers, 1994).

This intervention intends to reduce the prevalence of speeding violations by increasing the intensity level of manual stationary roadside enforcement.

4.3.2.2 Method

A distinction is made between manual speed enforcement using stationary methods and using 'mobile' methods or police patrols. The distinction is relevant because halo effects have been found in time and space for stationary enforcement, but not for mobile patrols (Vaa, 1997). 'Halo effects' in time and space means that an effect can be found during a given period of time or at a certain distance from the spot where the speed enforcement is carried out. The mechanism which establishes the halo effects, includes the visibility of enforcement symbols, such as marked cars and uniformed police officers. According to Elvik *et al.* (2009), two types of stationary speed enforcement can be distinguished: one, often found in European countries (including Portugal), using an unobtrusive/hidden or exposed speed measuring device, and a clearly visible apprehension site some distance downstream; the other, predominantly found in the USA, in which the measuring equipment is installed in a stationary car, which is then used to pursuit and apprehend the offender in case of speed violations. In both cases, real time ticket processing voids the violator's potential travel time speeding benefits.

Overall, it has been found that the effectiveness of police enforcement is larger if it is accompanied by communication campaigns, a mix of conspicuous and unobtrusive means of detection, unpredictable and difficult to avoid, focused on the locations and periods with high levels of violation, and continued over a longer period of time.

4.3.2.3 Resources

Currently, the police applies stationary manual speed enforcement, as well as manual speed enforcement with unmarked cars.

The implementation of this intervention involves the intensification of the stationary manual speed enforcement activity and the execution of supplementary communication campaigns.

4.3.2.4 Estimated effects

According to Elvik *et al.* (2009), the introduction of stationary visible speed enforcement kinemometer devices (e.g. radar or laser) was found to result in a significant decrease in the number of accidents (-17 %). Most results refer to injury accidents. To these authors there is no significant difference between the effects on injury accidents and on those accidents with unspecified severity (mostly property damage only). All studies are from countries other than the United States (Australia, Sweden, and Finland) and all studies have applied some type of comparison group.

There is little knowledge about the long-term effect of introducing a speed enforcement program or on the functional form of the dose-response relation between enforcement intensity and traffic crash risk. Elvik (2011), based on the review of 13 studies and using meta-analysis, developed an accident modification function (AMF) to describe the functional form of the relationship between traffic law enforcement by police officers and developments in crash frequency. These results are shown in Figure 4.4, which also includes the results obtained from interventions on IP5, a single carriageway trunk road of the Portuguese NRN (Cardoso, 2012).

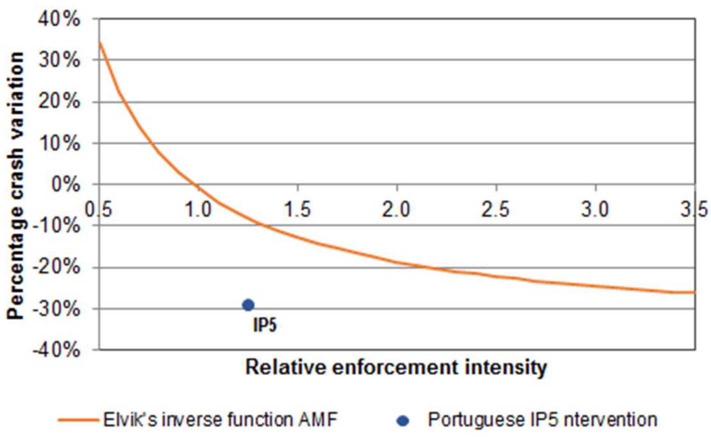


Figure 4.4 – Effect of speed enforcement on crash occurrence (adapted from Elvik, 2011 and Cardoso, 2012)

In this figure, the level of enforcement is stated as a relative level compared to a baseline level of 1. Thus a level of 0.5 represents a 50 % reduction in enforcement intensity, and a level of 2 represents a doubling of enforcement compared to the baseline level. As usual, the AMF expresses the relative risk, as the ratio between the analyzed situation and the baseline situation (initial level of enforcement).

Elvik (2011) concluded that the effects of speed enforcement on accidents exhibit a dose–response pattern that is theoretically plausible. The inverse function was fitted to non-weighted grouped data, and the logarithmic function was fitted to weighted grouped data. Based on 15 data points, the following logarithmic function was obtained:

$$AMF = 0.997 - 0.248 \times \ln\left(R_{enf}\right) \quad (2)$$

Where:

AMF – Crash modification factor (ratio of the numbers of crashes with and without an intervention);

R_{enf} – Relative change in enforcement intensity.

Both functions are very close, at relatively low levels of enforcement, but diverge at higher levels of enforcement. This result reflects the existence of fewer data points at high levels of enforcement change than at low levels, and the lower precision of the data points referring to high levels of enforcement changes. The divergence between the curves can be taken as an indication of the uncertainty on the effects of high enforcement level modifications (Elvik, 2011).

Cardoso (2012) analysed the effects of infrastructure and enforcement interventions on a 170 km single carriageway two lane Portuguese trunk road. Initially, low-cost road engineering measures (LCEM) were implemented; followed a year later by the commitment of exceptionally intense and strict traffic law enforcement; subsequently (after two years) these enforcement measures were relaxed, returning to the original situation. The sequential application of these safety interventions and the planned monitoring of resulting developments allowed for the evaluation of their individual impacts through observational before-after studies (Cardoso, 2012).

Approximately six months after the LCEM implementation, a special enforcement campaign started on the IP 5 route. Under the motto 'Maximum safety - zero tolerance', this campaign (MSZT) was subject to widespread media coverage, including the personal intervention of high ranking government officials. Characteristics of the enforcement activity were changed in two ways: the tolerance levels were eliminated or reduced to the minimum technically allowed by the measuring devices (radars and alcohol tests). Secondly, the overall activity of the traffic police was increased by more than 75 % in the first four weeks of the campaign and by 25 % in the following 24 months. Growth in police activity was achieved by increasing the available types of enforcement actions and by raising the number of simultaneous traditional patrols. Traditional patrol activity (with marked cars and motorcycles) was complemented with helicopter patrols, automatic photo-radar devices and 'camouflaged' vehicles equipped with video and radar. The number of police patrols on the road was raised from the original 9 patrols (8 hours shifts) per day, to 16 patrols per day in the first four weeks and to 11, since then, during two years.

Safety impacts were analysed using an observational before-after study with control sections. The expected number of accidents and the observed number of fatalities and severe injuries were used as safety performance variables.

The enforcement campaign resulted in significantly lower speeds on the IP5 trunk road, as compared to other similar Portuguese trunk roads. The implementation of both LCEM and SMTZ contributed to a significant decrease (-41 %) in the expected number of injury accidents on IP5; roughly, this corresponded to less 75 % fatalities (on site or during transport to hospital) and fewer 70 % killed and seriously injured victims. Following the suspension of the enforcement campaign, a 20 % increase in the number of fatalities was registered, as well as a 17 % increment in the number of killed and seriously injured victims (more 18 victims in three years); nevertheless, the expected number of injury accidents on the IP 5 continued to decrease at a greater rate than in the rest of the IP road network (see Table 4.5).

Table 4.5 – Effects on injury crash frequency of 'Maximum safety – zero tolerance' enforcement and communication campaign (Cardoso, 2012)

Description	Crash severity	Type of crash affected	Percentage change in the number of crashes
MSZT	All	Unspecified	-29
Suspension of MSZT	All	Unspecified	-1

From the registered developments, it may be inferred that the combined effect of higher intensity level of enforcement and stricter application of traffic rules in the MSZT effort resulted in a 55 % decrease in the number of fatalities on the IP5.

4.3.2.5 Participants

Key participants in this intervention include ANSR, the enforcement agencies (PSP, GNR, and municipal police) and municipalities.

4.3.2.6 External dependencies and level of priority

The intervention is dependent on the capability of enforcement agencies to intensify current procedures, and on ANSR's capacity to process the expected increase in the number of detected violations – at least in the first months immediately after increasing the level of enforcement intensity.

As mentioned, information campaigns are recommended to foster acceptance by drivers.

Alternatively to its application at the national level, this type of intervention may be applied within a limited spatial scope, such as a village, metropolitan area or, even a route. However, in these cases the affected geographical area must be selected in such a way that no alternative routes are left uncovered, that may be used by speeding drivers.

4.3.2.7 Monitoring and evaluation

Execution of the intervention can be assessed by means of the strictness and level of enforcement monitoring.

Intermediate results are assessed through changes in the speed KPI – number of drivers exceeding the speed limit, by road category.

4.3.3 Component RSM03 – Increase the coverage of automatic speed enforcement

4.3.3.1 Objectives

Only a small proportion of all traffic violations are detected, although exceeding the speed limit is possibly the drivers' most common traffic law violation. The objective risk of being apprehended is very low. For example, a Norwegian estimate from 1976 suggested that the risk of being apprehended for speeding was less than 1 in 1,000, even on road sections subject to the highest enforcement levels (Endresen, 1978). A Swedish estimate indicated that only around 3 out of every 10,000 speeding incidences are detected by the police (Nilsson and Engdahl, 1986).

Speed cameras (automatic speed enforcement) are intended to provide an enhanced capacity for enforcement by applying technical solutions that do not require the presence of police officers at the scene of an offence. Being installed at a fixed location, they are best located ate sites in which speed is a known major road injury factor.

This intervention intends to reduce the prevalence of speeding violations at high risk speeding-related sections (section control) or sites (spot speed), by enlarging the number of automatic speeding detection locations and devices integrated in the Portuguese speed cameras system (SINCRO). Criteria for selecting these sites and sections were established in a dedicated study (Cardoso, 2009).

4.3.3.2 Method

Systems for automatic enforcement, including speed cameras, are designed to detect traffic violations and identify the vehicle or driver automatically, i.e., without police officers being physically present at the scene. Identification is based on photographs of the vehicle, usually a front view but in some cases a rear view is used. In Portugal, usually photographs of the vehicle rear are taken, which prevents obtaining evidence for confirmation of drivers' identification.

Automatic speeding detection can resort to spot speed measurements – by means of an average of instantaneous speed measurements – or to average speed calculation – by timing the travel time between two sections several meters apart (section control).

Section control is effective in avoiding the spot speed measurement halo effect and in obtaining good speed compliance on long high risk road links; to be effective, however, the road stretch between the starting and the ending sections should have no access nor egress roads, to prevent mixing speed-controlled and non-speed-controlled drivers. Section control has not been applied in Portugal yet.

Criteria for identifying potential sites for spot speed automatic enforcement and for assessing the relevance of speed on expected crash frequencies were developed previously (Cardoso, 2009). Criteria for section control need to be developed, in line with those for spot speed enforcement.

4.3.3.3 Resources

Implementing this intervention involves approval in the Council of Ministers, changes in enforcement procedures and the execution of information campaigns.

In case a decision is reached to start using section control, criteria for the selection of controlled links may be used as defined in a LNEC report (Cardoso, 2009).

4.3.3.4 Estimated effects

Table 4.6 shows the effect on accidents of speed cameras. The results indicate that fixed speed cameras reduce accidents at all severity categories by 16 %. The results refer to all accidents. For fatal accidents, a more important effect was found (-39 %). Speed camera programmes were sometimes, but not always, accompanied by different types of communication campaigns, either with a local scope or as part of a broader, more comprehensive, publicity campaign. In about half of the programmes, the speed cameras were accompanied by a publicity campaign (Elvik *et al.*, 2009).The effects on accidents are practically identical, irrespective of the type of publicity (not shown in Table 4.6). Mobile (hidden) speed cameras were found to reduce injury accidents by 10 % and fatal accidents by 16 %. However, neither result is statistically significant. The enforcement was invisible to drivers in all cases.

Table 4.6 – Effects on crash frequency of automatic speed enforcement (Elvik et al., 2009)

Description	Crash severity	Type of crash affected	Percentage change in the number of crashes (Best estimate)
Fixed (visible) speed cameras	All	Unspecified	-16
	All	Fatal	-39
Mobile (hidden) speed cameras	Injury	All	-10
	Injury	Fatal	-16
Section control	Injury	All	-30
	Fatal and serious injury	All	-56

According to Elvik *et al.* (2009), for both fixed and mobile speed cameras, the effects on injury accidents are slightly larger when a publicity campaign accompanies the enforcement than when there is no accompanying publicity. The differences in the results are, however, only small and not significant (not shown in Table 4.6).

Section control was found to reduce injury accidents by 30 %. This result is based on only one study (Stefan, 2006), which does not include many accidents. Afterwards, a study on the effect of section control in Norway (Høye, 2015) allowed to conclude that section control is effective in reducing both speed and crashes, especially serious crashes, and that spill over effects (crash reductions at non-enforcement sites) are more likely to occur than crash migration. The before–after study controlled for regression-to-the-mean (using the empirical Bayes method) and for the effects of trend, traffic volumes, and speed limit changes. The number of killed or severely injured was found to be significantly reduced by 49 % at the section control sites. In an international meta-analysis, De Ceunynck (2017) reported a 56 % reduction for accidents involving killed or severely injured victims following the installation of section control.

As mentioned in Cardoso (2009), special warrants apply for section control sites, namely full access control, in order to guarantee that all drivers pass in both measuring sections.

4.3.3.5 Participants

Key participants in this intervention include ANSR, the enforcement agencies (PSP and GNR, and municipal police), as well as road infrastructure operators (concessionaires, in the case of the National Road Network and local authorities in municipalities).

4.3.3.6 External dependencies and level of priority

The intervention is dependent on approval by the Government, authorizing the acquisition of new kinemometers and construction of installation sites, as well as ensuring the means for processing the expected increase in the number of detected violations.

As mentioned, information campaigns are recommended to foster acceptance by drivers.

4.3.3.7 Monitoring and evaluation

Execution of the intervention can be assessed by means of developments in the number of new speed camera (eventually also section control) sites, the number of certified active kinemometers, the average time to process tickets, the percentage of paid fines and the ration of expired tickets.

Intermediate results are assessed through changes in the speed KPI – percentage of drivers exceeding the speed limit, by severity of violation.

4.3.4 Component RSM04 – Safe System matched speed limit on municipal undivided interurban links

4.3.4.1 Objectives

Results from in-depth crash investigations suggest that current cars are able to provide occupant protection in case of frontal and rear-end collisions with closing speeds bellow 80 km/h (see section 4.1).

This intervention is intended to reduce the injury consequences of frontal and rear-end collisions on interurban municipal roads. Overall, design characteristics of these roads are of a lower standard than those of NRN single carriageway roads, namely as relates to shoulder width and pavement, as well as roadside obstacle-free zones, which provide for emergency escape areas in case of impending frontal or rear-end collisions.

4.3.4.2 Method

The projected reduction in speed limits may be achieved either changing the Highway Code, specifically in what concerns interurban roads, creating a new road traffic regime for municipal roads; or by installing speed limiting signs on all municipal roads. The former option seems more realistic. The comprehensive execution of the latter option entails the careful analysis of the municipal road networks in order to survey where installation of new traffic signs is required – namely at intersections. Presumably this would take more than a year to implement and, once completed, maintenance of the traffic signs would have to be ensured.

In addition to one of the stated measures, to achieve the pursued change in driving behaviour dedicated speed limits enforcement activity will need to be applied on municipal interurban roads, presumably resorting to manual and automatic devices. This corresponds to a change in police activity planning; normally, low levels of enforcement activities are expected by drivers on municipal roads, also due to lower average daily traffic than in NRN roads. Accompanying communication campaigns are expected to contribute for achieving acceptance by drivers and fostering acceptable levels of compliance since the early stages of implementation.

The current prevailing speed limit is set at 90 km/h outside urban areas; while the final target speed limit on interurban municipal roads will be 70 km/h. To improve the chances of social acceptability, it is suggested that a stepwise approach is taken, with an initial reduction of the speed limit to 80 km/h, followed by an evaluation period of three to five years, before a new reduction to 70 km/h process is initiated. An alternative approach is to carry out pilot projects in selected inter-municipal communities (to gain geographical scale), and trying to scale up after success.

Following success of the pilots and their scaling-up, a revision of the manual on the selection of speed limits (Cardoso, 2010) may be required, in order to include the new general speed limit on interurban links of municipal roads and to improve its alignment with safe and credible speed criteria.

4.3.4.3 Resources

The implementation of this intervention involves changes in police activity and procedures, the execution of information campaigns and, eventually, changes in legislation.

4.3.4.4 Estimated effects

This intervention component is directed at reducing the frequency and severity of frontal and rear-end crash injuries on interurban municipal roads, by means of lower speeds – matching safe system criteria – on these roads. Additional benefits are expected on other crash types, as research shows that all types of accident are affected by traffic speed reductions.

Relations between changes in average speed as a result of changing the speed limit were studied using meta-analysis by Elvik (2012), who reported a reduction of 3 km/h (with some variability) in the average speed following a 10 km/h decrease in the speed limit, and noted that a reverse effect exists (although at a smaller scale) if the value of a speed limit is increased. Elvik, *et al.* (2019) updated the meta-analysis on the relations between mean speed and safety (e.g., the number of victims), concluding that the best current estimates for the Power Model are 5.493 for fatalities and 3.951 for injury crashes. The Power Model relates the change in the number of fatalities, following a change in the average traffic speed.

In the estimation of the effects of this intervention, it was assumed that the Elvik's exponential for the Power model is applicable to Portuguese roads, that there is a uniform decrease across the whole speed distribution, that diminishing the speed limit by 10 km/h entails -3.0 km/h in the average speed, that there are no changes in the intensity and severity of enforcement, and that no driver behaviour adaptation occurs (e.g., driver will remain equally attentive to traffic). Furthermore, it was assumed that currently the average speed on interurban municipal roads is the same as the average speed measured on NRN interurban roads without access control (71 km/h), in the 2013 speed measurement campaign.

Under these assumptions, a 38 % reduction in the number of road crash fatalities (totalling 447 occurrences in the period 2017-2019) is expected, corresponding to 172 fatalities prevented annually. The initial change from 90 km/h to 80 km/h would correspond to a -24 % variation in the number of fatalities on interurban municipal and other roads (-94 occurrences).

4.3.4.5 Participants

Key participants in this intervention include ANSR, the enforcement agencies (PSP and GNR), municipalities and legislators.

4.3.4.6 External dependencies and level of priority

The intervention is dependent on legislative approval, by the Government or National Assembly, on the willingness of enforcement agencies to change current procedures, namely by increasing the frequency of speed checks on interurban municipal roads, and on their capacity to swiftly process the expected increase in the number of detected violations – at least in the first months immediately after changing the speed limits.

As mentioned, information campaigns are recommended to foster acceptance by drivers and ensure reasonable levels of compliance since the early stages of implementation. Cooperation with municipalities in this respect would provide further support to widen the acceptance by the community.

4.3.4.7 Monitoring and evaluation

Execution of the intervention can be assessed by means of the legislative approval, the success of the communication campaigns and the strictness and level of enforcement monitoring.

Intermediate results are assessed through changes in the speed KPI, on interurban municipal roads.

4.3.5 Component RSM5 – Road user speeding information and communication campaigns

4.3.5.1 Objectives

Some types of behaviour strongly increase the risk of accident and injury. These behaviours include, among others, exceeding the speed limit (Elvik *et al*., 2004). According to Elvik *et al.* (2009), if road users fully respected road traffic legislation, the number of injured road users could be reduced by 27 %. The number of road accident fatalities could be reduced by 48 %. The current amount of police enforcement is not sufficient to ensure total respect for road traffic legislation.

There are many reasons why drivers (and other road users) do not obey traffic rules or behave in ways that are unfavourable for safety. Bad attitudes, a lack of knowledge about traffic rules, and possible unawareness of consequences of not following traffic rules (accident risk, risk of being caught by the police) are examples of these reasons. It is often assumed that improving knowledge and attitudes might lead to a favourable change in behaviour. Though, the relationship between knowledge, attitudes, and behaviour is only weak; even if one succeeds in changing these, a corresponding behaviour change will not necessarily occur. There are various other determinants of road user behaviour besides knowledge and attitudes, e.g., a desire to reach the destination as fast as possible (speeding).

Road user speeding information and campaigns are intended to reduce accidents by promoting safer behaviour in traffic, by giving road users improved knowledge and more favourable attitudes towards such behaviour. Another objective is to inform about enforcement (Elvik *et al*., 2009).

Within the scope of speed management on interurban roads, communication campaigns are understood as complementing other enforcement and legal activities, especially as regards supporting general deterrence advancement and improving public understanding of legal restrictions. It is also understood that campaigns are more effectively performed if a common framework is applied, such as the one laid out in the practical manual prepared under the EU research project CAST (EC, 2010).

4.3.5.2 Method

Road user speeding information and campaigns include information through different types of media. Newspapers, journals, the Internet, TV, radio, cinemas, letters, and brochures sent directly to specific target groups, famous people as promoters, posters, advertisement hoardings, and signs along the roadside can be used for this purpose. The information may be directed towards specific target groups (e.g., by sending letters or using target group-specific print or online media) or towards the general public (e.g., signs along the roadside).

Information and campaigns are often directed towards specific types of behaviour. The most significant part of (evaluated) campaigns is directed towards speeding or drink-driving. Some campaigns aim at influencing attitudes only, whereas others are combined with police enforcement. In the latter case, the campaigns inform about the ongoing enforcement, while enforcement strengthens the message of the campaign (Elvik *et al.*, 2009).

4.3.5.3 Resources

The implementation of this intervention involves the execution of information campaigns.

4.3.5.4 Estimated effects

The results are summarised in Table 4.7. Results are based on a random effects model of meta-analysis and controlled for publication bias. The results show that significant reductions of accident numbers were found for speeding campaigns. However, this estimate is not statistically significant at a 5 %-level (Vaa *et al.*, 2004). The results refer mainly to changes of accident numbers in the campaign period. Some studies also include a period after the campaign period. The results are based on all types of campaigns, regardless of whether or not these are combined with enforcement.

Table 4.7 – Effects on crash frequency of road user speeding information and campaigns (Vaa et al., 2004; Elvik et al., 2009)

Description	Crash severity	Type of crashes affected	Type of target crashes	Percentage change in the number of injuries (Best estimate)
All campaigns	All	Unspecified	All crashes	-9
Speeding campaigns	All	Unspecified	All crashes	-8

When campaigns are divided into groups according to whether or not they are combined with enforcement, only those campaigns that are combined with enforcement were found to reduce accidents. Campaigns alone do not seem to have any effect at all. Only local individualized campaigns were found to reduce accidents significantly, also without targeted enforcement (Elvik *et al.*, 2009).

4.3.5.5 Participants

Key participants in this intervention include ANSR, media, central government, local authorities, road safety NGOs, insurance companies, motoring organisations, road infrastructure and transport operators and private companies.

4.3.5.6 External dependencies and level of priority

Information campaigns are recommended to foster acceptance by drivers and to ensure reasonable levels of compliance since the early stages of interventions implementation. Communication campaigns are an auxiliary tool for supporting the implementation of other road safety interventions. Therefore, strategies for their implementation should be aligned with the overall ramping up of other interventions, focused on their objectives and relevant public, and synchronized with their time schedules, rather than being pursued as an autonomous intervention.

4.3.5.7 Monitoring and evaluation

Execution of the intervention can be assessed by the success of the road safety campaign.

Recommendations for effectively raising awareness to road safety and for developing and executing communication campaigns and for evaluating their effect on influencing road user behaviour were produced in the EU research project CAST (Adamos *et al.*, 2009, Boulanger *et al.*, 2009a and 2009b) and laid out in a practical manual (EC, 2010).

Intermediate results are assessed through changes in the speed KPI.

5 | Concluding remarks

The implementation of VisãoZero 2030 involves the identification, development and execution of specific interventions projects, which are the building blocks for adopting a Safe Systems approach. Seemingly, these will require substantial funding over a sustained period of time, encompassing the full 10 years duration of the road safety plan. The source of these funds will need to be identified, but it is clear that the Portuguese Government will need to show its political will to address the severe road safety problem, by dedicating (and possibly sourcing) funds toward taking this next step. Considering the important dimension of the urban road safety problem, it is also clear that, in general, Portuguese Municipalities will also need to show a similar political will, and actively cooperate with the Government and among themselves to provide for their citizens the conditions for a sustainable mobility that is inherently safe.

This report presents the overall methodology to follow in the preparation of VisãoZero2030 biennial plans, which comprises the preparation of a problem statement and analysis, a list of evidence based and data driven suitable potential interventions, the congregation of political and public support on potential interventions, the design of packages of interventions fitting implementation scenarios, and making estimates on effectiveness, impacts assessment and setting priorities. It also provides a global overview of potential projects on speed management in urban areas and in interurban roads, which can be integrated as part of the overall strategy developed in the second activity of Stage 2 (Cardoso *et al.*, 2021b). However, they do not cover the whole spectrum of required key areas. The example interventions proposed also need to be discussed among officials and stakeholders in Portugal.

Lisboa, LNEC, June 2021

APPROVED

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