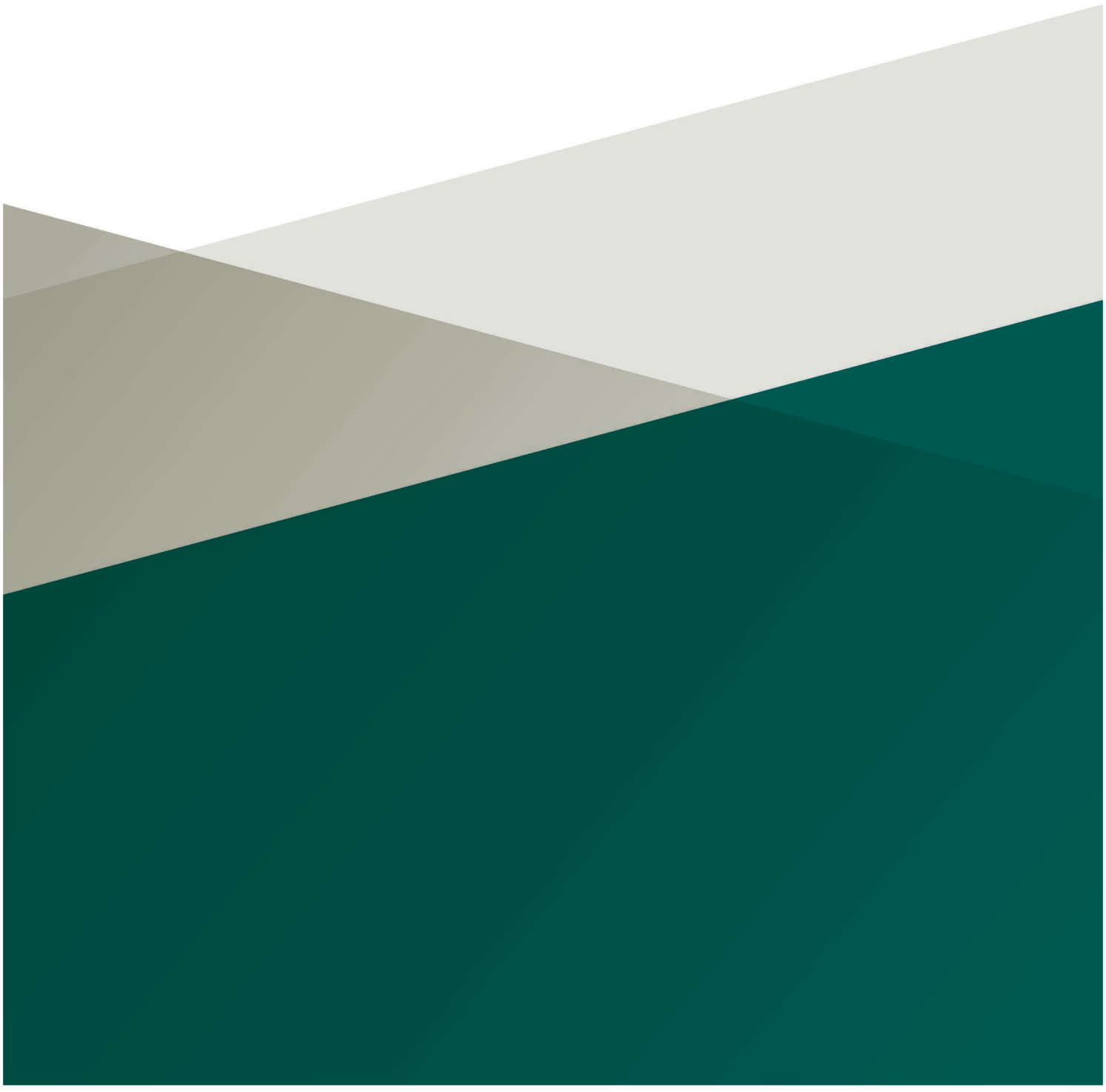
An Roinn Iompair
Department of Transport

Speed Limit Review
International Research



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Transport Infrastructure Ireland

Setting and Managing Speed Limits

Executive Summary

Reference: 26418558-TNS-000001-I01

I01 12 October 2022

Commissioned in support of Action 6 of the Government Road Safety Strategy (2021-2030)

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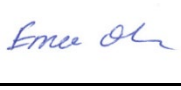
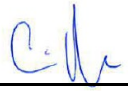
		Signature			
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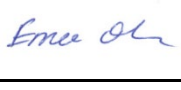
		Signature			
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Contents

Appendices

1. Introduction

1.1 Background

In 2019, the European Commission adopted novel approaches to European Union (EU) road safety for the years 2021-2030, reaffirming its intention to reduce road deaths and serious injuries by 50% by 2030. In terms of speed limits, the European Commission encouraged the Member States to:

- Draw up a road classification framework (hierarchy) that matches speed limit to road design and layout.
- Support cities in setting up speed limit databases and promote the deployment of intelligent speed assistance technology.
- Produce a recommendation to apply Safe Speed limits, such as maximum default speeds of 30km/h in residential areas and areas where there are high numbers of cyclists and pedestrians present.
- Prioritise investment in speed enforcement and to apply penalties to deter speeding.

1.2 Scope

The primary aim of the government's new road safety strategy is to reduce the number of deaths and serious injuries on Irish roads by 50% over the next 10 years. This means reducing deaths on Ireland's roads annually from 144 to 72 or lower and reducing serious injuries from 1,259 to 630 or lower by 2030.

The aim of this research is to evaluate current mechanisms and policies regarding the setting and management of speed limits internationally. This will inform the best approaches to changes to speed limits which may be made in Ireland, including identifying the potential safety, environmental and operational benefits, and risks which may arise as a consequence of changing how speed limits are set and managed.

1.3 Methodology

The methodology chosen was to follow two main approaches, literature review and stakeholder engagement, to determine current mechanisms and policies to determine the most appropriate approach to apply in Ireland.

1.3.1 Literature Review

The first part of the project undertook an in-depth literature review to meet the following objectives:

- Understand the policy and legislation areas relevant to the setting and management of speed limits internationally.
- Understand the impacts of decisions to amend speed limit policies, particularly where speed limits have been reduced. This includes identifying the effects of such decisions on the behaviours of drivers (e.g. speed choices) and other road users, road safety, congestion, and the environment.

1.3.2 Stakeholder Engagement

The second part of the project interviewed 10 stakeholders in countries that had recently changed speed limits on either urban or rural roads. Interviews were conducted to:

- Investigate the existing legislative context.
- Understand current practices for setting speed limits.
- Evaluate the wider implications of reducing speed limits.

One to one consultation was conducted with personnel from the selected countries, and a topic guide was developed prior to consultation in order make the questions asked more consistent.

2. Literature Review

The literature review looked at three main aspects:

- Speed limits, policy and legislation
- Effects of speed limit implementation
- Methods for setting speed limits

2.1 Speed Limits, Policy and Legislation

The results from the literature review demonstrated that the current speed limits on Ireland's road network are broadly consistent with the countries reviewed across all road types. This is particularly the case for roads in towns and streets, regional and local roads and special speed limits. For national roads and motorways the results were more varied with a mix of countries with lower and higher speed limits. Refer to Appendix A for further details of speed limits for different road types in the countries reviewed.

2.2 Effects of Speed Limit Implementation

The literature review identified some recurrent themes related to the reduction of speed limits. These themes were in the areas of road injuries and economic and environmental impacts.

2.2.1 Road Injuries

Road injuries and fatalities are major factors which are impacted by traffic speed. A number of international studies were reviewed as part of this project. Overall, the literature reviewed suggests that even a slight reduction in speed could have a significant impact on the reduction of fatalities and serious injuries and that the implementation of reduced speed limits has led to significant improvement on road safety. However, all studies noted the need for more evaluation following implementation of speed limit changes to determine more robust correlations between speed limits and resultant deaths and injuries.

2.2.2 Economic and Environmental Impacts

Recent literature has also investigated what impact speed limit changes could have on economic and environmental factors.

Overall, the potential economic gain from the reduction of speed limits seems to be driven by road safety. Furthermore, the literature seems to suggest that the environmental impact of reducing the speed limit is relatively small. However, as for the case of France, even a non-statistically significant reduction in air pollution could lead to a cumulative monetary gain, for which speed limit reductions could be partially justified.

2.2.3 Methods for Setting Speed Limits

A number of methods have been employed by the subject countries to setting speed limits. The common theme is the importance of having data available to support whichever approach is chosen to proceed with.

- Expert Systems Approach – data-based risk assessment approach using expert opinion
- Optimisation Approach – not fully risk based, focuses on economic assessment of proposed changes
- Netherlands Safe and Credible Speed Limits (SaCredSpeed) – data-based risk assessment using algorithms
- New Zealand Speed Management Framework – data-based assessment to prepare speed management maps

3. Stakeholder Engagement

Although all the countries that were consulted had specific speed limits for each type of road, there were different approaches to how these limits were set:

- Assessing the function of the road – traffic volumes, vulnerable road users etc
- Assessing the number of amenities – schools, shops, hospitals, pedestrian crossings
- Using the Safe Systems Approach – speed limits that are survivable in a collision (occupants and pedestrians)
- Adopting standards from other countries – Belgium uses the Netherlands approach

While each approach is different, it is important to note that some countries used a combination of two or more approaches. For example, many speed limits in New Zealand are set by assessing the function of the road, identifying the Safe Speed, and what local amenities are close-by.

In all cases the importance of buy in from a wide range of stakeholders was noted in relation to the success of implementing changes and how they are adhered to by road users.

4. Summary

Both the literature review and the stakeholder engagement showed that many road authorities in high-income countries are changing their attitude toward speed limits for a variety of reasons.

In general, a mixed approach is used for setting the speed limit, where the national government set a general (or default) set of speed limits for each main road type. Local governments or road agencies can typically amend the speed limits of roads under their jurisdictions; mainly based on safety grounds. Local governments can generally apply only to reduce speed limits although they can occasionally increase the speed limit that are set by the national government.

Stakeholders are almost always involved in the speed limit setting process, and in some cases are required to authorise the speed limit changes (for example the police need to approve any speed limit changes in Denmark). Having stakeholder support is reported to be important in the process to alter the speed limits.

The Safe System approach was reported to be frequently applied by several countries in both the literature review and stakeholder engagement. This finding reaffirms how many countries are focusing on reducing the number of deaths and serious injuries by setting speed limits to a ‘Safe Speed’.

4.1 Impact of Speed Limit Reductions

4.1.1 Policy Acceptance

Although the process to change the speed limit typically went smoothly, both the stakeholder engagement and literature review showed that policy acceptance is still an ongoing issue. From the stakeholder engagement, it emerged how the implementation of speed limits are usually a compromise between what is safe and what the road users want. For example, the stakeholder from Sweden noted that they had only reduced the speed limit on rural roads to 80km/h rather than 70km/h; reducing the speed limit further would be “a little bit hard to chew”.

4.1.2 Road Safety

The literature review consistently reported a reduction of fatalities and serious injuries on different types of roads when speed limits were reduced. Nevertheless, these studies are not without limitations in the assessment of speed limit changes as there are confounding variables in the evaluation. Nevertheless, the stakeholders did report that although a decrease in speed limit does correspond with decreased traffic speed, the average traffic speed does not always decrease by the full amount.

4.1.3 Environmental Effects

The environmental effects of reducing the speed limit are still not clear. The literature review reports contrasting evidence of the impact of speed limit on noise and air pollution. This seems to be mainly due to the difficulty in the implementation of a comprehensive evaluation model, capable of addressing several key confounding metrics.

4.2 Recommendations and Next Steps

4.2.1 International Examples

Good practice and practicable approaches identified for two countries, Sweden and France, give some indications of approaches that could be taken in Ireland.

4.2.1.1 Setting Speed Limits – Sweden

The Swedish approach takes into account possible crash types which can occur on road types/sections and aims to set the survivable speeds as the speed limit whilst taking into account local population/residents' feedback that may cause them to ignore the speed limit where deemed unreasonable.

4.2.1.2 Evaluating the Impact of Speed Limits – France

Although the approach to setting speed limits in France was not always fully scientific, they had evaluated many of the impacts of a speed limit change. These included, but were not limited to:

- Change in vehicle speeds.
- KSIs patterns.
- Change in travel time.
- Environmental impacts.
- Public acceptance of speed change.
- Economic impacts.

Refer to Appendix B for further details on the evaluation of setting speed limits in France.

4.2.2 Recommendations

A wide variety of advice was suggested by the literature review process or given by the stakeholders during the discussions. This advice is presented in the general order it should logically be applied in a process to develop proposals to change speed limits:

- Need for a change
- Functional Hierarchy
- Safe Systems – 'safe' or survivable speeds
- Conversation – monitor international trends
- Consistency
- Communication – stakeholder engagement and public awareness of the benefits of road safety

- Support from stakeholders
- Enforcing compliance – traffic calming etc
- Evaluation of the change – follow-up on changes to understand the effects

Appendix A

A.1 Speed Limit Policies

	Ireland[1]	Italy[2]	England[3]	France[4]	Spain[5]	Norway	Wales[6]	Denmark[7]	Sweden[8]	Austria[9]	Netherlands[10]	Belgium[11]	New Zealand[12]
Town and city speed limits	50km/h	50km/h	30mph (50km/h)	50km/h	50km/h	50km/h	30mph (50km/h)	50km/h	50km/h	50km/h	50km/h	50km/h – 70km/h	30km/h – 50km/h
National road speed limits	100km/h	110km/h	70mph (110km/h)	110km/h	100km/h	90km/h	60mph (95km/h)	80km/h	100km/h	100km/h	100km/h	90km/h	80km/h – 100km/h
Regional and local road speed limits	80km/h	90km/h	60mph (95km/h)	80km/h	80km/h	80km/h	60mph (95km/h)	80km/h	70km/h	100km/h	80km/h	70km/h	60km/h – 80km/h
Motorway speed limits	120km/h	130km/h	70mph (110km/h)	130km/h	120km/h	100km/h	70mph (110km/h)	110km/h – 130km/h	110km/h	130km/h	100km/h – 130km/h	120km/h	100km/h – 110km/h
Special speed limits (e.g. urban streets)	30km/h	30km/h – 50km/h	20mph – 30mph (30km/h - 50km/h)	30km/h – 50km/h	10km/h – 30km/h	30km/h	20mph (30km/h)	40km/h	30km/h	30km/h	30km/h	30km/h	10km/h – 30km/h

[1] https://www.rsa.ie/docs/default-source/se rvices/s1.8-learner-driver-resources/rules-of-the-road-.pdf?sfvrsn=6d948b39_34
[2] https://www.aci.it/i-servizi/normative/codice-della-strada.html
[3] https://www.gov.uk/government/publications/setting-local-speed-limits/setting-local-speed-limits#:~:text=The%20three%20national%20speed%20limits,on%20dual%20carriageways%20and%20motorways
[4] https://www.gouvernement.fr/sites/default/files/document/document/2018/01/dossier_de_presse_-_comite_interministeriel_de_la_securite_routiere_-_mardi_9_janvier_2018.pdf
[5] https://www.boe.es/buscar/doc.php?id=BOE-A-2018-18002
[6] https://gov.wales/sites/default/files/publications/2017-10/setting-local-speed-limits-in-wales.pdf
[7] https://www.retsinformation.dk/eli/lta/2005/1079
[8] https://www.rac.co.uk/drive/travel/country/sweden/
[9] https://www.oesterreich.gv.at/en/themen/freizeit_und_strassenverkehr/kfz/10/Seite.063300.html
[10] https://www.universiteitleiden.nl/binaries/content/assets/customsites/study-abroad-exchange-students/road_traffic_signs_and_regulations_jan_2013_uk.pdf
[11] https://ec.europa.eu/transport/road_safety/going_abroad/belgium/speed_limits_en.htm
[12] https://www.nzta.govt.nz/roadcode/heavy-vehicle-road-code/road-code/about-limits/speed-limits/

Appendix B

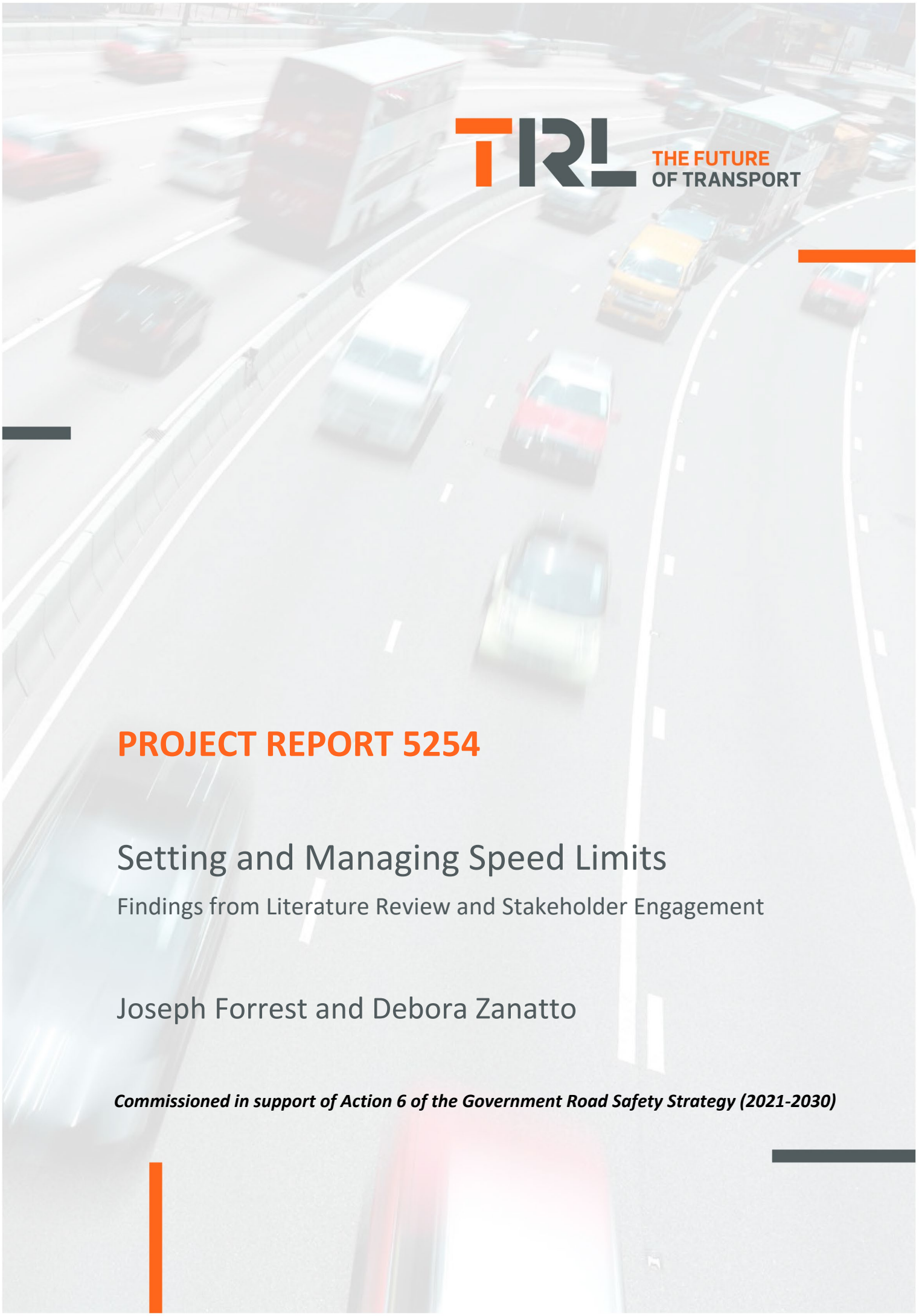
B.1 Evaluation of Speed Limit Changes in France

Evaluation	Speeds	Accident rate	Travel time	Environmental impact	Acceptance of the measure	Socio-economic calculation
Results	Reduction in the average speed of all vehicles by 3.3km/h.	Significant decrease of 8-10% in the number of deaths.	For 30km journeys, 30 seconds increase during the week and 40 seconds at the weekend. For 80km journeys, one minute increase during the week and less than 2 minutes at the weekend.	Overall decrease in the main pollutants. However, this decrease is very small and at this stage cannot be considered as significant.	Drop in those most opposed to the measure (supporters increase from 30% in April 2018 to 48% in June 2020). Supporters more numerous in rural areas. 75% report complying with the measures.	€721 million - €917 million loss for journey times. €1.2 billion gain for road safety. €251 million (low traffic scenario) - €320 million (high traffic scenario) gain for the fuel saving. €54 million (low traffic scenario) - €65 million (high traffic scenario) gain related to greenhouse gas emissions.
Methods	Speed observatory to assess the impact of speed reduction. Continuous speed data collection from all road users driving on the sites concerned. Time Headway (TH) is also recorded to identify vehicle interactions. Indicators monitored: Average speed. The distribution of individual. speeds and percentiles (V15 and V85). • The exceeding of speed thresholds with respect to the speed limit.	Data from Road traffic crash and injury report data were adjusted for seasonality. Odds ratio approach, returning the percentage change in the death rate on the 80km/h network compared to the rest of the network where speed was unchanged. The odds ratio calculation included: number of deaths on the 80km/h network (and rest of the network) before and after introducing the new speed limit.	Google Maps application. Historical GPS tracks. Historical Floating Car Data (FCD) vehicle tracks.	Acoustic simulation models, carried out on 4 road sections affected by the measure (N31; N79; N94 and D612). Emission and propagation method, based on NMPB08 (-New Noise Prediction Method 2008 [13])	A questionnaire was sent out by a survey institute to a large sample of drivers' representative of the French people, including the different dimensions of the acceptability/ acceptance of the measure, in particular its perceived effectiveness and usefulness, fairness, impact on behaviour and the general attitude of the respondents.	Estimation models considering: • Estimate traffic considered in km travelled. • Travel time and speeds. • Fuel consumption. • KSIs. • Amount of greenhouse gas emissions. • Investment costs.

[13] NMPB-Routes-2008. 2009b. "Methodological guide, Road noise prediction, volume 2: NMPB 2008 – Noise propagation computation including meteorological effects." Référence: LRS 2008-76-069. SETRA (Service d'études sur les transports, les routes et leurs aménagements).

Appendix C

C.1 Setting and Managing Speed Limits - Findings from Literature Review and Stakeholder Engagement Full Report



THE FUTURE OF TRANSPORT

PROJECT REPORT 5254

Setting and Managing Speed Limits

Findings from Literature Review and Stakeholder Engagement

Joseph Forrest and Debora Zanatto

Commissioned in support of Action 6 of the Government Road Safety Strategy (2021-2030)

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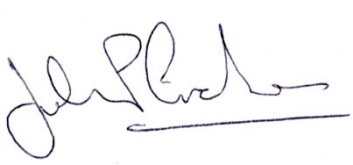
Richard Oliver (Project Manager)		John Fletcher (Technical Reviewer)	

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Table of Contents

1 Extended executive summary:

1.1 Recommendations and considerations for Speed Limit management

Managing speed on road networks is fundamental for road safety but also extremely challenging (Davis 2018). One of the clearest aspects of the Safe Systems approach is that managing the speed of traffic is (generally) regarded as the most important and effective way to achieve reductions in Killed and Seriously Injured (KSI) casualties. Ireland has adopted a Safe System approach to manage road safety generally and to develop its recent Road Safety Strategy.

Speed management is challenging because implementing the measures to achieve meaningful reductions in vehicle speeds can be is unpopular with drivers. Setting appropriate speed limits is fundamental to effective speed management. However, again, the speed limits which are safe for the risk levels on roads and also the road users present can also be in conflict with the perception of what drivers think is appropriate. Thus speed management can be interpreted as a personal rights limitation by frequently vocal individuals and organised road users groups. In addition the clear societal level benefits of managing speed are not generally clear to individual road users in all cases. Authorities who base their approach to improving road safety through the Safe Systems are effectively committing themselves to major reductions in speed limits and operational traffic speeds, if they are to adhere to the approaches' principles and aims.

This project aimed to identify a range of evidence based best practices and recommendations for manging speed limit change processes. The complexity and scope of the tasks required to change speed limits are very broad, given the challenges indicated above; the resources available for this review were however limited. This work has identified a range of the key aspects that require to be investigated when changing speed limits.

When considered in more detail the tasks and actions needed to effectively change the approach to speed limits at a national and local level are seen to be even more complex and inter-linked. This project cannot definitively define what the relevant Irish authorities should do in fine detail to change its arrangements for speed limits. It has identified a number of clear recommendations and also technical and process-based areas that need particular consideration to support this process together with identifying how a range of European authorities have managed the process. This will serve as a strong basis for the Irish Authorities involved to plan how they will achieve implementation. This project has been conducted with a focus on what impacts a Safe System approach requires for the management for speed limits and impacts on the actual speeds that drivers adopt.

The work has been undertaken in response to High Impact Action No. 6 of the Safe System priority intervention area: safe speeds within the Irish Government's Road Safety Strategy 2021 to 2030 which seeks to "*Establish a working group to examine and review the framework for the setting of speed limits. As part of this review there will be a specific consideration of the introduction of a 30kph default speed limit in urban areas.*" The work has also considered the processes in relation to Irelands new safety strategy and the relevant Safety Performance Indicators e.g. SPI5 "*% of vehicles travelling within the speed limit by road and vehicle type –*

Road and vehicle types to be specified" which will be a measure of the success of any processes established as a result of this research in relation to setting and managing speed limits.

Organising the report output for this project has been challenging due to the underlying complexity of the interlinked technical and process/organisational areas. To give more clarity to this summary, a framework has been developed which divides the main aspects into a number of main subjects. The high-level framework is shown in **Figure 1**.

The over-all process has been separated into 1) Technical development, which encompasses the work and task required to develop the framework for making changes and 2) Implementation processes, which encompasses the more process or organisational provisions to achieve the desired changes.

This project has identified a number of key recommendations and aspects that need to be developed to support the speed limit change process.

The technical elements are complex and require the development of guiding principles, led by technical committees and specific projects. The technical aspects are further expanded into more detailed areas in **Figure 2**

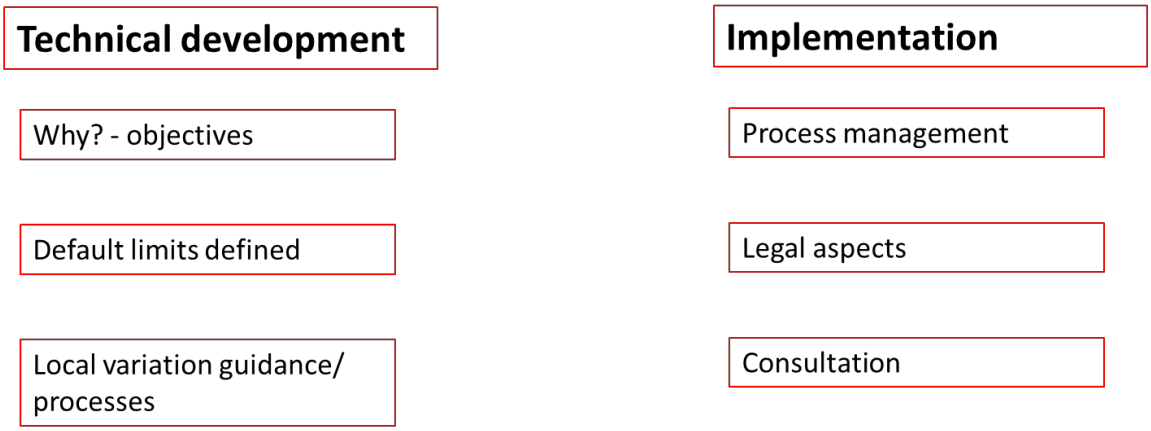

Figure 1: High level speed limit management areas

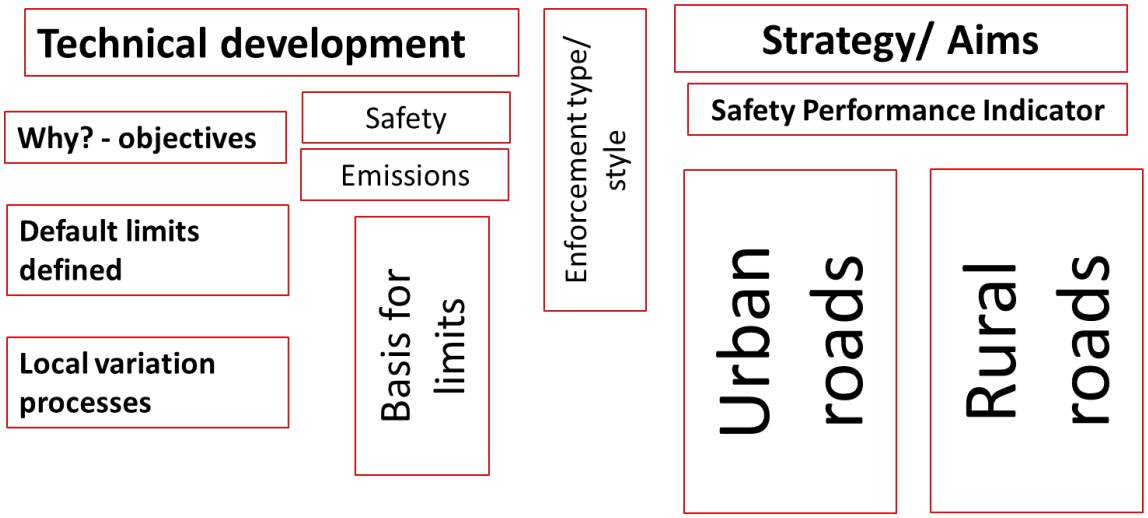

Figure 2: Expansion of technical aspects to wider considerations

An indication of the complexity of just some of the interdependencies between the different technical aspects of speed limit framework development is shown in

Figure 3. Basing the approach to speed limit setting on Safe Systems lines has a fundamental impact on how the development is framed.

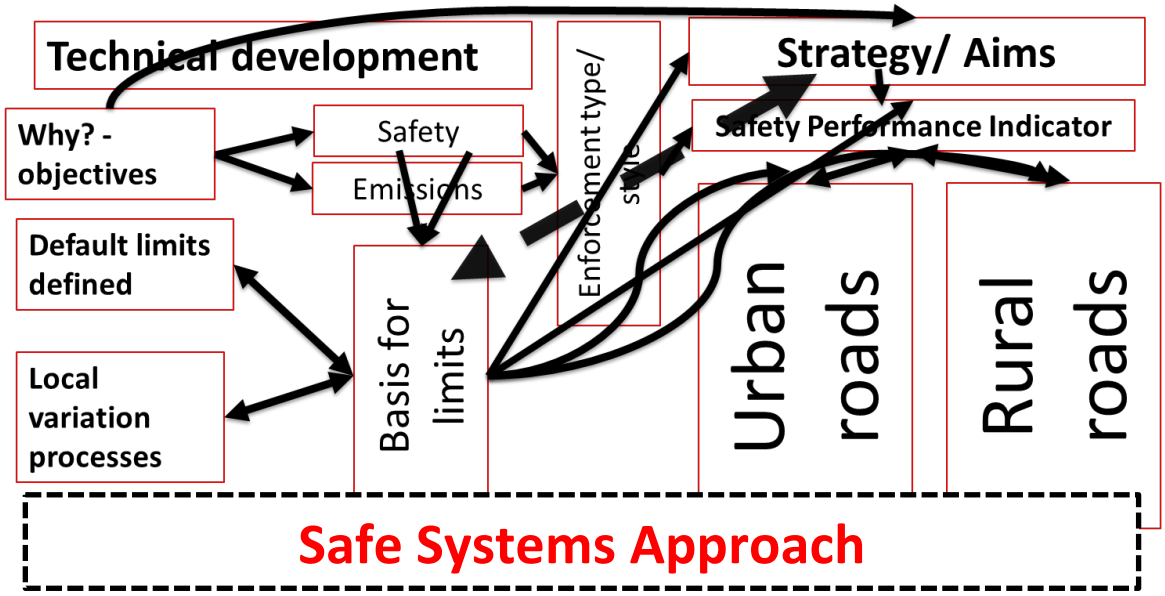

Figure 3: Interlinkages between technical aspects of speed limit framework development

The following sections summarise the main recommendations and fundamental observations[1] systematically. It starts with an over-view with the processes reflecting and explaining the complexity and the inter-relations between the technical areas that need to be prepared that have been identified by the study. The supporting evidence for these points and observations are given; this came from 1) the literature review that was conducted, 2) the consultation exercise and 3) additional expert knowledge from the project team, 4) additional review of specific papers following client feedback on the first draft.

A format has been developed to make the information being imparted and the supporting evidence as clear as possible.

1.2 Overview of technical approaches required

As indicated this section summarises key technical tasks that are required to prepare for changing speed limits. Again as indicated this is complex because a range of the decisions

[1] Aspects that need particular consideration in the framework

made will have fundamental knock-on effects and implications for other technical tasks but also for the more organisational activities.

The impacts of changing speeds and speed limits are impacted fundamentally by adopting a Safe Systems approach. The implications of this, which is the situation for the client, are indicated.

1.2.1 Why? / objectives

Major Point 1: It is important that the Irish technical stakeholders to be clear on the detailed motivations for changing speed limits, and the results of this that are required

At a simplistic and high level this would obviously primarily be to reduce the number of KSIs occurring across the road system. This needs to contribute to the over-all KSI reduction target and fit with the associated SPI i.e. % of vehicles travelling within the speed limit.

Related Point 1a: There is most evidence that enhanced safety is the key benefit that can be expected from changing traffic speeds (which speed limit changes assist with and can support).

Evidence base: Speed impacts on safety

- Work by (Wramborg, 2005)and TRL (Quimby *et al.*, 1999):, developed further by Elvik e.g. (Elvik, 2019)a (Elvik *et al.*, 2019)b has quantified the benefits in crashes and casualty reductions resulting from specified changes in mean traffic speeds.
- Reviews by (Davis, 2018) and TfL 2018 of the impacts of changing lower urban speed limits report safety as the main and most evidenced benefit.

- **Related Point 1b: Reductions in emissions are frequently quoted as a motivation for managing traffic speeds. There is far less clear evidence for this compared with the safety case.**
    - The impacts on emissions seem to be most pertinent in urbans settings where more pedestrians/ cyclists are likely to be subjected to high levels of emissions
        - Reductions in braking and accelerating achieved by smoother traffic flow (resulting from lower urban speed limits) will likely benefit particulate emission which are the current key concern to health
        - NO_x levels emitted from modern vehicle engines are far lower than for older models – this is the main reason for this being less of a consideration.
    - The benefits for emissions from reducing traffic speed on rural, higher flows are less clear and evidenced (Folgerø *et al.*, 2020))
    - There was no clear mention of benefits to, or evidence identified for, Carbon emission of reducing speeds in urban areas – likely because vehicle engines are inefficient at lower speeds
    - Most environmental benefits in London are expected from change of journey choices to active travel modes - particularly to cycling (but also walking) – but

this has been/ should be accompanied by major investment in bicycling facilities

- **Related Point 1c: The client needs to consider that the cheaper option - changes solely to limits only - will achieve far less actual reduction in traffic speed than reductions supported by traffic calming and enforcement in urban areas and enforcement in rural areas (with higher existing speeds).**
    - This will impact achievement of the related indicator i.e. SPI5 - % of vehicles travelling within the speed limit - and more importantly the level of reductions in KSIs that will be achieved.
        - Limit changes alone will achieve far lower actual speed reduction than for example 'zones' in urban areas, where there is additional investment in accompanying calming and enforcement (Davis 2018, TfL 2018).

    - This estimate for the expected impact of traffic speed changes should fit with similar approaches to all other SPIs in the strategy and in total their impact should be calculated to achieve the longer-term over-all KSI reduction aim.

Evidence base: Safe System Speed Limits

IMPACT SPEEDS ABOVE WHICH CHANCES OF SURVIVAL DECREASE RAPIDLY		
Crash Type	Impact Speed	Example
Car/Pedestrian or Cyclist Car/motorcyclist	30 km/h	Where there is a mix of vulnerable road users and motor vehicle traffic..
Car/Pole or Tree	40 km/h	Where unprotected road hazards exist within defined clear zone.
Car/Car (Side impact)	50 km/h	Where there is a likelihood of side impact crashes (eg, intersections or access points).
Car/Car (Head-on)	70 km/h	Where there is no separation between opposing traffic streams

'Safe System' – the key to managing road safety, Transport and Roads Authority, New South Wales,

https://roads-waterways.transport.nsw.gov.au/saferroadsnsw/safe-system.pdf

Crash type	Safe Speed, km/h
VRUs present	30
Hi risk road sides	50
Side impact risk	60
Head on risk	80
Other roads	> 80

Safe speed limits for a safe system: The relationship between speed limit and fatal crash rate for different crash types (Doecke, 2018).

- This source is less severe for suggested Safe System limits for given collision situations

1.2.2 Default limits defined

Major Point 2: *SAFE SYSTEM IMPACT* – The survivability of different road user types in the possible main collision types that can occur subject to the present road features should define the speed limits and traffic speeds on roads

Related Point 2a:

Additional related issues:

- Changing speed limits alone has very different impacts on traffic speeds compared with changes re-enforced by traffic calming and enforcement (e.g. see zones vs limits comments, - summarised for UK by Davis 2018).
- Intermediate urban roads (with higher flows/ existing speeds than streets) are problematic – if there is any reasonable presence of vulnerable road users then these should be set to a 30km/h limit in line with Safe Systems guidance (Consultant experience and consideration of what Safe Systems implies)
- More people speed proportionally on lower limit urban roads than generally do on undivided rural roads which have higher limits (Consultant experience from analysis of the English Strategic Road Network)
- Changing urban speed limits from 40 km/h to 30 km/h is more acceptable and understood by drivers than changing rural speed limits to the levels recommended by Safe System guidance (Consultant experience and consideration of what Safe Systems implies)
    - Where there are roadside risks on rural roads the limits should be 30 km/h or 40 km/h, these might be 80km/h at present. This is a challenging change

Evidence base: Safe System limits on rural roads with roadside risks

- Related evidence – impact on implementation: Swedish and Spanish interviewees indicated that they did not change speed limits on rural roads with roadside risks present down to the Safe System recommended levels because these were deemed to be unacceptably low for drivers (lacking credibility)

Related Point 2b: Frameworks for setting limits

A range of the models used by leading Safe System countries were reviewed. These are used at the network and section level to identify the speed limit that should be in place.

The general conclusion was that the methods developed require significant data to be collected. The models developed were generally complex. The models they have developed would need to be calibrated for Ireland's road network. There was still a heavy emphasis on staff judgement to set localised speed limits in all cases, despite the information supplied by the complex algorithms.

TRL developed a simpler approach for National Highways that could be adapted for use in Ireland. This method is Safe System based and (only) requires:

- The road hierarchy level and the desired operational speed relating to road function:
    - As already assigned or defined or
    - Simple definitions based on road flow, some cross section features and environment (rural vs urban)
- The existing speed limit
- The traffic mean and 85th percentile speeds
- Safe System 'safe' speed - which relates to the crash types that can occur. This is assigned based on relatively simple road features present:
    - VRU presence/ flows
    - Junction types present – possibility of side impact crashes if not grade separated or roundabouts
    - Roadside severity risk – relating to run off crash risk (TII have collated this as an index on the trunk network)
    - Whether the road is divided or not – which influences if head-on collisions can occur.

When all these speed metrics are aligned then the speed limit is likely to be appropriate from a safe systems point of view. However, if the speeds are out of alignment then speed management through limit changes and enforcement and/or engineering upgrades will be required.

1.3 Implementation

Evidence of (operationally) how new approaches to speed limits was implemented came primarily from the stakeholder interviews. This was because the details of the implementation approaches were far less likely to be published in academic journals or grey literature.

1.3.1 Process management

The stakeholders interviewed noted that the process for setting and managing speed limits was typically separated into two main aspects – 1) setting the national speed limit, and 2) some leeway for local governments to adapt speed limits in response to localised aspects of the roads:

All the stakeholders interviewed mentioned that the central government set regulations defining speed limits based on a range of aspects. The range was:

- Assessment of the number of amenities (i.e. shops) (e.g. Wales).
- Using the safe system approach (e.g. Sweden).
- Assessing roads main features (e.g. France).
- Adopting standards from other countries (e.g. Belgium copying the Netherlands' standards).

The speed limits at the local government level could generally be lowered for the following reasons:

- If a high number of accidents or deaths occurred on a road (e.g. Spain).
- If a road had a tight bend or intersection (e.g. Sweden).

In some countries the local government could choose roads where the speed limit was not reduced in line with national guidance, or to increase the speed limit on certain roads:

- In Wales local governments could choose roads that were exceptions to the new reduced speed limit (typically due to them being arterial roads away from vulnerable road users).
- As a consequence to the French 'Yellow Jacket' protests, French local governments could choose to increase the speed of a road within their area from 80 km/h to 90 km/h.

1.3.2 Legal aspects

Stakeholders told us that changes to the speed limit first need to be created as a proposal. This proposal then needed to be agreed by a number of stakeholder groups:

- In Spain any cases created by the minister of the interior need to be approved by the council of ministers before it becomes legislation.
- In the Netherlands, stakeholders have six weeks to put forward any objections to proposals to change the speed limit; the government then reviews these objections and can 1) accept (i.e. if it is a valid reason) or 2) reject (i.e. if the reasons given are not deemed relevant).
- In Denmark, the police must agree to any changes to legislation before any changes to the speed limit can occur.

1.3.3 Consultation

As mentioned above, many of the interviewees noted that consultation with key stakeholders was vital to allow any changes to the speed limit to be implemented. In particular, the following key information was noted:

- The most important stakeholders were the emergency services, in particular the police, as altering the speed limit would likely affect the number of people violating the speed limits. In some countries (e.g. Denmark) the police ratify any changes to the speed limit.
    - Physical traffic calming measures introduced to support a lowered speed limit also needed to be considered as it is argued that these could slow down ambulances and fire engines.
- Other key stakeholders included the local councils, academics, road authorities and local residents.

It is important to get the stakeholders onside from an early stage of the process (the interviewee from Wales particularly mentioned this), in order to ensure that the process is as smooth as possible. A few stakeholders suggested that a good way of doing this was to ask stakeholders to raise concerns and communicate how these fears would be alleviated.

- In some countries there could be a lot of opposition (e.g. in France, where the Yellow Jacket protests occurred partly due to a reduction in speed limit) but in others (e.g. Belgium) there was a limited amount of opposition from Stakeholders.

1.3.4 Evaluation

Evaluation of the change: Current evidence shows a strong causal link between speed limit and road safety. However, greater efforts to conduct follow-up evaluations should be considered in order to further understand the extent of these effects, as well as the effect on other factors. In particular, the following should be assessed both before and after any speed limit changes:

- Traffic speeds (mean and 85th percentiles) should be sampled in the before and after periods at levels which can be statistically tested. This should be linked to a Safety performance Indicator developed in line with safe System best practice
- Safety – KSIs numbers should be monitored but also statistically assessed by a robust approach (such as Empirical Bayes) which takes account of confounding factors such as changes in traffic flows
- Compliance – If road users adhere to the speed limit, and how much they slow down due to the lowered speed limits.
    - The impact of enforcement or engineering changes made at the same time as changing limits should be evaluated compared to changes achieved by changing signs only.
    - Variable Speed Management might be considered on higher flow motorways where the installation of the required technology might be economically viable
    - Economic – monetary value due to saved casualties/collisions, or potentially more even flow (which might improve journey time reliability rather than increasing commutes).
    - Environmental – less pollutants can be emitted per km travelled at certain speeds (where the engine is most efficient). If this is produced as a model, then it could be tailored around the countries' environmental targets to understand how different traffic speeds may assist.

  These evaluations should be run for a consistent amount of time and tailored around the network and countries features, in order to reduce potential confounding variables (i.e. traffic flow) as much as possible.

2 Short Executive Summary

Speeding is a key factor in road crash occurrence and injury generation; importantly for the Safe System approach it has a greater influence on the most serious outcomes. Setting safe speed limits and related management of traffic speeds is therefore a vital approach to improve road safety. This project has identified international best practices and the recommended approaches for managing the processes for achieving changes to speed limits. This work also investigated the benefits, risks and challenges of changing speed limits. The project has been conducted in the context of Action 6 of the government Road Safety Strategy 2021-2030. .

The study had two main approaches:

- A literature review to identify available information on how countries have changed speed limits and also the resulting impact of the changes.
- Stakeholder interviews, these focussed on speaking to organisations in countries that have changed speed limits recently; the aim was to understand in depth the steps taken to achieved changes, the outcome and the aspects that worked and that did not.

Improving road safety was the key motivation to reducing speed limits. The Safe System approach was the basis for this in many cases, so the aim was to make limits (particularly in urban areas) more survivable. Countries that follow Safe System applied a clear road hierarchy to define the roads' functions. This has consequences for the safety standard of the infrastructure and road users present, which impact speed limit setting.

Managing speed limits was also identified to 1) potentially reduce carbon emissions and pollution, 2) encourage drivers to adopt alternative forms of transport, and 3) to make cities and communities more liveable.

Central government tended to set default speed limits in relation to defined road types, but generally local government can vary these limits on sections of the road where localised factors warrant this on safety grounds.

The evidence reviewed indicated that a decrease in the speed limit leads to a reduction in traffic speeds, but this is not always to the full extent of the change. Reductions to speed limits were found to be associated with reductions in road injuries and fatalities, although the evaluation approaches tended not to be statistically robust. There was evidence indicating that a speed limit decrease does have economic benefits resulting from avoided crashes and injuries. Small increases in journey times were identified which is an economic cost. There was little firm evidence on the environmental benefits.

Recommendations to achieve changes to (primarily national) speed limits were made. The safety case for this needs to be assessed. A functional hierarchy of roads is recommended. Safe System recommended speeds should be implemented, or where the safe limit is challengingly low, posted speeds should be lowered as far as is acceptable towards these values. Compliance to the new limits can require enforcement and/or engineering changes. Organisations leading the process must communicate early and clearly with relevant stakeholders (particularly police/emergency services, local government and the general public). Persuading road users of the benefits of reduced limits is desirable rather than relying completely on harder measures such as strong enforcement or engineering.

A clear evaluation plan to assess impacts should be in place. Two countries that exhibited a range of aspects of best practice (Sweden and France), their approaches were summarised.

3 Introduction

3.1 Background

According to the World Health Organisation's "Global Status Report on Road Safety", the number of people killed in road crashes reached 1.35 million in 2016 (World Health Organization, 2017). Although in Europe the number of road deaths decreased by 43% between 2001 and 2010, and by 21% between 2010 and 2018, 25,150 deaths were recorded in Europe in 2018 and about 135,000 were seriously injured. Furthermore, speeding is a key factor in around 30% of fatal road crashes and is an aggravating factor in most crashes (European Commission, 2019).

What makes managing speed particularly important is that relatively small changes in mean traffic speeds lead to disproportionately larger changes in the number of crashes occurring and also the severity of resulting injuries. This works in both directions as any increases in traffic speed result in far worse safety levels (without changing any other aspects of the road system), whereas achieving even modest reductions in traffic operational speeds results in large reductions. This effect is more marked for higher severity road casualties and fatalities.

There are two main effects of speed. At higher speeds the distance covered during the reaction time and also the braking distance increases. Put simply, it is far harder to stop in time in an emergency situation at higher speeds (World Health Organization, 2017). This leads to more crashes occurring. Compounding this is that the energy and related thrust[2] in crashes are both proportional to V^2 (the speed squared). This is why increasing speed by a small amount increases the severity of injuries much more greatly. When the likelihood and injury aspects are brought together, the relationship between speed has a four-power relationship with the increase in road fatalities (Institute for Road Safety, 2012).

This extremely strong and fundamental relationship between speed and injuries has led to the management of traffic speeds being at the heart of the Safe Systems approach. This road safety framework, (advocated by those countries/organisations most serious about reducing road casualties) aims to manage energy in crashes to levels below that which will result in death or serious injuries; managing speed is a fundamental way to achieve this.

In 2019, the European Commission adopted novel approaches to European Union (EU) road safety for the years 2021-2030, reaffirming its intention to reduce road deaths and serious injuries by 50% by 2030 (European Commission, 2019). In terms of speed limits, the European Commission encouraged the Member States to:

- Draw up a road classification framework (hierarchy) that matches speed limit to road design and layout.
- Support cities in setting up speed limit databases and promote the deployment of intelligent speed assistance technology.

[2] It is the thrust in a crash – stopping abruptly – that causes injuries, particularly to the neck/spine.

- Produce a recommendation to apply Safe Speed limits, such as maximum default speeds of 30km/h in residential areas and areas where there are high numbers of cyclists and pedestrians present.
- Prioritise investment in speed enforcement and to apply penalties to deter speeding.

3.2 Objectives

The aim of the project is to evaluate current mechanisms and policies regarding the setting and management of speed limits internationally. This will inform the best approaches to changes to speed limits which may be made in Ireland in response to High Impact Action No. 6 of the Government Road Safety Strategy[3] which requires the establishment of a working group to examine and review the framework for the setting of speed limits. As part of this review there will be a specific consideration of the introduction of a 30kph default speed limit in urban areas. The project also considers the potential safety, environmental and operational benefits, and risks which may arise as a consequence of changing how speed limits are set and managed.

This report gives the results of this study which has evaluated recent mechanisms and policies used for the setting and management of speed limits internationally. This was done to identify potential best practices and effective ways to achieve a speed limit review, which could help such a process conducted for the Republic of Ireland (ROI). The proposed study has two elements:

- A review of the research literature in relation to best practice for setting and management of speed limits; and
- Undertaking of stakeholder interviews on specific countries or cities which have undergone this process recently.

3.3 Method

This section proposes a high-level overview of the methodologies used for the literature review and the stakeholder engagement. Detailed descriptions of the methods for the literature review and the stakeholder engagement are provided in Appendix A , and Appendix B respectively.

3.3.1 Literature review

The first part of the project has undertaken an in-depth literature review to meet the following objectives:

[3] https://www.roadsafety.gov.au/sites/default/files/documents/National-Road-Safety-Strategy-2021-30.pdf

- Understand the policy and legislation areas relevant to the setting and management of speed limits internationally.
- Understand the impacts of decisions to amend speed limit policies, particularly where speed limits have been reduced. This includes identifying the effects of such decisions on the behaviours of drivers (e.g. speed choices) and other road users, road safety, congestion, and the environment.

The literature review followed a systematic approach consisting of two main tasks:

- Definition of:
    - The literature review search terms used, and
    - The inclusion criteria applied to identify which studies to review, which was based on their relevance and quality.
- Literature search and review – the papers retrieved by the search terms (from Google Scholar and TRID databases) were first scored against the inclusion criteria. The most relevant papers were then fully reviewed and the relevant information was collected into a spreadsheet.

3.3.2 Stakeholder engagement

The second part of the project interviewed 10 stakeholders in countries that had recently changed speed limits on either urban or rural roads. We conducted these interviews to:

- Undertake an investigation of the existing legislative context.
- Understand current practices for setting speed limits.
- Evaluate the wider implications of reducing speed limits.

Stakeholders were selected according to defined criteria:

- Countries where rural and urban speed limits have recently reduced.
- Countries where there has been widespread adoption of 30 km/h zones on urban roads where vulnerable road users are present.
- Countries where road safety policies are influenced by the Safe System approach.

One to one consultation was conducted with personnel from the selected countries, and a topic guide was developed prior to consultation in order make the questions asked more consistent.

The information collected was then synthesised and analysed. Summaries were created for each city or country's approach to setting and managing speed limits. The following subject areas were a focus for the analysis:

- Structure and mechanisms in place for setting and managing speed limits.
- To what extent Safe System principles influenced the setting and management of speed limits, and how these were applied.

- Results of changing speed limits and what the wider impacts were.

4 Results

4.1 Literature Review findings

This section presents the main findings from the literature review structured around the key objectives of the project. Section 4.1.1 outlines the findings related to the speed policy and legislation. Section 4.1.2 outlines the findings related to the effects of the implementation of the speed limit policy, with focus on road safety and economic and environmental impacts. Section 4.1.3 outlines a range of methods for setting the speed limit.

4.1.1 Speed limit policies and legislation

Table 1 sets out speed limit policies in place in several European and non-European countries. For each country, main speed limits by road type are indicated. Table 2, outlines the approval procedures and changes to the legislation for each country consulted during the stakeholder engagement.

Table 1. Speed Limit policies

	Ireland[4]	Italy[5]	England[6]	France[7]	Spain[8]	Norway	Wales[9]	Denmark [10]	Sweden[11]	Austria [12]	Netherlands [13]	Belgium [14]	New Zealand [15]
Town and city speed limits	50km/h	50km/h	30mph (50km/h)	50km/h	50km/h	50km/h	30mph (50km/h)	50km/h	50km/h	50km/h	50km/h	50km/h – 70km/h	30km/h – 50km/h
National road speed limits	100km/h	110km/h	70mph (110km/h)	110km/h	100km/h	90km/h	60mph (95km/h)	80km/h	100km/h	100km/h	100km/h	90km/h	80km/h – 100km/h
Regional and local road speed limits	80km/h	90km/h	60mph (95km/h)	80km/h	80km/h	80km/h	60mph (95km/h)	80km/h	70km/h	100km/h	80km/h	70km/h	60km/h – 80km/h
Motorway speed limits	120km/h	130km/h	70mph (110km/h)	130km/h	120km/h	100km/h	70mph (110km/h)	110km/h – 130km/h	110km/h	130km/h	100km/h – 130km/h	120km/h	100km/h – 110km/h
Special speed limits (e.g. urban streets)	30km/h	30km/h – 50km/h	20mph – 30mph (30km/h - 50km/h)	30km/h – 50km/h	10km/h – 30km/h	30km/h	20mph (30km/h)	40km/h	30km/h	30km/h	30km/h	30km/h	10km/h – 30km/h

[4] https://www.rsa.ie/docs/default-source/se rvices/s1.8-learner-driver-resources/rules-of-the-road-.pdf?sfvrsn=6d948b39_34
[5] https://www.aci.it/i-servizi/normative/codice-della-strada.html
[6] https://www.gov.uk/government/publications/setting-local-speed-limits/setting-local-speed-limits#:~:text=The%20three%20national%20speed%20limits,on%20dual%20carriageways%20and%20motorways
[7] https://www.gouvernement.fr/sites/default/files/document/document/2018/01/dossier_de_presse_-_comite_interministeriel_de_la_securite_routiere_-_mardi_9_janvier_2018.pdf
[8] https://www.boe.es/buscar/doc.php?id=BOE-A-2018-18002
[9] https://gov.wales/sites/default/files/publications/2017-10/setting-local-speed-limits-in-wales.pdf
[10] https://www.retsinformation.dk/eli/lta/2005/1079
[11] https://www.rac.co.uk/drive/travel/country/sweden/
[12] https://www.oesterreich.gv.at/en/themen/freizeit_und_strassenverkehr/kfz/10/Seite.063300.html
[13] https://www.universiteitleiden.nl/binaries/content/assets/customsites/study-abroad-exchange-students/road_traffic_signs_and_regulations_jan_2013_uk.pdf
[14] https://ec.europa.eu/transport/road_safety/going_abroad/belgium/speed_limits_en.htm
[15] https://www.nzta.govt.nz/roadcode/heavy-vehicle-road-code/road-code/about-limits/speed-limits/

Table 2. Procedures and Changes to Legislation

Country	Procedure for approval	Changes to legislation
Ireland	Minister of Transport sets speed limits. Local council can set up special speed limits.	
England	Default speed limits are in place according to the broad road features (e.g. divided, undivided, and urban, rural). Local speed limits are determined by traffic authorities having regard to guidance issued by the Department for Transport.	
France	La Comité interministériel de Sécurité Routière (CISR) sets speed limits – Local authorities can set 80 or 90km/h limit.	The French Inter-ministerial committee for road safety of 9 January 2018 proposed to: • Reduce speed limits from 90km/h to 80km/h on two-way rural roads with no central carriageway divider. • Proceed with license suspension for excess speed of 40km/h above limit. Presidents of the County Council, presidents of intermunicipal associations can raise the speed limit to 90km/h. Any section of rural road with a pedestrian crossing present must be reduced to 70km/h.
Spain	Direction General de Trafico (DGT) - following a proposal from the Minister of the Interior, dependent upon Council of Ministers approval.	In 2019, speed limits on rural roads was reduced from 100km/h to 90km/h. In 2021, on urban roads, 3 default speed limits were introduced (20,30, and 50km/h) to be lowered by the local authorities dependent upon the number of Killed and Seriously Injured (KSI).
Wales	Welsh Government set rules on speed limits for national roads and guidelines for local authorities. It is then up to the local authorities to apply the guidelines in their network.	In 2021 Welsh Government published guidelines to reduce speed limits on restricted road from 30mph to 20mph. In 2021, a trial reducing the speed limit from 70mph to 50mph in 5 locations on the motorway was initiated.

		Guidance introduced suggesting that any roads in the vicinity of schools or hospitals should be reduced to 20mph.
Denmark	Ministry of Transport - Local authorities and municipalities propose new speed limits, then these are approved by the police.	Ministry of Transport on 6th January 2022, allowed 16 municipalities to lower local speed limits from 50km/h to 40km/h on selected road sections in urban areas. Trial in 2017 increasing speed limits from 80 to 90km/h on some rural roads and from 110km/h to 130km/h on motorways.
Sweden	Sweden Transport Administration (STA) in charge of national speed limits. Local authorities set limits for urban areas. Regions can reduce the STA limit in critical sections of the road (e.g., tight bend, intersection).	From 2010, the following speed limit reductions were introduced: • From 90km/h to 80km/h. • From 70km/h to 60km/h. • From 50km/h to 40km/h.
The Netherlands	Four road authorities: national government (Rijkswaterstaat; RWS, in charge of highways), municipalities (they set speed limits within their area), provinces, water authority. National government sets guidelines on roads design, speed limits, parking, cycling, regulations, to help municipalities. Local road authorities have the freedom to decide on their speed limits and implementations. Prior to approval, stakeholders have 6 weeks to object to proposed plans.	In 2020, speed limits were reduced from 130km/h to 100km/h on motorways. Between 7:00 p.m. and 6:00 a.m., drivers can increase their speed to 130km/h on designated sections of the road. 70% of urban roads are now 30km/h.
Belgium	Belgium/Flanders Ministry of Transport sets overall speed limits or defines guidelines. Then responsibility is delegated to: • Regional administration for regional roads. • Local government for local roads.	In 2017, the Northern Belgian region of Flanders reduced the default speed limit on roads outside built-up areas from 90km/h from 70km/h.
New Zealand	Road Controlling Authority (RCA) may set a speed limit for a road under its control (other than a temporary speed limit).	Setting the speed limit, April 2022:

	Agency (as RCA) or a territorial authority may set a speed limit. For a road under its control only with the Director's approval and after following the public consultation.	• Encouraging a reduced speed limit of 100km/h (where previously set to 110km/h) for undivided roads. • 30km/h speed limit around schools. • A more effective process to select and set speed limits. • Greater regional consistency, both in process and in transport outcomes. • Greater alignment of all parties involved.

4.1.2 Impact of policy decisions

The literature review identified some recurrent themes related to the reduction of speed limits. These were the areas of road injuries and economic and environmental impacts. These are discussed separately in the following sections.

4.1.2.1 Road Injuries

Road injuries and fatalities are major factors which are impacted by traffic speed (see Introduction). The most recent literature has focused on identifying the potential benefits of reducing the speed limit in relation to road safety benefits. A review assessing motor vehicle impact speed and pedestrian fatality or injury for several different countries (e.g., UK, Germany, China, US, Japan) suggested that an impact speed of 30km/h has a fatality risk of around 5%. The risk increases to 13% for an impact speed of 40km/h and 29% at 50km/h (Hussain *et al.*, 2019). This is the reason that urban streets should have a speed limit of 30km/h under the Safe System principles.

Some examples of studies assessing the effect of speed limit reduction on road safety are reported below.

USA – Urban and rural

In 1995 in the US, the National Highway System Designation Act devolved powers to individual states to set their own speed limits (104th Congress, 1995). This empowered many states to raise speed limits from 105km/h to 113km/h or higher on both rural and urban interstate roads. By the end of 2015, the maximum speed limit was 120km/h in 10 states, 130km/h in 6 states, and 137km/h in 1 state (Insurance Institute for Highway Safety, 2015). In 2019, a meta-analysis assessed the effects of increasing speed limits on traffic fatalities in the US (Castillo-Manzano *et al.*, 2019). This was conducted following the international PRISMA (Preferred Reporting Items of Systematic reviews and Meta-Analysis) and QUORUM (Quality Of Reporting Of Meta-analyses) protocols established for both systematic reviews and meta-analysis studies (Moher *et al.*, 2010). Filters for the selection of the relevant papers were applied based on geographical location, increased speed limits studied, roads studied, control variables, measurement of outcome, methodology used, result of the experiment, sample size, and accuracy of measures. The selection led to a sample of 17 papers that were separated into two subject areas: rural interstate roads and state-wide (e.g. the entire road network). Results from the meta-analysis reported that traffic fatalities went up on both types of roads, although the effect was greater on rural interstates. This could suggest that a possible reduction in fatalities was occurring on roads where the limits were not increased. However, the authors stated that the hypothesis could not be tested as it was not possible to perform a separate meta-analysis only for roads where speed limits were not raised due to the lack of suitable estimates from primary studies.

Canada - Rural

In 2014, the British Columbia (BC) Ministry of Transportation and Infrastructure (MoTI) increased speed limits on 1,300 km of provincial rural highways from 110km/h to 120km/h stating that the goal was to improve road safety by reducing speed variance (Shaw, 2014). A

follow up evaluation of the speed limit implementation was conducted in 2018 (Brubacher *et al.*, 2018). Data assessed included:

- Motor Vehicle Crash (MVC) fatalities from police reports, including location (2000–2015)
- Automobile insurance claims, including date and location of crash, crash configuration, crashes involving vulnerable road users, and crashes involving a heavy vehicle. (2000–2016)
- Ambulance call dispatch numbers to crashes, compared to non-MVC trauma events (2004–2016)
- Gasoline sales (2009–2016)
- Vehicle speed travel data from permanent count stations (2005–2016)

GIS coordinates were used to map crashes and ambulance dispatches onto relevant road segments, defined by the BC Ministry of Transportation. For insurance claims, crash location was reported by the claimant and then converted to GIS coordinates. For each outcome, counts were aggregated by month and converted to rates per 1,000,000 residents. Results showed a statistically significant increase in injury claims (30%), and fatal crashes (118%) on affected road segments.

Canada - Urban

Between January 2015 and December 2016, the city of Toronto (Canada) imposed a reduction from 40km/h to 30km/h speed limit on local roads. This change applied to a total of 850 roadway segments totalling 303.8 km (Levinson King, 2015). A follow-up study compared Pedestrian Motor Vehicle Collisions (PMVC) rates before and after the implementation of the policy (Fridman *et al.*, 2020). A total of 390 roadway segments in the Scarborough District were included as control streets, where the speed limit remained at 40km/h; these totalled 289.5 km. The Toronto Police Service data were used to identify all PMVCs from January 2013 to December 2018. Additional information was obtained from police reports, including pedestrian age, injury severity, and collision location (intersection or midblock), as well as environmental conditions (traffic control devices, visibility, lighting, and road surface). Information on other speed-related co-interventions on local roads included information on senior safety zones, flex-post signs, red light cameras, watch your speed boards, and school safety zone interventions (such as pavement markings, flashing beacons, school signage, and zebra crosswalks). Analysis of the PMVC rates per 100 km per month showed a decrease of 28% (1.99 pre-intervention, 1.43 post intervention), after adjusting for season. In addition, a statistically significant 67% decrease in major and fatal injuries on streets with speed limit reductions was detected. No differences between pre and post intervention were found for the streets where the limit remained at 40km/h. On the other hand, the authors noted that a limitation of this study is that the City of Toronto does not regularly collect vehicle and pedestrian volume data.

France - Rural

In France, after reducing the speed limit from 90km/h to 80km/h on undivided rural roads in 2018, a significant decrease of 8 to 10% in the number of road deaths was found. Conversely, on roads where speed limits were not reduced, a statistically significant increase in the number of deaths (9%) was detected (Cerema, 2020). The crash data were retrieved from the Road traffic accident and injury report (Bulletin d'Analyses d'Accidents Corporels de la Circulation - BAAC). These files are entered by the police for any traffic accident occurring on a road open to public traffic, involving at least one vehicle and resulting in at least one injured person. Crash data was adjusted for seasonality. The comparison between the 80km/h areas and the unchanged network was made using an odds ratio approach, thus returning the percentage change in the death rate on the 80km/h network compared to the rest of the network where speed was unchanged. The odds ratio calculation included the number of deaths on both the 80km/h network (and rest of the network) before and after introducing the new speed limit. However, it should be noted that the authors did not consider the role of any confounding variable in their evaluation.

UK - Urban

In 2019, following the implementation of a 30km/h speed limit on Bristol (UK) urban roads, Bornioli et al. (2020) investigated the effect on the number of urban road injuries. Each injury was coded with its area code, severity, the intervention period (preintervention or postintervention), the speed limit of the road (30mph or 48km/h) and sociodemographic features of the injured people. Both serious and slight injuries were lower after the lower speed limits were introduced, and fatal injuries were reduced by 63%. However, no information on the traffic flow was given.

Overall, the literature discussed here suggests that even a slight reduction in speed could have a significant impact on the reduction of fatalities and serious injuries and that the implementation of reduced speed limits has led to significant improvement on road safety.

4.1.2.2 Economic and environmental impact

Recent literature has also investigated what impact speed limit changes could have on economic and environmental factors.

From an economic perspective, an increase in speed limit seems to result in more losses than benefits. For example, following the increased speed limit on rural highways in British Colombia in 2014, insurance claims numbers rose by 43% on the affected roads, and by 25.7% on nearby road segments (Brubacher *et al.*, 2018).

Following the reduction of the speed limit from 90km/h to 80km/h on undivided rural roads in France, an economic analysis of the impact of such policy was conducted (Cerema, 2020). This analysis reported a positive socio-economic balance of €700 million over one year, broken down as follows:

- Annual monetary loss of between €721 million and €917 million for journey times – for journeys of around 30km, the average increase in journey time was estimated to be 30 to 40 seconds. For journeys of around 80km, the average increase in journey time is around 1 to 2 minutes. The increase in journey time is then estimated to cause

a loss of €721 million in a low traffic flow scenario (220 billion km), and a loss of €917 million in a high traffic scenario (280 billion km).

- Annual monetary gain of €1.2 billion for road safety (considering prevented deaths, hospitalised injuries, and minor injuries).
- Annual monetary gain of between €251 million (low traffic scenario) and €320 million (high traffic scenario) for the fuel saving.
- Annual monetary gain of between €54 million (low traffic scenario) and €65 million (high traffic scenario) related to greenhouse gas emissions.

Interestingly, the monetary loss caused by the lengthening of the journey time is lower than the monetary gain derived from road safety.

From an environmental perspective, previous literature has indicated that there is a positive correlation between speed and both noise and air pollution (ADEME, 2014;ATMO, 2018;van Benthem, 2015). However, research is still reporting contrasting results with evidence for increased pollution with reduced speed limits (Gately *et al.*, 2017;Zhang *et al.*, 2011). For example, the previously mentioned evaluation work on the French speed limit reduction impacts (Cerema, 2020), showed a slight reduction in noise pollution (less than 0.8 dB(A), which is undetectable by the human ear) and an overall decrease in main air pollutants. However, the decrease (from 3% to 4.5%) was too small to be considered statistically significant.

In line with this result, evaluations on the impact of speed limit reduction on local air pollution in Oslo showed that lowering the speed limit from 80km/h to 60km/h had no significant impact (Folgerø *et al.*, 2020).

Overall, the potential economic gain from the reduction of speed limits seems to be driven by road safety. Furthermore, the literature seems to suggest that the environmental impact of reducing the speed limit is relatively small. However, as for the case of France, even a non-statistically significant reduction in air pollution could lead to a cumulative monetary gain, for which speed limit reductions could be partially justified.

4.1.3 Methods for setting the speed limits

The following sections highlight the most recent approaches and methodologies for setting the most appropriate speed limit. This gives an overview of the potential instruments that future policies and legislation could consider for the evaluation and implementation of speed limits.

4.1.3.1 Expert Systems Approach

The Expert Systems Approach is a well-established approach for setting speed limits implemented using software packages that derives speed limit rules on the basis of expert opinion. This method usually requires a wide range of data (speed, crash, traffic flow, and geometric characteristics) to compute the most appropriate speed limit on a limited range of roads (motorways, rural roads, and urban roads). This approach is risk-based, thus considering whether the level of safety provided by the road characteristics are appropriate for the speed

limit and requiring knowledge of the 50th (mean) and 85th percentile traffic speeds for the assessed roads.

An example of this approach is the USLIMITS2 (Federal Highway Administration, 2017) developed by Federal Highway Administration (FHWA). The algorithm is set to propose the most appropriate speed limit on the basis of the type of road and site-specific characteristics, such as:

- Operating speed
- Traffic volume
- Road characteristics (adverse alignment, terrain, access density)
- Number of through lanes, driveways, and traffic signals, the presence of on-street parking
- The extent of pedestrian and bicycle activity
- Whether the section is one-way
- Crash data for at least three years are recommended to be collected

The approach is considered comprehensive, reliable, and consistent. However, it needs to be calibrated for every region or country in order to estimate Safe Speeds. The methodology has been applied in Portugal (Gregório *et al.*, 2016), where it has been adapted to new traffic rules and road information, while network crash data and expert guidance/experience developed an understanding of acceptable risk levels within Europe.

4.1.3.2 Optimisation Approach

The Optimisation Approach (Oppelander, 1962) is focused on establishing the overall economic benefits of operating roads at different speed limits. The approach requires significant research to estimate all the transport costs involved, such as:

- Pollution
- Noise
- Travel time
- Crashes (recovery and value of life)

Furthermore, it is not fully risk-based, as it implies that some level of casualties can be tolerated in economic terms. Therefore, an Optimisation Approach would lead a road authority to change speed limits on the basis of economic reasons. However, Zia et al., (2019) demonstrated that this method actually closely matches the Safe System approach outcomes for speed limits. The reason could be that crashes and casualty costs are a substantial proportion on the total societal costs, as also demonstrated by Cerema (2020) where the greatest economic gain from the reduction of speed limit was driven by road safety.

The model has been tested on the Australian road network (Cameron, 2012), estimating that fatalities and serious injuries would be reduced by 57 and 248 per year respectively. Furthermore, the model suggested that the optimised speed on rural freeways should be 110km/h, while for other divided roads it should be set to 90km/h.

4.1.3.3 Netherlands Safe and Credible Speed Limits (SaCredSpeed)

SaCredSpeed was developed by SWOV (Stichting Wetenschappelijk Onderzoek Verkeersveiligheid, Netherlands) as a safe system approach that uses data available to local authorities in the Netherlands. This approach draws from broad data sources for network traffic information, road characteristics, and knowledge of Safe Speeds which are then fed into the algorithm for calculating Safe Speeds (Aarts *et al.*, 2009). The main characteristics used include the following:

- Road surface type
- Road layout
- Traffic situation (mixed, agricultural vehicles, vulnerable road users)
- Current speed limits
- Existing speed enforcement
- Travelling speed data

Crash data is not considered under the SaCredSpeed approach (they considered that numbers were too low to provide reliable insights).

SaCredSpeed consists of three individual algorithms: evaluation of the Safe Speed versus the speed limit or operating speed (90th percentile by default), evaluation of the credibility of the speed limit from the road layout, and assessment of enforcement needs if operating speed data is available. Three main outputs are then produced:

- An indication of the safety of the speed limit and operational speeds.
- Indication of the credibility of the current speed limit on a road section. This considers issues such as the function of the assessed road network, the layout and speeds of adjacent roads, and the cost-benefit of possible improvement measures.
- A set of physical road changes to achieve improvement of the safety level and the credibility of the speed limit.

4.1.3.4 New Zealand Speed Management Framework

The New Zealand Speed Management Framework was developed as an extension of the 'Safe System Safer Journeys Safer Speeds Programme' action plan (NZ Government: National Road Safety Committee, 2013). The aim was to promote a consistent nationwide approach to setting speed limits, in particular to improve and achieve the following:

- Drive evidence-based changes (so that speed limits are "appropriate for road function, design, safety and use").
- Prioritise high-benefit areas that improve both safety and economic productivity, and areas that contribute to the credibility of speed management.
- Good value for money.
- Build better understanding between road authorities and the public around speed management.

Roads have been separately classified for urban and rural areas, mainly on the basis of the route function (flow, connection, or access). Subsequently, the classification was defined by traffic flow level and the mix of user types. Safe and appropriate speeds were then set out for each of the road categories, these being based on traffic volume and the risk to users from the road geometry/features and road user types. The assessment of the risk from the road environment is based on the Infrastructure Risk Rating (IRR) model, which requires data on eight key road features to be coded:

- Road stereotype (also known as road category).
- Alignment (road geometry).
- Carriageway width.
- Roadside hazards (such as trees, lamp posts, signposts, hedgerows, fencing, etc.).
- Land use.
- Intersection density (the number of intersections on the reviewed road).
- Access density (the number of access routes onto the reviewed road).

The output of the model is a risk rating in five categories (from low to high) for the road assessed.

All the information is computed together, to create the speed management map which identifies parts of the network which will have the "highest benefit opportunities". Ideally the map should identify the most suitable speed limit in several areas of the network depending on the function, design, and traffic on the road. However, areas where the current speeds are too high or too low will be typically identified as areas with a poor road safety performance. These road sections are broken down into; "engineer up", "challenging conversations" or "self-explaining" indicating the type of solutions required to make the roads safe.

All changes implemented to the network are then monitored and evaluated on the basis of previous data collected and follow up evidence, in order to assess the framework's effectiveness and the changes in death and injuries rates.

4.2 Stakeholder Interviews findings

4.2.1 Framework for setting speed limits

Although all the countries that were consulted had specific speed limits for each type of road (e.g. motorway, undivided bidirectional road, urban roads), there were different approaches to how these limits were set:

- **Assessing the function of the road:** In this approach, a country would examine the road's purpose as a guide for what the speed limit should ideally be (i.e. the speed limit for the road should align with the infrastructure of the road and traffic flow levels). For example, arterial roads (a road that is designed for high volumes of vehicles to move longer distances, between various places), which have low numbers of cyclists and vulnerable road users (or none ideally) require high speed limits in order to fulfil that purpose. Furthermore, an absence of bicyclists and vulnerable road users

permit a high-speed limit since it will not endanger these groups. For example, speed limits on motorways in the UK are mostly set at 70mph (112km/h) as these roads are designed for vehicles to travel around the country quickly and VRUs and slower vehicles are banned. Ideally, urban roads are typically designed with cyclists and vulnerable road user safety as a primary consideration. Therefore, urban roads should have low speed limits in order to significantly reduce the risks of death or serious injury to these (vulnerable) road users.

- **Assessing the number of amenities:** In this approach, a country would examine the number of amenities (e.g. schools and shops) around each road to assess the speed limit. For example, Wales has created guidance that suggests that speed limits on any roads close to schools or hospitals should be reduced to 20mph (32km/h), although this is not legally binding. Any pedestrian crossings are also taken into consideration in this approach (for example in France speed limits on any rural roads with a pedestrian crossing must be reduced to 70km/h).
- **Using the Safe Systems approach:** A few countries mentioned that the Safe Systems approach influenced the way that they set speed limits. The Safe Systems approach relates to setting speed limits that are survivable in a collision. According to the Safe Systems approach, the lowest speed that a high proportion of vehicle occupants can survive in a head-on-collision is 80km/h. This drops to 30km/h for a pedestrian in a collision with a car. Therefore, countries such as Sweden use the Safe Systems approach to set speed limits of 80km/h on most undivided roads (where there is no barrier in the middle of the road), and 30km/h for many urban roads which have a significant number of vulnerable road users present.
- **Adopting standards from other countries:** The respondent from Belgium mentioned that they used the framework that the Netherlands has developed (SaCred Speed) for setting speed limits.

While each approach is different, it is important to note that some countries used a combination of two or more approaches. For example, many speed limits in New Zealand are set by assessing the function of the road, identifying the Safe Speed, and what local amenities are close-by.

4.2.2 Centralised or decentralised government

Both the national and local governments had an influence in setting the speed limits within their countries. Whilst the national governments set the guidelines for (default) speed limits for each road type, the local governments from each of the countries we spoke to were able to adjust the speeds on (local) roads under their jurisdiction. Examples of the way local government can alter the speed limits include:

- **High number of killed and seriously injured (KSI) on a certain road:** In Spain, local governments are permitted to reduce the speed limit from 20km/h, 30km/h or 50km/h if the number of KSIs is too high.
- **"Exceptional" features of a road:** In Sweden, local governments are permitted to reduce the speed limit if there is a tight bend present, or at intersections.

- **Local governments suggesting exceptions to the reduced speed limit:** In Wales, the local government can suggest roads that should be exempt from the new 20mph (32km/h) speed limits. Note however that some governments aim to have as few exceptions to the 30km/h rule as possible to promote this process. Similar approaches were noted in New Zealand and the Netherlands.
- **Local governments able to increase the local speed limit:** As a consequence of the French Gillet Jaunes or Yellow Jacket popular protests[16], which sought to promote a popular egalitarian approach on a range of issues, the local governments are permitted to increase some speed limits from 80km/h to 90km/h.

Note that in many countries the only speed limit changes that the local government can make are to decrease the speed limit (for example in the Netherlands).

4.2.3 Process to change the speed limit

Although the major systematic processes to change speed limits typically originated from the national government, the stakeholder from the Netherlands suggested that politics at a local level could pressurise the government to put forward legislation to lower the speed limit. Furthermore, in France the national roads are reviewed every five years. If the posted speeds are not appropriate for the roads, a speed limit change could occur.

Any changes to the speed limit need to be created as a proposal. For example, in Spain the minister of the interior creates a case that needs to be approved by the council of ministers in order for it to go on to become legislation. All of the interviewees that we spoke to told us that any potential change to the speed limit would also need to be agreed by stakeholders within their own country. These stakeholders included, but were not limited to:

- **The police:** Decreasing (or increasing) the speed limit would lead to a change in how the police might enforce the new limit. Altering the speed limit could also increase the burden on the police.
- **Other emergency services including the fire department and ambulances:** Decreasing the speed limit would lead to increased speed differentials between the emergency services and other vehicles, and any traffic calming measures could also slow down their ability to reach incidents.
- **Local councils:** Local councils are likely to be more aware of any potential safety or environmental issues with their local roads than the national government, and therefore their input is crucial.
- **Academics and road authorities:** Both academics and road authorities have a good understanding of setting and managing speed limits and can suggest changes as appropriate.
- **Local residents:** People are obviously affected by speed limit changes, therefore getting the support of the local residents is important.

[16] https://www.bbc.co.uk/news/world-europe-46424267

Note that the support of stakeholders (especially the emergency services and local councils) is vital for introducing new speed limits. Stakeholders should be contacted at an early point in the proposal development process. The police were noted as the most important stakeholder, and in some countries (e.g. Denmark) they must consent to any proposed speed limit changes before they can be implemented.

Once the stakeholders have been contacted, the stakeholders typically have time to put forward any opposition to the proposals. For example, in the Netherlands, stakeholders have six weeks to express any objections to the plans. Then the government go through the objections and see if they are relevant. If the proposal passes the stakeholder phase, the local government can go ahead with the speed limit changes and make any changes to the road infrastructure as necessary.

A final step to the process to change the speed limit is to assess how the introduction of the new speed limits affects the road in terms of traffic speeds, safety and the environment. For example, Wales has implemented 20mph (32km/h) speed limits in eight settlements close to schools to evaluate the impact of the change as a pilot.

4.2.4 Reason for changing the speed limit

A wide variety of reasons were raised for lowering the speed limit:

- **Safety:** The only unanimous reason for a speed limit reduction was to increase the level of safety on the road. In particular, the stakeholders from Denmark and Sweden noted how adherence to the Safe Systems approach led to them lowering the speed limit.
- **Environment:** A few stakeholders mentioned that the decrease in speed limit would lead to a decrease in greenhouse gas emissions and pollutants. A reduction in noise pollution was also noted as a positive environmental contribution. For example, the speed limit of five motorways in Wales has been reduced during the day in response to poor air quality.
- **Liveability:** An unexpected finding was that speed limits had been reduced to make urban areas more pleasant to live in. As stated by the stakeholder from New Zealand, a reduction in speed will create areas where people are happier to walk and live.
- **Encouraging other forms of transport:** A few countries had brought in lower speed limits in order to persuade drivers to change to public transport or cycling. Sweden and Wales were the two main countries with a goal to reduce car use.
- **Traffic flow:** The stakeholders in both England and New Zealand both mentioned that reducing the speed limit could lead to a greater flow of traffic for some stretches of road.
- **Adhering to international recommendations:** Countries could choose to change the speed limit based on international guidelines. Spain were the main country that stated this reason.

Note that although some countries (e.g. France) only changed the speed limits for reasons of safety, many countries had brought in lower speed limits for a variety of reasons. Note also

that France, Spain and Sweden could bring in higher speed limits if required. For example, Sweden can implement higher speed limits if the infrastructure is in place to support these new speeds (i.e. if roads had physical separation of carriageways which prevents head-on crashes). Local government presidents in France can also increase the speed limit from 80km/h to 90km/h, to increase a feeling of "freedom" for road users.

4.2.5 Ensuring compliance

Many of the countries used some form of enforcement to ensure compliance with the speed limits. These consisted of speed cameras, speed humps and variable speed limits. For example, the average (operational) speed of traffic has greatly reduced in Belgium after the introduction of average speed checks. Although some drivers went faster than the speed limit at first, the fines received acted to slow many of these drivers down.

On the other hand, some countries had no intention of introducing enforcement measures such as speed cameras. The stakeholder from Spain told us that they did not want speed cameras to be the only reason for drivers to slow down as the drivers could then reject the speed limit. Instead, they wanted to focus on communicating the benefits of driving more slowly, in order to cause meaningful behavioural change. The stakeholder from Wales also communicated a similar message. Furthermore, in England it is deemed bad practice to use speed cameras to "pick up on the shortcomings of the design", and the road speed should therefore match the design and inherent safety level of the road. Therefore, there are two contrasting approaches to speed enforcement in relation to limits.

4.2.6 Opposition/ support for the changes

Most of the countries who had implemented a reduction in the speed limit reported that there was some opposition to the changes. This opposition tended to originate with the following groups:

- **The general public, in particular automobile associations:** In some countries this amounted to organised opposition, for example, in Wales where 60 respondents replied to a survey from the same IP address. The main opposition was that a reduction in speed limit would increase commuting times to a great extent. Many of the stakeholders noted that the actual increase in commuting times was in fact almost negligible (for example in France, where the Yellow Jacket protests took place, a distance of 25 kilometres which decreased from 90km/h to 80km/h would increase commuting times by around one second per kilometre).
- **The police:** A few countries noted that the police had concerns about reducing the speed limits as this would increase the burden on them to detect people breaking the speed limit. In Wales this started off as an opposition point, but then changed to wide support for the changes.
- **Other emergency services:** Fire departments and ambulances in the Netherlands had also expressed concerns about reducing the speed limit due to the increased speed differential which would result between the emergency services and other road traffic. In addition, the stakeholder from England noted that while increasing traffic calming measures such as speed humps would lead to a reduction in speed for road users, this

would also slow down emergency vehicles. This could therefore increase the time taken to get to injured or sick persons to a hospital, potentially impacting negatively on the ultimate outcome for the patient.

- **Governments or politicians:** The main reason for opposition was a lengthening of commuting times.

On the other hand, some stakeholders felt that there was little or no strong opposition to the proposals (e.g. Belgium). In fact, some countries (Spain for example) had much support for the speed reductions from vulnerable road users and local politicians.

4.2.7 Evaluation of the changes

As the speed limit had only been changed recently in many cases, and as the need for a lengthy period of time to pass to detect changes in casualty numbers had not occurred, some countries had not performed or completed an evaluation. The evaluations that had been conducted on the speed limit changes are described below:

- **Speed changes:** The countries who had conducted traffic speed assessments typically found that whilst the traffic speed would reduce due to a reduced speed limit, the traffic would not always amend their speed to be fully in accordance with the new speed limit. When the new speed limit of 80km/h came into effect in France, the speed limit reduced by 10km/h whilst the average traffic speed reduced by 4km/h. On the other hand, when the speed limit was increased from 110km/h to 130km/h on motorways in Denmark, traffic speeds only increased by between 5km/h to 7km/h. In addition, the presence of shops and vulnerable road users seemed to influence how drivers approached the new speed limit. For example, after the change in speed limit from 50km/h to 30km/h in the Netherlands, the 85th percentile for drivers in areas with many shops was 28km/h (lower that the speed limit of 30km/h). The roads with few shops had 85th percentile traffic speeds of 39km/h however, which was far higher than the speed limit. These findings may indicate that a change in speed limit will alter the traffic speed to some extent. Many drivers may opt for a speed that they feel comfortable with on particular road stretches, in response to visual cues and features.
- **Safety:** Most countries who had initiated a safety assessment found a decrease in the number of KSIs on the roads. For example in France, the stakeholder noted that roads with a drop in speed limit from 90km/h to 80km/h led to a drop in the number of deaths by 16% whilst the roads that kept their speed limit at 90km/h had no decrease in deaths. In Spain there was a 10% drop in fatalities when the speed limit fell from 100km/h to 90km/h. On the other hand, whilst these results suggest that a reduction in speed limits is beneficial for traffic safety, they may need to be treated with caution as the effects of the COVID-19 pandemic may have impacted on the results. The stakeholder from Spain suggested that it is also unclear as to the link between correlation and causation for speed limits and traffic deaths. In addition, although not officially published, the findings from Belgium suggest that there have been no significant changes to the safety of each road. Therefore it may be prudent to carry on assessing the number of KSIs in roads where the speed limits have been reduced, to assess how a lower speed limit affects the safety level of the road.

- **General public perception:** The findings here were mixed. In some countries (e.g. France), there was a shift in the acceptance of speed limit reductions from 90km/h to 80km/h which rose from 30% to 48%. On the other hand, Wales experienced a shift in the acceptance in the opposite direction, with support for 20mph roads in urban environments (32km/h) roads falling from 70% to less than half.
- **Environment and Economy:** None of the stakeholders that we spoke to were aware of any evaluations of the environmental or economic effects of a speed limit reduction. These evaluations should be conducted, especially for the countries that proposed a speed limit reduction in order to reduce the environmental effects, or help the economy.

5 Discussion

This section summarises the findings of both the literature review and stakeholder engagement. It describes how the knowledge from these exercises can be applied to assist with the setting and management of speed limits.

To recap, the aim of the research was to:

- Review the literature to identify the experience of, and best practice for, the setting and management of speed limits.
- Undertake stakeholder interviews targeted on specific countries or cities to understand their policies and approaches to the setting or changing of speed limits.

Findings have been summarised into two key themes, policy and legislative requirements, and impact of speed limit reductions.

5.1 Policy and Legislative Requirements

Both the literature review and the stakeholder engagement showed that many road authorities in high-income countries are changing their attitude toward speed limits for a variety of reasons. Although some countries (e.g. France) have increased some limits, many other countries have decreased speed limits. The main reason for reducing speed limits is related to road safety concerns. However reduced speed limits have also been introduced in order to reduce the negative impacts on the environment, make residential areas more liveable, and to encourage more people to use public transport, cycle or walk.

In general, a mixed approach is used for setting the speed limit, where the national government set a general - or default - set of speed limits for each main road type. Local governments or road agencies can typically amend the speed limits of roads under their jurisdictions; mainly based on safety grounds. Local governments can generally apply only to reduce speed limits although they can occasionally increase the speed limit that are set by the national government.

Stakeholders are almost always involved in the speed limit setting process, and in some cases are required to authorise the speed limit changes (for example the police need to approve any speed limit changes in Denmark). Having stakeholder support is reported to be important in the process to alter the speed limits.

Many of the stakeholders in this project had not seen evidence from robust evaluations of the impacts of changes to the speed limits. This was because the speed changes had only been implemented recently, and evaluations require longer time windows for patterns to develop.

The COVID-19 pandemic (notably lockdowns and longer-term changes in working patterns) have influenced road traffic volumes. Anecdotally this has led to increases in speeding, with lower crash rates but higher severities on average of injuries. These impacts are likely to confound or influence KSIs patterns and environmental and economic factors in the short to medium term.

Correlations were found between crashes/casualty patterns and changes in speed limits. It is tempting to imply causation but without robust statistical analyses this can only be inferred. However, the casual relationship between mean traffic speeds and casualties/crashes is

extremely well established (Elivk, 2018) There are a number of models (power, exponential) which predict the reduction in numbers of crashes/casualties expected (with reasonable accuracy), with changes in mean traffic speed. Safe Systems therefore recommends that a Safety Performance Indicator (SPI) or Intermediate Indicator based on what speed reduction is achieved is used for the short-term evaluation of success of the limit changes. This is recommended precisely because it will take considerable time for reductions in KSI numbers to become apparent. However, none of the interviewees stated that they were taking this approach.

The Safe System approach was reported to be frequently applied by several countries in both the literature review and stakeholder engagement. This finding reaffirms how many countries are focusing on reducing the number of deaths and serious injuries by setting speed limits to a 'Safe Speed'.

5.2 Impact of Speed Limit Reductions

5.2.1 Policy Acceptance

Although the process to change the speed limit typically went smoothly, both the stakeholder engagement and literature review showed that policy acceptance is still an ongoing issue. From the stakeholder engagement, it emerged how the implementation of speed limits are usually a compromise between what is safe and what the road users want. For example, the stakeholder from Sweden noted that they had only reduced the speed limit on rural roads to 80km/h rather than 70km/h; reducing the speed limit further would be "a little bit hard to chew". Although the general public are typically understanding of the speed limit changes, it was noted that they don't always understand how dangerous excess speed can be. The general public were mostly concerned about the lengthening of their journey time, and a restriction on their level of freedom, with this organised opposition mainly coming from automobile associations. There is a hope that attitudinal change can occur however so that people's behaviour towards road speeds will change.

5.2.2 Road Safety

The literature review consistently reported a reduction of fatalities and serious injuries on different types of roads when speed limits were reduced. Although there was less evidence presented during the interviews, the stakeholder consultations found some similar findings. Nevertheless, these studies are not without limitations in the assessment of speed limit changes as there are confounding variables in the evaluation. However, there does seem to be a general trend that areas with a reduced speed limit show an improvement in the level of road safety, and none of the studies found that a decrease in speed limit increases safety risks. Nevertheless, the stakeholders did report that although a decrease in speed limit does correspond with decreased traffic speed, the average traffic speed does not always decrease by the full amount (traffic speeds decreased by between 3km/h - 6km/h for a 10km/h speed limit reduction, though this was location dependent as outlined in Section 4.2.7).

5.2.3 Environmental effects

The environmental effects of reducing the speed limit are still not clear. The literature review reports contrasting evidence of the impact of speed limit on noise and air pollution. This seems to be mainly due to the difficulty in the implementation of a comprehensive evaluation model, capable of addressing several key confounding metrics. None of the stakeholders were aware of any changes in the environment due to a reduction in speed limits.

5.2.4 Compliance

It is likely that it is easier to set the recommended Safe System speed of 30km/h which applies on low flow urban roads (streets) with many vulnerable road users present. However, the pattern in speed in the UK is that most speeding proportionately occurs on urban roads with lower speeds. It may therefore be harder to achieve compliance with 20mph (30km/h) zones and roads if there is no or weak enforcement. This aspect should be investigated further to establish what reductions in speed may realistically be achieved.

In the UK the opposite is true on rural undivided roads (i.e. drivers are more likely to comply with the speed limit) because the default limit (60mph; 95km/h) is generally frequently far too high for the risks present in the road. Drivers typically slow down because the road geometry often limits the reasonable speed they can travel at. However, the Safe System recommended speeds where there are any aggressive objects within 5m of the running lane is 30mph (48km/h) for example which is less likely to be feasible to implement than 20mph (32km/h) on urban streets. Another rural speed setting problem is the presence of significant numbers of bicyclists, which may be encouraged by the low speed limits. This scenario could require a Safe System speed of 30km/h which again may be unpalatable to drivers.

6 Recommendations and Next Steps

This section provides an overview of some good practice and practicable approaches identified for two countries, Sweden and France. These examples give some indications of approaches that could be taken in Ireland.

6.1 Examples

6.1.1 Sweden (setting speed limits)

In accordance with the Safe Systems approach, Sweden identifies the possible crash types which can occur on road types/sections and aims to set the survivable speeds as the speed limits. For example, the survivable speed in a head-on-collision and for a pedestrian hit by a vehicle is 80km/h and 30km/h respectively. Many undivided rural roads (so head on collisions are possible) in Sweden had speed limits of 90km/h. However, after applying the Safe Systems approach, many of these roads have now been altered to 80km/h.

Local governments are also able to reduce these speed limits further in exceptional cases (i.e. for an intersection which can lead to side impact crashes if they are cross roads/ T junction types). The speed limits can also be lowered in order to make local communities more liveable, and to persuade others to take public transport, cycle or walk instead of driving.

Note however that the emphasis is not always to reduce the speed limit to as low as that indicated by Safe Systems approaches. As stated above, the stakeholder from Sweden suggested that setting speed limits too low might be “hard to chew” for the local population, and could cause residents to ignore the speed limit due to these speed limits being perceived as being unreasonable. Therefore, the speed limit is mainly set due to the risk factors present, but also to ensure that road users comply with the limit. Furthermore, if the infrastructure or features of a road suggests that the speed limit could be increased and the road should be safe then the limit could be increased.

6.1.2 France (evaluating the impact of speed limits)

Although the approach to setting speed limits in France was not always fully scientific, they had evaluated many of the impacts of a speed limit change. These included, but were not limited to:

- Change in vehicle speeds.
- KSIs patterns.
- Change in travel time.
- Environmental impacts.
- Public acceptance of speed change.
- Economic impacts.

See Appendix C for a full breakdown of these evaluations.

6.2 Recommendations for Ireland for setting speed limits

A wide variety of advice was suggested by the literature review process, or given by the stakeholders during the discussions. This advice is presented in the general order it should logically be applied in a process to develop proposals to change speed limits:

- **Need for a change:** Research is required identifying why the speed limits should be changed.
- **Functional Hierarchy:** ideally the function of roads should be clearly defined and understood; This gives a target or ideal traffic speed linked to the road's purpose and also has implications for the safety quality of the infrastructure present.
- **Safe Systems:** combined with the target speed the Safe Systems 'safe' or survivable speeds need to be identified. This may be in conflict with the hierarchy target speed, for example, if vulnerable road users are present in a high mobility (arterial) road, and therefore the following may need to be considered:
    - Segregating vulnerable road users in the example above rather than changing the speed limit
    - Improving the safety of the infrastructure present to achieve a better level of risk which is more appropriate for higher speed traffic.
- **Conversation:** Continue liaising with other countries to understand any changes to the policies that they have in place.
- **Consistency:** Ensure that similar roads have similar speed limits (links to having a well-defined hierarchy), and that speed limits do not frequently change over shorter road sections of the same route.
- **Communication:** Communicating these factors to stakeholders and the general public. In particular the effect of speed limits on vulnerable road users should be emphasised. The stakeholders should then be allowed to share their opinions, and raise any concerns. If possible, communication should focus on changing people's perceptions and behaviours, as this can help lead to a better compliance without the need for expensive or heavy-handed enforcement or engineering approaches (which are likely more effective).
- **Support:** Getting support from stakeholders is vital to be able to change the speed limits. In particular getting the police "onside" from an early stage in the proposal development is advisable.
- **Enforcing compliance:** Consider the impact of including measures to enforce the speed limit:
    - If traffic calming measures are used, consider the effect that this could have on the emergency services. Drivers may also drive faster in areas that have no enforcement restrictions.
    - If there are no traffic calming or compliance enforcement measures (i.e. variable speed limits), consider the extra burden that this places on the police to catch anyone breaking the speed limit.

- **Evaluation of the change:** While literature suggests a correlation (and a strong causal link) between speed limit and road safety, a follow up evaluation should be considered in order to further understand all the effects of reducing the speed limit. In particular the following should be assessed both before and after any speed limit change:
    - Traffic speeds (mean and 85th percentiles) should be sampled in the before and after periods at levels which can be statistically tested. This should be linked to a Safety performance Indicator developed in line with safe System best practice
    - Safety – KSIs numbers should be monitored but also statistically assessed by a robust approach (such as Empirical Bayes) which takes account of confounding factors such as changes in traffic flows
    - Compliance – If road users adhere to the speed limit, and how much they slow down due to the lowered speed limits.
        - The impact of enforcement or engineering changes made at the same time as changing limits should be understood compared to changes achieved by changing signs only.
        - Variable Speed Management might be considered on higher flow motorways where the installation of the required technology might be economically viable
    - Economic – monetary value due to saved casualties/collisions, or potentially more even flow (which might improve journey time reliability rather than increasing commutes).
    - Environmental –less carbon dioxide can be emitted per km travelled at certain speeds (where the engine is most efficient). If this is produced as a model then it could be tailored around the countries' environmental targets to understand how different traffic speeds may assist.

These evaluations should be run for a consistent amount of time and tailored around the network and countries features, in order to reduce confounding variables as much as possible.

- **Patience:** Changing speeds limits to the speed that you want can take a while. Do not try to lower the speed limit too quickly, or you will meet much opposition.

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Appendix A Literature review methodology

A list of search terms related to speed limit management was developed based on the review objectives. First level terms targeted the search to focus on speed limit literature. Second level terms further refined the search to the setting and management of speed limits. Third level terms specifically targeted literature relating to outcome variables.

These search terms are shown in Table 3 and were applied systematically within a Google Scholar and TRID database as Boolean search expressions. 'Wild card' searches (using * as a Boolean operator) allowed for variations of a term to be covered in a single search (e.g. 'effect*' generated search results for 'effect', 'effects', 'effecting', 'effective', and 'effectiveness'). This process allowed for the most thorough search possible.

Table 3. Search Terms

1st Level		2nd Level		3rd Level
Traffic		Legislat*		Effect*
Road		Regulat*		Impact*
Speed		Policy		Assess*
Speed Limit(s)		Manag*		Risk*
Speed Restriction		Setting		Benefit*
Safe Speed		System*		Safe*
Reduced Speed		Approach		Accident*
Reducing Speed		Framework*		Crash*
Speed Reduction		Method*		Collision*
Lowering Speed	AND		AND	Hazard*
Lowered Speed				Driver*
Appropriate speed				Congestion*
Speed Variance				Environment*
				Vision Zero
				Death*
				Injur*
				Vulnerable road user*
				Cyclist*
				Pedestrian*

In addition to the terms listed in Table 3, known speed assessment methodologies were considered within the search; in particular, the following methodologies were targeted to understand their impact:

- Expert Systems Approach.
- Optimisation Approach.
- Netherlands Safe and Credible Speed Limits (SaCredSpeed).
- New Zealand Speed Management Framework.

Inclusion Criteria

In order to ensure that only relevant and high-quality literature were included in the review, specific inclusion criteria were used to assess the suitability of identified sources. Each identified piece of literature was scored on relevance and quality (see Table 4). The timeliness of each paper was also considered, with focus being given to research published within the past 5 years.

Table 4. Inclusion criteria for the review of the literature

	Score = 1	Score = 2	Score = 3
Relevance	Not relevant to the objectives of the project	Some indirect relevance to the objectives of the review (e.g. research regarding similar offences, broader research on theory regarding deterrence and how to optimally design penalties)	Directly relevant to the objectives of the review (i.e. research which evaluates the impact of penalties to deter the specific offences)
Quality	Non-scientific article (e.g. online source, newspaper, or magazine article)	Evidence review / case study investigation / non-peer reviewed grey lit	Peer reviewed journal paper Official document – e.g. by a 'DfT' type body on the process Randomised controlled trial / before-after comparison of real-world data

These inclusion criteria were applied two-fold; once during an initial review of abstracts and again during the full-text review. A standard abstraction document was used to collate information collected from the review. This document took the form of a spreadsheet with each identified piece of literature occupying a row and relevant details (e.g. study purpose, study approach, study findings) being summarised in columns. This standardised approach

allowed for a comprehensive summary of all relevant information to be collected in a single place and contributed to a more stream-lined approach to reporting.

An initial search was conducted to obtain a list of 28 titles and abstracts, which were reviewed and scored according to the Inclusion Criteria. A shortlist of 9 high-scoring papers were then identified and full texts sourced for a full review. The findings were grouped where appropriate to aid in structuring the report.

Appendix B Stakeholder engagement methodology

In order to understand how other countries set and manage speed limits, we interviewed stakeholders from countries with similar speed limits to Ireland. The topic guide focused on:

- The countries' approach to setting and managing speed limits.
- The countries' process of changing speed limits, and what obstacles they overcame.
- The effects of the speed limit change (for example if any evaluations had been conducted).

Recruitment and Sampling

Relevant stakeholders were identified who had been influential in lowering the speed limits in either an urban or rural setting, and had confirmed that they would like to be interviewed on the subject. These stakeholders were sent an information sheet and consent form to read through and sign, and then asked to pick a time that they would be free to take part in the interview, which took place over Microsoft Teams. Ten stakeholders completed the consent form and took part in the interview, and these are noted in **Table 5**.

Table 5: Stakeholders interviewed

Country	Number	Role
Belgium	1	Government
Denmark	2	Government
France	1	Public Agency
Netherlands	1	Government
New Zealand	1	Consultancy
Spain	1	Government
Sweden	1	Government
United Kingdom	2	Government

Stakeholder Engagement Method

Interviews were conducted via Microsoft Teams during June 2022 and were recorded with the consent of each participant. Two interviewers were present at each interview. One interviewer asked the questions from the topic guide and probed for responses with supplementary questions. The other interviewer made detailed notes of the interview but were also free to ask questions to clarify their notetaking. Each stakeholder was given a brief reminder of the aim of the project at the start of the interview. With the exception of one interview which was conducted with the two Danish stakeholders (we were advised that this

would help to gain a better understanding of speed limits on the road network), one stakeholder was interviewed during each session. Each interview lasted around an hour.

Appendix C Evaluation of speed limit changes in France

Evaluation	Speeds	Accident rate	Travel time	Environmental impact	Acceptance of the measure	Socio-economic calculation
Results	Reduction in the average speed of all vehicles by 3.3km/h.	Significant decrease of 8-10% in the number of deaths.	For 30km journeys, 30 seconds increase during the week and 40 seconds at the weekend. For 80km journeys, one minute increase during the week and less than 2 minutes at the weekend.	Overall decrease in the main pollutants. However, this decrease is very small and at this stage cannot be considered as significant.	Drop in those most opposed to the measure (supporters increase from 30% in April 2018 to 48% in June 2020). Supporters more numerous in rural areas. 75% report complying with the measures.	€721 million - €917 million loss for journey times. €1.2 billion gain for road safety. €251 million (low traffic scenario) - €320 million (high traffic scenario) gain for the fuel saving. €54 million (low traffic scenario) - €65 million (high traffic scenario) gain related to greenhouse gas emissions.
Methods	Speed observatory to assess the impact of speed reduction. Continuous speed data collection from all road users driving on the sites concerned. Time Headway (TH) is also recorded to identify vehicle interactions. Indicators monitored: Average speed. The distribution of individual. speeds and percentiles (V15 and V85). • The exceeding of speed thresholds with respect to the speed limit.	Data from Road traffic crash and injury report data were adjusted for seasonality. Odds ratio approach, returning the percentage change in the death rate on the 80km/h network compared to the rest of the network where speed was unchanged. The odds ratio calculation included: number of deaths on the 80km/h network (and rest of the network) before and after introducing the new speed limit.	Google Maps application. Historical GPS tracks. Historical Floating Car Data (FCD) vehicle tracks.	Acoustic simulation models, carried out on 4 road sections affected by the measure (N31; N79; N94 and D612). Emission and propagation method, based on NMPB08 (-New Noise Prediction Method 2008 [17])	A questionnaire was sent out by a survey institute to a large sample of drivers' representative of the French people, including the different dimensions of the acceptability/ acceptance of the measure, in particular its perceived effectiveness and usefulness, fairness, impact on behaviour and the general attitude of the respondents.	Estimation models considering: • Estimate traffic considered in km travelled. • Travel time and speeds. • Fuel consumption. • KSIs. • Amount of greenhouse gas emissions. • Investment costs.

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