European Road Safety Observatory

Road Safety Thematic Report –
Safe System Approach

This document is part of a series of 20 thematic reports on road safety. The purpose is to give road safety practitioners an overview of the most important research questions and results on the topic in question. The level of detail is intermediate, with more detailed papers or reports suggested for further reading. Each report has a 1-page summary.

Disclaimer

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Summary

To reduce the number of road traffic casualties to (nearly) zero, a Safe System approach is now generally regarded as best practice towards reaching such an ambitious goal. Key components that have been identified are:

1) People make errors, which is accommodated by system design that supports safe road user behaviour to prevent crashes.
2) As people are vulnerable, the system design is forgiving and prevents exposure to large crash forces to reduce the probability of severe injury.
3) System providers share the responsibility for safe system design.
4) All elements of the system are strengthened in combination to multiply their effects and to ensure safety when one of the elements fails.
5) Robust institutional governance is established by permanent institutions to organise a safe system.

A Safe System approach differs from more traditional approaches such as black spot management or crash clustering methods in that it is more proactive and draws on more general knowledge of weaknesses in the system to address these weaknesses. The starting point of both approaches being the reduction of human failure, the traditional approach is more directed at improving the behaviour of individual road users, while the Safe System approach is much more directed at accommodating human error by an inherently safe design that is less dependent on individual choices of road users.

Countries, cities, or organisations adopting 'vision zero' do not always start from the idea of a Safe System. There are several examples where the emphasis is mainly on getting support from the public and trying to educate road users how to behave safely but without explicitly addressing the responsibility of system providers to accommodate human error and prevent large impact forces on the human body. Although public and political support is also relevant in successfully organising the adoption and implementation of a Safe System approach, such support is generally not considered to be key element of a Safe System.

More and more countries and organisations are in the process of adopting a Safe System approach, following early adopters such as the Netherlands and Sweden. Their experience started in the 1990s and demonstrated that a Safe System approach can lead to relatively large reductions in casualties, ranging from a 30% to 50% reduction in fatalities over several years.

Although there is no fixed recipe for adopting a Safe System approach in every detail, it is generally accepted that an important starting point is to set an ambitious goal and use opportunities to take steps in the right direction. Interim targets may help further in guiding the process.

The Safe System approach is expected to be inspirational for meeting UN global sustainability goals in the ambition to reduce societal harm. A Safe System approach is also expected to become more important in a traffic system with more automated systems, as a discussion on what the public sees as an 'acceptable risk' for such services is foreseen.

1   Highlights

1. The Safe System approach is generally seen as the way to achieve near casualty-free road traffic (**vision zero**). The approach has been adopted by the European Commission and the World Health Organization as the way forward.
2. The Safe System approach starts from the fact that crashes can be prevented by **accommodating human error**: design should support safe road user choices and, in the event of an error, the **system is redundant** (if one part of the system fails, other parts provide protection) **and forgiving** to prevent large crash impact forces causing death or severe injury to the human body.
3. An increasing number of countries have adopted a Safe System approach. Early adopters like the Netherlands and Sweden demonstrate that **reductions of 30%-50% in fatalities** can be achieved.
4. A Safe System approach is **proactive**, especially when road safety performance indicators are used to give information on hazards on the roads. This contrasts with traditional reactive approaches where crash concentrations are mainly used for prioritising and mitigating countermeasures.

2   What is the Safe System approach?

2.1   Essentials of the approach

The Safe System approach starts from the idea that there is no acceptable number of fatalities and serious injuries (vision zero, e.g., ITF, 2008, 2016, 2022; European Commission, 2019; WHO, 2021). The approach is generally characterised as a proactive and preventive approach that starts from a human-centred perspective (e.g. ITF, 2016, 2022; WHO, 2022): first, humans are fallible, and this contributes to the cause of road crashes. Secondly, humans are vulnerable, which means that they will sustain physical harm when their body is exposed to large impact forces, such as in a crash. Road traffic can be safely combined with these human characteristics when these characteristics are systematically taken into account by the providers of the road traffic system. In a Safe System, road users are not blamed for road crashes: it is the system providers who bear the ultimate responsibility for preventing serious consequences of the use of the system. This means that, while humans make errors and are vulnerable, this does not mean that they have to sustain serious or fatal injuries by using the traffic system.

In practice, this means that the Safe System approach expects road users to normally obey the rules, but that it is the ultimate responsibility of planners, designers, builders, maintainers, and managers to care for a road traffic system that supports road users in safe behaviour that prevents crashes by anticipating and accommodating human error. In the event of a crash, the system has sufficient redundant and forgiving elements to prevent crash forces from exceeding the tolerance levels of the human body, causing serious injury or death. At a conceptual level, a Safe System has for instance been

visualised as a Swiss cheese (see Figure 1). The different slices of cheese represent the successive stages in the construction and use of the (traffic) system. The holes in the slices of cheese represent latent errors in the system and defence mechanisms in the system and unsafe actions by road users. In a Safe System, the different elements work together in such a way that unsafe actions and latent errors of the system do not coincide in time and place.
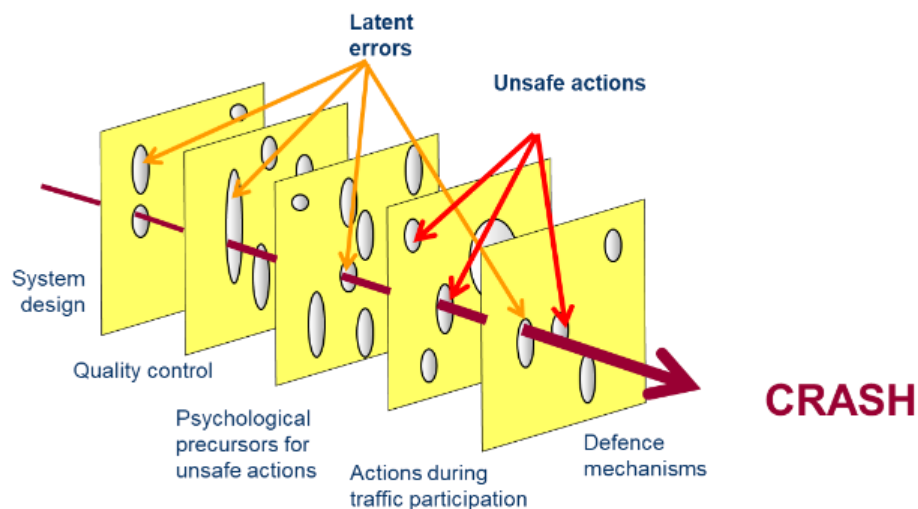

Figure 1: The Swiss cheese used to represent what needs to be done to achieve a Safe System: by reducing the number of latent errors in the system and making use of redundancy, unsafe actions will not lead to a crash or serious outcomes (Wegman & Aarts, 2006, after Reason, 1990).

2.2 Key components and road safety pillars

As the Safe System approach – also known under other names, of which 'vision zero' is undoubtedly the most famous – gains support from both road safety professionals and politicians (see for instance Björnberg et al. (2022) for an overview), there is a growing amount of literature addressing its key elements. These can be summarised as follows (see for instance ITF, 2016; 2022):

- People make errors, which is accommodated by system design that supports safe road user behaviour to prevent crashes.
- As people are vulnerable, the system design is forgiving and prevents exposure to large crash impacts to reduce the probability of severe injury.
- System providers share the responsibility for Safe System design.
- All elements of the system are strengthened in combination to multiply their effects and to ensure safety when one of the elements fails.

Also, the establishment of robust institutional governance by having permanent institutions to organise the Safe System has been mentioned as a key component in implementing a Safe System (e.g. ITF, 2022). Road safety pillars that have been identified for achieving a Safe System are in particular:

a) Safe speeds (operating speed safely linked to regulations and design)
b) Safe infrastructure (including safe roadsides)
c) Safe vehicles
d) Safe road user behaviour (in some publications including speed)

e) High-quality post-crash care.

Additionally, in some sources, road safety management (ITF, 2022), multimodal transport and land use planning (WHO, 2021) are mentioned as important road safety pillars.

2.3 Examples of Safe System approaches

The theoretical elements of a Safe System approach have been put into practice in a growing number of countries and organisations (see Björklund et al. (2022) for an overview). They provide concrete examples of what it means to elaborate a Safe System.

In the 1990s, the Netherlands and Sweden were the first countries to adopt a Safe System approach: the Safe System approach of the Netherlands (called Sustainable Safety), was announced in 1992, leading to several demonstration projects across the country in 1995 and adoption of the national start-up programme of sustainable safety in 1997. In the period 1999–2002 saw the implementation of the subsequent start-up programme.

A Safe System approach in Sweden started in 1995 with an agreement between the Director of Traffic Safety of the Swedish Road Administration and the Minister of Transport that no other number of road fatalities is acceptable than zero. Vision zero – as it was called later – was further conceptualised in 1996 as a statement of system provider responsibility for saving human lives and was adopted by Parliament in 1997. Implementation followed soon after.

As from 2000, other countries followed, such as Australia, New Zealand ('Towards zero'), and Norway ('Vision Zero'). Also, private companies adopted a Safe System approach, such as Volvo Cars and Mercedes Benz.

Examples of road safety measures that have been implemented or fit within the ideas of a Safe System approach include:

- Low speed limits (i.e. 30 km/h) on roads where vulnerable road users encounter motorised traffic but also on roads that are not designed as safely accommodating high speed motorised traffic (i.e. 70-80 km/h on rural roads without a median barrier to prevent head-on collisions).
- Physical separation of fast traffic moving in opposite directions (including low-cost implementation of 2+1-roads).
- Forgiving safety barriers along high-speed roads, especially at locations with obstacles or ditches along the road.
- Roundabouts at intersections to reduce speed and change the crash angle of cars to a less hazardous direction.
- Alcohol interlock systems to prevent drunk driving.
- Intelligent speed adaptation systems in cars to prevent speeding.
- Safe vehicle design and ways of promoting safety in the market (e.g. NCAP star ratings).

3   How does it relate to other approaches?

A large number of different approaches exist to reduce the number of casualties in road traffic (e.g. see Björnberg et al., 2022; Hagenzieker et al., 2014; SWOV, 2019). These approaches do not always align with the Safe System approach as mentioned before. We discuss here some common differences. Table 1 summarises several differences that have been identified between traditional road safety approaches and a Safe System approach.

Table 1 Comparison between the traditional road safety approach and a Safe System approach (source: ITF, 2016, page 26, inspired from New Zealand Transport Agency and VicRoads).

Viewpoints	Traditional road safety policy	Safe System Approach
What is the problem?	Try to prevent crashes.	Prevent crashes from resulting in fatal and serious casualties.
What is the appropriate goal?	Reduce the number of fatalities and serious injuries.	Zero fatalities and serious injuries.
What are the major planning approaches?	Reactive to incidents. Incremental approaches to reduce the problem.	Proactively target and treat risk. Systematic approach to build a safe road system.
What causes the problem?	Non-compliant road users.	People make mistakes and people are physically vulnerable. Varying quality and design of infrastructure and operating speeds provide inconsistent guidance to users about what is safe use behaviour.
Who is ultimately responsible	Individual road users.	Shared responsibility by individuals with system designers.
How does the system work?	Is composed of isolated interventions.	Different elements of a Safe System are combined to produce a summary effect greater than the sum of the individual treatments – so that if one part of the system fails, other parts provide protection (redundancy).

3.1   A Safe System approach and Vision Zero

Given that the Safe System approach was originally seen as a means of reaching zero fatalities and serious injuries (vision zero), it might be thought that all vision zero statements in a road safety context are explicitly linked to a Safe System approach. This is in fact not the case (see e.g. Björnberg, 2022; ITF, 2022). The main distinctions between Vision Zero policies with a Safe System approach and those without are (a) human nature

(fallible and vulnerable) and (b) provider responsibility. These are useful starting points in analysing the differences. Not all Vision Zero policies start explicitly from these principles, but use Vision Zero mainly as a political statement (with a variety of approaches) rather than as a Safe System approach. Vision Zero might in that sense be used mainly as a tool for public awareness and even for appealing to the responsibility of road users themselves. While public awareness is recognised as an important element in gaining political support for visionary approaches such as a Safe System (e.g. ITF, 2016; 2022), it is not really considered as the core of a Safe System approach.

3.2 The Safe System approach and preventing human failure

When looking at the history of approaches to road safety improvement, one approach which was - and still is - very common is that of blaming road users and trying to educate them to behave more safely (e.g. Björnberg, 2022; ITF, 2022; Hagenzieker et al. 2014). The idea that human failure is involved in a large proportion of or nearly all crashes is the starting point of both traditional and Safe System approaches, but with a very different choice of how to deal with this. While the traditional approach is more directed at interventions aimed at improving the behaviour of individual road users, the Safe System approach is much more directed at making system elements inherently safe so as to make the outcome of actions less dependent on individual choices. The starting point is that human failure is unavoidable (see Björnberg, 2022; ITF, 2022; SWOV, 2018). This means that the traditional approach is directed mainly at education, information, training, and enforcement of road users, while the Safe System approach is directed at making safe road design and using technology, supported by other measures such as enforcement, education, and communication with road users as well as system providers.

3.3 The Safe System approach versus black spot management

Especially where crash frequencies are high, a traditional approach to increasing road safety is by analysing crash concentrations (so called black spots) and mitigating the weaknesses of crash locations (e.g. Björnberg et al., 2022; SWOV, 2019). This can be quite an effective method to start with, but it is also a reactive method. Crashes could have been prevented by using a Safe System approach where the general weaknesses of the system are analysed, and effective measurements are prioritized. Especially in countries were crash concentrations are relatively low and move over the road network from year to year, a more proactive approach will be a more effective alternative. In addition to information on crashes, fatalities and injuries, the use of road safety performance indicators (SPIs or KPIs) is generally regarded as helpful in elaborating proactive safety management (e.g. EC, 2022). SPIs provide information on hazards in road traffic, examples of which are, for example, the proportion of drivers complying with the speed limit, the proportion of sober drivers, or the proportion of vehicles that meet current safety standards. Also the EU Directive on road infrastructure safety management (RISM) can be mentioned here. It requires Member States to carry out network-wide road safety assessments. The 2019 revision of the Directive adopted a more proactive approach (EC, 2019).

4   How effective is a Safe System?

The first results from countries that have adopted a Safe System approach – like the Netherlands and Sweden – show that quite impressive reductions in casualties can be achieved.

The Netherlands - Weijermars & Wegman (2011) evaluated the results of the country's start-up programme. Over 10 years, the implementation of the Safe System approach led to nearly all roads being categorised according to function, a huge expansion of lower speed limits in both urban (30 km/h) and rural (60km/h) access areas, and an increase in enforcement of several key behaviours such as speeding, drink-driving, and use of protective systems. The wide-scale implementation of these interventions was calculated to have resulted in a decrease in road deaths of 30% in 2007 compared to what could be expected without these interventions (see Figure 2). Also, the fatality risk reduced in that period from 2.6% to 5.8% on average. The reduction was mainly in crashes involving motorised vehicles. The benefits of the Safe System implementation were calculated as approximately 2-4 times as high as the costs.
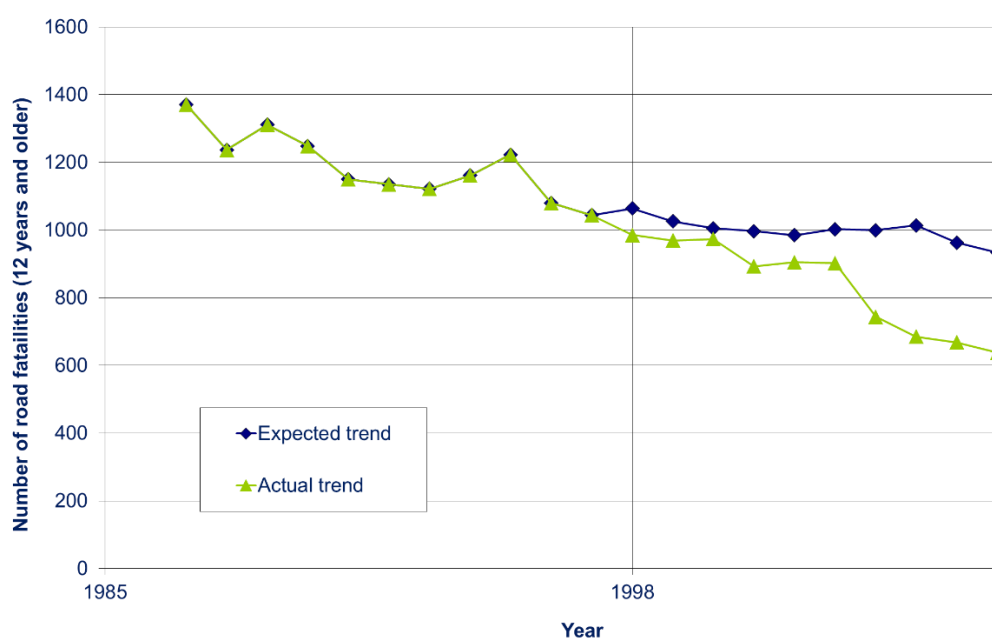

Figure 2: Calculated reduction in the number of road deaths in the Netherlands due to implementation of the national Safe System approach compared to outcomes without the interventions taken (adopted from Weijermars & Wegman, 2011).

Sweden - Good results have also been achieved in Sweden with the implementation of a Safe System approach. The implementation of 4,000km of 2+1 median separated rural roads was estimated to save 100 lives per year (Lindberg, 2017; see Figure 3). Combined with other measures such as lowering speed limits in urban areas from 50 km/h to 30 km/h and in rural areas from 90 km/h to 80 km/h, speed cameras to slow down speeders (rather than to catch speeders!), and implementation of roundabouts at intersections, fatalities were cut by more than half after those Vision Zero measures had been implemented, compared with the period before Vision Zero implementation (Lindberg, 2017).

Furthermore, Vision Zero has inspired an increasing number of countries, cities and companies to adopt effective measures to reduce the number of casualties in road traffic (e.g. Björnberg et al., 2022).
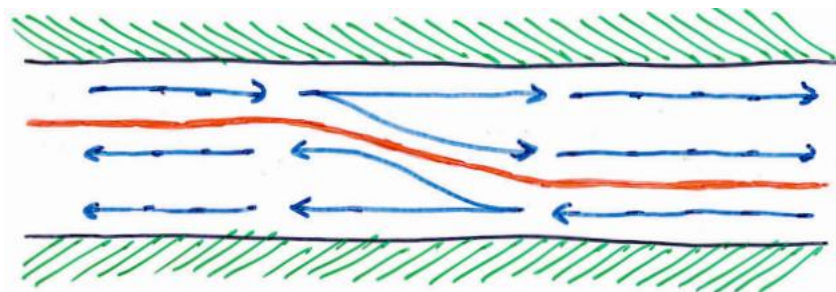

Figure 3: The original sketch of a 2+1 median barrier divided road, one of the first Safe System implementations in Sweden (source: Lindberg, 2017).

Norway – adopted a Safe System approach (Vision Zero) from 2000 and implemented road safety measures comparable to those in Sweden (e.g. 2+1 median barrier divided roads, safe speed limits) but also safe design of guard rails. During the period before adopting Vision Zero, the trend in road fatalities was -2.1% per year (1970-2000), but after adoption the reduction was much steeper: -6.1% per year (2001-2017; in Björnberg et al., 2022).

Since several other countries and private companies have started quite recently to adopt a Safe System approach, more effects are expected.

5 How can a Safe System be adopted?

Countries and private companies that have started with the adoption of a Safe System approach have shown that there is not one simple recipe for adoption (e.g. ITF, 2016; 2022; Björnberg et al., 2022). The way forward depends, for instance, on the policy context and opportunities that arise. There are however several experiences from these pioneers that can be inspiring for others. Furthermore, it is interesting to look at issues that have been identified for the future. These are addressed in the following paragraphs.

5.1 Lessons and inspiration

The ITF-report on the Safe System approach in action (ITF, 2022) has identified several lessons from case studies related to the use of a Safe System approach. The lessons from these case studies can be summarised as follows:

- **Create political climate and stakeholder commitment** – Several lessons about creating the right conditions have been identified and concern especially institutional governance and shared responsibility amongst stakeholders. They point to the importance of creating a climate for political change by, for instance, raising awareness of the road safety problem, including using support from NGOs and the media. A key element is also the development of strategies and programmes in which road safety risks are managed in an integrated way, addressing different

dimensions of causes and effective countermeasures. The coordination of activities between stakeholders is seen as an important organisational goal, as well as maintaining the commitment of all players. Smooth coordination requires that all relevant stakeholders are involved in the process and that commitments are made so as to have a clear overview of stakeholder contributions. Successful experiences show that one of the parties (an organisation or a person) needs to take the lead in organising the required actions.

- **Organise and use data, information, and knowledge** - The use of data and knowledge has been identified as an important means of supporting effective choices of Safe System measures. To help develop shared responsibility among stakeholders and institutional governance, it has also been established that it is very important to provide access to information and data. This allows strategies and interventions to be based on evidence and data. To obtain data that can be useful for road safety management, it is considered wise to invest in monitoring, performance tracking, and evaluations. For this, road safety performance indicators (SPIs) can be used, alongside information on crash statistics (e.g. Baseline, European Commission, 2019; 2022).

- **Provide dedicated annual funding** – One of the important issues related to institutional governance has been the availability of funding for the elaboration of a Safe System approach, including data gathering, monitoring, evaluation and implementation of the measures needed. It has been shown that dedicated annual funding can help in keeping focus within the Safe System approach and harmonising measures. Another lesson may be to link funding to the evaluation of the effectiveness of the measures implemented.

- **Develop skills and train stakeholders** – Organisations that want to move in the direction of a Safe System approach might face difficulties with changes over time: this holds for personnel involved as well as changes in the traffic system. Therefore, training of stakeholders is important to ensure the good quality of what will be delivered, as well as continuously updating knowledge about the road system and its changing elements and how that influences road safety risks and other outcomes. Accordingly, compared to a more traditional road safety approach, training in a Safe System approach is not so much directed at road users, but rather at the road system providers to ensure that they are well-prepared to take responsibilities.

- **Use supporting actions** – The ability to take responsibility also requires other supportive actions and tools for institutional governance as well as the support of stakeholders to strengthen all parts of the road traffic system. One of the lessons that has been identified here is to take an incremental approach from the starting point. This is important for showing how a Safe System might work, taking stakeholders on board, and preventing too large ambitions from becoming barriers. The method of back-casting has been identified by some pioneers as promising: this means that system-wide reflections and analyses are needed to define a desirable future (e.g. a system where fatalities and serious injuries have been eradicated) and then those involved work backwards to identify policies and programmes that will connect that specified future back to the present.

- **Co-operate, combine and coordinate actions** - Co-operation and coordination are important in gaining support and have positive effects on the implementation of a Safe System approach. This means that it is essential to identify which stakeholders should be involved in addressing specific road safety problems. Road safety problems on local roads, for instance, might need the involvement of other stakeholders than for national roads. The relevance of multi-stakeholder involvement becomes apparent when effective measures are analysed, for instance to address the vulnerability of road users. One of the lessons is that it is more effective to make a combination of measures regarding road infrastructure (e.g. blending vehicle measures and speed interventions). This all requires good coordination of activities, and in this respect the benefits of a lead agency have been mentioned earlier.

5.2 Which developments are expected?

Future developments cannot be safely predicted, but several organizations involved in the implementation of Safe Systems have identified issues they see as relevant for further development of the Safe System approach (see for instance Björnberg, et al., 2022). While these developments can be quite context-dependent, issues that have been raised can be summarized as follows:

- A Safe System approach might be used as inspiration for the way forward in meeting several Global Sustainability Goals (UN, 2020). This means that goals might be combined, with the ambition to reduce societal harm by making providers of systems responsible.
- In the approach towards a Safe System, the topic might be raised of what society perceives as an 'acceptable risk'. This question can be expected to arise if the road traffic system is used more and more by automatic driving vehicles, making a larger part of the road traffic system a service provided to the public rather than being actively engaged in it by driving a vehicle. As with professional transport devices, people may increase their expectations about acceptable safety levels. This might give a push to using Safe System approaches. For years now, there have been high expectations about the additional safety effects that vehicle automation might deliver.
- In order to help evaluate interim progress towards zero fatalities and serious injuries, the role and value of performance indicators might receive greater attention. This will increase the need for good data, as well as for sound evaluations and knowledge about interventions that deliver positive effects.

6   Further reading

A lot of documents are available for further reading on Safe System approaches. Apart from reports and road safety strategies of several national authorities that have adopted the Safe System, the following more general documents might be worth further reading:

- The **International Transport Forum (ITF)** of OECD has published several reports on vision zero with a focus on the Safe System approach as a way to achieve that. Reports from 2008, 2016 and 2022 provide useful overviews on the topic, including components and case studies. A follow-up of the 2022 report is still ongoing and directed at implementing a Safe System approach in low- and middle-income countries (LMICs).
- In recent years, several reports and strategic documents of the **European Commission** mention the Safe System approach as the strategy to reach vision zero. The Valetta Declaration (2017) can be seen as one of the starting points for this view, as new ambitious goals were proposed and proactive ways towards them. This was followed by a European transport strategy (2018), and a road safety policy framework for the period 2021-2030 (2019) where a Safe System approach was advocated.
- Also from a wider international perspective, the Safe System approach has been endorsed by parties such as the **United Nations** (UN; e.g. 2020, 2021), the **World Health Organization** (e.g. WHO, 2011, 2021; Stockholm Declaration, 2020), and the **World Bank** (WB; e.g. Bliss & Breen, 2014; cooperation on the report of ITF, 2022).
- Very recently several Swedish scientists took the initiative to write a **handbook on vision zero**, addressing experiences with vision zero and the Safe System approach, also in a wider context (see Björnberg et al, 2022).

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