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SWEDISH ROAD SAFETY ORGANISATION

The Ministry of Infrastructure is responsible for road traffic safety in Sweden. However, due to the decentralized structure in Sweden, the Ministry works with budget, targets, and policy related issues while the operations are managed by the **Swedish Transport Administration** based on the directions from the Ministry. The Administration is responsible for the planning of the entire transport system with all modes of transport. It is also responsible for building and maintaining roads and railroads. The Swedish Transport Administration also has an overarching role in the development of long-term strategies and plans for all modes of transport in the transport system, contributing to the targets set up by the government for the transport sector. The Transport Administration holds responsibility for research within the fields of mobility, environment and traffic safety. In-depth studies of each fatal crash in road traffic are also performed. The Transport Administration has the task of coordinating the road safety work in Sweden in collaboration with other stakeholders.

The other authority in the transport sector is the **Swedish Transport Agency** which has overall responsibility for regulations within air, sea, rail road and road traffic. Within the Swedish Transport Agency the Road and Railway Department formulates regulations, examines and grants permits, as well as exercise supervision within the field of road transport over e.g. road traffic, vehicles, driving licenses and commercial transport. The agency also conducts analyses of road traffic and manages the reporting of injury crashes within the road transport system. The Swedish Transport Agency also manages vehicle and driver license registers.

The Swedish Transport Administration and the Swedish Transport Agency are both responsible to work towards the transport policy targets. In Sweden the main other bodies active in road traffic safety efforts are the police, the local authorities and the vehicle importers association. Other important parties are the NGOs, for example the National Society for Road Safety (NTF), with its member organizations, and transport industry organizations. The Group for National Road Safety Co-operation (GNS) is a central body that coordinates the co-operation between the Swedish Transport Administration and Agency, the local authorities, the authority for occupational health and safety and the police.

ROAD TRAFFIC FATALITIES AND MANAGEMENTS BY OBJECTIVES

The Swedish overarching long-term safety objective within the road transport system was settled 25 years ago, in 1997, when the Swedish parliament voted for the “Vision Zero”. This vision states that ultimately no one should be killed or seriously injured in the road transport system (Johansson, 2009). The design and function of the system should be adapted to the conditions required to achieve this target. Since Sweden introduced a visionary goal in the middle of the 1990s several jurisdictions have taken the same approach. In some jurisdictions the name has been changed to Safe Systems Approach to avoid the strong focus on the number zero (OECD, 2008; ITF, 2016). The UN General Assembly Resolution 74/299 declared the current decade of action for road safety with the target to reduce road traffic deaths and injuries by at least 50% during the period 2021-2030 (UN, 2020), and the Commission of the European Communities has in its White Paper on transports set out the goal “by 2050, move close to zero fatalities in road transport” (EC, 2020).

In 2016 the Ministry of Infrastructure made a renewed commitment to Vision Zero (Swedish Government, 2016). The current Swedish road safety operation is based on a system of management by objectives. This system is based on cooperation between stakeholders, targets on Safety Performance Indicators (SPIs), and annual result conferences where road safety developments and targets are followed up. The aim is to create long-term and systematic road safety cooperation between stakeholders. The previous target for the period 2007-2020 aimed at reducing the number of road traffic fatalities and serious injuries by 50% and 25%, respectively. This meant a maximum of 220 fatalities in 2020. The targets for 2020, both in terms of fatalities and serious injured, were achieved and the positive trends for several SPIs during the period 2007–2020 can explain a large part of the target achievement. This applies especially to SPIs with great traffic safety benefits such as reduced average travel speed, increased vehicle mileage with safe cars, increased vehicle mileage on divided roads, and increased use of seat belts.

In February 2020, the government decided on a new road safety target for 2030, aiming at reducing the number of fatalities and serious injuries by 50% and 25%, respectively. The baseline for these reductions was set as the averages for the years 2017-2019, thus resulting in a target of maximum 133 fatalities by 2030.

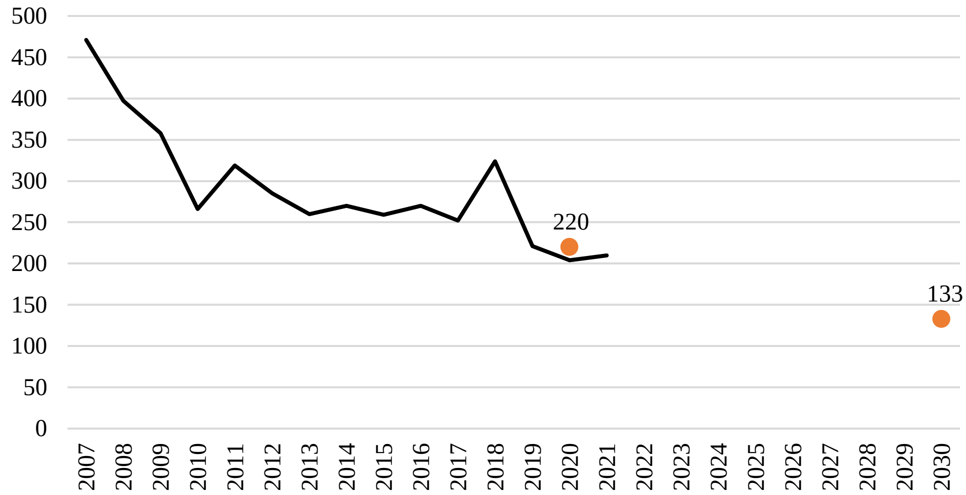

Figure 1. Number of fatalities in Swedish road traffic since 2007. The 2020 and 2030 targets are shown in orange. Since 2010, suicide in road traffic is no longer included among road traffic fatalities.

In 2021, 210 fatalities were recorded in Swedish road traffic. The outcome for 2020 and 2021 were unarguably influenced by changed boundary conditions in society due to the pandemic, for instance reduced vehicle mileage and changes in the composition of traffic. Although vehicle mileage returned to more normal levels towards the end of 2021, measurements showed a decrease of 5.1% for the whole year compared to 2019, i.e. before the pandemic. Compared to 2020, the vehicle mileage in 2021 increased by 4.2%. The pandemic has also led to increased unemployment, which historically has led to fewer fatalities and seriously injured (ITF, 2015). With roughly 200 fatalities per year Sweden is one of the safest countries when it comes to road traffic, with a level of 2.1 fatalities per 100,000 population in 2021. This is about half of the European Union risk average (4.2 fatalities per 100,000 population in 2021). As shown in Figure 2, the 2030 interim target would imply approximately 1.2 fatalities per 100,000 population, assuming an increase of Swedish population to approximately 11 million (SCB, 2022).

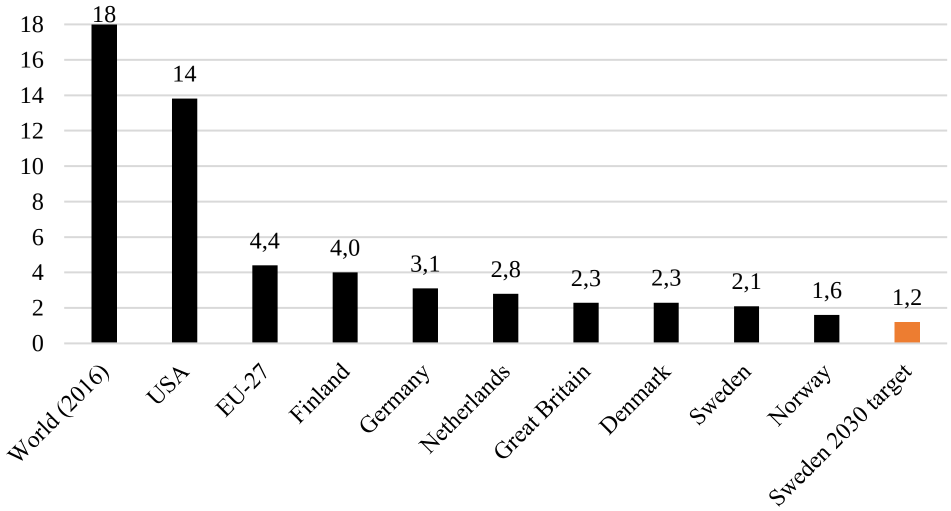

Figure 2. Number of road traffic fatalities per 100,000 population in 2021.

ALIGNING CRASH SEVERITY WITH CRASH PROTECTION

With the Vision Zero approach, an injured or killed road user is a victim of an inadequately designed road transport system unable to protect him/her from the human inability to handle certain complex traffic situations. The aim of the Vision Zero approach is not to totally eliminate the number of crashes but to align the crash severity with the potential to protect from bodily harm. This puts much greater focus on injury prevention, rather than crash prevention. Avoiding crashes is only one strategy if fatalities and severe injuries are to be eliminated. By focusing on the injury outcome, rather than crashes, the problem will have another profile and different countermeasures can be developed. An attempt to structure the problem was firstly done in a multidimensional model for safe driving by Tingvall and Lie in 1997.

This model has been previously used to analyze fatal crashes from 1998 and 1999, and more recently by the Swedish Transport Administration using 2016-2018 data. Every fatal case was classified in three groups, as follows.

1. The road users made a mistake or misjudgment, leading to a crash with fatal outcome,
2. The killed road users failed to protect themselves by using seat belts, helmets, etc,
3. The road users deliberately and widely overstepped the traffic rules and regulations and consequently exposed themselves to high crash severity beyond survival.

The results for the analysis based on 2016-2018 fatal crashes are shown in Figure 3. The classification of the fatal crashes shows that harmonizing the vehicle design, the road design and the travelling speed can do major improvements. It also shows that illegal behaviors involving deliberate violations (most often severe speeding) are a limited problem. However, it should be noted that minor offences of the speed limits were considered a mistake, not a deliberate violation, and were therefore coded in the first group.

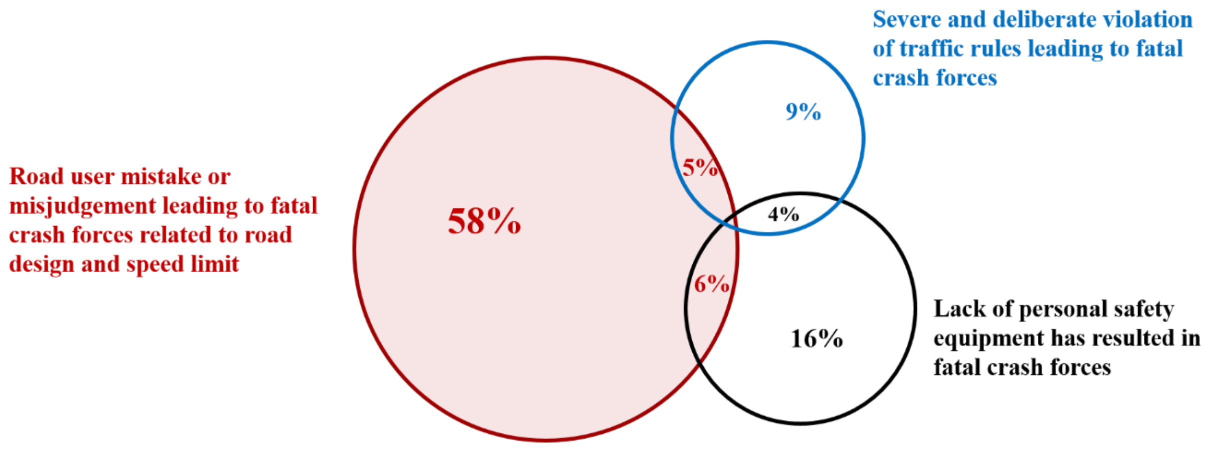

Figure 3. Classification of fatal crashes in Sweden 2016-2018.

Different trauma reduction strategies may be used to address fatalities in different groups. The largest group (up to 69%) consisted of road users being killed due to a mismatch between the crash severity they were exposed to, and the level of protection they were given. This implies that in order to address the gap, we would need to:

- lower the crash severity by lowering the collision speed, for instance with Autonomous Emergency Braking and/or lower travelling speeds.
- Increase the crash protection, for instance with increased vehicle crashworthiness, further developed personal safety equipment, and more crashworthy road designs.
- A combination of both lowered crash severity and increased crash protection.

The second group (up to 26%) consisted of road users who would have survived the crash if they had used seat belts or helmets. It should be noted that, unrestrained occupants of cars fitted with Seat Belt Reminders (SBR) were also coded in this group. In order to address these fatalities, further development and implementation of effective SBRs would be needed, in combination with other strategies aiming at increasing helmet use rates among bicyclists and PTW riders.

The third group (up to 18%) consisted of road users who deliberately exposed themselves to a high crash severity, most often through severe speed limit violations. Strategies to address such fatalities would include, among other things, police enforcement and vehicle technologies that actively control travel speed.

Overall, the results of this analysis suggested that more needs to be done to align crash severity with crash protection, thus providing valuable insights for the following steps aiming at the development of a new road safety strategy and a set of Safety Performance Indicators.

DEVELOPMENT OF ROAD SAFETY STRATEGY TO ACHIEVE THE 2030 TARGETS

In order to investigate what is needed to achieve a sustainable trauma reduction that achieves the 2030 targets, as well as creating a pathway towards close to zero fatalities in 2050, a trauma modelling task was undertaken by the Swedish Transport Administration. Many different approaches to modelling have been used in road safety strategy development. In this case, the main approach applied was a case-by-case methodology, a validated analytical approach to inform strategy development. Such method has been previously applied in Sweden and other countries (Strandroth, 2015). The case-by-case methodology is not only statistical modelling, but rather a logical reduction of current crashes into future casualty outcomes based on what we know about delivery of future safety measures and system improvements at specific points in time.

In addition to the case-by-case analysis of fatalities, a statistical dose-response model on serious injuries was developed to as close as possible mirror the analysis for the large number of serious injuries given it was not practical to analyze case-by-case (this analysis will be presented elsewhere). The stepwise approach undertaken throughout the trauma modelling process underpinning the plan was performed in several steps, as follows.

1. Develop a baseline “business-as-usual” scenario to illustrate future trends in fatalities and serious injuries, given no interventions are implemented in addition to the existing pipeline of road safety measures (including the impact of ongoing vehicle safety improvements, safety infrastructure programs, and speed camera programs). This gives also the possibility to analyze residual future trauma to guide future interventions;
2. Define a future Safe System to achieve close to zero fatalities and serious injuries in 2050;
3. Develop a strategic response scenario to achieve close to zero fatalities in 2050 and to achieve the 2030 targets;
4. Develop Safety Performance Indicators (SPI) and targets to monitor system transformation.

Step 1 - baseline “business-as-usual” scenario
In the first step, a critical aspect was predicting the fitment of safety technologies among new cars, i.e. when (which model year) a certain vehicle technology would become standard, either as a result of legislation or through other mechanisms e.g. Euro NCAP. In this case, standard means that almost all new cars would be equipped with the technology. For technologies that are already standard, for instance Seat Belt Reminders or Electronic Stability Control, this task is clearly straight-forward, although predicting the fitment rate of future technologies may pose a much greater challenge. In these cases, a group of vehicle experts from the Swedish Transport Administration, the Swedish Transport Agency and Folksam Research were consulted to reach consensus. A basic assumption was then adopted, that it would take approximately 5 years between the introduction in the Euro NCAP test protocol until a technology is largely standard among new cars. While historical data do support this assumption, it is evident that future follow-ups will be needed. In addition to the planned road treatments, an average 1% traffic growth per year was assumed for the period 2020-2030, thus resulting in increased exposure and crash likelihood.

The results of the baseline scenario are presented in Figure 4. It was calculated that by 2050 current fatalities would be reduced by approximately 50%. However, the best estimates for the baseline scenario in 2030 and 2050 were 185 and 102, respectively, thus pointing out a significant gap between the baseline scenario and targets set for 2030 and 2050.

An important aspect to take into account in the planning of traffic safety countermeasures is the time between introduction and benefits in terms of reduced fatalities and serious injuries. With regard to new infrastructure treatments, the effect is often immediate, although geographically limited to the treated road section or place. For vehicle safety technologies, however, it may be the other way around: the benefits may be more geographically spread although there is often a certain delay between the introduction of the technology and tangible benefits. This is simply because older cars are generally overrepresented in serious crashes. As a general rule of thumb, due to the current renewal rate of the Swedish passenger car fleet, it could be stated that it takes 10-15 years from introduction of a certain technology to significant benefits in terms of reduction of serious crashes. Among the included technologies in the baseline scenario, the delayed effect of Emergency Lane Keeping (ELK) and Lane Keeping Assist (LKA) could be mentioned. These technologies are generally expected to deliver significant reductions of fatalities, although the largest portion of these benefits is expected to be delivered after 2030.

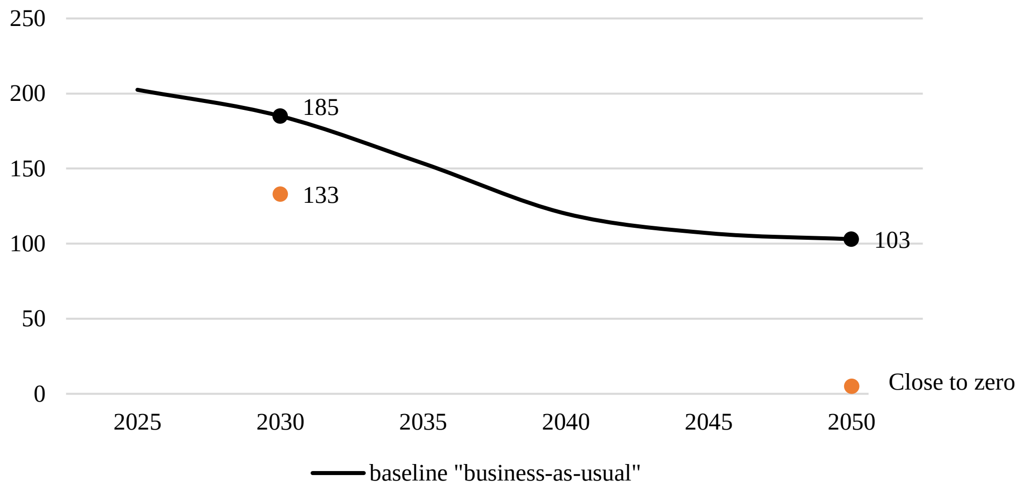

Figure 4. Best estimate for the baseline "business-as-usual" scenario, including a traffic growth of 1% per year up to 2030. The 2030 and 2050 targets are shown in orange.

Step 2 - definition of future Safe System
The following step was to define a Safe System to achieve close to zero fatalities and serious injuries in 2050. Overall, this implied full scale implementation of current road safety strategies aiming at aligning crash severity and crash protection. More specifically, the following components were included.

<u>Road infrastructure</u>

- All currently undivided roads with speed limit ≥ 80 km/h and AADT > 2000 are upgraded to divided roads
- Other currently undivided roads, with speed limit ≥ 80 km/h and AADT < 2000 have speed cameras, centerline rumble strips and maximum 80 km/h speed limit
- All roads with speed limit ≥ 70 km/h have road markings of good quality
- All roads with speed limit ≥ 80 km/h have a safety zone of good standard or roadside barriers
- All PTW-prioritized roads with speed limit ≥ 70 km/h have Motorcycle Protection Systems
- All intersections in the national road network are of good safety standard (STA 2016)
- All roads with speed limit ≤ 40 km/h have pedestrian and bicycle crossings of good safety standard (STA 2016)
- All roads with speed limit ≥ 50 km/h have separated pedestrian and bicycle paths and grade separated crossings
- All urban areas have speed limit 40 km/h or 30 km/h
- All pedestrian and bicycle paths are well-maintained (for instance, free of gravel, ice or snow)

<u>Vehicles</u>

- All passenger cars and light commercial vehicles have a 5-stars rating in Euro NCAP 2030
- All heavy goods vehicles meet EU-regulations
- All PTWs have Antilock Brakes and Traction Control
- All bicycles, including e-bikes, have winter tires during winter conditions and Antilock Brakes

<u>Usage</u>

- 100% speed limit compliance
- 100% vehicle mileage with sober drivers
- 100% seat belt use rate
- 100% helmet usage for bicyclists and PTW riders

- 100% usage of additional personal protection for bicyclists and PTW riders

It was calculated that the full implementation of all components would result in approximately 35 fatalities in 2050. Two main conclusions can be drawn from this result. Firstly, with currently known countermeasures, we have the theoretical possibility of almost halving the number of fatality every decade until 2050. In other words, the current toolbox of countermeasures can be expected to be more than sufficient to define a strategic response scenario to achieve the 2030 targets. Secondly, it can be concluded that the presented definition of Safe System could provide a reduction of current fatalities by almost 85%. Although this may be considered a very promising result, it is clearly not close to zero. If "close to zero" fatalities was interpreted as achieving the same level of safety offered to train passengers today, it would mean approximately 5 fatalities in road traffic per year in Sweden (Tingvall and Lie, 2021). Further research is needed to assess what kind of countermeasures would be needed to prevent the 35 fatalities that are expected to occur in 2050. It should also be noted that the current analysis did not include automated vehicles, thus the possible extra benefits of full automation were not quantified.

Step 3 - strategic response scenario

A strategic response scenario was developed with the purpose of closing the gap between the baseline outcome and the targets. In this context, a scenario is a combination of treatments that together over time would be expected to save the number of lives and prevent the number of severe injuries needed to achieve the targets. A strategic scenario would be considered one that includes interventions that are both long-term transformative and near-term cost effective, includes all components of the Safe System in terms of vehicles, infrastructure and road user behavior, and seeks to achieve interim targets but also ultimately to eliminate all fatalities and severe injuries.

The results are shown in Figure 5, in two separate layers, with the baseline scenario also shown as a reference. First, the best estimate for successively increasing speed limit compliance is presented (blue line), with a level of 80% in 2030, 90% in 2040 and 100% in 2050, respectively. While the number of fatalities would be further decreased compared to the “business-as-usual” scenario, it is evident that there still would be a significant gap between baseline outcomes and targets.

A further layer was applied, including the infrastructure treatments and the other components presented in the previous section. Here, the investments in the infrastructure between 2020 and 2030 were tuned so that the 2030 would be achieved, thus implying that even larger investments may be needed between 2030 and 2050 in order to close the gap between baseline scenario and 2050 target.

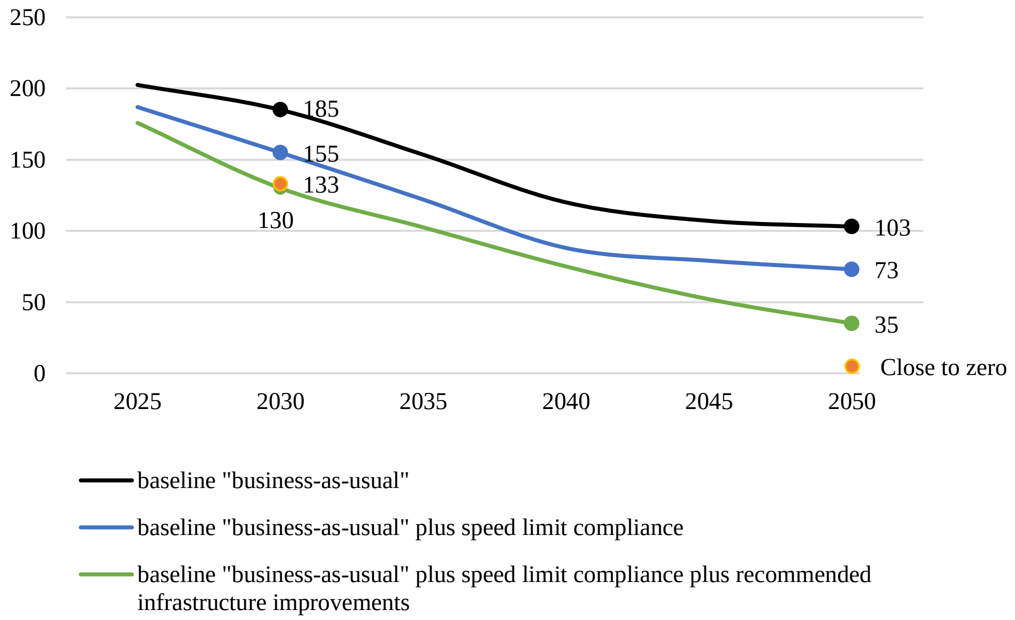

Figure 5. Best estimate for strategic response scenario, including a traffic growth of 1.0% per year up to 2030. The 2030 and 2050 targets are shown in orange.

Step 4 – Safety Performance Indicators
Based on the strategic response scenario, a set of revised Safety Performance Indicators were developed for the period 2020-2030. While the basic structure is still the same as for the previous decade, the new SPIs included a few additions, for instance safe intersections on national roads. The safety standards of intersections and pedestrian and bicycle crossings were defined according to STA's safety classification (STA, 2016). Naturally, the necessary levels to achieve the 2030 targets were also updated, see Table 1.

Table 1.
Safety Performance Indicators for the period 2020-2030

Safety Performance Indicators			**Status in 2020**	**Necessary to achieve the 2030 targets**
National road network	Mid-block sections	% of vehicle mileage on divided roads with speed limit ≥ 80 km/h	65 %	70 %
		% of vehicle mileage on divided roads with speed limit ≥ 90 km/h	85 %	96 %
	Intersections	% of AADT* in intersections with good or very good safety standard**	80 %	85 %
		% of AADT* in intersections with very good/good/medium safety standard**	93 %	99 %
	Ped & bike crossings	% of crossings with good or medium safety standard**	60 %	80 %
	Speed limit compliance	% of vehicle mileage within the posted speed limit	49 %	80 %
Municipal road network	Urban roads	% of urban roads with speed limit 30-40 km/h	65 %	99 %
	Ped & bike crossings	% of crossings with good or medium safety standard**	50 %	75 %
	Systematic work for VRU safety	% of surveyed municipalities with good results	17 %	70 %
	Speed limit compliance	% of vehicle mileage within the posted speed limit	67 %	80 %
Safe vehicles	Passenger cars	% of sold cars with a 5-stars Euro NCAP rating	89%	90 %
Safe road users	Seat belt use	% of observed car occupants using seat belts	97,9 %	99,5 %
	Bicycle helmet use	% of observed bicyclists using helmets	47 %	80 %
	Sober drivers	% of vehicle mileage with sober drivers	99,8 %	99,9 %

*AADT = Annual Average Daily Traffic
** Defined according to STA's safety classification

With regard to safe vehicles, it was calculated the proportion of sold cars with the highest safety rating in Euro NCAP needs to be at least 90 percent in 2030, which is approximately the same level as in 2020. While this may seem somewhat modest, it is important to point out that the Euro NCAP rating covers approximately 95% of new car sales in Sweden. More than 100 individual car models account for the remaining 5% of car sales, thus suggesting that increasing the number of tested cars would only have minor effects on the overall rating coverage. Furthermore, it should be stressed that the requirements for the highest rating are raised gradually between 2020 and 2030, which means that a 5-stars car tested in 2030 will have completely different safety features than a 5-stars car tested in 2020.

With regard to the use of seat belts in passenger cars, it was calculated that the necessary increase from 97.9% to 99.5% of vehicle mileage with restrained car occupants by 2030 would be achieved with the increased penetration of Seat Belt Reminders across the entire car fleet, including more advanced SBR technologies. Clearly, this calculation will need follow-ups in the future.

Significant investments in the road infrastructure will also be needed to achieve the 2030 targets, as follows:

- 1,000 km of new divided roads in the national road network
- 3,300 km of speed limit reduction on national undivided roads
- 800 intersections on national roads with low safety standards need to be upgraded to higher safety standards
- 2,500 km of new side crash barriers
- 5600 bicycle and pedestrian crossings with low safety standards need to be upgraded to higher safety standards (i.e. speed-calming treatments or grade-separation)

- Speed limits in urban areas need to be lowered to 40 km/h or 30 km/h

The biggest challenge appears to be speed limit compliance, especially on the national road network. While 2,300 speed cameras are currently installed on Swedish rural roads, further countermeasures need to be implemented to increase speed limit compliance from 49% to 80%. Intelligent Speed Assistance (ISA) is one of the vehicle safety technologies included in the EU's new General Safety Regulation for motor vehicles (European Union, 2021). Also, the recently published Euro NCAP road map can be expected to play an important role towards the implementation of more advanced ISA technologies beyond legislation (Euro NCAP, 2022). Finally, it should be stressed that further actions can be taken in addition to road treatments, vehicle technology development and implementation of lowered speed limits. During the 3rd Global Minister Conference on Road Safety 2020, important recommendations were presented, pointing out that he level of engagement from larger corporations and businesses needs to increase as a complement to road safety actions from governments (AEG, 2020). A preliminary analysis performed by STA and Folksam Research suggests that approximately 45% of all road fatalities in Sweden involve the value chain of at least one organized stakeholder. Therefore sustainable practices, reporting of road safety footprints, as well as targeted procurements, are essential tools to stimulate fleet management systems based on new technologies such as ISA as well as geofencing.

CONCLUSIONS

The present report outlined some of the strategic road safety work performed in Sweden during the last few years. The key points were:

- The previous targets for the period 2007-2020, aiming at reducing the number of road traffic fatalities and serious injuries by 50% and 25% respectively, were achieved.
- New interim targets for 2030 were set, in combination with the EU target 2050, close to zero fatalities. The 2030 targets aim at reducing the number of fatalities and serious injuries by 50% and 25%, respectively, thus resulting in maximum 133 fatalities by 2030.
- The majority of current road fatalities in Sweden (up to 69%) are still due to a mismatch between crash severity and crash protection.
- A road safety strategy was developed to achieve the 2030 and 2050 targets.
- A baseline scenario was developed, including the impact of ongoing vehicle safety improvements, safety infrastructure programs, and speed camera programs. This was calculated to reduce the number of fatalities by approximately 50% in 2050.
- Full scale implementation of current strategies aiming at aligning crash severity and crash protection would reduce current fatalities by approximately 85%.
- A strategic response scenario was developed, aiming at addressing the gap between baseline outcomes and targets.
- A set of new Safety Performance Indicators was developed to monitor system transformation towards the 2030 and 2050 targets.

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