Safe Road Transport Research Priorities for 2025

Safer and More Sustainable Mobility for All

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1 Table of contents

2 Introduction

Road safety is an important concern for the whole world as it deals with human life itself. In Europe, extraordinary steps forward have been taken in the past decades, drastically reducing road crashes and their effects. However, the challenges in road safety are still huge and demanding actions need to be undertaken to respond to them. This is the motivation for this document, that describes R&I needs proposed to be prioritised for the “Climate, Energy and Mobility” Work Programme 2025 of Horizon Europe.

2.1 Background

ERTRAC, the European Road Transport Research Advisory Council, represents the wide range of stakeholders in road transport research from vehicle manufacturers and suppliers to research providers, academia, public authorities and many others. The multi-stakeholder nature of ERTRAC makes it unique in being able to present a holistic and integrated view of road transport research needs. ERTRAC’s mission is to provide a framework to focus the coordinated efforts of public and private resources on the necessary road transport research activities. ERTRAC delivers roadmaps for cross-cutting research that provide a reference for the future planning of European research programmes. In addition, this reference shall provide an overarching framework for research, innovation and technological development, as well as guidance for individual research planning.

From a road safety perspective, this multi-stakeholder cooperation is of utmost importance to meet the challenges ahead following the *Safe System Approach*, which ERTRAC has adopted. This implies that responsibility for road safety is shared by all relevant stakeholders including individual road users as well as system designers and operators from the public and private sector. As a consequence, all layers of safety need to be strengthened: road safety management, road infrastructure, vehicles, road user behaviour and post-crash response. Traffic management plays an important role in this context, as well. The overall scope of the ERTRAC Safe Road Transport Research Roadmap, published by the end of 2021, is therefore broad, covering all these layers, all road transport modes, all users and all phases from preventive to post-crash safety. This roadmap summarizes the background, state of the art, policy context, challenges and objectives of European road safety research. In addition, it presents a total of eleven R&I needs for inclusion in Horizon Europe, the EU’s key funding programme for research and innovation. This document has been well received. So far, four of these eleven R&I needs are already very well reflected in the “Climate, Energy and Mobility” Work Programme 2023 – 2024 of Horizon Europe.

Therefore, this paper is not to replace the existing ERTRAC Safe Road Transport Research Roadmap, which still remains valid. The primary purpose is to highlight some of the remaining R&I needs from that roadmap and recommend them specifically for inclusion in the “Climate, Energy and Mobility” Work Programme 2025. This recommendation is based on a broad consensus within the ERTRAC Working Group Road Transport Safety & Security. Chapter 3 of this paper presents these R&I needs in detail, while the following sub-chapters give an update on the current challenges and objectives of European road safety research and innovation, underlining its importance in saving lives and protecting the health of EU citizens.

2.2 Policy context, challenges and objectives

With approximately 1.3 million fatalities each year[1], road crashes are one of the leading causes of death worldwide. According to WHO figures, more people die from the consequences of road crashes than from HIV/AIDS or tuberculosis[2] and road traffic injuries are the leading cause of death for children and young adults aged 5-29 years. With good cause, road safety is therefore well reflected in the UN Sustainable Development Goals (SDGs) and their related targets already set in 2015. This applies in particular to SDG 3.6 ("By 2020, halve the number of global deaths and injuries from road traffic accidents") and SDG 11.2 ("By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons").

In the EU, road safety has greatly improved in recent decades thanks to actions at European, national and local levels. Figures from the European CARE database, for example, show a 45% reduction of road fatalities between 2000 and 2010. Actually, European roads are considered the safest in the world today. However, the EU has entered into a phase of stagnation in its strive to further improve road safety. Fatality and injury figures have remained nearly constant from 2013 to 2019 (Figure 1). After the drop of 2020, in which the impacts of COVID-19 led to reduced numbers, 2021 shows a rebound, especially of fatalities close to the pre-pandemic level. For 2022, a total of 20,678 road fatalities is reported by the European Transport Safety Council (ETSC), which means another increase by 4% over the level of 2021.

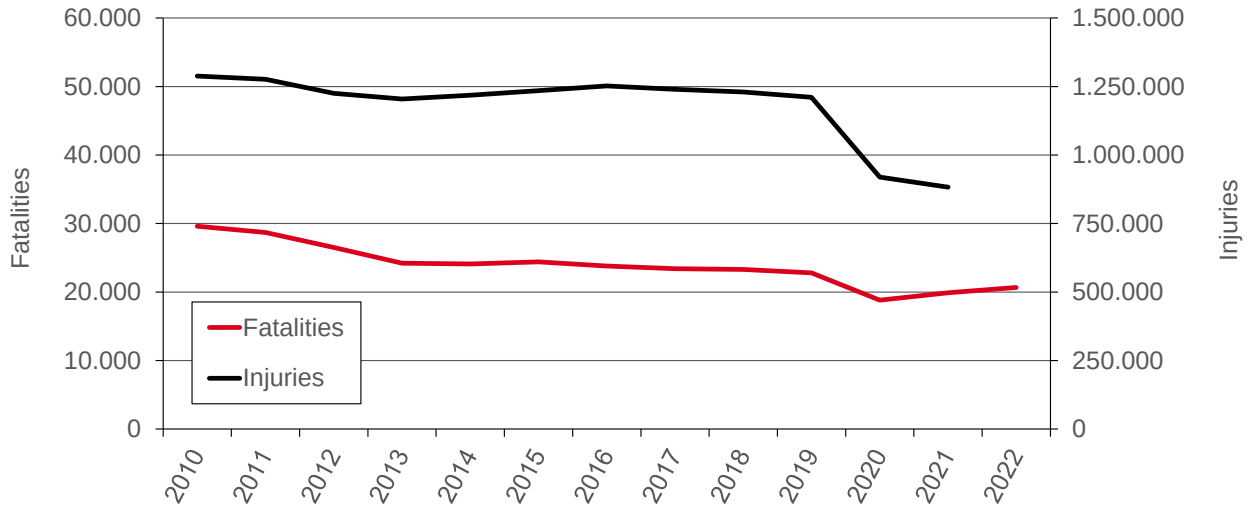

Figure 1: Evolution of Road Safety in the EU after 2010[3]

Analyses for the strict lockdown period in April 2020 reveal that the number of road fatalities did not decrease to the same degree as traffic volumes in many EU countries[4] [5]. Popular hypotheses[6] to explain

[1] Road traffic injuries, factsheet by the World Health Organisation, 20.06.2022
[2] Global status report on road safety 2018, the World Health Organisation, ISBN 978-92-4-156568-4
[3] European Road Safety Observatory, Annual Report, 13.03.2023, https://road-safety.transport.ec.europa.eu/statistics-and-analysis/data-and-analysis/annual-statistical-report_en, complemented by ETSC data for 2022
[4] The impact of COVID-19 lockdowns on road deaths in April 2020, report by the European Transport Safety Council, July 2020, https://etsc.eu/wp-content/uploads/PIN-Corona-Briefing_final.pdf
[5] Road safety annual report 2020, the International Transport Forum, https://www.itf-oecd.org/sites/default/files/docs/irtad-road-safety-annual-report-2020_0.pdf
[6] E.g. IRTAD/OECD Road Safety Annual Report 2021

this effect are increased speeding and drink-driving, both known for being related to very severe crashes. Reports from some national authorities also confirm that the reduction of road fatalities and injuries has slowed down or even reversed over the last few years. As a consequence, important European road safety targets are getting out of reach. In spite of the unprecedented fall in 2020, road fatalities have not been cut by 50% in the last decade, as called for in the EC Policy Orientations on Road Safety 2011-2020. Extrapolating the current longer-term trend, the EU is not likely to move close to zero fatalities by 2050, either, which was set as a target in the EC Transport White Paper 2011 and confirmed by the 3rd Mobility Package in May 2018. The latter even expands the target of moving close to zero also to serious injuries and adds the interim target of minus 50% for fatalities and serious injuries between 2020 and 2030[7], which seems very ambitious in view of the current trend, as well. In the EU Road Safety Policy Framework 2021-2030 "Next steps towards 'Vision Zero'", the EC emphasizes the importance of this vision not only as a numerical target, but as a new mind-set, and adopts the Safe System Approach as the basis of its future road safety policies. The Sustainable and Smart Mobility Strategy published in 2020 reflects the need to urgently improve road safety in several flagship areas, in particular in Flagship 10 "Enhancing transport safety and security" and re-confirms the EC's commitment to the afore-mentioned targets. Beyond fatalities and injuries, the EC has adopted eight key performance indicators[8] (KPI) as suggested by the EU funded research project BASELINE. These include KPI on "helmets of powered-two-wheelers and cyclists" and "distraction using a handheld mobile device", which have direct links to research priorities proposed in this ERTRAC paper.

In view of the limited progress in European road safety over the last few years, the human suffering and the cost burden of severe road crashes are at risk of continuing on an unacceptable level. In fact, the loss of more than 20,000 lives of EU citizens in 2022 during a daily life activity like travelling in the road transport system is fully unacceptable, while the estimated socio-economic costs from road crashes of about EUR 280 billion are a major burden to the European economy[9]. Clearly intensified efforts have to be made by all relevant stakeholders not to completely miss the long-term objective of "Vision Zero": a transport system in which human life is the paramount concern and no-one is killed or severely injured anymore.

2.3 Importance of European road safety research and innovation

Public budgets as well as the road transport industry are under enormous pressure in the EU: Geo-political tensions, discontinued or compromised trade relations with some countries and the need for unforeseen investments by national governments mean an enormous burden to public budgets in the EU. This is even made more critical by increasing public expenditure on debt interest due to rising key interest rates and the more and more apparent need to counteract climate change and its consequences.

The effects are such that substantial public investments in existing evidence-based and effective road safety measures have become more difficult or even unlikely to happen. Furthermore, the growing interest in active transport modes and micro-mobility devices implies that the share of completely or partially unprotected road users will further increase.

[7] Europe on the Move – Sustainable Mobility for Europe: safe, connected, and clean, Communication from the European Commission, COM(2018) 293 final, 17.05.2018
[8] https://road-safety.transport.ec.europa.eu/statistics-and-analysis/data-and-analysis/key-performance-indicators-kpis_en
[9] Handbook on the External Costs of Transport, EC Directorate-General for Mobility and Transport, version 2019 - 1.1, ISBN 978-92-76-18184-2, https://op.europa.eu/en/publication-detail/-/publication/9781f65f-8448-11ea-bf12-01aa75ed71a1

At the same time, the European road transport industry is facing the twin green and digital transition requiring substantial investments, while new challenges are emerging in its access to important global markets and new competitors are entering the EU market. In this setting, private spending on R&I that is not promising a short-term return on investment is hard to justify from the economic perspective.

A recent study[10] in four EU countries, published in 2022, reveals that socio-economic costs of fatalities and severe injuries are substantially higher than before. The value of a statistical life (VOSL) and of a statistical serious injury (VSSI) have risen to EUR 6.2 million and EUR 950,000 respectively. This is largely due to a rise in immaterial costs. Apparently people perceive road safety as more important than before. This socio-economic urgency for more road safety is hardly reflected in political attention.

Increased need for research and innovation

Road safety trends (fatalities, injuries, and associated costs) and recent trends in public spending show that it is unlikely that sufficient investments in effective known measures will be realised as needed to make significant progress towards the EU road safety targets. Therefore, and with the current, challenging situation of the European road transport industry, the need for public funding of road safety research and innovation is stronger than ever. The focus needs to be on solutions which are easy to implement and ideally support the transition towards a more sustainable European road transport system.

R&I approach

In the long term, Connected, Cooperative and Automated Mobility (CCAM) shows the potential to become a key enabler for substantial reductions in collisions on European roads as well as in the number of injured road users and fatalities. Consequently, improving road safety is quoted as the first expected societal impact of the CCAM Partnership in its Strategic R&I Agenda[11]. The first use cases of highly automated driving, however, are likely to address relatively safe domains of road transport, such as traffic in confined areas and on highways[12]. According to the ERTRAC CCAM Roadmap, experts question, if even in 2050, highly automated driving will be widely deployed on rural roads, which account for more than 50% of all road fatalities in the EU[13]. Therefore, CCAM will be an important contributor, but not the universal remedy to move close to zero road fatalities and serious injuries by 2050. There is significant potential in technological routes that are complementary to CCAM as well as in non-technological research, e.g. on the in-depth understanding of crash and pre-crash circumstances and human factors, on interaction between users, vehicles and road infrastructure and on the potentials and limitations of education and enforcement.

Actually, there is much consensus between policy, the private sector, science and road user organisations on the way forward: the Safe System Approach. Accordingly, all layers of road safety need to be

[10] Schoeters, A.; Large, M.; Koning, M.; Carnis, L.; Daniels, S.; Mignot, D.; Urmeew, R.; Wijnen, W.; Bijleveld, F.; van der Horst, M.; Economic valuation of preventing fatal and serious road injuries. Results of a Willingness-To-Pay study in four European countries, Accident Analysis & Prevention, volume 173, August 2022, Elsevier, https://www.sciencedirect.com/science/article/pii/S0001457522001415?via%3Dihub

[11] Strategic Research and Innovation Agenda of the CCAM Partnership, V1.4, 17.03.2022, https://www.ccam.eu/our-actions/sria/

[12] ERTRAC Connected, Cooperative and Automated Mobility Roadmap, Version 10, 18.02.2022, https://www.ertrac.org/documents/

[13] Road Safety in the EU – fatalities below pre-pandemic levels but progress remains too slow, EC Directorate-General for Mobility and Transport, news article, 21.02.2023, https://transport.ec.europa.eu/news-events/news/road-safety-eu-fatalities-below-pre-pandemic-levels-progress-remains-too-slow-2023-02-21_en

strengthened – road safety management, road infrastructure, vehicles, road user behaviour and post-crash response – so that if one fails, another one will compensate. Therefore, the EU Road Safety Policy Framework 2021-2030 acknowledges the need to strengthen funding support for the development and implementation of Safe System strategies, especially in Horizon Europe. However, the alarming road safety trend in numbers of casualties and socio-economic costs is not reflected in adequate R&I funding yet. An intermediate evaluation of Horizon Europe[14] reveals this. The R&I needs addressed in calls for proposals are certainly relevant, but far from complete, especially since limited budget requires making choices, and consequently important R&I needs cannot be tackled.

Funding support for European road safety R&I needs to be **upgraded significantly**,

- maintaining support for CCAM,
  but **increasing attention on active modes, human factors and on rural roads,**

- **bringing back balance with other thematic areas of R&I**,
  according to the increased socio-economic importance of road safety,

- **following the Safe System Approach**
  to ensure that normal human fallibility will not lead to premature death,

- **complying with the mind-set of Vision Zero** that no loss of life is acceptable.

Expected impacts are multiple:

- reducing human suffering by saving thousands of lives and serious injuries,
- reducing the burden on the health care system and total socio-economic costs by many billion euros[15],
- facilitating efficient investments in road safety by public and private stakeholders,
- making the road transport system more inclusive for all.

If Europe manages to stop the current trend and enter into a steady decrease of fatality and injury figures according to the EC targets from mid-decade onwards, a cumulative total of about 300,000 lives can be saved and several times as many serious injuries avoided until 2050. While this is already an objective more than worth pursuing, the estimated socio-economic cost saving would add up to a total of about EUR 2 trillion[16].

[14] FERSI: essential European road safety research lacking, position paper by the Forum of European Road Safety Research Institutes (FERSI), 21.03.2023, https://fersi.org/2023/03/21/essential-european-road-safety-research-lacking/
[15] The outcomes of the VALOR project for the Netherlands implied total costs of road crashes adding up to 27 billion, that is EUR 1500 per person per year, the equivalent of 3% of Dutch GDP.
[16] Estimation based on external accident costs from the Handbook on the External Costs of Transport, https://op.europa.eu/en/publication-detail/-/publication/9781f65f-8448-11ea-bf12-01aa75ed71a1

3 Research Priorities

Whereas road safety would benefit from significantly upgraded R&I support, such budgets are rather limited in the current situation on both the public and the private side. Hence, it is crucial to focus the available resources on priorities of particular relevance, urgency and good match with the budget constraints. Therefore, ERTRAC analysed in early 2023 the coverage of the contents of its current Road Safety Research Roadmap by the calls for proposals in 2023 – 2024 in order to facilitate clear recommendations of road safety research priorities for the "Climate, Energy and Mobility" Work Programme 2025. Based on this analysis, the ERTRAC Working Group Road Transport Safety & Security came to a consensus in February 2023 and agreed on priorities among the remaining research needs described in the existing roadmap. The descriptions of these priorities were updated by a group of experts in the respective areas, partly re-structuring the corresponding research needs as a consequence of additional input received from two Working Group meetings and additional electronic feedback loops. As the outcome of this process, three priorities are recommended for inclusion in calls for proposals in 2025:

- Safe Human-Technology Interaction in the Coming Decade
- Safety of Bicyclists and Users of other Micro-mobility Devices
- Safety of Users of Small Electric Vehicles

A guiding idea behind these priorities is that, ideally, future road safety R&I also supports the transition to a more sustainable road transport system for all. Therefore, they address different means of road transport and several trends which are likely to be part of this transition: small and very lightweight electric vehicles, bicycles and other micro-mobility devices as well as more and more automated motor vehicles and their interaction with their human users. The rationale of each of these priorities is explained in the following, while detailed descriptions of their contents are given in the following sub-chapters.

The range of functions that new motor vehicles offer is increasing. This is one of the main reasons why optimum design of their human-machine interfaces shall prevent driver distraction and prolonged reaction times in safety-critical situations. Research on the impact of human factors is becoming more and more important in particular with increasing levels of automation and the operation of a vehicle by the driver turning into a cooperative task performed jointly by a human driver and a technological system. This applies not only, but in particular to SAE Level 2 and Level 3 vehicles (partial and conditional automation). Understanding the combined behaviour of the human and the technological system in this context is crucial for developing effective safety measures and user-friendly systems. Investment in technology development can improve human-vehicle interaction, and address challenges associated to the transition to higher levels of automation.

At the same time, societal trends (urbanisation, growing health awareness and environmental consciousness) foster the use of active modes and micro-mobility devices such as e-scooters. However, according to ERSO figures[17] the share of cyclists and powered two-wheelers (PTW) in all EU road fatalities has increased from 7% to 10% and from 17% to 19% respectively during the last decade. Many of these

[17] https://road-safety.transport.ec.europa.eu/statistics-and-analysis/data-and-analysis/facts-and-figures_en

crashes do not involve other motor vehicles. Moreover, cyclists[18] are the only type of road users for which there has been no decline in the absolute numbers of fatalities since 2010. Therefore, their safety needs special attention. The private funds invested in research by the bicycle industry, however, are orders of magnitude lower than those invested by the automotive industry, due to the sizes of the respective businesses. Therefore, public funding of R&I on bicycle technology will make a significant difference, also in strengthening the market position of the EU bicycle industry. Promoting healthy and green active modes like cycling, will only be successful in the long term if their safety level is substantially raised at the same time. The research described below on the safety of bicyclists and users of other micro-mobility devices is intended to facilitate that and to finally prepare a common ground for healthy, safe and environmentally friendly road transport together with other mobility research within the framework of Horizon Europe.

The increased societal motivation to reduce the use of fossil fuels and the use of space for road infrastructure in cities has increased the interest of consumers to look for energy efficient, more compact and often electrified alternatives to conventional passenger cars. This is increasingly found in light quadricycles (L6e) and heavy quadricycles (L7e), defined by limitations in terms of weight, engine power and speed. Sources forecast that the quadricycle market will grow between 2022 and 2030 by 150%[19], reaching significantly above 100,000 registered units per year. Relevant for this paper, they only have to fulfil technical requirements like mopeds of category L2e (L6e) and tricycles of category L5e (L7e), which excludes advanced active and passive safety testing. Euro NCAP has done two rounds of assessments of the L7e category and found after the second round that the “standard of protection offered to the driver is still generally very low”[20]. Active safety features are rarely found, not even as optional equipment on quadricycles. Because of their regulated unladen weight limit of 425 kg for L6e (450 kg for L7e), it is obvious that safety requirements cannot be directly transferred from passenger cars, and also the limited power or speed and their design for urban traffic might justify reduced expectations. However, the lack of basic safety requirements and the fact that in some EU countries at least L6e vehicles can be driven by people from 14 years of age onwards suggest that there is a risk of increasing the human toll of road crashes in the EU with increasing registrations of such vehicles. For the obvious advantages of quadricycles in other areas, it cannot be the intention to simply remove these relatively lightweight means of private transport from EU roads, but it is strongly recommended to conduct research on what kind of safety threats exist and how they can best be addressed by cost-efficient means. This may go beyond in-vehicle solutions and include road infrastructure measures, road maintenance solutions as well as road safety and traffic management.

[18] Cyclist: Rider of a bicycle, which refers to vehicles with at least two wheels without an engine. It can also use electric power, such as powered cycles according to the L1e-A category, but this category does not include speed pedelecs, electric mopeds, nor other vehicles falling under the EU classification of motor vehicles.
[19] https://www.fortunebusinessinsights.com/motorized-quadricycle-market-103473
[20] https://www.euroncap.com/en/press-media/press-releases/quadricycle-safety-at-a-standstill/

3.1 Safe Human-Technology Interaction in the Coming Decade

Expected outcomes:

Until full automation in road transport is reached, the driver will play an important role in vehicle safety. In this context, the proposed research will lead to human-technology interaction (HTI[21]) systems for SAE Level 0 to Level 3 vehicles (with overlap to Level 4 vehicles) and development guidelines contributing to the following outcomes:

- Increased road safety by ensuring that the driver has the right level of vigilance, situation awareness and trust with respect to the context and the automation level and by facilitating the handling of both high-cognitive load situations and situations requiring instinctive manoeuvres by the driver
- Increased road safety by an increased understanding of the synergies between driver and assistance systems capabilities and by implementing tailored, "self-learning" HTI strategies
- Avoidance of crashes related to mode confusion during the use of driver's assist, the hand-over and take-over phase
- Advanced standardisable assessment tools and methods for improved HTI

Scope:

The increasing automation of road transport is bringing up new challenges especially in lower automation levels when driving control is transitioning from the driver to the vehicle or vice versa. For these levels, **ensuring the right level of driver vigilance with respect to the context and the automation level** is important to avoid dangerous situations because of cognitive distraction.

In addition, systems based on HTI are generally built on a non-stationary and non-deterministic foundation – human behaviour. Therefore, the concept of individually "adaptive" systems has to be followed and elaborated in all its particular aspects, as the consideration of "average" human behaviour is not sufficient.

This has large implications on the design of HTI systems.

Such systems should provide a reliable and seamless interface between the driver and the vehicle in normal driving conditions as well as in specific situations with a risk of generating high cognitive load, diverted attention, inattention, impaired driving or in the case of instantaneous limitations in driving capabilities.

As drivers and their experience, as well as driving conditions, may vary a lot, HTI systems will need to address a wide variety of use cases in order to ensure a relevant ODD (operational design domain). Therefore, in-cabin monitoring systems with adequate accuracy are key to have a clear understanding of

[21] "Human-technology interaction" reflects the increasing and broader seamless, indirect or direct interactions that the human is having with different technologies (e.g. mobile phone, V2X communication, personal devices, general public monitoring systems…), which are then also used as data sources for various interconnected services (e.g.; Google Traffic, general traffic management etc.). On the technology side, this aspect will be relevant for AI-managed systems, which observe human behaviour and then adapt themselves to such behaviour.

the driver state, while considering all contextual in/out cabin data, so that the vehicle can propose a pertinent and tailored strategy to prompt the required driver action or behaviour.

Advances in cabin monitoring and multi-modal sensing technologies as well as robust detection/prediction of driver cognitive status adapted to the situation awareness will be necessary to achieve these objectives. The same applies to the need of linking interior with exterior sensing capabilities.

In addition, it is necessary to **enhance driver's understanding of the assisted and automated driving system and avoid mode confusion.**

The automation status and the limits of the system should be clearly communicated via the human-machine interface to prevent mode confusion, enhance trust and avoid unnecessary deactivation of the assistance or automation systems.

Special attention should be dedicated to the "hand-over" and "take-over" phases. Hand-over/take-over requests should be done considering the context (e.g. information from other vehicles or infrastructure) and the state of the driver in a way to minimize cognitive stress related to hand-over and take-over. In this context, it is important to investigate standardized requirements for the human-machine interface (incl. in case of system failure) including their assessment.

In this respect, research should address the development of relevant strategies to avoid driver disengagement and to reduce cognitive load in critical situations, as well as behavioural models and methodologies to identify activities/behaviours that should be avoided or blocked by the human-machine interface (e.g. availability of systems, such as entertainment systems, or notifications that are most likely to distract the driver from the driving tasks). These strategies should be scalable to the available vehicle sensing sophistication.

Some specific use cases, such as elderly drivers with declining sensing and higher sensibility to cognitive load, young and inexperienced drivers and professional drivers performing other tasks simultaneously will also need to be addressed. For these populations a key research question will be how to meet their specific needs and how to realise the best compromise between tailored vs. standardised approaches.

Also, trust is mandatory for the acceptability of these systems: precision, reliability, and transparency need to be ensured. In particular, the vehicle response to a given situation as well as the level of information to be conveyed needs to be coherent and logical. Relevant research areas to achieve this objective will be the definition of multi-modal and multi-sensorial vehicle warning and response strategies for the safe management of critical phases considering user acceptance and the severity of scenarios.

HTI systems should be upgradable both in software and in hardware with minimal disruption for the users, while ensuring that the intended effect and functionality is improved or at least maintained. A cross-fertilisation opportunity would be to investigate how other transport modes (e.g. aviation) handle upgrades/ updates with minimal disruption for the user.

Social sciences and humanities (SSH) have high relevance in the context of identifying driver acceptability criteria and pain points as well as in setting up use cases.

Further research and data collection is needed to ensure a better understanding of the synergies between driver and assistance systems, to evaluate their performances in different contexts and user scenarios.

This will enable to tailor appropriate adaptive and “self-learning” strategies to the individual driver abilities and preferences.

These research needs are proposed be addressed in coherence and continuation with the call topics HORIZON-CL5-2021-D6-01-10 and HORIZON-CL5-2022-D6-01-02[22].

3.2 Safety of Bicyclists and Users of other Micro-mobility Devices

Expected outcomes: Research is expected to contribute to the following outcomes:

- Improved road safety, especially for (e-)cyclists and users of other micro-mobility devices[23]
- An advanced understanding of the specific safety needs of (e-)cyclists and users of other micro-mobility devices, with guidance for design approaches for such devices as well as safe and forgiving infrastructure
- Increasing use of active modes of transport in all age groups
- Assessment methodologies to evaluate the safety potential and the effectiveness of advanced safety measures

Scope:

In many regions, the share of trips made by active modes of transport is increasing, which is in line with the UN Sustainable Development Goals. At the same time, it is a development that needs to be supported by increasing the safety of these road users, taking into account e.g. age differences and cultural differences. To decrease the number of road fatalities and severe injuries, major actions regarding the protection of (e-)cyclists and users of other micro-mobility means are needed. Actions should include crash risk analysis to determine underlying mechanisms and baseline scenarios, leading to an increased understanding of the specific safety needs of these road users.

The safety of both completely unprotected and partially protected road users riding these vehicles needs to be continuously and properly addressed. The increasing use of communication technologies can be an enabler, as can be improved human-technology interaction technologies and methodologies. At the same time, cycling in particular should be an affordable means of transport for all citizens to foster the benefits of cycling.

For the interaction between motor vehicles and users of any micro-mobility devices, the detection by motor vehicle-based sensor systems is making progress. Research should focus on V2X based detection of these types of road users, advancing on e.g. the MeBeSafe and the SAFE-UP projects. The inclusion of behavioural aspects is an aspect that needs further research, including the area of safety coaching features (nudging). Research should lead to dedicated measures for automatic conflict resolution and protective safety measures for crash mitigation and a forgiving infrastructure. It shall result in new and

[22] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl5-2021-d6-01-10; https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl5-2022-d6-01-02

[23] “(e)-cyclists and user of other micro-mobility devices” refers to riders of vehicles with at least two wheels without an engine, with or without an electric drive, including powered cycles according to the L1e-A category, but not including speed pedelecs, electric mopeds, nor other vehicles falling under the EU classification of motor vehicles.

advanced safety measures both from a technological and a behavioural perspective, while limiting the costs. New assessment methodologies are needed to evaluate the safety potential as well as the effectiveness of these advanced safety measures. Both fatalities and injury severity reduction should be taken into account in such methodologies. An FOT approach is suggested here.

The risks of both single crashes as well as crashes with other micro-mobility devices and the underlying mechanisms should be evaluated, as these types of crash are increasing especially for elderly bicyclists who increasingly are able to participate in traffic at advancing ages due to e.g. electric bicycles. Special focus should be paid to supporting the safety of user groups with particular vulnerability including the elderly as well as people with disabilities. Targeted data collection, to look at safe riding, threats to stability and safety, and consequential falls or collisions is seen as a logical extension of an FOT and any pre-trial study. This, together with the aforementioned assessment methodologies, should be ready to be used in new conceptual designs of bicycles and other micro-mobility devices, as well as in the underlying development of a draft European regulatory framework on e.g. riding requirements, and the potential for type-approval of micro-mobility devices or self-certification based on harmonized standards.

This research requires the inclusion of relevant expertise in SSH, focussing on human-technology interaction, the acceptance of safety solutions and behavioural aspects.

3.3 Safety of Users of Small Electric Vehicles

Expected outcomes: Research is expected to contribute to the following outcomes:

- Improved road safety, especially for users of Small Electric Vehicles (SEVs)
- A set of minimum safety requirements for SEVs and a harmonised approach for its validation, while maintaining the balance with lightweight demands for such vehicles
- An enhanced integration of SEVs in the mobility ecosystem
- A regulatory framework for SEVs and their impact on road safety
- Harmonised validation methodologies and tools for safety assessment with integrated behavioural components

Scope:

Due to the transformation of especially urban mobility, there is an increased demand for new road mobility solutions. This is driven by the need to address challenges such as pollution, traffic density and lack of space. In this context, small and lightweight electric vehicles (SEVs; L6e, L7e and potentially a future M0 category) have the potential to replace conventional passenger cars (M1 category) due to their potential for environmental benefits, lower costs and individualisation, as well as reduced size which is appreciated especially in the urban environment.

However, despite the benefits which these new mobility solutions can offer, there are some challenges that need to be faced, with safety being the top priority. The fact that most of these vehicles aim for lightweight and low-price solutions has led to their safety equipment not being as extensive as for vehicles of higher mass which do not need to deal with such weight restrictions. Additionally, crash tests for these

vehicle categories are not required for EU type approval. In the case of heavy quadricycles, the effect can be seen in results from previous Euro NCAP tests[24]. Moreover, lighter structures of these vehicles contrast with the higher weights of other motor vehicles, compromising the occupant protection in terms of crash compatibility.

This leads to an emerging need to enhance the safety of SEVs, considering not only in-vehicle solutions related to both passive and active safety features, but also physical and digital infrastructure measures that could allow to better integrate these vehicles within the traffic eco-system. Research is needed to define the minimum level of safety requirements for such vehicles, which can be applied in a harmonised approach. This set of safety requirements also needs to accommodate future and emerging new types of SEVs resulting from fast market developments. These SEVs are expected to have more and closer interactions with vulnerable road users than regular passenger cars. This needs to be accommodated in the safety requirements as well.

As a further consequence, this work can help to define a regulatory framework around light electric vehicles, at least in terms of their impact on road safety.

The occupant safety of such vehicles needs to be continuously and properly addressed. Protective systems for one vehicle category domain might not transfer to another directly, and the options and limitations should be re-evaluated. Proposals for safety solutions should be based on a sound understanding of injury mechanisms and the potential for mitigating injury consequences. This requires an up-to-date enquiry into crash causation, injury causation, factors affecting the risk of more or less severe injuries and safety system effectiveness – considering all pillars of a Safe System.

Research should also address the option to broaden the current scope of the application of geofencing technologies. Effective means of implementing geofencing for SEV users' safety, opportunities and validation should be shown in relevant use cases.

This research requires the inclusion of relevant expertise in SSH, focussing on human-technology interaction and behavioural aspects.

The topic is suggested to receive funding via the 2Zero Partnership.

[24] In a Euro NCAP official campaign, none of the vehicles assessed with the special protocol for testing heavy quadricycles achieved a rating above two stars, https://www.euroncap.com/en/vehicle-safety/safety-campaigns/2016-quadricycles-tests/

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5 Annex

5.1 List of Abbreviations

Abbreviation	Meaning
AI	Artificial Intelligence
CCAM	Connected, Cooperative and Automated Mobility
ERSO	European Road Safety Observatory
ERTRAC	European Road Transport Research Advisory Council
ETSC	European Transport Safety Council
Euro NCAP	European New Car Assessment Programme
FOT	Field Operational Test
GDP	Gross Domestic Product
HTI	Human-Technology Interaction
IRTAD	International Traffic Safety Data and Analysis Group
KPI	Key Performance Indicator
ODD	Operational Design Domain
OECD	Organisation for Economic Co-operation and Development
R&I	Research and Innovation
SAE	Society of Automotive Engineers
SDG	Sustainable Development Goal
SEV	Small Electric Vehicle
SSH	Social Sciences and Humanities
V2X	Vehicle to Everything
VOSL	Value of a Statistical Life
VSSI	Value of a Statistical Serious Injury