SAFER ANNUAL REPORT

2021

YEAR 3/5 IN STAGE 5
JAN 1 – DEC 31 2021
OPERATIONAL YEAR 16

SAFER

VEHICLE AND TRAFFIC SAFETY CENTRE AT CHALMERS

SAFER Vehicle and Traffic Safety Centre at Chalmers is a research and competence centre where 44 partners from the Swedish automotive industry, academia and authorities cooperate to make a centre of excellence within the field of vehicle and traffic safety.

Research at SAFER spans a broad base, covering several disciplines and encompassing both safe mobility and vehicle safety in real environments. The centre's activities engage the very elite in the field of safe transport solutions, and the results contribute to increasing the competitive advantages of the partner companies and organisations. Chalmers University of Technology hosts the centre. By using the multidisciplinary scientific competence available within the centre, we make it a hub for excellent research and knowledge dissemination, with the vision to contribute to a safe and sustainable transport system for all.

SAFER conducts borderless research to save lives!

CONTENT

INTRO-
DUCTION

Welcome to our annual report! The purpose of this report is to present the effects and outcome of the third operational year in SAFER's fifth stage, extending between January 1st and December 31st 2021.

FIRST, WE WANT TO THANK all SAFER partners for an incredibly positive year of collaboration in traffic safety research! Due to the currently ongoing pandemic, we have collaborated on-line, using digital tools, most of the year. We think this has worked out very well; projects have been created, we have moved forward with various matters, we have influenced upcoming funding opportunities and shared knowledge with each other as well as presented and discussed a large amount of research results. A lot has happened at SAFER during the year, and we would like to share a summary of our main highlights with you:

First, our **project portfolio** and all **engaged researchers!** These are the foundations of our successful collaboration; the people and projects are the base for our centre of excellence and the portfolio supports SAFER to continue to be attractive to our partners, and also to other research actors around the world. Our project portfolio has been enriched with another 24 projects and the number of researchers involved in the network has increased by almost 100, from around 450 to close to 550 people. The number of partners is also growing and nine new organisations joined SAFER during the year.

The SAFER pre-study program! This investment has really been a true success. The program was launched in connection with the start of the current stage, and the initiative has developed even better than we could anticipate. It is valuable for our joint research and project portfolio, helping us getting started in new areas, exploring, thinking in new ways, trying out new groups of partners with the aim of even better utilizing the multidisciplinary arena to design larger projects, where suitable. Read more about the program on page 26–29. In 2021, seven new pre-studies have started up and we are looking forward to your new and inspiring ideas!

SAFER has continued the long-term efforts to secure the traffic safety content in **Horizon Europe**, the European research programme spanning from 2021 to 2027. This has been done through active participation in selected organisations and in 2021, focus has been on two major efforts: the formation of the CCAM (Connected, Cooperative & Automated Mobility) partnership in which several SAFER partners have been instrumental in safeguarding the road safety aspects in the strategic research and innovation agenda, and the recent update of the ERTRAC Road Safety Roadmap. The roadmap has been delivered to the Commission and will be used for further dialogue regarding the 2023–2024 and 2025–2026 work programmes. The main focus for our collaboration in 2022 is to continue to form strong consortia with SAFER partners to submit applications to relevant calls.

We are also proud of the positive development of our collaboration with India through the SITIS platform. Through this collaboration, we do not only share our knowledge about road safety to a country where many people lose their lives in the road traffic every year, but we can also learn, for example about accident data and road user behavior that in turn will contribute to valuable knowledge in our future research. You can read more about our activities in India and other **international collaborations** on page 20–23.

In 2021 we have also celebrated 15 years of borderless research to save lives in traffic by joining forces with the Swedish automotive industry, academia, research institutes and societal actors. Thousands of researchers have been active in the research and competence center over the years and since the start in 2006, close to 400 projects have been carried out, over 1000 publications have been published and 64 doctors have been examined in SAFER's unique collaboration environment. Several prestigious awards have also been granted to SAFER and its researchers over the years.

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SAFER's connected research resources have also been further developed; our databases are undergoing a major modernization to enhance the datasets by extracting features from interior recorded video and adding parametric data. When the upgrade is completed, we will be able to use the databases to a much higher degree than today. AstaZero, one of the most advanced full-scale test environments for road safety in the world, has expanded its operations, including the inauguration of the world's longest indoor autonomous vehicle test track. Reproducible environments are a fundamental prerequisite for ensuring the accuracy of test results and our researchers are now able to conduct tests 24 hours a day, 365 days a year.

The opportunity for researchers to be offered a stepping stone with cutting-edge expertise between theoretical models or simulators and full-scale tests has proven to be extremely important for efficient and successful research. The expertise at Revere, our vehicle lab for active safety and autonomous driving, plays an important role for our researchers in this task. The operations have been expanded over the past years and both electromobility, autonomous watercraft and collaborative flying drones are now included in the lab's knowledge repertoire.

Our focus on knowledge building has also continued through the formation of two **new competence networks;** System safety and Future proof test methodologies for validation of connected and automated vehicles. The purpose of the competence networks is to effectively build and share knowledge, start up new projects and build long-term relationships between our researchers and disseminate research results in an inspiring way.

It is also encouraging to see that Agenda 2030 and the **recommendations from the UN conference** in Stockholm in 2020 are now being embraced and used in the society. The 17 sustainable development goals are indivisible, and this essence makes us well positioned for the future; the broad range of competences available in our network is a great opportunity to contribute to the common societal challenges and to be inspired and guided by our research.

We are also pleased with the great commitment to start creating our **joint future research agenda for SAFER's next stage,** which starts in January 2024. In September, we organized a workshop in which nearly 100 participants generated as many as 500 ideas. When we sum up the input, we see that there are several new areas we need to jointly address in order to achieve our common vision, including a greater focus on for example new vehicles and forms of mobility, infrastructure, safety culture, traffic safety footprints and also an even greater focus on road user behaviour. We also see that much of what we do today generates high value and will continue into the next stage. We are very much looking forward to a continued dialogue with all of you in the co-creation of our common long-term research agenda.

Our mission to bring people together to create research and knowledge that save lives and prevent injuries will continue in 2022 and we are looking forward to yet another inspiring year of traffic safety research in close collaboration!

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Best Regards,
SAFER Board and Management team

THE MANIFESTO

The Manifesto presents our human-centric vision, mission and what SAFER's partners want to achieve together.

SAFER IS CONTINUOUSLY on a bold journey towards zero fatalities and injuries in road traffic. This is achieved through open, collaborative research projects where traffic safety is key for the creation of a safe, sustainable, connected and, where suitable, automated, transport system. SAFER's holistic traffic safety approach covers people, vehicles and infrastructure. This also means that SAFER is part of a larger societal project: the design and realisation of smart, adaptable, sustainable and resilient transport systems in our cities and beyond. SAFER's role is to be a thought leader in safe mobility of people and goods, offering world-leading knowledge. SAFER creates knowledge and value beyond what a single partner can achieve on its own.

VALUES AND IDENTITY

SAFER has a unique identity with clear values such as openness, mutual respect, curiosity and joy of discovery. We are passionate to make a difference, contribute to society, build relevant knowledge and we understand the benefits from interdisciplinary expertise and talents. Collaboration is a hallmark and thrives on diversity in all aspects and borderless networks seeking and attracting expertise where it is to be found.

OVERALL OBJECTIVES

Together, we want to create new knowledge and research findings that enable people and goods to be transported safely, effectively and sustainably. Vision Zero is our guiding star and we want to make significant contributions to this bold vision and save lives and reduce traffic injuries. Our research has a human centric approach. Protecting people is our primary goal, although there are secondary positive effects of our research that also contribute to a sustainable society, for example, reducing the number of traffic accidents contributes to lower environmental impact and more cost-effective freight transport. During SAFER Stage 5 we aim to fulfil our defined research targets, as well as work according to the four cornerstones in our strategy.

Of course, it is also a matter for SAFER to contribute with research results and knowledge striving to contribute to the global Sustainable Development Goals (SDG:s). The SDG:s are the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity, peace and justice. The work of integrating the sustainability goals in a clearer way has been a focus area during the year. The global UN-conference on road safety that was held in Sweden in February 2020 and its outcome in the form of the Stockholm Declaration and the recommendations in the book "Saving Lives Beyond 2020 – the Next Steps", have created engagement and inspired us in our research, read more about this work on page 12–13 and 50.

All road users travel safely in the road transport system.

We bring people together to create research and knowledge that save lives, prevent injuries and enable safe mobility for people and goods.

STRATEGY

TO SIGNIFICANTLY CONTRIBUTE to the vision and mission as well as being a well renowned international centre of excellence, SAFER will deliver results, build competence and create strong networks in selected areas. Furthermore, SAFER shall create value for the partners beyond what a single partner can achieve on its own.

SAFER's strategy consists of three different conceptual parts – SAFER Core, the SAFER Research and project portfolio and SAFER Assignments and investigations, see figure 1. SAFER Core is the name of the driving function of SAFER with its operational team including communication and support systems, research areas and their reference groups, the connected research resources, networks and the physical working and networking environment.

To realise our vision, our strategy is based on four interlinked cornerstones that direct our actions: *Create and share knowledge, Express identity and influence as a thought leader, Utilize the multidisciplinary research platform, Connected research resources.*

1. CREATE AND SHARE KNOWLEDGE

The basic task for SAFER is to create and share knowledge and to further develop the strong academic base. New knowledge and relevant facts should be made available and visualized. Furthermore, networks should be created and maintained to the benefit of all partners. SAFER should be promoting project generation and coordination and act as a catalyst for joint projects. By creating strong connections to world class research environments and nurturing an international reputation for outstanding collaboration between industry, society and academy, it is possible to influence the international research agenda. The research results should help facilitate innovation at our partners.

2. EXPRESS IDENTITY AND INFLUENCE AS A THOUGHT LEADER

The name SAFER should mean excellence in vehicle and traffic safety research and be of value to all partners to be associated with. This identity is built, expressed and made visible in different ways – seminars, conferences, website, the office and other activities. By communicating what SAFER represent and the achieved results we will attract international stakeholders, collaboration projects and funding. As a thought leader, SAFER should define strategic research agendas based on needs and trends, create and drive SAFER's research projects and develop road maps. The conclusions and needs of the SAFER community should be made visible and known.

FIGURE 1: OUR STRATEGY

SAFER RESEARCH Cutting edge applied research	SAFER Assignments and Investigations

SAFER CORE – THE PLATFORM
Cornerstones in SAFER Core
1. Create and share knowledge
2. Express identity and influence as a thought leader
3. Utilize the multidisciplinary research platform
4. Connected research resources

3. UTILIZE THE MULTIDISCIPLINARY RESEARCH PLATFORM

A cornerstone in the strategy is to have a multidisciplinary research environment that serves as a physical meeting place, open to all partners. The networks and meeting places we create together will provide added value to partners. The community will generate new knowledge and project ideas as well as develop the people involved, both on a professional and personal level.

4. CONNECTED RESEARCH RESOURCES

The concept of connected research resources is a hallmark for SAFER and we facilitate the access and utilization of different assets available within the network. These comprise the following: the collaboration setup with *the physical environment* providing workspaces, meeting and analysis rooms, support for seminars etc; *field data*, with databases of real-world data including their collection, storage and analysis tools are strong assets and SAFER will further develop business models to maintain them. *Revere* – Resource for Vehicle Research, the full-scale vehicle laboratory at Chalmers, which is increasingly important for active safety research, automated driving and a connected, sustainable transport system; the *AstaZero* test environment, co-owned by RISE and Chalmers, which provides a world class facility where SAFER supports research activities; simulators of different kinds exist in the network, most notably at the Swedish National Road and Transport Research Institute (VTI). *SAFER's Human Body Model* encompasses a scalable, tuneable, human body models that can be used for predicting injury outcome in any impact situation. SAFER provides a competence platform for SAFER partners as well as a natural contact point for external cooperation. SAFER's partner, the road safety organisation NTF Väst, gives our researchers the possibility to use a very closely located traffic training site, *Stora Holm*, offering various test tracks and a skid pad for tests and events.

MONITORING PROGRESS AND KPI:S

A number of criteria will help prioritise our research efforts and how we should work to reach SAFER's objectives. The overall objectives and criteria are regularly monitored and evaluated. Also, the key performance indexes and measures help the partners to evaluate the strategic and operational workplan.

01. IMPACT: The added value for the SAFER partners as well as the society as a whole is a key to our continued success and is an integral part of the strategic plan. This is primarily created through collaborative work where different partners contribute according to their needs and competence, the result is that we conduct excellent and relevant research with real-life applications and impact.

An example is SAFER's project portfolio, to which e.g. 24 new projects have been added during this operational year. Also, we have started up a new competence network, Future proof methodologies for validation of connected and automated vehicles, to build even more knowledge within this specific area. All in all, seven competence network have been active within the SAFER platform in 2021.

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02. CONTINUOUS RELEVANCE: In the ever-changing landscape of road transport systems, new types of vehicles and ownerships etc, it is of utmost importance that SAFER understands the needs and the context in which we work in order to put the focus on the right topics and issues. SAFER is continuously requested to contribute both on a national and an international level.

SAFER has continued to be a strong speaking partner in the processes shaping the upcoming research programmes in Sweden and the EU during 2021. For instance, in the formation of the CCAM (Cooperative, connected Automated Mobility) partnership in Europe, several SAFER partners have been instrumental in safeguarding the road safety aspects in the strategic research and innovation agenda. The result of this work is now evident in the framework programme for Horizon Europe with several calls based on this input. Also, we have several new partners contributing in supporting our collective understanding on how to design safe micromobility as well as safe automation.

03. COHERENCE WITH THEMATICALLY RELATED INITIATIVES: The global research environment in which we operate is changing continuously and new initiatives are created to which we need to relate to and make sure to benefit from and provide input to when applicable. By doing so, we are perceived as a major player in sustainable and safe transport, we consider safety as one of the main prerequisites. We are well-connected to, and cooperate with, other relevant organisations.

During 2021, we have been working in close collaboration with Drive Sweden and AI Sweden to build knowledge and generate projects in which AI can be used as a tool for improved traffic safety. SAFER has been leading a working group under the AI Driven mobility program, read more on page 29. Within Drive Sweden, we have further increased our presence, among other things through participation in the thematic area of public engagement. Drive Sweden is an arena where we get closer contact with cities and regions, which are important recipients of our research and helps us to understand needs and challenges.

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04. EFFICIENCY: Our operation needs to be efficient in order to use our limited resources as efficiently and effectively as possible; we need to be experts in streamlined working processes and our multidisciplinary research platform enhances research, networking and make work easier for our partners.

This year has been extraordinary in many ways due to the pandemic and we have used online tools for collaborations. Seminars, workshops and other meetings have been held fully, or in a few cases partly, online. Overall, the attendance has increased, as well as the international presence, which is very positive. We do however see some effects of the lack of (semi)spontaneous meetings, especially in the creative process when forming new project consortia.

KEY PERFORMANCE INDICATORS

| ACTIVITY	THE FIRST YEAR IN SAFER STAGE 5 (APRIL 1ST – DEC 31ST 2019)	THE SECOND YEAR IN SAFER STAGE 5 (JAN 1ST – DEC 31ST 2020)	THE THIRD YEAR IN SAFER STAGE 5 (JAN 1ST – DEC 31ST 2021)
	2019	2020	2021
Total number of projects ongoing	52	70	81[1]
New projects	12	38	24
Finalised projects	21	20	30
Publication volume	59	78	87
Number of seminars and other knowledge sharing activities	49	74	79[2]
Number of visits by external stakeholders	7	N/A	5[3]
Invitations to international projects	10	4	7[4]
Visability/references in conferences	18	15	33[5]
Connections to other research centres and collaborative organisations	25	25	27[6]
Partners on Level 1	7	7	7
Partners on Level 2	18	18	18
Partners on Level 3	12	12	19
Gender balance in SAFER Board and management team (women/men)	11/12	11/12	10/12
Number of SAFER partners per project, see figure 5 on page 33	No.	No.	No.
Partner satisfaction index	–	4,45	4,75[7]

2021

1. Read more about our project portfolio on page 32 and all the projects are listed in appendix 6.
2. See complete list of activities in appendix 7.
3. Very few visits have been made due to the Corona pandemic: GATE, DAFF, POLIS, IKEA, EARPA.
4. FAME, Sunrise, ZEFES WEBESAFE, Moodie, two SITIS-projects.
5. See complete list in appendix 3.
6. See complete list of SAFER's ecosystem in appendix 5.
7. A survey was performed among level 1 and 2 partners to answer the question "The overall benefit of the partnership?". The scale was 1–6, 6 was very good.

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Our mission to bring people together to create research and knowledge that save lives and prevent injuries will continue in 2022 and we are looking forward to yet another inspiring year of traffic safety research in close collaboration!

SAFER Board and Management team
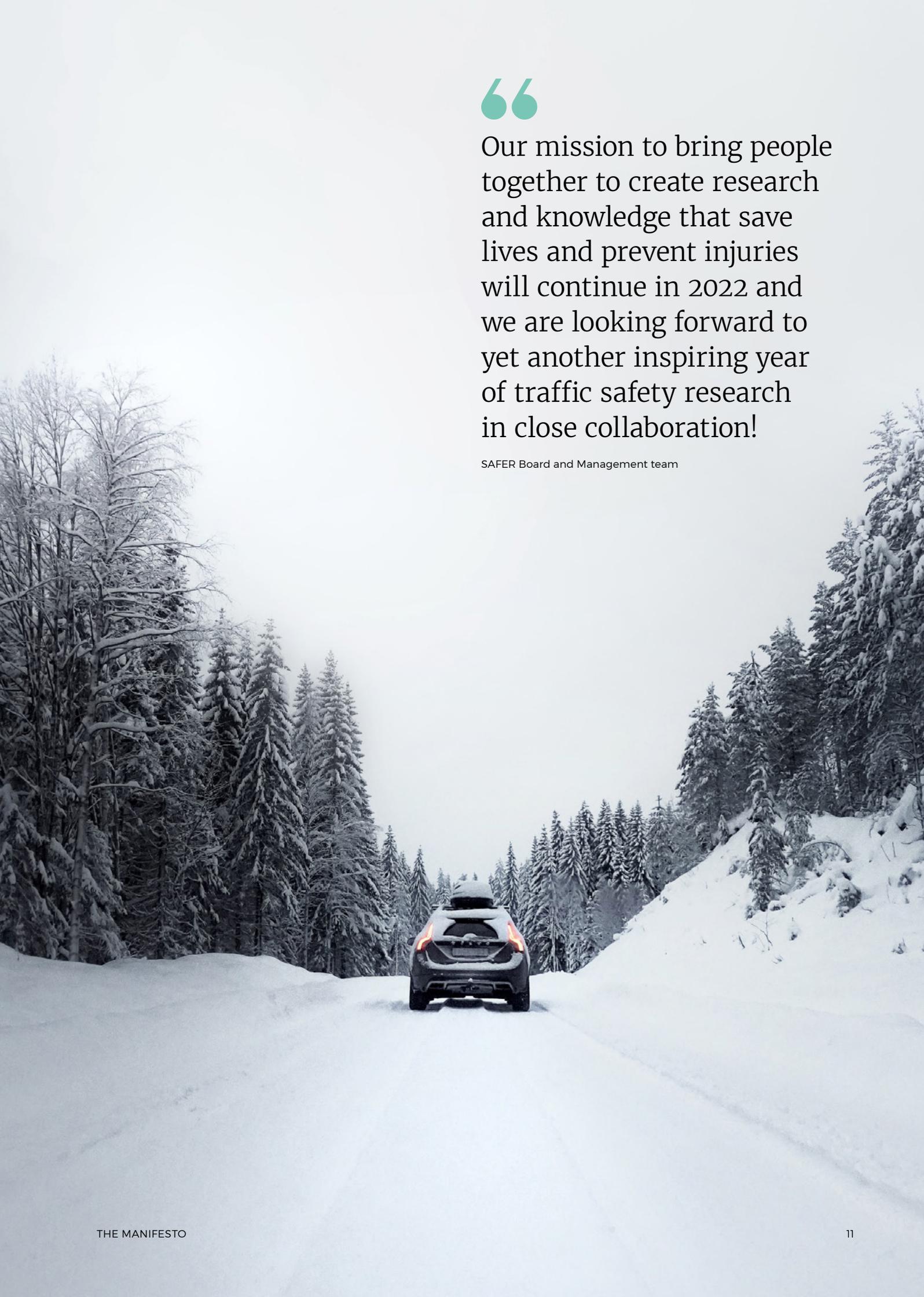
AGENDA 2030:

THE GLOBAL SUSTAINABLE DEVELOPMENT GOALS AND TRAFFIC SAFETY RESEARCH

AGENDA 2030 IS THE MOST ambitious set of sustainability goals ever adopted by the UN member states, and road safety is included both directly and indirectly in several of the goals. The goals are absolute and indivisible, which means that the work with different goals such as road safety, gender equality, poverty and climate change must take place in parallel. SAFER wants to continue to be proactive and contribute to Agenda 2030 through its research. We believe that broad collaborations and knowledge transfer are keys to success. The goals are inseparable and therefore several actors need to target the challenges provided by the goals, at the same time.

For us to succeed in our research, there must be funding opportunities for this new approach and we need to learn from inspiring examples of how to do this in practice. The long-term perspective is also still important, as is evaluating results; what works and what is less useful.

Transport connects societies, individuals, services and goods and has a great opportunity to contribute to a sustainable transformation of the society at the same time as the transport systems also must undertake considerable changes to be more sustainable. We indirectly contribute positively to many goals since safe transport often is a prerequisite for successful goal fulfillment, e.g. enable access to health care and food distribution. There is also a specific sub-goal for road safety; 3.6. "Reduce road injuries and deaths".

Below we present an overall summary of the assessment of our traffic safety research and how we aim to approach the global SDGs.

3. GOOD HEALTH AND WELL-BEING
Goal 3 is about ensuring healthy lives and promoting well-being for everyone. Good health is a fundamental prerequisite for people's ability to reach their full potential and to contribute to the development of society. Human health is affected by economic, ecological and social factors and goal 3 includes all dimensions and people of all ages.

SAFER'S CONTRIBUTION
SAFER's vision is that all road users should travel safely in the transport system and our project portfolio support this bold vision with a wide range of projects that will lead to more knowledge on how to design a safe and sustainable transport system, for all.

5. GENDER EQUALITY
Gender bias is undermining our social fabric and devalues all of us and it is a tremendous waste of the world's human potential. By denying women equal rights, we deny half the population a chance to live life at its fullest. Political, economic and social equality for women will benefit all the world's citizens.

SAFER'S CONTRIBUTION
SAFER has a strong focus on developing traffic safety solutions that are equal for all people. We work with injury protection for all, while the vehicle safety assessments of today are mainly based on men. Our human body models represent the entire population, men and women, young and old, in all sizes.

KEY AREAS AND SUCCESS FACTORS FOR SAFER'S FUTURE RESEARCH

Sweden hosted the third global ministerial conference on road safety in Stockholm in February 2020 and this major event resulted in "The Stockholm declaration", a strategic agenda and recommendations to achieve the global sustainable development goals and halve the number of fatalities in traffic between 2020 and 2030. The Stockholm declaration was adopted into a UN resolution in August 2020. In conjunction to the conference, the book "Saving lives beyond 2020 – the next steps", developed by the conference's Academic Expert Group, led by Prof. Claes Tingvall, was also launched. The book presents a new way of thinking on how road safety can be addressed in a much broader perspective. That, in turn, can open up great opportunities to even better utilize SAFER's road safety research, find new partners and start taking big steps towards a more sustainable transport system. The book will continue and inspire us in our research activities ahead.

We have identified many new, also several cross-cutting, topics and research questions, in which we in the traffic safety research community will be able to contribute. For example, support the understanding of which technologies for increased road safety that will be most effective in the future, also taking into account future scenarios, as well as other societal needs, such as the environment and health. Becoming even better at technology transfer has a large traffic safety potential, such as even deeper look into how protection systems and preventive safety systems that are currently found in cars, can be used for two-wheelers. Knowledge transfer and reliable data are other important issues.

Many people who loses their life in traffic is a victim of someone's value chain. This way of thinking can provide entirely new ways of looking at responsibility. If each company or organisation starts to regularly report its footprints for traffic casualties in the same way as for example climate impact, there will be an increased focus for improvement, for example with regards to requirements for procurement, actions and follow-up. Reporting and systematic follow-up is hence another important area that has huge impact on global road safety.

The global sustainable development goals are indivisible, which opens up completely new opportunities for road safety and SAFER's research.

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9. INDUSTRY, INNOVATION AND INFRASTRUCTURE

A functioning and resilient infrastructure is the foundation of every successful community. To meet future challenges, our industries and infrastructure must be upgraded and we need to promote innovative sustainable technologies.

SAFER'S CONTRIBUTION
Knowledge building and collaborative activities to support access to safe, affordable and sustainable transport systems for all, are the foundation of SAFER's research. We also work on development of various forms of collaboration and connect to other actors to put traffic safety in a broader context.

11. SUSTAINABLE CITIES AND COMMUNITIES

Goal 11 is about making cities and settlements inclusive, safe, resilient and sustainable. This in turn requires new technology and cooperation between several sectors.

SAFER'S CONTRIBUTION
An important component of a sustainable society is safe transport. This is also the basis of our research; to contribute with knowledge and facts to build a sustainable road transport system. We cooperate together with other actors to plan for future mobility and produce knowledge that can form the basis for new products and services that contribute positively to fulfillment of this goal.

THE FRAME-WORK

The framework is the context in which we work; the partners' agreement, the operational plan, financing, working processes, the operational team, partnerships and the connected research resources.

ORGANISATION AND MANAGEMENT OF THE CENTRE

SAFER'S VEHICLE and traffic safety research is completely based on partnership. The partners govern SAFER via the shareholders meeting and the Board, consisting of eight members. The Board meets 5-6 times a year, including at least one dedicated strategy meeting. At Chalmers, SAFER is the core of the research profile traffic safety within the Transport Area of Advance. The daily operation is run by the director, the secretariat and the management team. These teams consist of a few persons paid by SAFER and some partner employees' in-kind. Four Research areas create the formal arena for partners to meet and identify key issues and initiate needs-driven research. Each group is led by a Research area director and a Co-director who are supervising the project portfolio. The Research area directors are also members of the management team. The Competence networks, led by respected scientists, gather SAFER partners to share and develop new knowledge within their respective field. This ensures contact with centres and organisations with similar or complementary research, both nationally and globally. See appendix 2, 3 and 4 to read more about the Board, management team and Competence networks. More information about the four Research areas and their research result during the third year of SAFER Stage 5 can be found on page 34–47.

SAFER focuses primarily on pre-competitive research and projects including several partners. It is a multidisciplinary and diverse meeting place where the persons involved come from academia, institutes, industry and society. This means that those working at SAFER are employed by one of the partners. During this year, there have been about 550 researchers active in the community. In a creative and open research environment, diversity is an important aspect and a conscious concern. Other diversity aspects at organizational level include partners of different sizes, maturity in subject, etc. At individual level, diversity aspects of importance and present at SAFER include gender, multiculturalism, mixing senior and junior researchers, etc. SAFER consciously promotes a good gender balance and SAFER management team as well as the SAFER Board are close to a 50/50 balance.

PARTNERS

Safe mobility of people and goods in a sustainable system can only be realized when talented and dedicated people work together with a clear vision, shoulder by shoulder. The development of knowledge in vehicle and traffic safety is essential, and by applying results from collaborative research the SAFER partners create visible and measurable results in practice. The partners access – and contribute to – a unique competence and research collaboration platform. In SAFER's Stage 5, 35 partners joined the collaborative research agreement and during this year nine new organisations have joined the partnership.

In the field of micromobility, we have had the pleasure of welcoming both **TIER** and **VOI** to the community. These partnerships can contribute to SAFER's joint research through e.g. access to customer data and opportunities to study road user behavior, discuss and test different protection systems. The partnership can also bring valuable knowledge in new forms of mobility in general, that can be applied to future research on other new personal transport means.

AGREAT and **KNIGHTEC** offer cutting-edge expertise in functional safety and joined SAFER primarily to contribute with knowledge sharing within our competence network for System Safety.

ASTUS AB is an expert service provider with focus on safety argumentation for automated road vehicles. Besides providing consultant services in the area, the company also significantly invests in international standard work and in writing scientific papers.

CONSENZ develops a connected and fully voice controlled heads-up display that gives the driver a safe and comfort-able experience on an individual level. Being an affordable retrofit solution for any car, Consenz enables smart, interactive, and dynamic traffic planning as well as increased traffic safety.

DUWILL is working with systematic analysis of road safety, i.e. from goals to actions and evaluations. DuWill supports organisations to implement the recommendations included in the Stockholm declaration to reach the road safety goals by 2030.

HÖVDING's key product is an airbag head protection product called Hövding. The protection system is connected and enables automatic alerts in the event of an accident. Hövding will be a knowledgeable speaking partner in the area of unprotected road users and the data they collect regarding cyclists, traffic situations and accident sites will be valuable for various research activities.

VISCANDO is developing advanced 3D & AI stationary sensors for collection of naturalistic data on movements, behaviors, interactions and conflicts of all road users, as well as methods and data tools to identify and quantify safety risks in traffic, not least caused by traffic infrastructure. They have a broad expertise in sensor technologies, naturalistic data collection, traffic safety analysis and verification of autonomous and connected vehicles.

Together, they all contribute to create new knowledge and research findings that enable people and goods to be transported safe, efficient and sustainable. See the complete list of the 44 partners that have been active in the partnership in 2021 in appendix 1.

CONNECTED RESEARCH RESOURCES

SAFER is located at Lindholmen Science Park in Gothenburg, the Swedish hub for future mobility.

STRONG ASSETS FOR REAL-WORLD TRAFFIC SAFETY RESEARCH

As a SAFER partner you get access to SAFER's open research arena and, through relevant projects, research resources available within the network. Also, expertise to use these research resources is available in the community. The overall idea – and one of our strategic cornerstones – is that research should be easier, better and more efficient through collaborative partnerships. This unique set of platforms includes full-scale road traffic safety test environments, simulators and a research lab for active safety and auto-nomous driving. SAFER also provides physical work areas as well as a world-class naturalistic driving data platform. Together, these resources allow borderless research with outstanding opportunities of real-world testing and valid-ation.

LINDHOLMEN SCIENCE PARK – THE SWEDISH HUB FOR FUTURE MOBILITY

Lindholmen Science Park, in which SAFER is located, is both a dynamic area and an arena for collaboration across geographical borders. It is home to several of Sweden's leading development projects, with a focus on mobility for tomorrow. Lindholmen Science Park has become the most knowledge-intensive and expansive area in Gothenburg, and an important hub for automotive and mobility research. About 375 companies have elected to locate offices in the science park, as have two universities and six secondary schools. Some 25,000 people now spend time here every day, a figure that is expected to double over the next five years. The location is full of life and energy that allows you to meet and learn about each other's ideas. We feel that the environment at Lindholmen definitely is right for a collaboration platform like SAFER and the venue as such is a contributing factor to our successful way of researching and collaborating across borders and between different disciplines.

SAFER NATURALISTIC DRIVING DATA PLATFORM

The SAFER Naturalistic Driving Data platform is a secure, world-class platform for handling data from naturalistic driving data collection. Providing state-of-the-art data management, several large datasets and a leading research competence regarding naturalistic driving data, this platform gives unique access to naturalistic data derived from about 6.5 million driving kilometres. The SAFER partner researchers also have access to the in-depth crash databases INTACT and IGLAD.

In the summer of 2020, a work to transform the SAFER Naturalistic driving database to a more modern architec-ture was started. SAFER has been granted research funding for a major investment in developing the FOT databases by adding e.g. an improved eye tracking and body position features, to even better understand human behaviour in vehicles. The development will be conducted with the help of machine learning - powerful computers will track differ-ent driver states and behaviour in the database, instead of a real person doing the work. The result will thus be obtained faster, and probably also with a more precise result. When the upgrade is completed, the database will be able to support research to a much higher degree than today, e.g. to validate safety systems in future vehicles that keeps track of the driver's attention and drowsiness.

SAFER's research infrastructure will be expanded with a new asset for efficient traffic safety research; a data catalogue containing information about available quality assured datasets for research and description on how these can be accessed. With an ever-increasing focus on data in the community, we are now establishing a SAFER data portfolio to support projects and partners. Knowledge of the different datasets available in SAFER's network is important for efficient work within projects, providing new perspec-tives on past and present research, and being able to create completely new projects through data-driven research. By sharing knowledge on these datasets in a SAFER data catalogue, we will help ensure that SAFER continues to be attractive to other research groups in the world. The first release of the data catalogue is planned for publication in March 2022.

The simulator at VTI is a connected research resource at SAFER and often used in various research projects as a valuable tool.
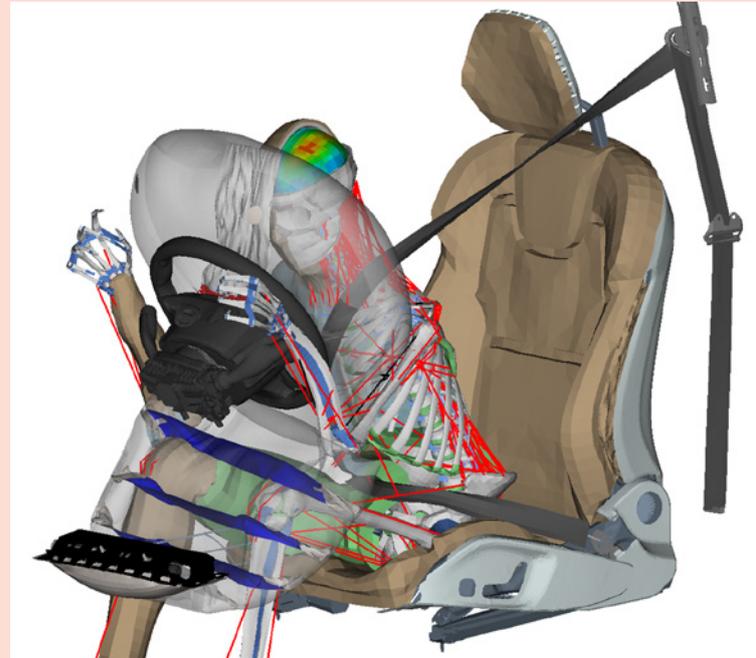
SAFER's HBM is one of the most advanced human body models in the world, being developed and used by SAFER's partners.

IGLAD is an *Initiative for the harmonization of Global in-depth traffic Accident Data* to improve road and vehicle safety. Each year more than 1000 accidents from 12 different countries across the world are coded according to a standardized data scheme and the resulting yearly dataset is shared between the 23 consortium members. The constantly developing IGLAD codebook provides a well-defined and simple layer that serves as a common denominator for the participating databases. In the autumn of 2021 the IGLAD consortium decided to include PCM (Pre-Crash Matrix) data into the dataset. A first dataset of at least 100 cases is planned to be available during 2022. The ambition is to successively increase the number and quality of PCM cases which will help to attract more companies and research institutions to join IGLAD. SAFER has a coordinating role, and the SAFER partners Autoliv, Chalmers, Volvo Cars and Volvo Group are members in IGLAD.

SIMULATORS

The driving simulator Sim IV at the Swedish National Road and Transport Research Institute (VTI) has an advanced motion platform system and permits significant linear movement along both x and y axes in combination with a hexapod. Sim IV is useful when motion feedback is important or if a wide field of view is prioritised. The SIM IV can facilitate cabins for a car, a truck and a bicycle. The simulator's visual system is now also complemented by introducing a VR head set that are used for bicycle applications. The simulator is used regularly by SAFER's partners, for example in MICA II and the CTS-project Heterogeneous Traffic Groups Cooperative Driving Behaviours Research under Mixed Traffic Condition. As an effect of the ongoing

corona pandemic, we have also conducted a task to update our hygiene procedures in test activities involving humans. The goal was to establish a set of general guidelines to consider when attempting to mitigate the risk of contagion while performing research or testing activities. Questions related to "How can experiments involving test persons in vehicles, driving simulators, virtual-reality studios, or similar test facilities continue?", "What safety procedures should we consider in order to ensure proper hygiene for the individuals involved?", "Is it required for drivers to wear a face mask?", and "How do we implement physical distancing provisions pre- and post-experiment interviews?" were addressed.

SAFER HUMAN BODY MODEL

Within human body modelling (HBM), SAFER provides a competence platform for our partners as well as a natural contact point for external cooperation. SAFER's HBM vision encompasses a scalable, tuneable, human body model with omni-directional injury prediction capabilities, suitable for use in high-g and low-g events and as any road user, occupant or vulnerable group. This means a virtual human substitute that can be used for predicting injury outcome in any impact situation and direction of loading, able to be morphed to replicate a large proportion of the population, standing or sitting, with humanlike kinematics in crash events as well as pre-crash manoeuvres. The SAFER HBM research combines several projects, all developing the existing model towards the overall goal of performance. The research is moving towards an open-source model, to enable wider use of the tool. On page 46 you can read more about the SAFER HBM and its development during 2021.

The traffic environments at AstaZero make it possible to test advanced safety systems for all kinds of situations.

At Stora Holm, a connected research resource at SAFER, various test tracks and a skid pad are available for tests and events.

AstaZero dry zone, the world's longest indoor test track, was inaugurated in 2021.

STORA HOLM – A CLOSELY LOCATED TEST TRACK

SAFER's partner, the road safety organisation NTF Väst, offers our researchers to use a very closely located traffic training site. Here you can drive on different surfaces such as gravel, asphalt, slippery surface and in hilly terrain. The facility's off-road course is located in a naturally area at the facility. There are also possibilities to practice driving in transverse upward and downward slopes as well as in a water-filled ditch.

ASTAZERO REAL-WORLD PROVING GROUND

AstaZero (Active Safety Test Area Zero) is one of the most advance full-scale test environments in the world for a safe, sustainable and connected automated road traffic future. Different traffic environments make it possible to test advanced safety systems and their functions for all kinds of traffic and situations – in city environments as well as on rural, multi-lane and high-speed roads. This enables a broad range of research, development and validation. AstaZero also serves as an international testing area open

for stakeholders within industry, society and academia. AstaZero is owned by RISE Research Institutes of Sweden and Chalmers University of Technology. AstaZero has in 2021 expanded its operations, including the inauguration of the world's longest indoor autonomous vehicle test track; 700 metres long and 40 metres wide. The track has a central part of 140 meters that is 60 meters wide. To be able to carry out tests with trucks, buses and ordinary cars, the indoor track has an internal ceiling height of 4.6 meters. Reproducible environments are a fundamental prerequisite for ensuring the accuracy of test results and vehicle operators are now able to conduct tests 24 hours a day, 365 days a year, with reproducible light and surfaces.

AstaZero is today a leader in the work of defining today's and tomorrow's test methods in various research and customer projects. AstaZero is also an important partner in several global collaborations and participates in working groups, e.g. in EuroNCAP, to develop and define test methods.

Revere (Resource for Vehicle Research) is a research laboratory facility, providing support to projects and related to e.g. autonomous driving, active safety, electromobility and vehicle dynamics.

REVERE – RESOURCE FOR VEHICLE RESEARCH

The Revere laboratory provides a complete research platform for development testing and verification of theoretical models, algorithms and technologies both in real traffic environments and in simulators. Revere contains a research lab with resources including technical equipment, several test vehicles, both light and heavy, and supporting personnel. The vehicles can be fitted with different types of sensors, equipment for data logging, communication technologies and other testing equipment. Tests in different traffic environments can be carried out in close cooperation with test facilities such as AstaZero, Stora Holm and on public roads. Real vehicle tests provide more credibility for the researcher's theories and Revere's set-up helps support interaction between researchers from different disciplines. The opportunity for researchers to be offered a steppingstone with cutting-edge expertise between theoretical models or simulators and full-scale tests is extremely important for efficient and successful research.

Revere has progressed with the research project Autofreight, funded by FFI, in collaboration with several partners. The overall objective is to make container transports more efficient and create conditions for self-driving trucks along highway 40 between Gothenburg harbor and Viared, a distance of about 75 kilometers. The vision is that the driver will drive the truck manually from the port to highway 40 and then activate the autonomous mode. Analysis of driving data from a truck in daily operation has been carried out and several scientific publications have been published. Revere has also been involved in several applications for major EU projects and is currently also involved in several other FFI projects. One growing area of research is electrification where advanced control systems play an important role for improving energy efficiency as well as traffic safety.

The lab's expertise is utilized in our Indian initiative SITIS where, among other things, data logging and analysis is managed by Revere, read more on page 22. Smart Urban Traffic Zones is another project that will contribute to increased traffic safety around construction sites in which Revere contributes.

Several successful tests with a reversing support system for an A-double trailer combination have been performed and the research project iDolly has been finalised. In this project technologies for local distribution of trailers with containers on public roads, completely autonomous, without drivers, has been developed.

The operations have been expanded over the past years and electromobility, autonomous watercraft and collaborative flying drones are now included in the lab's knowledge repertoire.

SAFER'S ECOSYSTEM, LOCAL AND GLOBAL COLLABORATIONS

A CORNERSTONE IN THE STRATEGY is to have a multidisciplinary research environment that also serves as a physical meeting place, open to all partners. This also contributes to the development of larger clusters and SAFER is an important part in the open research and innovation ecosystem around sustainable automated transport systems and smart cities. The purpose is to form an extended safety research environment, which connects researchers from academia, industry, institutes, and the public sector and which combines and enhances work carried out within SAFER with research activities financed through other programmes. In SAFER Stage 5 the aim is to take even more advantage of the ecosystem and world around us in order to leverage the efforts put in by the partners. During the year, the ecosystem has been developed, and new links were established, see the complete ecosystem in figure 2.

ACTIVITIES IN SWEDEN

A national center for AI was launched in 2019, AI Sweden, which has the task to promote the development and use of artificial intelligence in selected areas, where transport is one. AI Sweden provides resources, knowledge, data and capabilities that will accelerate applied AI research and innovation. The center is involved in SAFER's work to utilize AI as a tool in traffic safety research and during the year our connection has been strengthened since SAFER has been leading a focus group on traffic safety, read more about the research we generated via this collaboration on page 29.

The project portfolio within Care and Rescue, a former research area within SAFER, was moved to PICTA, the Prehospital ICT Arena at Lindholmen Science Park, in 2019. In this context, research can be conducted more efficiently because the arena has access to additional, crucial community actors to achieve results. SAFER's partners still have the opportunity to conduct post-crash research through SAFER, but the project portfolio is placed at PICTA. This approach has proven to be effective and several projects have started up. As a result of the collaboration with PICTA a knowledge sharing group with members from many different disciplines, meet regularly to map the needs for knowledge in safety linked to accidents with vehicles propelled by alternative fuels. The interest in collaboration has been great and we jointly explore and discuss the needs for rescue service, for example in terms of risk assessments. Future standardization and legislation as well as potential research questions are also being discussed. Furthermore, knowledge sharing on this topic and information about upcoming activities are included in the group's agenda.

Cykelcentrum is a national knowledge centre for research and education about cycling. Cykelcentrum and SAFER intend to jointly contribute to increased cycling safety in Sweden through a closer cooperation. We will do this by, for example, sharing knowledge between us, such as publications and other research results generated within our respective centres. We aim to arrange various knowledge building activities, gather around common research questions to create projects and inspire each other to think more broadly. Another purpose is to support our research–

Figure 2: SAFER's Swedish ecosystem

Centre

Strategic Innovation Programme and similar
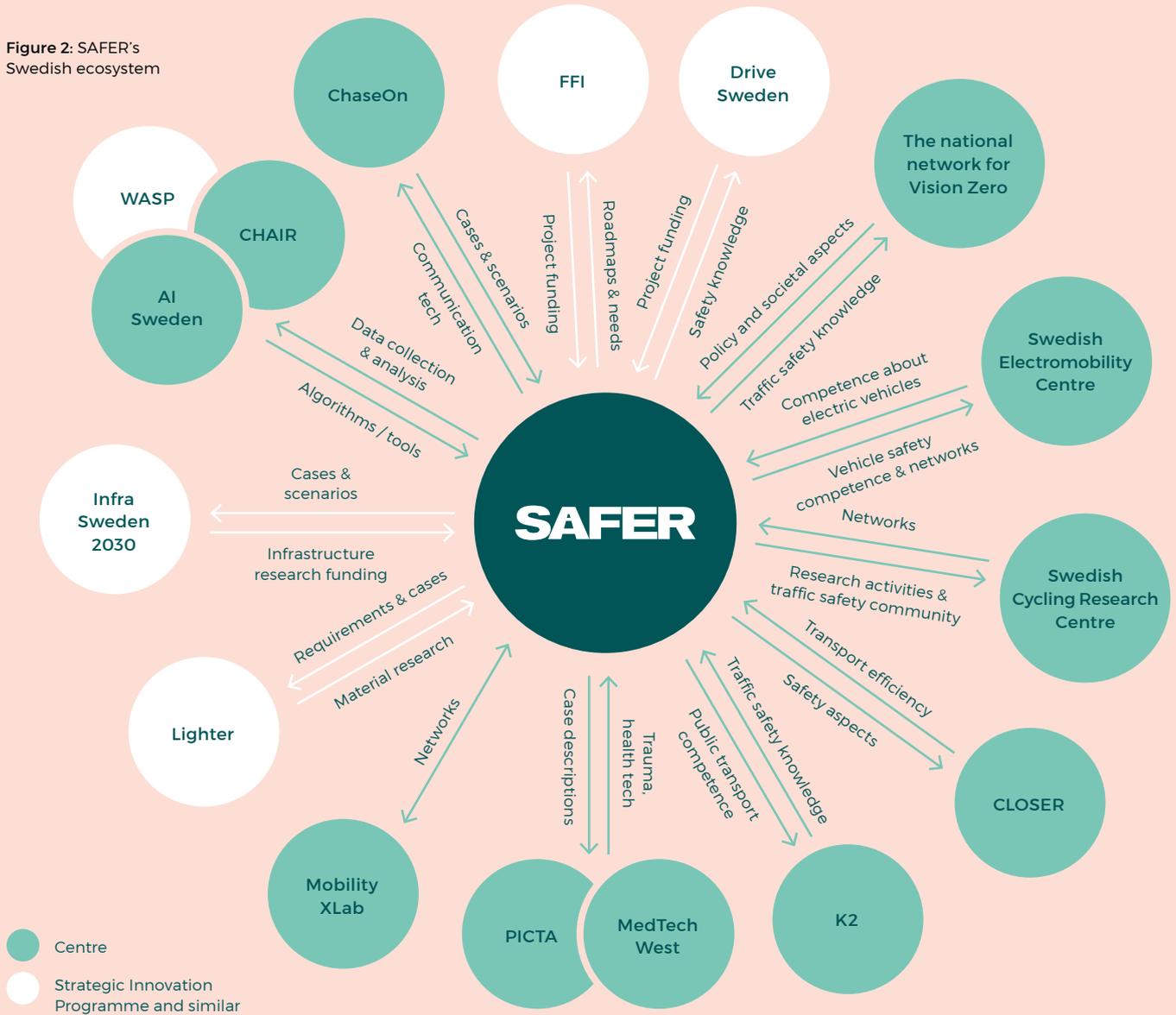
ers with access to a wider network of expertise and to find project funding. The two centres also want to encourage financiers and demonstrate the needs of continuously creating relevant knowledge, in-depth research and implement safe solutions for increased cycling.

Another example of a new link in the Swedish ecosystem is K2; Sweden's national centre for research and education on public transport. We see great potential for collaboration in public transport, for example to include and contribute with knowledge in the safety aspect and to clarify and resolve goal conflicts in various solutions for public transport. During the year, we have conducted a creative workshop to set up a project to learn more about various perspectives, including safety, at exchange points along a metro bus line.

SAFER's director Magnus Granström is Profile leader for traffic safety within the Area of Advance for Transport at Chalmers which supports a closer collaboration with top researchers at the university, as well as a closer link to

education and students. The Area of Advance provides funding for research projects and the possibility to employ post docs within the area, and it is also an important contact between the SAFER partners and the research community within Chalmers, both for knowledge exchange and project creation. During 2021, there has for instance been funding opportunities for postdocs in the area of active mobility as well as focus on traffic safety footprints and modal shift to more physically active traveling at the yearly open initiative seminar.

Drive Sweden is one of Sweden's Strategic Innovation Programs (SIP) financed by Vinnova, addressing opportunities and challenges with the next generation mobility system for people and goods. SAFER's director is a member of Drive Sweden's program committee. This, in turn, can contribute to SAFER's project creation and funding, as well as more knowledge building in the development of a sustainable transport system in a broader context. From a SAFER perspective, this collaboration provides both

Magnus Granström
SAFER's director

Buses in transport corridors are used for data collection in India.

possible funding opportunities, but also an extended network of partners, something that has been very useful in the ongoing AI for traffic safety activities. Some examples of relevant Drive Sweden funded projects are the following: AI Aware, Safety case for autonomous trucks, EU-coordination and AI Driven Mobility.

TRAFFIC SAFETY RESEARCH ACTIVITIES WITH CHINA

CTS (China Sweden Research Centre for Traffic Safety), with the Swedish partners Chalmers, Autoliv, Volvo Cars, Volvo Group and the Swedish National Road and Transport Research Institute (VTI) and the Chinese partners Tongji University, RIOH Institute for Highway Safety, Tsinghua University in Beijing and Geely Automotive Research has also developed in 2021. SAFER constitutes the Swedish research platform in this collaboration. Joint projects are ongoing as well as other activities to enhance road safety in China, for instance though road mapping workshops and development of joint project proposals. In 2018, a first bilateral call for research projects was launched in both China and Sweden and during the past year no less than three SAFER projects were granted funding. A second call was held in 2019, where three projects were approved, all with SAFER partners involved. The continuation of the programme is currently being negotiated, hopefully leading to a new, joint call in the near future. In 2022, the collaboration platform will celebrate its 10 years anniversary and planning for a celebration activity has started up. We aim to communicate the main research highlights and the value of the partnership during the next autumn.

PROGRESS IN THE SITIS PARTNERSHIP

SITIS (Sweden-India Transport Innovation and Safety Partnership) was launched in Stockholm in February 2020 on the third global conference on road safety within UN with the vision to leverage the know-how of India and Sweden to accelerate progress and deployment of safe and sustainable transport solutions and actionable policies, contributing to significant progress of Indian transport system. One of the first projects within the partnership, "Safe and Secure Transport corridors in India", is about collecting naturalistic driving data from buses in India. The project entails a long-distance coach over a corridor in customer service. The aim is to collect data e.g. about the driver, the vehicles, the passengers, the infrastructure as well as the surroundings like other vehicles, weather and road conditions. Example of research questions to be address are related to data analysis of the traffic system, weather conditions, driver behaviour, overall logistics, deploying connectivity solutions for critical moments, emergency response systems and the ability to communicate with the infrastructure. In the collaboration, Sweden also shares Vision Zero and how to build a successful structure for implementing traffic safety-enhancing measures at several different levels in society in a strategic and systematic way. In 2022 more projects are about to start, for example a project about creating a national database for traffic accidents in India. In addition, research activities related to emergency vehicle response to support faster and safer transit from the accident spot to the trauma centre, will be explored. A high level meeting with ministers from the two countries to further develop this valuable partnership are also being planned in the near future. SAFER partners include Autoliv, Volvo Group, Chalmers University of Technology, RISE Research Institutes of Sweden, Swedish National Road and Transport Research Institute (VTI) and the Swedish Transport Administration.

See the complete list of the
SAFER Ecosystem in appendix 5.

THE EUROPEAN RESEARCH FRAMEWORK – PROJECTS AND POSSIBILITIES

SAFER HAS CONTINUED the long-term efforts to secure the traffic safety content in Horizon Europe. This has been done through active participation in selected organisations, such as ERTRAC (the European Road Transport Advisory Council), EARPA (the association of automotive R&D organisations), EUCAR (European Council for Automotive R&D), ECTRI (The European Conference of Transport Research Institutes) and CLEPA (the European Association of Automotive Suppliers). During 2021, focus has been on two major efforts: the formation of the CCAM (Connected, Cooperative & Automated Mobility) partnership in which several SAFER partners are active, and the update of the ERTRAC Road Safety Roadmap.

The ERTRAC Road Safety roadmap is based on the 2019 version, but is now focusing on 2023 and beyond. Some prioritized areas in the recently released version are the following: Crash prevention for bicyclists and users of micromobility devices; Human-technology interaction for safer road transport, Effects of disruptive changes on road safety issues, and Reliability of safety-critical systems and components in future vehicles. The roadmap has been delivered to the Commission and will be used for further dialogue regarding the 2023–2024 and 2025–2026 work programmes.

The CCAM partnership has been officially launched during 2021, and the SAFER partners VTI, Volvo Group and the Swedish road administration hold leading positions in the CCAM Executive Board. An updated SRIA, the strategic research and innovation agenda, was recently released, providing building blocks for Societal, Economic, and Scientific impact of connected and/or automated vehicles, as well as input to the upcoming work programmes.

As always, it is important to be persistent and have a long-term vision, as well as a good overview of ongoing activities, as the processes leading up to the work programme content stretches over several years. Several position papers, roadmaps, meetings, and workshops are required to make sure that the desired topics are included in the final version. Also, having a platform such as SAFER means that we have a clear advantage in this kind of work, being able to communicate easily and also share the workload in an efficient way.

THE HORIZON 2020 PROGRAMME is still relevant as well since a number of projects funded by this programme are still ongoing, for example VALUE3S and PANACEA.

FINANCIAL REPORTING

Figure 3
The expenses and income of SAFER

SAFER HAS TWO main types of financing, one being SAFER Core which is the base for the core activities as well as the SAFER Pre-study program in terms of the secretariat, the office and open research area and base funding for the seminar and dissemination activities, the other being the project financing for research and project activities.

SAFER CORE – THE CENTRE FINANCES

SAFER Core is financed through funding from Västra Götalandsregionen and partners' cash contributions according to the overall partner agreement for the fifth stage of SAFER. The framework agreement stipulates an annual contribution of:

LEVEL 1: A total contribution to SAFER Core amounting to 1 MSEK per year, 650 kSEK in cash for industrial and public partners and 125 kSEK for other universities and research institutes. The remaining amount is provided through in-kind contributions. Chalmers, as the host of the centre, has a commitment of 1 MSEK in cash and 450 hours in-kind.

LEVEL 2: Contribution to SAFER Core funding in an amount of minimum SEK 125 KSEK in cash contribution per year for industrial partners and public partners. Other universities and institute partners contribute with 75 KSEK/year.

LEVEL 3: The cash contribution is 10 KSEK/year.

The contribution from Västra Götalandsregionen (VGR) is 2,5 MSEK per year. The total funding sums up to about 40,5 MSEK cash and minimum 25000 in-kind hours for the entire stage five (April 1, 2019 to December 31, 2023). Partners on level 1 contributes with 450–950 hours per year in-kind to SAFER Core, depending on type of partner. The roles/functions that the in-kind hours are used for are e.g. Research area directors, Competence network leaders and other management group members.

The result for the SAFER Core finances for the third operational year in SAFER Stage 5 (January 1st to December 31st, 2021) is shown in figure 3. With the pandemic still affecting us, this year has also been special in many ways; this is mainly reflected in costs such as travel and physical activities, which were almost non-existent. Revenues were somewhat lower than budgeted due to the reporting period to Västra Götalandsregionen; the financing for the last six months of 2021 will be booked in the beginning of 2022. In 2021, 9 new partners have joined SAFER and this increased the revenues compared to the budget for partners' cash contribution. The costs for the current year were in total

EXPENSES (KSEK)

Personell	5 379
Premises	928
Running costs office	176
IT costs	178
Knowledge sharing and communication activities	240
Other costs, e.g. travel etc	88
SAFER pre-study program	815
SUM	7 804

INCOME (KSEK)

SAFER Partner cash contribution	5 749
Partner cash contribution to SAFER's pre-study program	800
Funding from Region Västra Götaland	1 137
SUM	7 686

RESULT	-118

lower than budget, primarily because of fewer physical activities. Although, the budget is balanced for the whole period, 2021–2023.

The cash resources for SAFER are governed by the Board, who has continuously monitored the budget and decided on changes in expenditure when required.

PROJECT FINANCES

The project financing comes from a variety of sources, primarily national programmes such as the FFI programme (Strategic Vehicle Research and Innovation), different strategic innovation programmes funded through Vinnova, Trafikverket and Energimyndigheten. Also, Skyltfonden, Stiftelsen för Strategisk Forskning (SSF), and others are providing project funding from a national perspective. The other important project funding source is through EU's Horizon 2020 programme and now of course the Horizon Europe programme that started in 2021. In addition to this, internal funding from all partners play an important role, whether it's academic, institute or industry partners. The overall budget for the projects in SAFER's third year of Stage 5 sums up to 2023 MSEK for all project partners and 638 MSEK for SAFER partners. That clearly shows the benefit for the partners to join in the SAFER projects that generally have a high hit rate in the competitive programmes. Also, the leveraging factor of collaboration projects is clear, especially when accessing the knowledge and financing power on the European arena.

THE RESEARCH

Entering SAFER Stage 5, we focus our research primarily in four areas, representing world-class, multi-disciplinary research – all with the single-minded vision to save lives, prevent injuries and enable safe mobility:

· Systems for accident prevention and automated driving
· Road user behaviour
· Human body protection
· Safety performance evaluation

Our research areas also create an open arena where our partners meet and identify key issues to initiate new research, based on real-world needs.

RESEARCH SCOPE

SAFER'S RESEARCH includes road traffic, for example, pedestrians, cyclists, various vehicles and goods services. However, rail traffic is not included in our scope of work. We cover a "complete-travel-perspective", from door to door, in which a human is interacting with a vehicle in the road traffic environment. For example, our research does not generally include single pedestrian accidents. However, there is no obstacle if there are a number of partners who want to start a project that is beyond the scope of the above.

THE SAFER PRE-STUDY PROGRAM

SAFER's pre-study program successfully started in October 2019 and has been developed further during the last two years. In 2021 seven out of eleven submitted proposal have been granted. New research areas have been explored, collaboration partners found, workshops organized, competences acquired, knowledge distributed, reports written, and funding for larger projects secured, making SAFER's pre-study program a success story with well spent efforts. In 2022 the program will continue with 3-4 calls

providing at least 600 KSEK to grant 6-8 new pre-studies that will help to lead SAFER forward and contribute to the constant development of SAFER's collaboration platform. Two new pre-studies have already been accepted in the first call for 2022 and started in January.
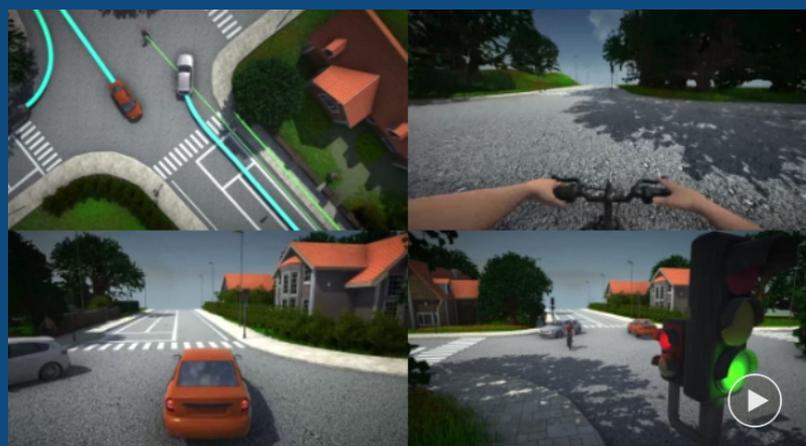
VIRTUAL REALITY INTERACTIONS WITH AUTONOMOUS VEHICLES

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PARTNERS: LUND UNIVERSITY, AUTOLIV, SWEDISH TRANSPORT ADMINISTRATION, VOLVO GROUP, VTI

Virtual reality (VR) is a hot topic at many institutions and companies, but there seems to be no real consistency in using it in research. The newly established Virtual Reality Hub on Traffic Safety at Lund University will change that. The connected pre-study started to investigate how a VR environment can be used to study interactions between connected an automated vehicle (CAVs) and vulnerable road user (VRUs). Relevant research questions have been worked out to explore how different infrastructure designs and CAV behavior affect the safety perception of VRUs. In a workshop previous experiences with CAVs and VR were discussed, collaboration partner approached, and relevant project ideas collected, resulting in an approved FFI-project.

EXPLORING THE IMPACT OF EMBODIED COGNITION ON AD DESIGN

PARTNERS: UNIVERSITY OF SKÖVDE, AUTOLIV, FOLKSAM, VEONEER, VOLVO CARS, VOLVO CONSTRUCTION EQUIPMENT, VOLVO GROUP

This ongoing pre-study aims to explore how the embodied cognition (EC) approach can provide additional and alternative solutions for increased traffic safety on semi-automated vehicles. It is suggested that EC can be defined into a theoretical framework for autonomous vehicles including drivers, passengers, other road users and infrastructure, a design tool, and tentatively and evaluation framework for the automotive domain. Four interactive seminars which bring together theory (and theorists) and practice (and practitioners) will be arranged. As a result, a white paper on the implications embodied cognition has on automated driving functionality will be manifested, based on the ideas presented in the seminars. Also, an application, going from theory to practice, exploring the discussed concepts of the final seminar will bridge the current gaps between theory, method and practice. An additional outcome is a network for competence of benefit for Sweden.
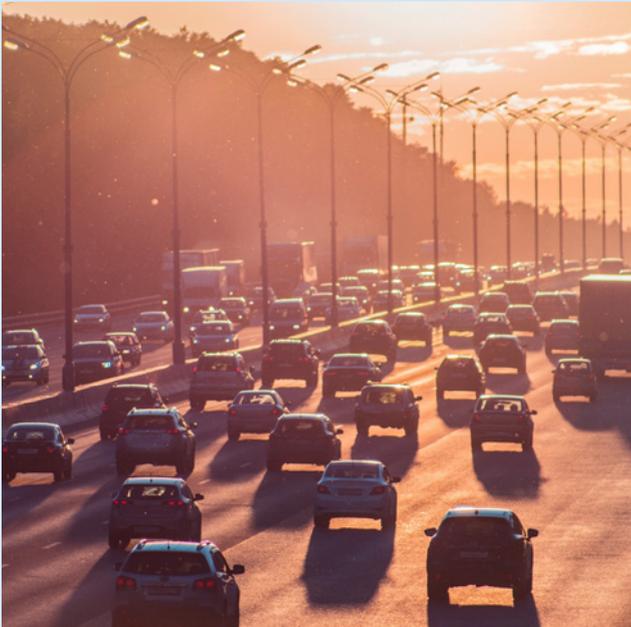

HÖVDING DATA FOR RISK ASSESSMENT

PARTNERS: RISE, HÖVDING

With the help of data from Hövding helmets used in traffic, the possibility of predicting where, and when, accidents are likely to occur will be investigated. Acceleration and GPS information collected by connected Hövding helmets will be combined with other data sources such as weather, traffic, and surface data, like friction or local topography. By that the design of the infrastructure will be linked to the cyclists' accident risk estimation under various conditions. This ongoing pre-study will show how Hövding helmets as a safety system can contribute to a safe traffic environment in the future and demonstrate how large amounts of data can be combined and made available through public databases.

COOPERATIVE AUTOMATED DRIVING USE CASES FOR V2X COMMUNICATION

PARTNERS: HALMSTAD UNIVERSITY, VISCANDO, ZENSEACT

What are the latency requirements for collective perception systems to enable Advanced Driver Assistance System (ADAS) functions to fulfil the state-of-the-art safety norms in a realistic traffic use case? With the goal of answering the above question, the pre-study focused on establishing a tool chain data-scenarios-simulation-requirements that will help to understand the needs and shortcomings of data and tools, and to set the requirement on latency of V2X communication systems based on safety requirement of ADAS functions. The pre-study findings support a theoretical basis for a variety of comprehensive intelligent transportation systems and will serve as a basis for an FFI project.

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> Besides the safety of cyclists, especially during the long winter in Sweden, lighting is important to encourage more active travel with bikes.

Drone light system investigates an innovative opportunity for lightning infrastructure along cycle paths.

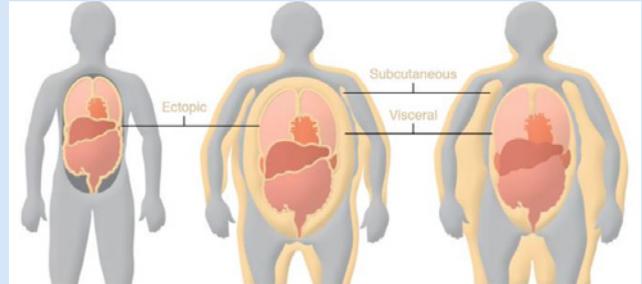## REPORT ON THE SAFETY AND TRAFFIC FLOW IMPACT OF MIXED TRAFFIC CONDITION

PARTNERS: VTI AND CHALMERS

The development and application of automated driving technology has shown a great potential in improving traffic safety and efficiency. However, since the technology is not yet mature, it can be foreseen that the situation of automated driving mixed with manual driving will last for a long time in the progressing stages of automated driving. The CTS (China Sweden Research Centre for Traffic Safety) project *Heterogeneous Traffic Groups* has been initiated by VTI to to study the coupling relationship between different levels of automated driving and manual driving, and to develop methods for evaluating the safety and traffic flow impact. This ongoing pre-study extends the work from the students and the team will report the result in a scientific publication to disseminate the gained knowledge on modeling and simulation of heterogenous traffic.

ADIPOSE TISSUE RATE DEPENDENT RESPONSE

PARTNERS: CHALMERS AND AUTOLIV

Since there is no standard or accepted method to characterize soft (adipose) tissue under impact loading, this pre-study will design a test set-up (i.e., to a detail that equipment can be purchased or manufactured) to ensure that the relevant mechanisms of the material and the model are properly activated, as well as to specify what kind of precision is needed for sensors and sample sizes, etc. Industrial partners will contribute with knowledge on what range of strain and strain rates are of most interest when investigating injury prediction in traffic safety simulations. The designed test set-up for adipose tissue is expected to be adaptable to other soft tissues as well.

DRONE LIGHTING SYSTEMS

PARTNERS: JÖNKÖPING UNIVERSITY, MUNICIPALITY OF SKARA, RISE UNIVERSITY OF SKÖVDE

Lighting of bike paths is a costly endeavor, as the light poles are placed at short intervals on relatively long bike paths, which leads to a high investment and maintenance costs during its lifetime. Besides the safety of cyclists, especially during the long winter in Sweden, lighting is important to encourage more active travel with bikes. The project team is exploring the idea that drones equipped with lighting capability could be a viable replacement for bike poles in rural areas with a low frequency of cyclist and long distances.

AI AS A TOOL TO IMPROVE TRAFFIC SAFETY

AI BRINGS AN ENORMOUS potential to enable new products and services, to make existing processes more efficient. AI therefore drives societal solutions and competitiveness for companies and organizations embracing the opportunities. At SAFER, we see great potential to take advantage of AI as a tool to improve traffic safety, but also as a tool to help make our research better and more efficient. In 2020, we initiated major strategic work within SAFER to investigate how AI could be used to improve our road safety research. The stakeholder group for AI started in June 2020 and about 75% of all partners have been involved in the work. We have concluded 6 joint workshops and about 130 researchers have been engaged during this period. Our common knowledge about AI as a tool in research has certainly increased and we have identified that AI has a great potential to enhance our research in many different ways. Three prioritised areas have been identified:

1. **IDENTIFY AND ASSESS EXTERNAL OBJECTS AND SAFETY CONDITIONS**
2. **FINDING RISKS IN THE TRAFFIC ENVIRONMENT BY COMBINING DATA**
3. **DETECTION AND CLASSIFICATION OF DRIVER STATE AND DRIVING PATTERNS**

In 2021 SAFER was given the opportunity to lead a focus group on traffic safety within the Drive Sweden/AI Sweden project AI Driven Mobility, giving us great opportunities to utilize AI competence and connect to other initiatives and partners as well as get access to funding opportunities. The overall scope of work of the complete project has been to set up a network of organizations and individuals who can drive concrete change with a focus on AI as an enabler of sustainable mobility as well as increase knowledge and awareness of AI and its potential for the mobility sector. Also, pre-studies have started up, with the aim to create larger projects to concrete solutions that would benefit society and citizens.

As a result of our strategic initiative, we now have several pre-studies and projects ongoing, and more ideas have been created. The pre-studies that we have concluded in 2021 have aimed to build knowledge within automated safety classification of the road environment and exploring how AI can support risk reduction of accidents by identify patterns and near-incident situations from large datasets.

SAFER will continue to explore opportunities using AI and in 2022 will the activities continue under the AI Driven Mobility umbrella. In the focus group for AI in traffic safety, we will continue to work on finding opportunities in using AI as a tool in our research and for improved road safety. Our joint objectives are to identify funding opportunities, generate pre-studies and start up larger projects, create and maintain our network and also to connect to other relevant initiatives and spread the results from the projects. We aim to create synergies for everyone involved, not least for partners and funding agencies. To further create synergies, we will continue to work closely with CHAIR (Chalmers' AI centre) and other relevant stakeholders in the SAFER ecosystem.

SAFER CELEBRATES 15 YEAR ANNIVERSARY

FOR FIFTEEN YEARS, SAFER has now conducted borderless research to save lives in traffic by joining forces with the Swedish automotive industry, academia and societal actors. Thousands of researchers have been active in the research and competence centre over the years and during the period close to 400 projects have been carried out, over 1000 publications have been published and 64 doctors have been examined in SAFER's unique collaboration environment. Several prestigious awards have also been granted to SAFER and its researchers over the years.

In 2006, 20 partners from industry, academia and public organisations that shared a common view on the importance of traffic safety signed an agreement, which included a 10-year framework. Additional partners have been attracted over time and currently SAFER consists of 44 partners. SAFER has its roots in decades of cooperation between Chalmers and several of the industrial partners. The successful collaboration on neck injury research, gave confidence in the potential of a joint research centre for vehicle and traffic safety.

SAFER is today, 15 years later, a world leader in several research areas. A significant example is **SAFER's data collection and analysis of naturalistic driving studies** and our designated hub for European data collection. Over the years, the unique databases have contributed to several prestigious international assignments and projects.

Child safety is another area in which SAFER became an initial leader. "Småfolk" was one of the early projects within SAFER. It was created, in line with SAFER's ambitions, to elaborate research by joining efforts. This project was the starting point of SAFER's child safety and rear seat safety research that quickly reached international recognition. Numerous SAFER publications and presentations, resulted from these projects, have contributed to international regulations and standards.

Another of SAFER's great successes over the years is the cluster of **Human Body Model** (HBM) projects. They have resulted in the two families of HBM's; SAFER-HBM and VIVA+. These two HBM-families put SAFER on the world map in the field of occupant crash simulation. At the early stages of SAFER a vision was established to develop a model that was "tunable and scalable, with omni-directional biofidelity and injury prediction capabilities for whole sequence, i.e. both low-g and high-g events". Fifteen years ago, this was utopia that now is reality. This area is not only a role model for excellent and borderline research, it is also a role model for how the collaboration within the SAFER

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> SAFER is today, 15 years later, a world leader in several research areas. A significant example is SAFER's data collection and analysis of naturalistic driving studies and our designated hub for European data collection.

community can achieve more than just single project execution.

SAFER's Active-HBM activities started with an exploratory and relatively high-risk project, taking on a significant computational challenge. It grew to a successful and important research area, not only for SAFER, but also contributing to the global evolution. The project pioneered an area that has grown to be one of the main topics in biomechanics and crashworthiness research today. The continuous evolution, by the strategical project portfolio over the years, and the constant referencing to "SAFER research" have substantially contributed to spread SAFER's name as such, and to make it associated to state-of-the art research specifically. SAFER is a globally acknowledged main contact for expertise within research on Active human body modelling.

We celebrated our 15th anniversary September 29th by inviting our partners to workshops to begin creating a more long-term strategic research agenda to SAFER Stage 6, starting in January 2024. During the day, we also organized an inspirational seminar "Innovation, co-creation and collaboration - what can we learn from the past to create SAFER's future?, including highlights from our 15 years of research. We also awarded an honorable prize to the project that was elected the most ground-breaking so far in SAFER's history, During this week our partners were also able to enjoy a delicious SAFER 15-year anniversary cake from L's Café.

SAFER'S 15 YEAR ANNIVERSARY AWARD

Johan Iraeus, Chalmers University, and Lotta Jakobsson, Volvo Cars, received the SAFER 15 year anniversary award as representatives from the cluster of HBM-projects at the prize giving ceremony.

The cluster of SAFER's human body model projects was awarded the 15 year anniversary prize for the most ground-breaking project in the research- and competence centre's history.

AT THE CELEBRATIONS we congratulate everyone who has been involved in these important projects, contributing to creating SAFER's world leading position in human body modelling as well as our entire family of human body models. Our family of human body models has contributed significantly to SAFER's excellent research results and to our partners' product development over the years. The cluster of projects has helped to speed up the process of industrial implementation significantly, providing the SAFER partners with a state-of-the art human body model.

This award acknowledges the humble beginnings of HBM research at SAFER, the hard work of researchers involved in the cluster of HBM projects over the past 15 years and the increasing importance and relevance of these tools to the research community and industry. However, developments have not stopped now. Projects stemming from those original seeds continue looking into injury prediction capabilities and active musculature for postural control.

Furthermore, we have an ongoing project looking to refine an HBM for use as a motorcycle rider to address injury risk for this group of road users and partners are involved in European projects making a family of scaled HBMs available openly.

This cluster of projects has been elected as the most ground-breaking projects by SAFER's partners and management team from a short list of a total of 7 nominated excellent SAFER high-profile projects; SALIENCE4CAV, Virtual, Småfolk, SAFER's naturalistic driving databases / Euro-FOT, Cluster of HBM-projects, AI Aware and Active-HBM.

THE JURY'S MOTIVATION

The award was presented during the 15 year anniversary celebrations September 29 and the jury's motivation states that: The cluster of SAFER HBM projects has provided the partners with world leading human body model functionality, used by the industry in safety developments to save lives and prevent injures in traffic. The model has also contributed to position SAFER's multi-disciplinary research excellence internationally. This area is not only a role model for excellent and cross-border research, it is also a role model for how the collaboration within the SAFER community can achieve more than just single project execution.

PROJECT PORTFOLIO

THE PROJECT PORTFOLIO is the base for the SAFER collaboration, comprising of different types of projects, but all focusing on one or more of the issues addressed in our joint strategic research agenda, created through the multidisciplinary research. The project portfolio is created, maintained and developed through the joint efforts in the Research areas and among the partners. Throughout 2021 the focus has been to boost the SAFER pre-study program and to secure a solid foundation of projects and related activities through suitable available funding from various national and international (primarily EU) research and innovation programmes.

A research project at SAFER relates to one or several of the four Research areas. Projects that cover multiple Research areas or focus on general questions are called Competence projects. The distribution of projects between the Research areas is illustrated in figure 4. The primary forum for initiating and discussing projects at SAFER is the Research areas, which recommend project proposals to the management team and Board for decision. The agenda covers new project ideas, project reports and final results as well as strategic issues like input from all partners on research questions and on conferences, seminars and international collaborations and calls. Each Research area include representatives from level 1 and 2 SAFER partners and are the base for establishing world class competitive project portfolios. Each Research area hosts a mix of projects;

pre-studies for future projects, small and large national and international projects. Projects are either "own" or "associated". A project present at SAFER can be initiated at SAFER and/or funded by SAFER ("own") or started by SAFER partners in another context and brought into the SAFER environment ("associated") where it can thrive and benefit from the presence of other projects and researchers. A SAFER associated project can also be an externally funded larger projects that has had a previous successfully performed pre-study, financed by SAFER.

Since interdisciplinary collaborative research is a key to excellence and successful dissemination, we encourage projects to involve at least two partners, preferably from different stakeholders. Some projects, however, have only one part for natural reasons, e.g. PhD students' projects and special investigations and assignments. The majority of the projects involve 2-4 SAFER partners and some 16% involve 5 or more, see figure 5.

During operational year 16, 7 SAFER funded pre-studies, one SAFER funded strategic task and 16 projects with external funding have been added to the project portfolio adding up to a total of 81 projects that have been ongoing during the year. 71 of them belong to one of the four research areas whereas 10 projects were competence projects (complete list in appendix 6). 30 projects have been successfully finalized during the year and SAFER will enter its 17th operational year with 53 ongoing projects.
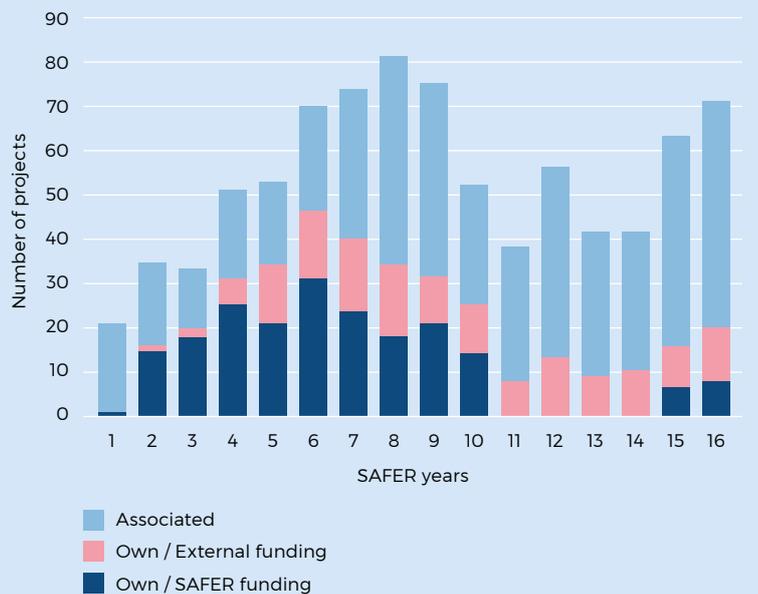
Figure 4
Ongoing projects during stage 5, year 3.
The distribution of projects between
the research areas.
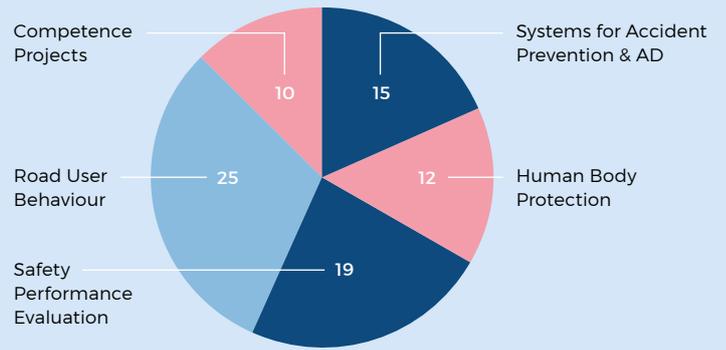
Figure 5
The number of partners in
SAFER's projects.

Figure 6
Number of projects in SAFER's project
portfolio (competence projects are not
included in this diagram)

RESULTS FROM THE RESEARCH AREAS

ROAD USER BEHAVIOUR

HOW DO PEOPLE BEHAVE IN TRAFFIC and how can they be stimulated to a safe behaviour? In an era where traffic complexity is increasing as quickly as the technology is evolving, answering this question becomes vital. Taking a broad multidisciplinary approach, the research area Road User Behavior at SAFER focuses on developing scientific methods and attractive solutions that facilitate safe behavior in traffic. It covers a variety of topics, from understanding pedestrian behavior to developing algorithms that enable assessment of vehicle occupant behaviours, as well as exploring safety implications of new mobility means such as electric scooters.

RESULTS FROM OUR PROJECTS

Several projects within the Road User Behaviour area have during the past year delivered impressive results that are in line with the objectives of this area. Firstly, the results have extended our understanding of how short-term driver impairments such as fatigue, intoxication, and inattention affects driving performance and how these states can be detected and counteracted. This, in turn, will help stakeholders design new, or improve existing, safety systems in vehicles. It is also useful in determining drivers' fitness to drive in automated and partly automated vehicles and to identify effective countermeasures for driver impairments.

Several studies on interactions between automated vehicles and other road users in their vicinity have been carried out. For example, it has been demonstrated how an external HMI can support the interaction between automated vehicles and vulnerable road users (VRU) at zebra crossings and bus stops. This has extended our knowledge on evaluation methodologies and tools, e.g. VR, as well as deepened our understanding of how to support interactions between different road users in future road environments with mixed traffic.

Two SAFER pre-studies about safety culture and automation have, through extensive exchange of knowledge between companies that develop autonomous vehicles and machines and their customers, generated knowledge about how to implement automated vehicles and at the same time develop a good safety culture. Our projects addressing safety of new electric vehicles for personal mobility (ePVMs) have advanced the understanding about their impact on infrastructure and traffic safety, about mechanisms causing e-PMV crashes, and about public opinion on the safety concerns and ease-of-use of e-PMVs. The results can support the design of policy instruments and guide

technological development of e-PVMs, to ensure a safe utilization of these vehicles. Furthermore, ongoing projects are expected to deliver results on how to create safe transition strategies in future partially automated vehicles by studies on re-engagement in manual driving after being engaged in another activity. The project portfolio is also hosting projects addressing a rather neglected topic in the research community – human factors in remote operation of automated vehicles.

STRONG PROJECT PORTFOLIO

During the past year, the Road User Behaviour project portfolio has been further enriched through the association of six new projects and financing of three SAFER pre-studies. In addition to these recently associated projects, our portfolio hosts additional 16 projects. The project portfolio currently holds many follow-up studies of previous SAFER projects and several SAFER pre-studies have produced successful applications for larger projects during 2021. The Horizon2020 project **PANACEA** and the FFI funded projects **DrivER** and **CO2** are newly associated projects focusing on different aspects of fitness to drive. PANACEA will design, develop, and test a holistic driving ability assessment system for commercial drivers to be used pre-driving, during driving and at the roadside, paired with targeted countermeasure solutions during and post driving. DrivER aims to evaluate three related concepts for driver state detection using unobtrusive physiological monitoring: 1) sleepiness detection in a naturalistic driving; 2) assessment of stress level and mental load of professional drivers in simulated high-stress scenarios; 3) detection of sudden cardiac illness in drivers. The CO2 project investigates how carbon dioxide levels inside the vehicles affect driver state and performance. These projects are in line with the stage five goals to monitor driver and passenger state and position and to diagnose driver fitness based on monitoring data. Driver re-engagement in autonomous driving by means of HMI adapted to human activity (**RE-Engage**) is a new project that builds further on DRAMA, a former SAFER project that developed methods for supervising the driver and passengers in the car to give them the best possible support in different situations. The main task of the project is to explore, implement and demonstrate solutions for driver support when regaining control again when the vehicle has been active in automated mode. The researchers will work with recognition of driver activities, such as taking a power nap and reading a book. Another new project is Heavy Automated Vehicle Operation Center (**HAVOC**) which addresses a portion of numerous human behavior challenges identified in a recent SAFER pre-study. The aim is to compare and contrast different needs and require-

> **In 2022, the Road User Behaviour group will widen its perspectives by encouraging research on new mobility solutions and on traffic safety in relation to health and sustainability.**

ments posed on the human operator and automated vehicle in the following remote operation applications: remote assessment, remote assistance and remote emergency driving. Three SAFER pre-studies were completed focusing on safety culture and automated vehicles, virtual reality interactions with autonomous vehicles, and multimodal data for road user behaviour analysis.

COMPETENCE NETWORK HUMAN BEHAVIOUR

The competence network focusing on Human Behaviour is led by Dr. Giulio Bianchi Piccinini, Chalmers. Combining knowledge from different disciplines, this competence network aspires to be a forum to discuss methodologies and challenges for the research on human behavior, with the final aim to improve the safety of the road transportation system. During 2021, the network has conducted seminars on fitness to drive in professional drivers, engagement in non-driving related tasks during travel in automated vehicles and on e-scooter safety. In the spring of 2021, the RUB research area also hosted a seminar on how to create long lasting behavioural change and how this can be applied to road safety.

OUTLOOK FOR 2022

In 2022, the Road User Behaviour group will continue to contribute to the development of safer vehicles on our roads, but also widen our perspectives by encouraging research on new mobility solutions and on traffic safety in relation to health and sustainability. Road user behavioural issues such as short- and long-term driver impairments and risk perception will continue to be an important topic as well as the communication between humans and vehicles, devices, and infrastructure in the transport system. The welcoming of new SAFER partners in 2021 and an increased focus on sustainable travel in society has inspired us to engage in research focusing on the shift towards more active means of travel and how such modal shifts will impact traffic safety. To achieve global sustainability goals, a shift from car traffic towards walking, cycling and public transport is needed. While fatalities among vehicle occupants are decreasing in many countries, the situation is not improving or may even be negative among VRUs. The challenge is therefore to ensure that traffic safety is on the agenda in the shift towards health promoting and environmentally sound mobility solutions.

KEY HIGHLIGHTS FROM PROJECTS

SAFETY CULTURE AND AUTOMATED VEHICLES

The project is an FFI pre-study and a follow up from a pre-study financed by SAFER. Safety culture is the prevailing way of thinking and acting at a workplace in relation to risks and safety, i.e. how safety is actually managed. Companies that develop autonomous vehicles and machines and their customers, such as terminals and transport companies, need to gain knowledge about how to implement automated vehicles and at the same time develop a good safety culture that supports sustainability work. The purpose of the study was to anchor the view of safety culture through workshops. An inventory of survey design was performed to integrate measurements of sustainability, gender equality with safety culture. The study also prepared models for the main study that aims to support a process to integrate safety culture in the design and tests of autonomous vehicles. The pre-study has enabled extensive exchange of knowledge between the partners through workshops about safety at system and organizational levels and has created a readiness for a full application to FFI/Vinnova in December 2021 about safety culture as a factor in the design process of automated vehicles and how to implement them in business and safety culture contexts.

BRAVE

The EU-funded project BRAVE developed two predictive ADAS and HMI concepts for increased user adoption and validated their performance. In tested situations, BRAVE's AI-based predictive system has one second shorter delay in detecting lane changes of vehicles ahead of current systems and about half a second faster than human drivers, meaning that potential hazards or safety risks can be detected earlier and, therefore, allow for earlier reaction and hopefully avoidance of safety risks. Additionally, test protocols that recognise these types of systems were developed and have been proposed for inclusion in official test procedures for regulation and consumer testing (e.g. EuroNCAP). Tests and surveys with different types of road users show that for adoption, it's not just the driver who has to trust an automated vehicle – we also have to think about other road users like pedestrians, motorcycle riders and cyclists, as well as drivers of conventional cars or vehicles with lower degrees of automation.

QUADRAE

The Quantitative Driver Behavior Modeling for Active Safety Assessment Expansion (QUADRAE) project addressed two crucial components of the technology development process: driver models and simulation methodology. The main objectives of the project were to:

- develop and validate models of driver behaviour needed in current and future simulation tools for virtual testing of active safety and automation.
- carry out prioritized virtual tests to estimate the safety benefit of a system, tune system parameters, and explore potential outcomes in scenarios when the system is active.
- learn more about the best methods for performing virtual testing using driver models.

As a result of the project, the partners now have an established virtual simulation framework using Predictive Processing (PP) as a general paradigm for modeling driver behaviour. The modeling, based on the latest knowledge and ideas about human behaviour in driving, draws on extensive research using volunteer drivers as study participants. Data from both controlled experiments and naturalistic driving were used to develop and validate the models. QUADRAE has not only advanced the state of the art in the area of driver modeling but has also allowed the partners to remain at the forefront of international research in this field.

RESEARCH OBJECTIVES

- **STUDY** road user behaviour in their door to door travels.
- **MONITOR** driver and passenger state and position.
- **DIAGNOSE** driver fitness based on monitoring data.
- **ENSURE** safe interactions between automated vehicles and other road users.
- **DEVELOP** and evaluate novel interaction principles, including nudging.
- **DEFINE** and measure user experience indicators related to safety.

SYSTEMS FOR ACCIDENT PREVENTION AND AUTOMATED DRIVING

THE CHALLENGE OF putting self-driving vehicles on the roads is enormous. Automation affects everyone and the potential social benefits are huge, partly through increased traffic safety, but also increased efficiency. Everyone in the system must collaborate and take the steps forward in the process together. It is not just technology that needs to work, but also the conditions for implementation, such as regulations and public acceptance. Some of the most important research challenges we work with at SAFER are to:

UNDERSTAND THE ROLE of the driver or rider.
DESIGN AND PROVE sufficiently safe technology.
SCALE APPLICABILITY from somewhere / sometimes to everywhere / always.

During the past year we have been working to further strengthen the expertise in this research area, meeting the challenges ahead of us regarding safety aspects of vehicles, road users and infrastructure when we are moving towards higher degrees of automation, in most cases in a mixed environment. Also, the scientific base for verification and validation is of utmost importance in order to ascertain that correct methods are used in an area that is much more complex than previously. This base is also required to create a foundation for future standardization of test methodologies. Another important area we have focused on developing is our connection to Artificial Intelligence, which is gaining momentum in society.

HOW TO EVALUATE RISKS IN AUTONOMOUS MODE

We have built a lot of new knowledge through our ongoing projects, but also through our competence networks. The network Automotive safety assurance, led by Dr. Fredrik Sandblom, also Research area director for Systems for accident prevention and Automated driving, has kept together a valuable discussion about methods and nomenclature for how to show that autonomous vehicles are acceptably safe. The network has been the "place to go" for SAFER partners to discuss how to make safe automated vehicles and to show that they are. The group's work has been intensive and very constructive; for example, the group now has a much clearer picture of what constitutes a useful operational design domain (ODD), and what it should and can be used for. The group has also made use of the term User Expectation Domain (UED), which makes it possible to separate discussing where nominal driving may never fail from a safety perspective (the ODD) and the domain in which 9x% availability is a really good achievement. Also,

the Safety Norm, meaning and definition is made clear. We know even better how to apply a risk norm and we have been able to move on to the interesting topic of how to meaningfully evaluate that a risk norm is met and is predicted to be met. In the creative dialogues paradoxes that emerges when applying methodology are discussed and often straightened out, albeit sometimes after long discussions. The group is also influencing and participating in ongoing standardization activities by engagement in various working groups. The members also see great value in being able to ask questions and discuss in a way that helps in their daily work.

PERCEPTION, SENSING AND COMMUNICATIONS

Another value-creating competence network has been active during 2021; Perception, sensing & communication. The competence network leader is Dr. Lars Hammarstrand, Chalmers. Sensors and communication enable technologies for a plethora of safety systems. The scope of this group is to create and share research ideas around vehicular communications, sensors systems, and signal processing. Testing and validation of perception algorithms and systems, Machine learning methods and new approaches to driver state estimation, e.g., pose, gaze, inattention, fatigue, etc. are included in the group's main interest. Communication technology, like applications for 5G and beyond 5G for intelligent transport as well as cyber security is included in the knowledge building agenda.

SYSTEM SAFETY

The Competence network for System Safety, led by Dr. Per Johannesen, Volvo Group is about reducing risks related to malfunctioning systems and components of various technologies, including electronics, mechanics and software. As these are the part of a vehicle, this is a highly interdisciplinary approach connected to most other competence networks in SAFER. The network started up in January 2021 and the meetings have been very well-attended.

FUTURE PROOF METHODOLOGIES FOR VALIDATION OF CAVS

The competence network Future proof methodologies for validation of connected and automated vehicles was also launched in 2021. The group discusses validation of automated and connected vehicles. including e.g. relevant test cases, virtual methods and their connection to physical tests, the role of Operational Design Domains (ODD) and relevant connectivity scenarios. The network is lead by Fredrik Åkeson and Viktor Johansson, AstaZero.

The collaboration project ENSEMLE has been successfully completed during 2021 with a public demonstration in Spain.

KEY HIGHLIGHTS FROM PROJECTS

ASSERTED

How can we deliver safe autonomous vehicles by continuous development and deployment? This is what the recently associated project ASSERTED – Assuring Safety for Rapid and Continuous Deployment for Autonomous Driving – will find out. The research goal is to explore methods to better manage the safety of autonomous driving in a context of rapid and continuous development and implementation. To achieve this, we aim to understand and find solutions on how to adapt the safety argumentation for automated driving to this new context and which methodological and technical solutions can handle the identified challenges.

ENSEMBLE

The collaboration project ENSEMBLE has been successfully completed during 2021 with a public demonstration where a truck platoon, including various brands, drove autonomously on a Spanish motorway. Truck platooning includes driving of two or more trucks in a convoy by using connectivity technologies and driver support systems in order to make the platoon, the convoy, behave as one connected system. The advantages with platooning are for example a more safe and efficient transport system. The project's vision has been to speed up the implementation of platoon driving in Europe. The project has not only looked into technology development, but also aligning and working on for example standardization. As a result of the project a platooning protocol definition and communication strategy is now in place. This deliverable provides a specification of the V2X communication protocol to enable platooning using the wireless communication standard ITS-G5. Also, a security framework for platooning has been developed, describing which measure should be applied to ensure trucks can communicate with each other in a secure and private way.

TESTING AND VERIFICATION DEFINED IN HEADSTART

One of the main challenges for the implementation of self-driving vehicles is the testing and validation process. The project HEADSTART (Harmonised European Solutions for Testing Automated Road Transport), a project in the Horizon 2020 framework program, has taken on the challenge to define testing and validation procedures of functions including its key enabling technologies, i.e. communication, cyber-security and positioning.

The project was successfully concluded in 2021. SAFER has in this project been a joint research unit with its partners RISE, Chalmers, AB Volvo, Veoneer and AstaZero.

RESEARCH TARGETS

- We can evaluate different ways to act in the traffic situation and decide upon how to progress safe and efficiently.

- We have developed a methodology to verify and validate assisted and automated systems in cooperation with international researchers in this area.

- We have developed prediction models for human cognition and behaviour in the areas of "driver engagement", transitions between manual and automatic driving, and interaction between human and ADAS features.

- We have obtained knowledge essential for development of new perception components that enable high-performance, reliable information about the vehicle environment and the driver/riders in the vehicle.

SAFETY PERFORMANCE EVALUATION

THIS RESEARCH AREA is essential to all the other research activities at SAFER and is a cornerstone of future safety research, i.e. SAFER uses the research area to orient future research activities. The fundamental studies determine road safety priorities and examine safety benefits through statistical analyses of road traffic data, including accident, incident, and near-miss data. Development and standardisation of methods, recording and sharing of data, are important tasks. It can thus be considered complementary to all SAFER research areas and is in fact integrated in many different SAFER research projects on new safety strategies. Results of the safety performance evaluation studies are critical for securing the utility of new safety systems and providing confidence in their market introduction. The safety performance evaluation area gives SAFER a strong identity and a position in the global research community. For instance, SAFER's world leading cluster of researchers connected to naturalistic data activities has an internationally acknowledged reputation to a large extent due to conscious strategic choices and activities throughout all years from the start of SAFER. The datasets available cover about 6.5 million km of real-world driving in different contexts, countries and vehicle types. The databases with field data have a long history at SAFER and have continuously evolved together with the kind of data collected and the analysis to be performed. These activities have made it possible for SAFER partners to take leading roles in international research projects on data analysis and SAFER has become a data node for in-depth naturalistic driving data. The main current ongoing projects are described in the following part of this chapter.

WELL POSITIONED FOR THE FUTURE

The introduction of advanced driver assistance systems has increased the need to understand how they are used and how they perform in real world traffic, and eventually understand how these systems should be improved further. The need to understand technologies for accident prevention goes together with the need to understand the underlying complex system of factors behind crashes, which has made the interest for FOT and NDS studies even stronger – an area in which SAFER is deeply committed and will continue to develop spearhead competence and leadership. These activities bring new research collaborations, which in turn is an effective mechanism for SAFER to expand its access to larger amounts of data, providing opportunities for new research insights for the partners. Data collection is expensive and is typically limited to specific regions. Hence, international collaboration makes research for instance on socio-geographical differences possible. For example, during the past year, projects within a strategic collaboration with India have started. Within the framework of this platform, data collection is ongoing, giving valuable information about the traffic environment back to the researchers, read more on page 22. Also, a major upgrade of SAFER's data bases has started up, with the goal to enable us to use the databases to a much higher degree than today, for example to validate safety systems in future vehicles that keeps track of the driver's attention and drowsiness.

In our ongoing work to further explore how AI can be used in our research the availability and quality of data is crucial to be successful. SAFER has a great potential and a unique edge to be able to support this need since useful data already is available within the network. This opportunity will be further explored in 2022.

The Horizon 2020 project Hi-Drive was started during 2021 and secures funding for SAFER's FOT databases for several years to come. Hi-drive builds on the recently finished project L3Pilot, one of our largest projects, engaging several SAFER-partners. Hi-Drive will test and demonstrate high automation driving by taking intelligent vehicles technology to conditions neither extensively tested nor demonstrated earlier in European and overseas traffic. The project concept builds on an extended and continuous ODD (Operational Driving Doman) making it possible to operate vehicles longer periods and stay interoperable across borders and brands.

Other challenges that will be in focus for the years to come if to further investigate how the FOT databases can be of even better value for more SAFER partners. How to relate to open sources and other data sharing initiatives are other examples.

Algorithms and technology for efficient real-time traffic data collection are other interesting areas of research, as well as how we can best link our research to the global sustainable development goals. ITS and connectivity means new security challenges; in this area we need more knowledge and new competence. The important question "How safe is good enough?" is of course also an important research question that goes across the entire research platform. Other new research questions to address are safety in big number, Swedish micro-cultural differences and definition of the concept of road safety. SAFER is well positioned with multidisciplinary research to take on board new challenges regarding accident prevention, based on a profound knowhow regarding all kinds of road traffic data analysis.

KEY HIGHLIGHTS FROM PROJECTS

AI-AWARE

As the latest in a 5-generation series of research projects related to AD Aware Traffic Control Projects, AI Aware was associated with the SPE research area in 2021. Aiming for research on how artificial intelligence can enable predictive awareness in smart cities, this Sweden/Singapore collaboration looks deeper into traffic accidents as one of the initial use cases for this promising field. Highlights during 2021 included an AI-powered traffic management view for smart cities, and demos along with report findings.

STRADA IN-DEPTH STUDIES

During 2021, SAFER continued a pilot study to investigate how data can be used to develop a national in-depth database for traffic accidents. To accelerate the development of a safer transport system, researchers, authorities and vehicle manufacturers need access to detailed information on traffic accidents. In this pilot-study, the project uses existing Swedish databases; the STRADA database and Fatal Accident database. The pilot will add more variables and reconstructions, for accidents involving fatal and seriously injured people. The plan is that the in-depth studies will cover not only fatal accidents but also serious injuries (AIS2 +). This will create opportunities for better follow-up of the traffic safety situation in Sweden. The data format developed will be designed to be able to make comparisons with existing European and global accident databases and the analysis is ongoing aiming for the completion of the project during 2022.

ICV-SAFE

ICV-SAFE is a Sweden–China bilateral project with focus on investigating the safety aspects of intelligent connected vehicles (ICV) in mixed traffic environments. The project aims at taking advantage of the rapid development environment in China for ICV risk analysis, mitigation, as well as testing and validation. The ultimate goal is to develop safety assessment methods that take account of risk factors from both ICVs and road environment and contribute to accelerated deployment of ICV. With the test site as a partner and rapid infrastructure introduction, the project will also improve the understanding of infrastructure support for ICV.

ROAD DATA LAB

Road data lab has been a SAFER associated project that supported improved road safety by making datasets accessible. There are many potential benefits and opportunities for innovation if data from different sources in the traffic environment are combined and made available to others, e.g. more accurate road maintenance planning, better understanding of traffic flows and improved road safety. However, integrating and merging data from different stakeholders is tedious and time consuming – sometimes with legal obstacles as well. The goal was to provide a platform that supports contribution and integration of data from various sources, providing a technical infrastructure enabling innovation and learning as well as a legal baseline supporting various licenses.

TRAFFIC ACCIDENTS AND RISK FACTORS AMONG ELDERLY DRIVERS

We have an aging driver population and studies show that our elderly drivers are overrepresented in fatal and serious crashes. Cars have never been safer, but may, in some cases, be less optimized for older and more fragile occupants. Some drivers adjust their behaviour when they become older, for example by only driving closer to home. But this is not always the case; some also lose automated driving tasks and may overestimate their driving capabilities. The overall aim of this SAFER associated project is to investigate motor vehicle accidents with elderly drivers (65+) involved regarding accident circumstances, driver diagnoses and medications as well as occupant injuries versus vehicle safety level.

SAFETY DATASET FOR TRAINING AND VALIDATION OF AI PERCEPTION FUNCTIONS IN AD AND ADAS

AI, in particular deep learning algorithms, are becoming the state-of-the-art technology used in AD and ADAS. However, the interpretability and reliability of these algorithms are known to be challenging due to their data-driven and hence black box nature. This is not acceptable for automated systems deployed on the roads, where guarantees on safety are required. Since these data-driven AI algorithms are to a large extent determined by the training dataset, it is very important to create a dataset such that it is fully aware of the safety requirements. Within a project partly funded by the Open Research at AstaZero program and the FFI project "Safety-driven data labelling platform to enable safe and responsible AI", SAFER partner Asymptotic provides a public dataset of driving scenarios relevant for safety studies, that is ready-to-use for state-of-the-art AI algorithm validation and can be downloaded from https://github.com/AsymptoticAI/PREPER. The dataset will support researchers to have easy access and utilization of data to trigger research and development on safety aspects and improve the robustness of AI perception systems used in AD/ADAS. It can help in removing the last barriers for a wider introduction of AD and thus improve overall safety and contribute to the roadmap towards Vision Zero.

RESEARCH OBJECTIVES

- **Identified safety gaps**, e.g. long-term injury types.
- **Identified critical use cases**, e.g. driving a heavy truck in fog among vulnerable road users.
- **Identified new critical load cases**, e.g. multiple impact car crash.
- **Evaluation of implemented safety systems performance**, i.e. safety benefit analysis.
- **Prediction of safety benefits** of new safety systems.
- **Prediction of future safety critical scenarios**, automation included.
- **Determination of required safety level** for automated drive.

> "We have an aging driver population and studies show that our elderly drivers are overrepresented in fatal and serious crashes. Cars have never been safer, but may, in some cases, be less optimized for older and more fragile occupants. We aim to learn how we even better can protect this group of road users.

> "
> The research in the Safety performance evaluation group determines road safety priorities and examine safety benefits through statistical analyses of road traffic data.

SUCCESSFUL FINAL EVENT FOR THE SAFER PROJECT L3PILOT

How do we make sure that the human is a reliable fallback and can promptly, safely, and efficiently take back the driving task from automated driving? That has been the key question for over 30 stakeholders from academia and industry in Europe's first comprehensive pilot test of automated driving on public roads. The result is believed to help speed up and harmonize the development of automated driving systems in the future.

The European research project L3Pilot, led by Volkswagen and co-funded by the European Commission, has run from 2017 to 2021 with stakeholders from the whole value chain: car manufacturers, suppliers, academia, research institutes, infrastructure and governmental agencies, user groups and the insurance sector. The four-year project successfully ended with performing its final event in conjunction with the ITS World Congress in Hamburg 2021 on October 11–15.

Present at the ITS World Congress were Chalmers researchers from Vehicle Safety at the department of Mechanics and Maritime Studies – Marco Dozza, Linda Pipkorn, Pierluigi Olleja, along with SAFER representative Erik Svanberg – to show-case their research findings, which once started with the quest to find out how to optimize safety in automated driving:

"We all want full automation, that is, a vehicle that pick us up and takes us places without us having to think about driving. But tech is not there yet and there will be a transition phase with partial automation. That means humans and vehicles need to help each other and take turns in the driving task. The most relevant scenario is when a vehicle needs help from the human to sort out a critical situation that may lead to a crash. In such case, the research question is "how do we make sure that the human is a reliable fallback and can promptly, safely, and efficiently take back the driving task?" In our research, we tackled this question by exposing drivers to critical situations, where they need to take over control, and see how they do it. In this way, we can design vehicles that help the driver to efficiently coming back to the driving task rather than setting unreasonable expectations on human beings," says Marco Dozza, professor at Vehicle Safety at the department of Mechanics and Maritime Sciences at Chalmers.

EUROPE'S FIRST COMPREHENSIVE PILOT TEST ON PUBLIC ROADS

The project is the first comprehensive pilot test of automated driving on public roads in Europe, which makes it unique in its kind. Fourteen partners focused on testing automated driving functions in normal motorway driving, traffic jams, urban driving and parking. The pilots, running from April 2019 until February 2021, involved six countries besides Sweden: Belgium, Germany, France, Italy, Luxemburg and the United Kingdom and included two cross-border activities between Germany and Luxemburg as well as Germany, Belgium and the United Kingdom.

The project equipped 70 vehicles and the test fleet comprised 13 different vehicle brands, from passenger cars to a SUV. More than 400,000 kilometers were driven on motorways including 200,000 kilometers in an automated mode and 200,000 km in a manual mode as a baseline for comparison of the user experience and evaluation of the impacts. More than 24,000 km were travelled in the automated mode in urban traffic. With the aim to put the focus on the user experience of automated driving functions, over 1,000 persons participated in piloting and complementary virtual environment tests.

"We're proud about the high number of advanced studies, with a real vehicle on test track and public roads, that we managed to perform within this project, especially given the pandemic. All of these studies advanced our understanding of how drivers behave – how they act and where they look – when transitioning from automated driving to manual in response to take-over requests," says Linda Pipkorn, PhD student at Vehicle Safety at the department of Mechanics and Maritime Studies at Chalmers.

UNIQUE DATA COLLECTION TO ENHANCE SAFETY IN AUTOMATED DRIVING

The four-year project has also involved a considerable collection of valuable data based on the research findings on how pilot participants reacted when going from automated to manual driving in real traffic scenarios. The data will in the next step enable virtual testing to further enhance safety in automated driving.

"We found out that, in real traffic, drivers are able to transition control from automation to manual in response
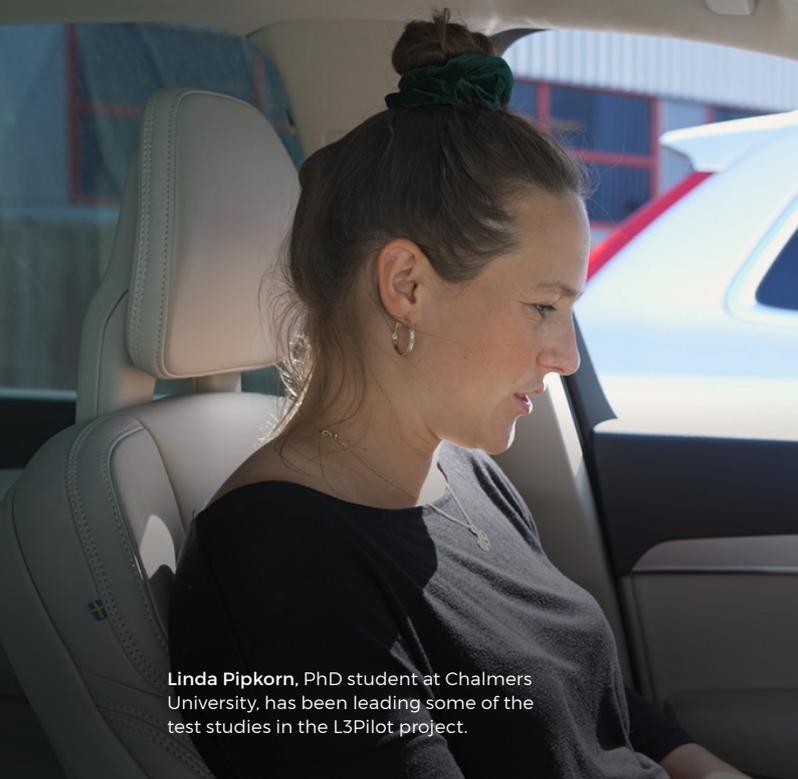
Linda Pipkorn, PhD student at Chalmers University, has been leading some of the test studies in the L3Pilot project.

L3Pilot's final event took place at ITS World Congress in Hamburg in October.

L3PILOT FACTS

L3Pilot is an Innovation Action, co-funded by the European Union under the Horizon 2020 programme with the contract number 723051. 34 organizations have committed to scientifically test and assess the impact of automated driving systems on driver comfort, safety and traffic efficiency as part of the project.

Web: www.l3pilot.eu
Duration: 50 months, 1 September 2017 – 31 October 2021
Total cost: €68 million
EC contribution: €36 million
Coordinator: Volkswagen AG

to a take-over request. The transition should be considered as a process of actions - look to instrument cluster, putting hands on wheel, look forward, deactivate automation - that requires a certain amount of time: up to 10 s in real traffic. Our research also showed that, in real traffic, drivers' visual attention towards the forward road return to similar levels as in manual driving 15 s after a take-over request. In response to take-over requests, drivers may look away from the road towards the instrument cluster rather than to the road. This means that, designing safe automated driving functions requires take-over requests to be issued in all situations that require driver input. In addition, it is important for the automated driving function to be responsible for safe driving at least up to the moment of the automation deactivation but preferably also some time after," says Linda Pipkorn.

As a part of the L3 pilot project, PhD student Linda Pipkorn carried out a study on a public road in Gothenburg (E6) together with Volvo Cars, aiming to find out how the drivers' gaze behavior changed when going from driving with automation to driving manually again.

"It turned out that, paradoxically, a take-over request, i.e., the signal from the car that the driver needs to take control can contribute to the drivers looking away from the road rather than looking at the road, which from a traffic safety point of view is not optimal," Linda explains. Her work received the Honda Outstanding Student Paper Award at the 2021 Driving Assessment Conference, an achievement that Linda herself believes can be explained by the project's unique design:

"I believe that an important factor is that our results are based on data collected on public roads, with a real car and a realistic human-machine interface, which is relatively rare in our research area as tests in a simulated environment are

more common. Data collected in a realistic environment is important to be able to draw conclusions that are in line with how the systems will be used in real scenarios in the future," says Linda Pipkorn.

L3Pilot is now believed to pave the way for scaled-up driving tests with automated series vehicles in real-life traffic. Together with 40 partners – OEM:s, automotive suppliers, research institutes, traffic engineering and deployment companies – Chalmers researchers have already started working on the project Hi-Drive with the main objective to extend the data collection across EU borders in variable traffic, weather and visibility conditions.

HUMAN BODY PROTECTION

THE HUMAN BODY PROTECTION RESEARCH AREA encompasses research to understand injury risks arising from transport collisions and events. This understanding supports the work of our partners in the development and evaluation of countermeasures to protect the body, to prevent injuries or at least to mitigate them. Focus for the research area is on emerging challenges in transportation, creating a knowledge base as well as a toolbox for human body protection evaluations and enablers. Specifically, Human Body Protection covers traffic-related injury mechanisms, biomechanical responses and consequences and the principles for protection including safety system usage. It addresses the needs for mechanical and mathematical occupant and vulnerable road user models for use in complete crash sequences including the immediate pre-crash period. In addition, it includes research to develop new simulation approaches for the development and assessment of novel crashworthy structures.

FFI-CRASH2

The Vinnova-funded project FFI-Crash2 is an example of how SAFER is at the forefront in the development of CAE (computer-aided engineering) approaches that can model the in-crash behaviours of composite materials. The modelling moves us incrementally closer to robust, accurate and efficient predictions of composite material responses under loads typically seen in crash events. This understanding goes hand-in-hand with increased use of lightweight composites in vehicles and our knowledge of what happens in a crash. This project produced 1 PhD thesis, 4 journal papers, 6 conference papers and more presentations. It tackled the fundaments of composite material responses in high strain rate settings. A vital building block as we seek efficient numerical crash simulation methods and system design optimisation tools targeting lightweight vehicles and their compatibility in modern transport conflicts.

When it comes to crash safety, SAFER partners have a world leading position in applied biomechanics research; exemplified by child safety and whiplash injury research, development of crash test dummies and human body models. SAFER has pioneered this research area for car occupants. However, we recognise that the transport system contains more varied types of vehicles, such as motorcycles, bicycles, electric scooters and other personal mobility transport means. Therefore, we aim to continue this journey considering those less-well or unprotected road users outside of the car as well. All road users are united in our need to understand how loading to the human body can lead to injury.

LONG-TERM CONSEQUENCES

The identification and prediction of injuries with long-term consequences was the title of another recent project completed with FFI funding. This project avoided concentrating on any one type of road user or collision, but instead focussed on the development of necessary injury assessment tools and methods. This included the use of the SAFER Human Body Model (HBM) in various simulations to predict the risk of long-term consequences for the head or upper extremities (arms). Specifically, these studies were bicycle helmet impact tests, free-motion headform impact tests, evaluation of airbags in frontal oblique crashes and a comparison of state of the art finite element (FE) head models in response to impacts applying short or long duration of impulses. With respect to the arms, as well as simulations with the SAFER HBM and related model improvements, a novel instrumented crash test dummy forearm was developed. Both tools were used in the development and evaluation of an airbag concept to protect against car occupant hand injuries caused by the instrument panel in frontal crashes. This project showcases how, with a focus on long-term consequences from traffic crashes, SAFER can develop new methods and assessment tools to enable innovative safety concepts to be proposed and evaluated.

WORLD LEADING HUMAN BODY MODEL FUNCTIONALITY

The previous two project descriptions highlight the importance of CAE and human body modelling in the future of protective system development. For human body modelling, SAFER provides a competence platform for partners as well as a natural contact point for external cooperation. The growing activity in human body modelling has already placed SAFER amongst other well-known organisations, and the interest shown by other universities proves its high academic relevance globally. SAFER's HBM vision encompasses a scaleable, tuneable, human body model with omni-directional injury prediction capabilities, including high-g and low-g events. This means a virtual human substitute that can be used for predicting injury outcome in any impact situation/ direction, able to replicate a large population of people, standing as well as sitting, with humanlike kinematics in impacts as well as vehicle-manoeuvre events. The SAFER strategic investment which began more than ten years ago, together with funding mainly from the FFI programme, has helped to speed up the process of industrial implementation significantly, providing the SAFER partners with a state-of-the art human body model.

However, we cannot rest yet. Future challenges for human body protection include vehicles with a higher degree of

> **Looking towards new protective systems generates additional research needs for our crash test tools which now have to represent vehicle drivers and occupants, pedestrians, riders of two and three–wheelers.**

automation, likely leading to fewer collisions, but with those remaining collisions potentially being further from conventional crash testing scenarios and norms of today. As vehicles increasingly become more and more automated, it opens opportunities such as for the car's seats to be placed in other ways: facing each other or diagonally. Chasing safety improvements in diverse circumstances requires more detailed methods for evaluation, which are based on more refined biomechanics research. It calls for further development of tools and methods for the safety evaluation. It might also add complexity to the methods and tools, by including vehicle pre–crash dynamics to account for the effect of the automated systems before the in–crash phase starts.

As we move towards future transport systems, road users must be and are being presented with sustainable travel options. Looking towards new protective systems generates additional research needs for our crash test tools which now have to represent vehicle drivers and occupants, pedestrians, riders of two and three-wheelers. In the new SAFER associated project, **Motorcycle rider model for injury prediction** the aim is to deliver updates to the SAFER HBM validating it for prediction of motorcycle rider kinematics in the most common crashes. It is the project goal that the updated SAFER HBM will also be able to predict the risk for critical injuries sustained by the riders. A tool that can transform the model in a biofidelic manner to different postures is included in the work and will have uses beyond the project and motorcycle riding postures. This project helps promote broader applications for the SAFER HBM, helping it to become even more useful.

RESEARCH OBJECTIVES

- **HUMAN BODY MODELS** with enhanced omnidirectional injury prediction capability, and posture adjustments, capable of serving as industrial and research tools; and furthermore, also addressing the needs arising from increased vehicle automation.

- **METHODS TO SCALE AND TUNE** human body models, accommodating the need to simulate the variety of humans in a crash, including preceding events.

- **AN INCREASED UNDERSTANDING** of how pre-crash factors and individual differences influence injury outcome, by monitoring and quantifying sitting postures and behaviour in vehicles and other road users together with the research area Road User Behaviour.

- **BIOMECHANICAL INVESTIGATIONS** addressing future challenges which require more in-depth understanding of injury occurrence and tolerances. For car occupants, the pelvis area is one key area in which significant steps will be taken.

- **MODELLING CHALLENGING MATERIALS**, e.g. fat tissues and complex structural composites.

- **EXPANDING THE APPLICATION** of tools and knowledge on road users beyond vehicle occupants, such as the different interactions for pedestrians, two-wheelers, scooters, boards and other emerging transport trends.

KNOWLEDGE DISSEMINATION & RESEARCH OUTREACH

PART OF THE SAFER MISSION is to disseminate results and knowledge to the partners and be a well renowned international centre of research excellence. To achieve this SAFER regularly arrange activities for knowledge sharing. SAFER has arranged and participated in a wide range of events over the year – primarily to present results and findings of the research and knowledge production activities, but also to connect researchers, discuss future needs and generate new projects and insights. A complete list of engagement to share knowledge, scientific findings and create future research is listed in appendix 7.

SAFER SEMINARS AND PROJECT CREATION WORKSHOPS

SAFER is acknowledged as a meeting place and the various seminars are appreciated by the partners as efficient means to share knowledge and create visibility among SAFER researchers on current topics, as well as offering great opportunities for networking. More or less all our networking and knowledge sharing activities in 2021 have taken place online due to the Corona pandemic. However, we have found new ways and good digital tools to still conduct a close dialogue and arrange knowledge sharing events together with our partners, e.g. through online meetings, webinars and even project-creating workshops. Our online activities have worked very well and been appreciated, we have, for example, become more national and have also had the opportunity to invite more international speakers to seminars. Our Thursday seminars, primarily for the internal cross-fertilization and exchange of knowledge and ideas, have transformed into well-attended online webinars, with more participants than ever.

Our project creation workshops have mainly focused on creating strong proposals for the first calls in Horizon Europe. The purposes of the workshops have been to start up a dialogue about ideas and identify how the SAFER partner would like to contribute in potential projects and which knowledge we jointly would like to build. Another purpose has been to get to know each other for future deeper collaboration, in EU projects and elsewhere, and to find further areas where joint projects could add value and inspire each other.

The Lindholmen Open Day 2021 was a digital event with the theme "Local attractiveness & global competitiveness". For 21 years, owners and partners have worked together to invest and purposefully develop a modern and inspiring innovation environment for several of Sweden's leading development projects and thereby created real innovative power. SAFER is an important partner in this development and actor in the current innovation environment. We contributed to the event by hosting a well-attended panel dialogue together with SIBC, Swedish India Business Council, about SITIS, the Sweden-India Transport Innovation and Safety Partnership. During the Open Day Lindholmen Science Park awarded the Collaborator of the Year to the SAFER collaboration environment in 2021. The award is a true confirmation that the collaboration we jointly conduct within SAFER to contribute to a safe and sustainable transport system actually works in practice, creates added value, contributes to utilization in society and also is appreciated by the partners.

For the first time, SAFER has been co-hosting the Scandinavian Conference on System and Software Safety (SCSSS) together with KTH, the Royal Institute of Technology. More than 130 experts from almost 50 different companies and organisations gathered at Lindholmen Science Park in Gothenburg for two days in November to take part in the conference and learn about the latest trends and developments in system safety research. The conference aimed to inspire, grow knowledge and increase networking through gathering experts from both industry and university to discuss techniques and methods for developing complex and safety regulated software-based systems. The research question of how we can ensure that self-driving vehicles are safe and contribute to a sustainable transport system is an extremely important issue for our research community and we see great opportunities to connect to these expertise

Figure 7
Number of SAFER publications per type

Master theses — 5
Doctoral and licentiate theses — 5
Reports — 11
Peer reviewed journal articles — 33
Conference papers/ presentations — 33

PUBLICATION VOLUME

SAFER's research projects have produced close to 90 publications during the third year in SAFER Stage 5, including peer reviewed journal articles (38%), conference papers and posters (38%), reports (12%), master theses (6%) and doctoral and licentiate theses (6%). Publications which are still listed as "in preparation/in press" will be made available in the near future (e.g. accepted papers of conferences that have not yet been held) are not included. In addition, these numbers also exclude publications from research conducted within SAFER but not belonging to a specific project (e.g. some PhD and post-doc research). A certain degree of underreporting should also be considered.

In the SAFER Knowledge library, www.saferresearch.com/library, you'll find most of the our public project publications that have been produced since the start in 2006.

SAFER DOCTORS AND LICENTIATE SEMINARS

During SAFER's 16th operational year one student working in the SAFER environment has written her doctoral theses and four have written a licentiate thesis, see appendix 9.

How can self-driving trucks support a safer transport system?
What about truck-drivers of the future? Fredrik Von Corswant, project leader at SAFER, participated in the podcast Liv och Trafik and gave his view on these research challenges.

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and field of research even more. All in all, close to 80 collaborative activities have been concluded in 2021. Welcome to read more about our activities in appendix 7.
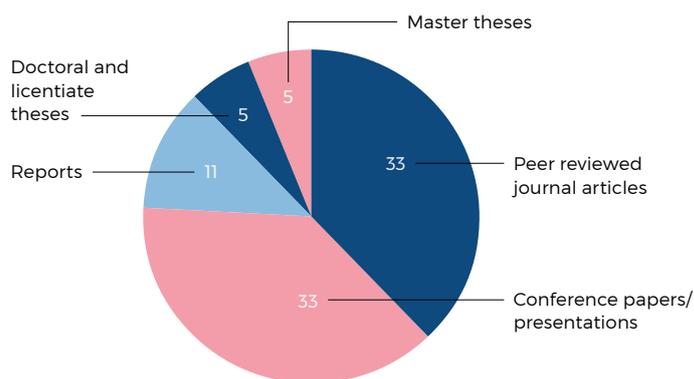
TRAFFIC SAFETY PODCAST

Liv och Trafikpodden is a knowledge podcast about road safety with interviews about current research, successful practice and traffic policies. The podcast is hosted together with NTF Väst and in 2021 we have published a series on traffic safety and the global sustainability goals. In the episodes we have elaborated on the key steps to achieve the SDGs and discussed the role road safety play in a sustainable society. During the autumn, our researchers also presented the results of several of our major projects, such as Autofreight, AI Aware, L3 Pilot and MeBeSafe. Take the opportunity to listen to the episodes at livochtrafikpodden.se

REGULAR REPORTING TO PARTNERS

SAFER's partners have been kept informed about the research results and ongoing activities and opportunities through regular newsletters and social media seedings. We have also continued with the SAFER Update concept which is an online meeting in connection with our Research area days in which we inform about our collaboration opportunities, main ongoing activities and upcoming events. More formal meetings with partners through the research areas have been performed six times during the period, including one Shareholders meeting. Nine board meetings have been held, including a two-day strategy meeting. Information about the project portfolio, activities and other news are also communicated through our website saferresearch.com

SETTING THE TRAFFIC SAFETY RESEARCH AGENDA FOR 2030

"How can we in the research community together continue to utilize the opportunities that come with the UN Conference, the Stockholm Declaration and the new UN resolution on traffic safety that was adopted in August 2020?"

THIS CORE QUESTION has been the focus for the webinar series that SAFER has conducted together with partners and external experts during the spring 2021. The webinar series comprised three sessions to get an even deeper understanding of the recommendations from the global UN conference, in order to utilize the outcome and initiate strategic work to support the new global traffic safety targets according to the new UN resolution. In the webinars, the members of the Academic Expert Group that developed the concepts behind the Stockholm Declaration and the recommendations in "Saving lives beyond 2020 – the next steps", presented their strategic thoughts behind the recommendations and new ideas on how to approach traffic safety.

"Saving lives beyond 2020 – the next steps" has been the base for the new UN resolution on traffic safety and will continue to inspire and guide us in our research.

NEW WAY OF APPROACHING TRAFFIC SAFETY

"The overall objective with the webinars has been to increase knowledge and inspire us to take on the new way of thinking, presented in the book. We have gathered our researchers around the recommendations to identify relevant research questions, current state of knowledge, possible gaps and to create project ideas for future multi-disciplinary research within SAFER", Malin Levin, project leader for the activity, explains.

An additional goal has been that certain of the ideas we found in the seminars will be included in future project applications and that the knowledge will contribute to the Swedish partners becoming more relevant also in larger applications, for example within the European framework programs.

"We have in this webinar series primarily worked with the recommendation #1 and #2, Sustainability reporting and Procurement, #9 Technology (research and implementation of already existing knowledge) and the more general

question of which actors can be relevant for researchers in traffic safety to collaborate with to a greater extent than is done today.", Malin says.

EXCITING RESEARCH TOPICS TO TAKE ON

During the seminar series, we have identified many new, also several cross-cutting, topics and research questions, in which we in the traffic safety research community likely are able to contribute. For example, support the understanding of which technologies for increased road safety that will be most effective in the future, also taking into account future scenarios, as well as other societal needs, such as the environment and health as well as costs and conditions in different countries. Becoming even better at technology transfer also has a large traffic safety potential, such as even deeper look into how protection systems and preventive safety systems that are currently found in cars, can be used for two-wheelers.

> It has been very inspiring to participate in the conversation with the traffic safety researchers. The fact that SAFER is now taking on the task of analyzing the research topics in the new recommendations linked to the global sustainable development goals is very positive. It is a challenging job and it is gratifying to see that it has started off so well within SAFER.

Prof. Claes Tingvall, the chairman of the expert group shares his view on the seminar series.

Claes Tingvall
Professor and chairman of the Academic Expert Group that developed the concepts behind the Stockholm Declaration and the recommendations in "Saving lives beyond 2020 – the next steps".

Knowledge transfer is another important issue – how do we ensure that the knowledge about road safety that we already have becomes available for everyone, in different parts of the world? How can we truly democratize road safety? Reliable data, and data that really creates added value and is useful, is another key to success. How do we ensure that we can collect, store and share data between different countries in an efficient way?

Most people who loses their life in traffic is a victim of someone's value chain. This way of thinking can provide entirely new ways of looking at responsibility. If each company or organisation starts to regularly report its footprints for traffic casualties in the same way as for example climate impact, there will be an increased focus for improvement, for example with regards to requirements for procurement, actions and follow-up. Reporting and systematic follow-up is hence another important area that has huge impact on global road safety. In this work there are several new research questions we can support, e.g. the safety performance evaluation of various kind of road safety index and how to priorities different initiatives for improved road safety.

About 150 people from over 50 different companies and organizations have participated in the activities, the majority in all three sessions.

"We have gathered many good ideas and relevant research questions for how we as a next step could contribute with value-creating research for the implementation of the recommendations", Malin concludes.

Malin Levin, Deputy director and
Magnus Granström, Director at SAFER

Lindholmen Science Park awarded the Collaborator of the Year to the SAFER collaboration environment in 2021. Malin Levin received this prestigious award at Lindholmen Open Day in September.

APPENDICES

APPENDIX 1: SAFER PARTNERS

The following partners have been engaged during operational year 16:

PARTNER LEVEL 1 & 2

- Aptiv AB
- AstaZero AB
- Autoliv Development AB
- BETA CAE Nordic AB
- Chalmers tekniska högskola AB
- China Europe Vehicle Technology AB (CEVT)
- Combitech AB
- Folksam
- Halmstad University
- If Insurance
- Institute of Transport Economics – Norwegian Centre for Transport Research (TØI)
- Jönköping University
- National Electric Vehicle Sweden AB (NEVS)
- RISE Research Institutes of Sweden AB
- Scania CV AB
- Smart Eye AB
- Swedish National Road and Transport Research Institute
- Swedish Transport Administration
- University of Gothenburg
- University of Lund
- University of Skövde
- Veoneer Sweden AB
- Volvo Car Corporation
- Volvo Group AB
- Zenseact

PARTNER LEVEL 3 (ASSOCIATED PARTNERS)

- Agreat (as of May)
- Afry
- ASTUS AB (as of March)
- Asymptotic
- City of Gothenburg
- Consenz (as of May)
- DuWill (as of March)
- Cycleurope AB
- HiMinds Göteborg AB
- Hövding (as of March)
- Knightec (as of May)
- Malmeken AB
- Nationalföreningen för trafiksäkerhetens främjande (NTF Väst)
- Svanberg & Svanberg AB
- Swedish Transport Agency
- Tier Mobility (as of May)
- Trivector
- Viscando (as of March)
- Voi (as of August)

APPENDIX 2: SAFER BOARD

The following members have been part of SAFER Board during the third year of SAFER Stage 5:

- Autoliv: **Cecilia Sunnevång**
- Chalmers: **Sinisa Krajnovic** and **Angela Hillemyr** (until November)
- RISE: **Stefan Nord**
- Swedish Transport Administration: **Maria Krafft**
- Volvo Car Corporation: **Malin Ekholm**
- Volvo Group: **Claes Avedal** (as of March)
- VTI: **Jonas Jansson** (until March), **Astrid Linder** (as of March)
- Independent chairperson: **Karin Svensson** (until March), **Thomas Andersson** (as of March)
- **Hans Fogelberg** (Region Västra Götaland) and **Eric Wallgren** (Vinnova) has joined the Board as observers

APPENDIX 3: SAFER MANAGEMENT TEAM

The following members have been part of SAFER's management team during SAFER's operational year 16:

- **Anna Sjörs Dahlman,** Research area director Road user behaviour (as of August)
- **Azra Habibovic,** Research area director Road user behaviour (until August)
- **Fredrik Sandblom,** Research area director Systems for accident prevention and automated driving
- **Fredrik Von Corswant,** Connected research resource leader for Revere
- **Fredrik Åkeson,** Connected research resource leader for AstaZero
- **Ines Heinig,** Project coordinator
- **Ingrid Skogsmo,** Senior research advisor
- **John-Fredrik Grönvall,** Connected research resource leader for Naturalistic driving data
- **Jolyon Carroll,** Research area director Human body protection
- **Linus Wågström,** Research area director for Safety performance evaluation
- **Magnus Granström,** Director
- **Malin Levin,** Communications and partnerships, Deputy director
- **Matteo Rizzo,** Research leader for Safe System Principles
- **Robert Thomson,** Chalmers
- **Sofia Fagrell,** Controller

APPENDIX 4: COMPETENCE NETWORKS AT SAFER

The following competence networks have been active during the reporting period:

Automotive Safety Assurance
Focus is preliminary around how to design L3-L4 automated vehicles such that the accident risk is tolerable, and how to prove that the risk is tolerable with sufficient confidence, and how to design with explainability at all times. Competence network leader: **Fredrik Sandblom**

Human behaviour
By applying an interdisciplinary approach, the scope of this competence network is to understand human behaviour in traffic and develop scientific methods and tools to create prerequisites for safe driving. It is also about the interplay between humans and technical systems in different contexts; how technical systems should be designed to achieve efficient and safe interaction with the users. Competence network leader: **Giulio Bianchi Piccinini**

Future proof methodologies for validation of connected and automated vehicles
The group discuss validation of automated and connected vehicles. including e.g. relevant test cases, virtual methods and their connection to physical tests, the role of Operational Design Domains (ODD) and relevant connectivity scenarios. Competence network leader: **Fredrik Åkeson and Viktor Johansson**

Perception, sensing & communication
Sensors and communication enable technologies for a plethora of safety systems. The scope of this group is to create and share research ideas around vehicular communications, sensors systems, and signal processing. Competence network leader: **Lars Hammarstrand**

Structures and materials
The purpose of this competence area is to gather researchers concerned with vehicle architectures and lightweight materials suitable for future efficient vehicles with new powertrains. Competence network leader: **Christopher Cameron**

System Safety
System Safety is about reducing risks related to malfunctioning systems and components of various technologies, including electronics, mechanics and software. As these are the part of a vehicle, this is a highly interdisciplinary approach connected to most other competence networks in SAFER. The network develops new competence in the area and targets to create more collaboration across the other competence networks. Competence network leader: **Per Johannesson**

Vehicle Dynamics
Vehicle dynamics is creating a collaborative arena connecting vehicle dynamics research carried out in academia/institutes and the corresponding advanced engineering activities in the automotive industry. Competence network leader: **Bengt Jacobson**

APPENDIX 5: THE SAFER ECOSYSTEM

Institutes and academy
- Children's hospital of Philadelphia
- Japanese Automotive Research Institute Nagoya University
- Tokyo university of Agriculture and Technology
- University of IOWA
- University of Michigan Transportation Research Institute (UMTRI)
- Xiamen University of Technology

Collaborative organisations and research programmes
- Australia Driverless Vehicle Initiative (ADVI)
- CLEPA European Association of Automotive Suppliers
- CTS (China Sweden Traffic Safety Centre)
- Cykelcentrum (Swedish Cycling Research Centre)
- Drive Sweden
- European Automotive Research Partners Association (EARPA)
- European Council for Automotive R&D (EUCAR)
- European Road Transport Research Advisory Council (ERTRAC)
- Forum för Transportinnovation
- HUMANIST
- K2 Centre
- Movéo
- Neuroscience Research Australia
- POLIS Network
- SDNS Northern Europe (Sustainable Development Solutions Network)
- SDNS Northern Europe (Sustainable Development Solutions Network)
- Swedish electromobility Centre
- The Association for the Advancement of Automotive Medicine (AAAM)
- The Association for the Advancement of Automotive Medicine (AAAM)
- The Group for national cooperation (GNS Väg)
- The Group for national cooperation (GNS Väg)
- The national network for Vision Zero
- WARA-CAT (Collaborative and Autonomous Transport)
- WARA-CAT (Collaborative and Autonomous Transport)
- WASP (Wallenberg Autonomous Systems and Software Program)
- WASP (Wallenberg Autonomous Systems and Software Program)

APPENDIX 6 / PROJECT PORTFOLIO

PROJECT	PROJECT LEADER	START	END	FUNDER	PARTNERS
Human Body Protection					
ADOPTIVE – Application for Automated Design & Optimization of Vehicle Ergonomics	Erik Brolin	01-03-2021	29-02-2024	KK-Stiftelsen	University of Skövde, Volvo Group, Scania, VCC, CEVT, Fraunhofer-Chalmers Research Centre for Industrial Mathematics (FCC)
A-HBM 4 – Active human body models for virtual occupant response, step 4	Linus Wågström	01-04-2018	31-12-2021	FFI	Autoliv, Chalmers, VCC, DYNAmore Nordic
A-HBM 5 – Active human body models for virtual occupant response, step 5	Lotta Jakobsson	01-04-2021	31-03-2023	FFI, TSAF	VCC, Autoliv, Chalmers, DYNAmore
CAR PASSENGER PROTECTION – To the Next Level / Passenger Safety, part 2	Lotta Jakobsson	01-11-2020	31-10-2023	FFI, TSAF	VCC, Autoliv, Chalmers
DUCTILE FIBER REINFORCED COMPOSITES	Martin Fagerström	06-12-2016	31-12-2021	Energi-myndigheten	Chalmers, KTH, VCC, Biteam
INJURY HBM, STEP 4 – Pelvis and spine injury predicting models for women and men in a variety of sitting postures in future autonomous cars	Bengt Pipkorn	01-04-2019	31-03-2022	FFI	Autoliv, VCC, Chalmers, GU/ Sahlgrenska
MOTORCYCLE MODEL FOR PREDICTION OF INJURY RISK	Bengt Pipkorn	01-06-2021	31-05-2024	FFI	Autoliv, Chalmers, MIPS, Beta CAE
OSCCAR – Future Occupant Safety for Crashes in Cars	Johan Davidsson	01-06-2018	30-11-2021	EU H2020	VCC, Autoliv, Chalmers, other EU/ international partners
SAFER Pre-Study: ADIPOSE TISSUE RATE DEPENDENT RESPONSE	Håkan Johansson	01-06-2021	31-12-2021	SAFER Pre-Study Funding	Chalmers, Autoliv
SAFER Pre-Study: SAFER CYCLING	Magnus Larsson	04-05-2020	01-04-2021	SAFER Pre-Study Funding	VTI, Folksam, Chalmers, GU/ Sahlgrenska, Vätternrundan
VIRTUAL – Open Access Virtual Testing Protocols for Enhanced Road User Safety	Astrid Linder	01-06-2018	31-05-2022	EU H2020	VTI, VCC, Chalmers, TØI, other EU/ international partners
VIRTUAL EVALUATION TOOLS FOR PEDESTRIAN INTEGRATED SAFETY	Robert Thomson	01-04-2019	31-12-2022	VINNOVA MOST China Sweden call	Chalmers, VTI, Autoliv, VCC, Tsinghua University, University of Science and Technology Beijing (USTB), Geely, RIOH, Brillizance Auto
Road User Behaviour					
AHA II - Design Ethnographic Living Labs for Future Urban Mobility – A Human Approach	Vaike Fors	01-10-2019	31-12-2021	Drive Sweden/ VINNOVA	Halmstad University, VCC, Gothenburg City, Helsingborg City, Skånetrafiken, Västtrafik
BRAVE - BRidging gaps for the adoption of Automated Vehicles	Ingrid Skogsmo	01-06-2017	28-02-2021	EU H2020	VTI, other EU/ international partners
CHARACTERIZING AND CLASSIFYING NEW E-VEHICLES FOR PERSONAL MOBILITY	Marco Dozza	01-08-2019	01-10-2021	Skyltfonden (STA)	Chalmers
CO2 - Effects on driver state and driving performance	Ignacio Solís	01-10-2020	31-03-2022	FFI	VTI, SENSEAIR
DRIVE2THEFUTURE	Anna Anund	01-05-2019	30-11-2022	EU H2020	VTI, TØI, other EU/ international partners
DRIVER - Driver physiological monitoring for vehicle Emergency Response	Stefan Candefjord	01-04-2021	30-09-2023	FFI	Chalmers, Autoliv, VTI, VGR, Raytelligence
EHMI - External Interaction Principles for Creating Trust in Heavy Automated Vehicles	Yanqing Zhang	01-04-2020	30-06-2022	FFI	Scania, Halmstad University, RISE
ENHANCED ADAS – Improving drivers' experience, acceptance and trust in assistance systems	Jonas Andersson	15-10-2020	15-10-2022	FFI	RISE, Aptiv, SmartEye
EVALUATION OF A FRAGRANCE SYSTEM TO COUNTER SLEEPINESS AT THE WHEEL	Anna Sjörs Dahlman	01-04-2020	31-12-2021	FFI	VTI, VCC, KI, Moodify, WIS
FIT2DRIVE	Katja Kircher	01-04-2020	31-12-2022	FFI	VTI, SmartEye

PROJECT	PROJECT LEADER	START	END	FUNDER	PARTNERS
Road User Behaviour					
GLAD – Goods delivery under the Last-mile with Autonomous Driving vehicles	Mikael Söderman	01-06-2020	30-09-2022	Swedish Transport Administration	RISE, Aptiv, Combitech, Halmstad University, Clean Motion
HAVOC – Heavy Automated Vehicle Operation Center - Requirements and HMI design	Jonas Andersson	01-11-2020	11-03-2022	FFI	RISE, Scania
IN THE HUB – Interaction between operators and driverless vehicles in the transport system of the future	Yanqing Zhang	01-04-2020	31-10-2022	FFI	Scania, RISE, Boliden, Icemakers
MEDIATOR – Mediating between Driver and Intelligent Automated Transport system on our roads	Anna Anund	01-05-2019	30-04-2023	EU H2020	VTI, Autoliv and Zenseact, other EU/ international partners
PANACEA – Practical and effective tools to monitor and assess commercial drivers' fitness to drive	Anna Anund	01-05-2021	30-04-2024	EU H2020	VTI, Chalmers, SENSEAIR, Transdev, other EU/ international partners
QUADRAE – Quantitative Driver Behaviour Modelling	Thomas Broberg	01-01-2016	31-07-2021	FFI	VCC, Volvo Group, Autoliv, VTI, Chalmers
RE-ENGAGE – Driver re-engagement in autonomous driving by means of HMI adapted to human activity	Jonas Andersson	01-04-2020	31-12-2022	FFI	RISE, VCC, SmartEye
SAFE-EPMVS – Safety and ease-of-use assessment of new electric vehicles for personal mobility (e-PMVs) in urban environment	Marco Dozza	01-01-2020	31-12-2021	Chalmers AOA Transport	Chalmers
SAFER Pre-Study: DRONE LIGHTING SYSTEMS	Henrik Svensson	01-08-2021	01-08-2022	SAFER Pre-Study Funding	Jönköping University, University of Skövde, RISE, Municipality of Skara
SAFER Pre-Study: EXPLORING THE IMPACT OF EMBODIED COGNITION ON AD DESIGN	Henrik Svensson	01-04-2021	01-04-2022	SAFER Pre-Study Funding	University of Skövde, Autoliv, Folksam, Veoneer, VCC, Volvo Group, Volvo Construction Equipment
SAFER Pre-Study: MULTIMODAL DATA FOR ROAD USER BEHAVIOR ANALYSIS TO SUPPORT SAFE DRIVING PATTERNS	Yacine Atif	01-01-2021	30-09-2021	SAFER Pre-Study Funding	University of Skövde, SmartEye
SAFER Pre-Study: SAFETY CULTURE FOR AUTOMATION IN TRANSPORT COMPANIES	Christina Stave	01-03-2020	31-03-2021	SAFER Pre-Study Funding	VTI, Volvo Group, TØI
SAFER Pre-Study: VIRTUAL REALITY INTERACTIONS WITH AUTONOMOUS VEHICLES	Carmelo D'agostino	01-02-2021	31-08-2021	SAFER Pre-Study Funding	Lund University, VTI, Volvo Group, Autoliv, Swedish Transport Administration
SAFETY CULTURE AND AUTOMATION	Christina Stave	01-03-2021	31-10-2021	FFI	VTI, RISE, Scania, Toyota
SCALE-UP – Crowdsourcing for scaling up evaluation of external interfaces on automated vehicles	Azra Habibovic	01-03-2019	31-08-2021	FFI	RISE, VCC
Safety Performance Evaluation					
AI AWARE – AI Powered Awareness for Traffic Safety	"Johan Amoruso-Wennerby Martin Ivarson"	01-11-2020	31-12-2021	FFI	VCC, Gothenburg City, Swedish Transport Administration, Zenseact, LSP, Carmenta, Ericsson, HERE Technology
AI ROAD SIDE – Recommendation for methodology on AI-based Road-side object identification	John-Fredrik Grönvall	10-05-2021	30-09-2021	Chalmers AOA Transport	Swedish Transport Administration, Chalmers, Asymptotic, VCC
ARCADE – Aligning Research and innovation for Connected and Automated Driving in Europe (CARTRE2)	John-Fredrik Grönvall	01-10-2018	30-09-2021	EU H2020	SAFER, Chalmers, Volvo Group
FOT-E – Field Operational Test-Feature Extraction from Video	John-Fredrik Grönvall	01-11-2019	31-10-2022	FFI	Chalmers, Autoliv, Smarteye
HANDBOOK OF ROAD SAFETY MEASURES	Alena Hoye	01-01-2013	no	Norwegian Public Roads Administration	TØI

PROJECT	PROJECT LEADER	START	END	FUNDER	PARTNERS
Safety Performance Evaluation					
HETEROGENEOUS TRAFFIC GROUPS – Heterogeneous Traffic Groups Cooperative Driving Behaviours Research under Mixed Traffic Condition	Jiali Fu	01-04-2019	31-03-2022	VINNOVA MOST China Sweden call	VTI, Chalmers, VCC, Volvo Group, RIOH, Geely , Beijing Jingwei HiRain, Tsinghua University, Tongji University
HIDRIVE (ART-06)	John-Fredrik Grönvall	01-01-2021	31-12-2024	EU H2020	Chalmers, VCC, Volvo Group, Zenseact, other EU partners
ICV-SAFE – Testing safety of intelligent connected vehicles (ICV) in open and mixed road environment	Lei Chen	01-08-2020	31-07-2023	VINNOVA MOST China Sweden call	RISE, Chalmers, Alkit Communications, WSP Sverige, Fellowbot, Tongji University (CN), Changan University (CN), Shanghai Songhong, Intelligent Automotive (CN), Highway research institute Ministry of Transportation (CN), TuSimple (CN), Guangzhou O.CN (CN)
L3PILOT - Piloting Automated Driving on European Roads	John-Fredrik Grönvall	01-09-2017	31-10-2021	EU H2020	SAFER JRU, VCC, Autoliv, other EU Partner
MIDAS – anonyMIsing DAta collection for traffic Safety	Cristofer Englund	01-04-2020	31-03-2023	FFI	RISE, Halmstad University, Viscando, Berge Consulting
Open Research project: SAFETY DATASET FOR TRAINING AND VALIDATION OF AI PERCEPTION FUNCTIONS IN AD AND ADAS	Jörg Bakker	01-11-2020	31-03-2022	Open Research at AstaZero Program	Asymptotic, Revere
RODL – Road Data Lab	Thomas Olsson	09-12-2019	31-03-2022	FFI	RISE, Lund University, Zensact, AI Sweden, Univrses
SAFER DATA PORTFOLIO	John-Fredrik Grönvall	01-11-2020	30-06-2022	SAFER Core	Chalmers, Svanberg&Svanberg
SAFER Pre-Study: HÖVDING DATA FOR RISK ASSESSMENT	Viveca Wallqvist	05-04-2021	28-02-2022	SAFER Pre-Study Funding	RISE, Hövding
SAFER Pre-Study: REPORT ON THE SAFETY AND TRAFFIC FLOW IMPACT OF MIXED TRAFFIC CONDITION	Jiali Fu	01-03-2021	31-12-2021	SAFER Pre-Study Funding	VTI, Chalmers
STRADA - Swedish Traffic Accident Data Acquisition Indepth study	John-Fredrik Grönvall	01-04-2020	31-03-2022	FFI	Chalmers, Autoliv, Folksam, IF, VTI, VCC, Volvo Group
TRAFFIC ACCIDENTS AND RISK FACTORS AMONG ELDERLY DRIVERS	Jesper Sandin	01-09-2020	30-09-2022	Swedish Transport Administration	VTI, Folksam
UDRIVE Data User Group	John-Fredrik Grönvall	01-07-2017	28-02-2021	Consortium financed	SAFER, DLR, IFSTTAR, LAB, SWOV, University of Leeds
VRU – E-SCOOTER "TARGET"	Fredrik Åkeson	01-10-2020	30-09-2021	FFI	AstaZero
Systems for Accident Prevention and Automated Driving					
ASSERTED - Assuring Safety for Rapid and Continuous Deployment for Autonomous Driving	Ali Nouri	01-11-2021	31-03-2025	FFI	VCC, Chalmers, Zenseact
AUTOFREIGHT - Self-driving trucks for smarter logistics	Lena Larsson	01-04-2017	31-08-2022	FFI	Volvo Group, Combitech, Chalmers, City of Borås
ENSEMBLE - ENabling SafE Multi-Brand pLatooning for Europe	Xu Wen	01-06-2018	31-03-2022	EU H2020	Scania, Volvo Group, KTH, other EU/ international partners
ETAVEP – Enablers for Testing Autonomous Vehicles at Existing Proving ground	Albert Lawenius	01-04-2020	31-03-2022	FFI	VCC, Volvo Group, AstaZero, RISE, Chalmers, SafeRadar
HEADSTART – Harmonised European Solutions for Testing Automated Road Transport	Jonas Sjöberg	01-01-2019	31-12-2021	EU H2020	SAFER JRU, RISE, Chalmers, Volvo Group, Veoneer, other EU/ international partners
"MICA 2 – Modelling Interaction between Cyclists an Automobiles"	Marco Dozza	22-11-2019	22-11-2022	FFI	Chalmers, Autoliv, Veoneer, VCC, IF, Viscando, VTI
Open Research project: TRACTION ADAPTIVE MOTION PLANNING FOR CRITICAL SITUATIONS	Lars Svensson	20-01-2020	20-02-2021	Open Research at AstaZero Program	KTH, Revere
Open Research project: VALIDATION OF AUTONOMOUS HIGHWAY DRIVING ALGORITHM AT ASTA ZERO	Johan Karlsson	01-08-2020	31-03-2021	Open Research at AstaZero Program	Chalmers, Revere

PROJECT	PROJECT LEADER	START	END	FUNDER	PARTNERS
Systems for Accident Prevention and Automated Driving					
REDO – Remote Driving Operations	Maytheewat Aramrattana	01-01-2020	30-11-2022	FFI	CEVT, NEVS, VTI, Einride, Ericsson, Ictech, KTH, Voysys
SAFER Pre-Study: COOPERATIVE AUTOMATED DRIVING USE CASES FOR V2X COMMUNICATION	Stephanie Milena Alvarez Fernandez	01-05-2021	30-06-2021	SAFER Pre-Study Funding	Halmstad University, Viscando, Zenseact
SAFESMART – Safety of Connected Intelligent Vehicles in Smart Cities	Alexey Vinel	01-09-2019	31-08-2023	The Knowledge Foundation	Halmstad University, AstaZero, Scania, H&E Solutions, Terranet, Gutec, Quviq, KPIT
SAFETYNET FOR TRUCKS	Stefan Koychev	01-10-2018	31-03-2022	FFI	Volvo Group, Chalmers
SALIENCE4CAV – Safety lifecycle enabling continuous deployment for connected automated vehicles	Fredrik Warg	01-01-2021	30-06-2023	FFI	RISE, Veoneer, Zenseact, Agreat, Comentor, Epiroc, KTH, Qamcom, Semcon
SMILE III – Safety analysis and validation of systems based on machine learning	Cristofer Englund	01-04-2020	31-03-2022	FFI	RISE, QRTECH, Infotiv, Combitech, ESI Nordics, Semcon
VALU3S – Verification and Validation of AutomatedSystems' Safety and Security	Behrooz Sangchoolie	01-05-2020	30-04-2023	EU H2020	RISE, VTI, KTH, other EU/ international partners
Competence					
AI DRIVEN MOBILITY	Vanja Carlén	01-01-2021	31-12-2024	VINNOVA, Drive Sweden pro-gram	Zenseact, Ericsson, Volvo Group, Polestar, Viscando, Univrses, UniqueSec, VGR, Swedish Transport Administration, Kista Science City, Örebro kommun, Chalmers, University of Borås, Malmö University, Region Örebro län, Region Jönköpings län, Sjöfartsverket, AFRY, DOKIV AB, NSR
DRIV – Data Law Innovation	Ebba Josefson Lindqvist	15-10-2021	15-10-2023	VINNOVA	LSP (coordinator), Delphi, Chalmers, GU/ Sahlgrenska, Helsingborgs kommun, Lunds universitet, MAQS Advokatbyrå, NCC, Patent- och registreringsverket, Region Halland, Region Stockholm, RISE, Chalmers Industriteknik, Swedish Transport Administration, Tyréns Sverige, VGR,
FUTURE-HORIZON Coordination and Support Action	Magnus Granström	01-02-2021	31-01-2023	EU H2020	Chalmers, Volvo Group
IGLAD Phase 4 - Initiative for the global harmonisation of accident data	Ines Heinig	01-01-2020	31-12-2022	Consortium financed	SAFER/Chalmers, Autoliv, VCC, Volvo Group, Asymptotic, other EU/ international partners
KNOWLEDGE DISSEMINATION AND IMPLEMENTATION OF THE STOCKHOLM DECLARATION'S 9 RECOMMENDATIONS	Malin Levin	01-01-2021	30-06-2021	Skyltfonden (STA)	SAFER
SMART URBAN TRAFFIC ZONES	Ines Heinig	01-09-2020	01-09-2022	FFI	SAFER/ Chalmers, GU, RISE, AstaZero, VTI, Gothenburg City, Scania, VCC, other Swedish partners
SUS – Sensor testing in adverse weather conditions	Peter Eriksson	01-10-2020	30-09-2022	FFI	AstaZero, Chalmers
TRAFFIC SAFETY FOOTPRINT	Tania Dukic Willstrand	15-01-2021	01-05-2022	Skyltfonden (STA)	SWECO, DuWill, NTF, Gothenburg City, Partille Kommun
EU-coordination Drive Sweden	Ingrid Skogsmo	01-11-2020	31-08-2021	VINNOVA, Drive Sweden pro-gram	VTI, SAFER/Chalmers, Volvo Group, Autoliv, RISE, Scania
YOUNG MOBILITY	Malin Levin	01-01-2021	30-11-2021	NTF	NTF, SAFER, Halmstad municipality

APPENDIX 7: COLLABORATIVE KNOWLEDGE SHARING AND PROJECT CREATION ACTIVITIES

Conducted SAFER seminars, conferences, workshops and other events during year 16 include:

- SAFER's session at Transportforum: The transition to new kinds of mobility, January 14, 2021
- Kick-off new competence network Structures and materials, Jan 18, 2021
- UN seminar series "Implementation of the nine recommendations supporting the new UN resolution and Agenda 2030" – first session: Technology and implementation research, Jan 19, 2021
- AI as a tool for traffic safety research – stakeholder workshop, Jan 20, 2021
- Vivekendra Singh, Chalmers, licentiate seminar: Strain rate dependent material model for polymer composites, January 20, 2021
- Horizon Europe project creation workshop, Jan 26, 2021
- Workshop – SAFER cycling, Jan 28, 2021
- SAFER Lunch webinar: Zenseact – a new partner in SAFER, Jan 28, 2021
- SAFER seminar: How can sound design be used to enhance the user experience in self-driving cars of the future?, Jan 29, 2021
- SAFER lunch webinar: SAFER's connected research resources – Strong assets for real-world traffic safety research, Feb 4, 2021
- SAFER Research area day, Feb 9, 2021
- SAFER Update for the research community, Feb 9, 2021
- SAFER webinar: HEADSTART & VALU3S - How do we know automation is safe?, February 11, 2021
- Kick off workshop competence network Functional safety, February 23, 2021
- UN Seminar series: Integration of road safety in the SDGs – how to connect to other SDGs to gain momentum, February 25, 2021
- SAFER webinar hosted by the competence network; Perception, Sensing & Communication; Semantics- and Uncertainty-aware Perception for Autonomous Driving & Technologies for wireless V2X communication: update on recent development, March 4, 2021
- SAFER Research & Project Day 2021, March 9, 2021
- SAFER Annual shareholder meeting, March 9, 2021
- SAFER Research area day, March 10, 2021
- SAFER Update for the SAFER community, March 10, 2021
- SAFER lunch webinar: Virtual models for human body protection, March 11, 2021
- SAFER webinar: Användning av bilbältet bland gravida; hur ser det ut i verkligheten och hur kan vi rädda liv genom korrekt användning?, March 12, 2021
- SAFER webinar: Funding opportunities through Trafikverket & Revere – 60 seconds of highway driving in Sweden and India, March 18, 2021
- Lunch & Learn with Drive Sweden: Geofencing in the Mobility system, March 24, 2021
- SAFER webinar: Theme Vision Zero, March 25, 2021
- Emma Larsson's licentiate seminar: Towards a human body model for prediction of vehicle occupant kinematics in omni-directional pre-crash events, March 31, 2021
- UN seminar series: The Value Chain – reporting and procurement (recommendation #1 and #2), March 31, 2021

- SAFER Webinar: Folksam – four road traffic safety research projects, April 8, 2021
- SAFER Research area day, April 14, 2021
- SAFER Update for the SAFER community, April 14, 2021
- SAFER Webinar hosted by the competence network Human behaviour; PANACEA – project overview and Will drivers be able to engage in non-driving related activities while on the move in automated vehicles?, April 15, 2021
- Alexandros Leledakis licentiate seminar: Pre-Crash and In-Crash Car Occupant Safety Assessment, April 15, 2021
- SAFER webinar: Pre-study on driver distraction analysis & simulation infrastructure, April 22, 2021
- Prateek Thalya's licentiate seminar "Making overtaking cyclists safer: Driver intention models in threat assessment and decision-making of advanced driver assistance system", April 23, 2021
- SAFER webinar: Road safety trends in Sweden 2020 – overview of the Swedish road safety performance indicators, April 29, 2021
- Kick-off for new competence network - workshop: Future proof methodologies for validation of connected and automated vehicles, May 5, 2021
- SAFER webinar: IGLAD & STRADA in-depth study, May 6, 2021
- SAFER webinar: New SAFER partners (ASTUS, DuWill, Hövding, Viscando), May 20, 2021
- Conference organized by the SAFER Competence network for Vehicle Dynamics, Vehicle Dynamics for Future Mobility …and not only Lateral, May 26, 2021
- SAFER webinar: How to create long lasting and sustainable behavioral changes - and how can this be applied to road safety?, May 27, 2021
- SAFER Research area day, June 3, 2021
- SAFER Update, June 3, 2021
- Idea creation workshop for the second set of calls in Horizon Europe, June 7, 2021
- Master thesis presentations at Division of Vehicle Engineering and Autonomous Systems at Chalmers University, June 8, 2021
- Sweden-Malaysia Road Safety Webinar: Creating safer environment for vulnerable road users, June 10, 2021
- Master Thesis Day - Division of Vehicle Safety at Chalmers University, June 14, 2021
- Ghazaleh Ghaffari's doctoral thesis defence: Postural and Muscular Responses of Car Occupants under Pre-Crash Condition, August 27, 2021
- Annual Tylösand road safety seminar, several SAFER engaged researchers participated with presentations, August 31, 2021
- Seminar and Workshop: Batteries in automotive crash- what challenges do we face in the near future?, Sep 1, 2021
- SAFER webinar, New SAFER partners - Agreat, Consenz, Knightec and Tier, Sep 2, 2021
- SAFER webinar: Safety for electric vehicles, Sep 9, 2021
- IRCOBI, several SAFER engaged researchers presented, Sep 8-10, 2021
- SAFER participated in Lindholmen Open Day with the webinar "Lives saved through road safety collaboration between India and Sweden", Sep 16, 2021
- Transport Area of Advance annual Initiative Seminar: Where are we going? Trends and research directions in transports, several SAFER engaged researchers presented, Sep 21, 2021

- Celebrations of SAFER's 15 year anniversary, Sep 29, 2021
- Workshop: Looking 15 years ahead - SAFER's collaborative agenda, Sep 29, 2021
- Inspirational seminar: Innovation, co-creation and collaboration - what can we learn from the past to create SAFER's future?, Sep 29, 2021
- SAFER webinar: Drivers Acceptance of Automating Bus Stop Docking & Safety ahead of the curve, Sep 30, 2021
- SAFER webinar: Voi Technology & The Trouble With E-Scooters – learnings from Norway, Oct 7, 2021
- SAFER webinar hosted by Combitech: Safety Critical Systems at Combitech & The importance of Systems Engineering in development of Safety Critical System, Oct 14, 2021
- The 7th International Conference on Driver Distraction and Inattention (DDI2021), online, Oct 18–20, 2021
- SAFER webinar hosted by Lund University: Surrogate measures of safety / Video analysis for traffic applications, Virtual reality in safety research, Autobus - evaluation of autonomous busses in mixed traffic environment in Norway, Oct 21, 2021
- SAFER webinar: focusing results from the SAFER Pre-study program: Cooperative Automated Driving Use Cases for V2X Communication & Multimodal Data to Support Safe Driving Patterns, Oct 28, 2021
- The International Cycling Safety Conference (ICSC), Nov 10-12, 2021
- SAFER webinar focusing on the Open Research at AstaZero and the SAFER Pre-study program, Nov 11, 2021
- SAFER Research area day, Nov 17, 2021
- SAFER Update – information for the SAFER community, Nov 17, 2021
- SAFER webinar hosted by the competence network for Vehicle dynamics: Power loss minimization through wheel torque allocation for electric cars and Assessment tool of safety and congestion of long heavy vehicles, Nov 18, 2021
- The Scandinavian Conference on safety critical systems and software (SCSSS), Nov 23-24, 2021, Gothenburg (SAFER is co-hosting)
- Workshop: Automated driving level 3 and 4 – How to argue safety and what counts as evidence?, Nov 24, 2021
- Safety Cultures in Automotive – workshop, Nov 24, 2021
- Safety for Testing Autonomous Vehicles at Existing Proving Grounds, workshop, Nov 24, 2021
- Seminarium om Ung mobilitet- co-hosted with NTF Väst, Gothenburg, Nov 25, 2021
- SAFER Thursday lunch webinar hosted by the competence network for System Safety: Operational Safety for Autonomous Transport Solutions, Nov 25, 2021
- Adjunct professor inaugural lecture by Nils Lübbe, Autoliv: "Learning from crash data to make road traffic safer", Dec 1, 2021
- SAFER webinar hosted by the partner – Jönköping University presentations from the School of Engineering, School of Health and Welfare and a short introduction to the Jönköping AI Lab, Dec 2, 2021
- SAFER is hosting the Safety and Security working group of POLIS, Dec 3, 2021
- HEADSTART final event, Dec 14, 2021
- SAFER Christmas breakfast, Dec 16, 2021

APPENDIX 8: CONFERENCES

Conferences in which SAFER's research has been presented:

- 14th World Congress on Computational Mechanics, Paris (online), January 2021
- Transportforum, Sweden (online), January 2021
- ION, International Technical Meeting (online), January 2021
- TRB 2021 Human Factors in Road Vehicle Automation Subcommittee meeting (online), January 2021
- EUCAD 2021 Conference Connected and Automated Driving (online), April 2021
- Injury Biomechanics Student Symposium, The Ohio State University (online), May 2021
- IFIP/IEEE International Symposium on Integrated Network Management (online), May 2021
- Virtual Testing, Human Modelling in Pedestrian Protection, Carhs Seminarium, June 2021
- Virtual Advances in Child Injury Prevention Conference (APIC) by CChIPS (online), June, 2021
- International Research Council on the Biomechanics of Injury: IRCOBI Asia, June 2021
- 21st Congress of the International Ergonomics Association: IEA 2021, (online), June 2021
- 19th Mediterranean Communication and Computer Networking Conference: MedComNet (online), June 2021
- Conferences on Human Factors and Simulation, and Digital Human Modeling and Applied Optimization: AHFE (online), July 2021
- 21st Congress of the International Ergonomics Association: IEA 2021, (online), June 2021
- Conferences on Human Factors and Simulation, and Digital Human Modeling and Applied Optimization: AHFE (online), July 2021
- 19th IFAC Symposium on System Identification: SYSID (online), July 2021
- 32nd IEEE Intelligent Vehicles Symposium (online), July 2021
- 27th Symposium of the International Association for Vehicle System Dynamics: IAVSD (St. Petersburg, Russia), August 2021
- The annual traffic safety conference - Tylösand (online), August 2021
- 8th ECCOMAS Thematic Conference on the Mechanical Response of Composites: COMPOSITES (online), September 2021
- International Research Council on the Biomechanics of Injury: IRCOBI (online), September 2021
- Euromicro Conference on Software Engineering and Advanced Applications: SEAA (online), September 2021
- 24th IEEE International Conference on Intelligent Transportation: ITSC (online), September 2021
- 17th European Dependable Computing Conference: EDCC (online), September 2021
- 13th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (online), September 2021
- 33rd IFIP International Conference on Testing Software and Systems: ICTSS (online), September 2021
- 94th IEEE Vehicular Technology Conference (online), September/ October 2021
- The 7th International Conference on Driver Distraction and Inattention - DDI2021 (online), October 2021
- ITS World Congress (Hamburg, Germany), October 2021
- Conference on Human Modeling and Simulation in Automotive Engineering (online), November 2021
- The International Cycling Safety Conference -ICSC (online), November 2021
- 9th Scandinavian Conference on System and Software Safety (Gothenburg, Sweden), November 2021
- IEEE ICAV Workshop on Intelligent Connected and Autonomous Vehicles, November 2021
- EEE 29th International Conference on Network Protocols: ICNP (online), November 2021
- POLIS (Gothenburg, Sweden), December 2021
- International Conference on Protection of children in Cars (online), December 2021

APPENDIX 9: THESES

Doctoral Theses
- Postural and Muscular Responses of Car Occupants under Pre-Crash Conditions, Ghazaleh Ghaffari, Injury Prevention, division of Vehicle Safety/Mechanics and Maritime Sciences, Chalmers University of Technology, August 27, 2021

Licentiate Theses
- Strain rate dependent material model for polymer composites.
  Vivekendra Singh, Industrial and Materials Science, Material and Computational Mechanics, Chalmers University of Technology, January 20, 2021
- Towards a human body model for prediction of vehicle occupant kinematics in omni-directional pre-crash events.
  Emma Larsson, Division of Vehicle Safety at the Department of Mechanics and Maritime Sciences at Chalmers University, March 31, 2021
- Pre-Crash and In-Crash Car Occupant Safety Assessment.
  Alexandros Leledakis, Division of Vehicle Safety at the Department of Mechanics and Maritime Sciences, Chalmers University and Volvo Cars, April 15, 2021
- Making overtaking cyclists safer: Driver intention models in threat assessment and decision-making of advanced driver assistance system.
  Prateek Thalya, Vehicle Safety/Mechanics and Maritime Sciences, Chalmers University, April 23, 2021

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