In 2012 FFI had identified a need for a collaborative platform regarding the quickly emerging issue automated driving. SAFER offered to use the existing SAFER structure and was granted a project in 2013 named Boundary conditions for Automation (ARV). ARV support the target that Sweden should be in a lead position in the area of vehicle automation. Focus is to identify and explore the non-competitive prerequisites for the introduction of Automated Vehicles (AVs) in regular traffic.

### Benefit to the project partners and impact on society:
- **An arena for creative collaboration in non-competitive areas in automated driving**
- **A cross-brand dialogue to find major implementation obstacles - beyond technology**
- **Shared competence in the most critical areas in cooperation with institutes and academia**
- **A common understanding of key areas where Sweden can take a lead position**
- **Found and analysed experiences gained in non-automotive areas- where automation is more established**
- **Keep SAFER partners informed on state-of-the-art and current focus areas for research**
- **Find ways of promoting AVs for increased safety and reduced carbon footprint**

### Think outside the box:

The approach from start, trying to identify the true challenges in the introduction of AVs, has been to “think outside the box”. Initially the project worked with Mines ParisTech using a 3-step method (KCP) for idea generation. Building on the results from this Chalmers (MORE) was involved to refine four ideas generated at the workshops. The project core team developed a comprehensive mind-map covering all areas of interest and this is used continuously to find new areas to explore in workshops and pre-studies. Another approach has been to look at potential opportunities and benefits of AVs from other angles – e.g. the assumption is that we can read or work while “driving” – but what about motion sickness?

### Measurable results:
- Numerous pre-studies, workshops and inspiration days for SAFER partners
- Numerous presentations to FFI and SAFER
- Scientific paper accepted and presented at FISITA 2014 World Automotive Congress
- State-of-the-art report on global activities within the area of vehicle automation
- White paper on the grounds and purposes for the ARV collaboration platform
- On-going pre-study with Luftfartsverket (LFV) for increased safety on airports

### Funding:
- **3.5 MSEK external (cash and inkind)**
- **Partners:** SAFER (the partners that are not FFI partners), AB Volvo, Autoliv, Scania, Swedish Transport Administration, Volvo Cars (CPAC Systems (Volvo)), LFV, Saab AB - non SAFER partners
- **Funders:** FFI
- **Period:** 2013 – ongoing

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**SAFER SUCCESS STORY: Boundary Conditions for Automation (ARV)**

"The ARV project has provided a creative arena for cross-brand collaboration around vehicle automation."

**Christian Grante**

*Volvo Group Technical Specialist Preventive Safety and Automation*

*Volvo Group Trucks Technology (GTT)*
SAFER SUCCESS STORY: Care and Rescue

“The multi-disciplinary approach and the deep and broad competence, which are found in the SAFER focus topic Care & Rescue, have paved way for new and important research, development and innovation within the traffic injury area.”

Per Örtenwall
Associate Professor in surgery
Chief Physician

According to WHO, EU and others postcrash actions play a significant role in order to reduce overall mortality and injury severity for road traffic accidents. Improvements in this area will significantly reduce society costs and human suffering. The focus topic Care & Rescue started as a consequence of a revitalization of the postcrash reference group activities during 2012. In 2014 it was recognized as a new SAFER Focus Topic and today several projects are running under this umbrella.

Benefit to the project partners and impact on society:

- New products and solutions for industry, and new and improved care processes and methods
- Societal cost savings and less human suffering
- New national and international networks and co-operations
- Potential to have impact on future regulations and policies
- New research infrastructures and research fields
- Invitations to seminars/project collaborations

Approach:

Care & Rescue address post-crash challenges for all road-users through research and development within two defined domains: 1) Incident Detection, Prioritizing & Dispatch, 2) On-scene support. Within Incident Detection, Prioritizing & Dispatch, the objectives are quicker and more accurate detection and notification of incidents (e.g. improved eCall functionality), and improved incident assessment and prioritization including injury severity prediction. Within On-scene support, the objectives are to improve care and prioritization of causalities on-scene and in transport. This includes detection of occult traumatic injuries like TBI (Traumatic Brain Injury), improved triage and clinical decision support, and improved extrication methods. Care & Rescue covers cross-disciplinary research and development involving a broad spectrum of stakeholders and disciplines within academia, industry and society. These include SAFER partners as well as new actors representing areas like emergency rescue services, healthcare, ICT and MedTech industry.

Measurable results:

- 2 post-docs
- Masters theses
- Publications
- Conference presentations and abstracts
- Initiation of Competence area Human Monitoring

Funding: 5,4 MSEK SAFER internal (cash and inkind), and 5,4 MSEK external

Partners: AB Volvo/WirelessCar, Autoliv, Chalmers, Cycleurope, Folksam, If, irezQ, Landräddningen, Lindholmen Science Park (TUCAP and Prehospital ICT Arena), Region of VästraGötaland, Sahlgrenska Academy, SOS Alarm AB, SOS International, University of Borås, University of Gothenburg, Volvo Cars

Period: 2012– ongoing

Oct 2015
The aim is to reduce child car passenger injuries and fatalities by research and knowledge sharing that focus real world safety needs. Sweden has a long history in child safety and this program has, and shall continue to, ensure that Sweden remains a hub for child safety research, contributing to setting the global agenda of child safety.

**Benefit to the project partners and impact on society:**
- Perceived as world leading in the field, frequently requested as lecturers
- Significant contribution to national child safety guidelines (e.g. NTF, Trygg Trafikk)
- Child restraint developments for increased usage and safety; including significant influence on ECE regulation
- Creation of new product ideas which Autoliv are working on internally and also together with Volvo Cars
- Initiated and co-organized first international child safety conference in China
- An extensive global network with eminent child safety researchers
- New products will be implemented in cars on the market within a few years and the effect from these will then be visible in statistics on the number of children injured in traffic

**The approach is based on five pillars:**
Perform research based on real world needs, e.g. research on pre-crash child behaviour relevant for protection; Continuously scan and contribute to the global dialogue, including standards, regulation, rating and consumer information; Gather skilled SAFER partners, invite the best child safety researchers in the world and on a win-win basis share experiences and identify future focus areas and actions; Funding principles: SAFER money used for pre-study, international workshops and national child safety seminars; Flexible time plan and content, to adapt to needs in the national/international current topics, e.g. timely presentation at the GRSP significantly influencing the upcoming regulation on boosters (UN ECER129 phase 2).

**Measurable results:**
- Two Ph.D., one Lic.Eng
- Numerous publications and presentations
- Kristy Arbogast - Chalmers Honorary Doctor 2014

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**SAFER SUCCESS STORY: Child safety research**

“Our SAFER front-line research and global reputation helps us act with a stronger voice internationally, protecting children in cars around the whole world.”

Lotta Jakobsson, Senior Technical Leader, Injury Prevention, Volvo Cars
Adjunct Professor, Vehicle Safety, Chalmers

- Product on market: Input to comfort support cover for integrated booster cushion
- Project results have contributed to EuroNCAP introducing rating of the rear seat
- Autoliv experiences a great demand from almost all customers who want products which decrease the injury risk for rear seat passengers
- Influence on global child safety agenda, incl. ISO, UN ECE update

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Funding: 4.8 MSEK SAFER internal (cash and inkind) and 27 MSEK external
Partners: Autoliv, Chalmers, Saab Automobile, Volvo Cars
Funders: FFI
Period: 2006-ongoing

Oct 2015
SAFER SUCCESS STORY: CoAct – building competence in active safety and connected vehicles, preparing for automated driving

“The CoAct project has led to an increased interest from the universities for the Automotive Sector in general and vehicle automation in particular. VCC has employed several former CoAct participants.”

Henrik Lind
Technical Expert
Volvo Car Corporation

In 2010 SAFER entered the GCDC student competition with the aim to form a strong coordinated initiative for competence building. The ambition was to make Sweden a center for active systems research, development and testing. This initiative is named CoAct (Cooperative Active Safety). It is a part of the vision to globally rollout automated and cooperative vehicles for increased safety and reduced carbon footprints. Challenge driven innovation is used as an engine to create cost-effective and innovative solutions in collaboration between industry, institutes and academia.

Benefit to the project partners and impact on society:

- Attracting and educating students and researchers in cooperative driving
- Contribution to and validation of existing ETSI and CEN communication standards for advanced automated vehicle maneuvers
- Increased collaboration between universities (course planning and content) and industry (requirements on technical skills)
- Building valuable international networks in relevant areas of business and technology
- Facilitating roll-out of automated vehicles on an international level

Step-by-step to lead position:

Industrial partners in SAFER identified a competence gap in active safety and cooperative driving. Decision was taken to enter an international student competition, the first Grand Cooperative Driving Challenge (GCDC) taking place in Helmond (NL) in May of 2011. Three Swedish student teams, supervised by senior researchers and industry experts, participated successfully. SAFER with partner Viktoria Swedish ICT as project lead, fostered the acquired knowledge and in 2013 were awarded an FP7-project together with TNO, IDIADA and TU/e to organize the challenge in 2016. SAFER decided to sponsor the participation of the Swedish teams under the CoAct name. Swedish OEMs are contributing with vehicles and expertise. Universities supervise student teams.

Measurable results:

- Successful participation by three Swedish teams in the Grand Cooperative Driving Challenge (GCDC) 2011 with places 2, 3 and 4 out of 9 participating teams
- Currently four Swedish universities (five teams) have signed up for GCDC 2016
- 90% of the individual participants in CoAct 2011 where absorbed by the automotive industry within 3 months after the competition
- Numerous technical papers and positive and visible media attention
- Testing of systems at AstaZero
- CoAct teams collaborating with in-house development projects at OEMs
- Viktoria Swedish ICT is a core team partner of EU-project iGames organizing GCDC 2016

Funding: 3 MSEK SAFER internal (cash and inkind) and 14,2 MSEK external

Partners: AB Volvo, AstaZero, Chalmers, Halmstad University, KTH, Linköping University, Scania, Swedish Transport Administration, Viktoria Swedish ICT, Volvo Cars, and a number of 2:nd tier suppliers for the OEM industry.

Funders: IVSS, FFI
Period: 2013 - 2016
To understand cyclist behavior and how cyclists interact with other road user, in order to guide the development and evaluations of countermeasures to bicycle accidents.

**Benefit to the project partners and impact on society:**

- In 2012, Chalmers pioneered collection and analysis of naturalistic data from instrumented bicycles at SAFER. These data provided novel insights into accident causation, infrastructure design, and road user behaviour and supported the development of a cooperative application to assist cyclists and drivers at intersections.
- Starting 2013, data was also collected from instrumented electrical bicycles. Interaction between cyclists and other road users was found to be the pivot point for cycling safety analysis and one of the major challenges, together with visibility, for new e-bikes.
- The 3rd International Cycling Safety Conference was organized in Gothenburg, November 18-19 2014,
  - Over 160 delegates participated. 65% of them came from 22 different countries outside Sweden.
  - Over 50 oral presentations and papers were presented.
  - Several stakeholders including the city authority, the cycling manufacturers, and the vehicle manufacturers actively participated to the conference success.
- Insurance and exposure data on bicycles from SAFER partners was combined to naturalistic data in 2015. Novel data analysis tools and methodologies were developed to combine these data as pieces of the same puzzle. The results gave new insight about rider behaviour and intoxication in particular.

**Step-by-step to lead position:**

Cycling is increasingly popular in Europe raising new safety concerns. SAFER responded to these safety concerns by porting established methodologies from vehicle and traffic safety research to cycling safety to support and promote this healthy and environmental friendly activity by making it safer. As cycling data is limited, novel analyses methodologies combining different data types from different institutions were employed to partly overcome this limitation leveraging on the SAFER network.

**Funding:**

- 2 MSEK SAFER internal (cash and inkind), and more than 2 MSEK external

**Partners:**

- Chalmers, City of Gothenburg, If

**Funders:**

- VINNOVA, Swedish Transport Administration

**Period:**

- 2012-2015

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**SAFER SUCCESS STORY: Cycling safety**

“The unique collaboration between SAFER’s partners has focused on cycling safety research, a very important area for the holistic view of traffic safety and the possibility to reach zero accidents.”

Irene Isaksson-Hellman, If P&C Insurance
SAFER SUCCESS STORY: Fibre reinforced polymer composites in automotive applications

“We need to develop accurate and efficient CAE tools for structural polymer composites, to help meet future emission requirements by reducing weight.”

Kaj Fredin, Manager Strategy, Concepts and Advanced Engineering, Volvo Car Corporation

Transportation road vehicles need to significantly reduce emissions of greenhouse gases, whereby weight reduction is a key. As a consequence, increased usage of fibre reinforced polymer composites, which have high stiffness, strength and energy absorption capabilities per kilogram material, is of highest priority. A crucial enabler for the introduction of these materials is however an increased capability to, by numerical simulation, predict the material response in a crash.

Benefit to the project partners and impact on society:

- A strong national consortium with 10 partners from industry, institutes and academia (out of which 7 are SAFER partners) collaborating on crash modelling of composites.
- Partner involvement in all five European SEAM cluster projects related to vehicle safety, lightweighting and composite materials.
- Formation of Chalmers Composite Cluster, a joint initiative between Chalmers and Swerea SICOMP involving industry partners such as Volvo Car Corporation and GKN Aerospace.
- Strong link between SAFER and LIGHTer (the national Strategic Innovation Area on lightweight).
- An increase from zero to seven PhD student projects in the period 2009-2015. Resulting in Europe’s largest training effort of doctoral students for the modelling of energy absorption in composite crash structures.
- New materials for increased safety, e.g. a composite that can reduce its stiffness by 90% in a few microseconds and thereby provide increased pedestrian protection.

The approach:

A significant journey starting with the SAFER pre-study “CAE Tools for composite body concept assessment” conducted in 2010 has been achieved. A direct outcome of the focused work on developing the area is the Chalmers Composite Cluster, a strong formation jointly driven by Chalmers and Swerea SICOMP with active contribution from industry. The current research portfolio comprises five national PhD projects on modelling and characterization of composite materials for automotive applications, the majority focusing crashworthiness. On top of this, SAFER researchers are active in four European Projects related to vehicle safety and composite materials. The ultimate goal of these efforts in a ten years perspective is to establish confidence in crash predictions of composite vehicles to a level comparable with current state of the art for conventional metallic structures.

Measurable results:

- 1 Ph.D., 1 post-doc
- 1 new full Professor in Lightweight Materials and Structures
- 1 open seminar series on composites in the automotive industry (3 seminars during 2010)
- Numerous publications and presentations

Funding: 4.3 MSEK SAFER internal (cash and inkind), and more than 33 MSEK external
Partners: AB Volvo, Autoliv, Chalmers, Swerea SICOMP, Volvo Cars, ÅF. (Semcon, DYNAMore Nordic, Escenda, Altair Engineering – non SAFER partners)
Funders: FFI, EU, Energimyndigheten, Chalmers (SOT)
Period: 2009-2016

SAFER
Vehicle and Traffic Safety Centre at Chalmers

Oct 2015
Develop a platform for field data collection and analysis to further improve the understanding of real-world accident problems.

**Benefit to the project partners and impact on society:**
- The national infrastructure for accident data collection (INTACT) was developed by SAFER partners and was later adopted by the EU to be used for in-depth accident investigations on European level.
- INTACT contributed to Sweden becoming the hub for the Initiative for the Global Harmonisation of Accident Data (IGLAD).
- A new test-based assessment method for crash avoidance systems effectiveness measured by its ability to reduce the number of injuries in rear-end collisions.
- Provided input on motor-vehicle crash risk of EU and US vehicles to the negotiations concerning the Transatlantic Trade and Investment Partnership (TTIP).
- Analysis concerning High Capacity Transports used in negotiations for longer truck combinations in the EU.

**Approach:**
The field data platform was initiated by the collaboration in INTACT and was extended to include advanced analyses. SAFER’s commitment widely contributed to this success by supporting the development of a field data analysis platform to recruit a senior research analyst. This led to deeper collaboration in field data analyses among the SAFER partners as well as other organisations world-wide.

**Measurable results:**
- Up-to-date accident data.
- Hub for the IGLAD consortium.
- Several peer-reviewed papers.
- Research driven policy making.
- European acknowledged methods.
- Collaborative research with University of Michigan Transportation Research Institute (UMTRI)

**Funding:** 5 MSEK SAFER internal (cash and inkind) and 53.6 MSEK external

**Partners:** AB Volvo, Autoliv, Chalmers, City Of Gothenburg, Folksam, If, Saab Automobile, Scania, Swedish Transport Administration, TØI, University of Gothenburg, Volvo Cars, VTI

**Funders:** VINNOVA, VR, EU, and others.

**Period:** 2007 - ongoing
The aim is to build competence on human body models (HBMs) among the SAFER partners. HBMs are important tools for advanced safety system developments. The challenge is to provide omnidirectional HBMs that can predict injury and have a biofidelic response in scenarios ranging from emergency events to crashes in all different impact directions, representing a broad range of the human population.

Benefit to the project partners and impact on society:

• Enhanced tools for development and assessment of safety systems; the SAFER A-HBM (active adult occupant), an active child occupant model and a pedestrian HBM with detailed head and neck involving muscle activation possibility.
• Enhanced tools for development and assessment of safety systems; i.e. the SAFER A-HBM and an active child model.
• New insights to injury mechanisms and protective principles by combining fundamental biomechanical research and applied research, such as reconstructions of real world crashes with omnidirectional loading.
• Harmonized HBMs and shared model improvements. Several SAFER workshops to identify needs and prioritize future research actions.
• A strong international network that contribute to research.
• Yearly invitations to international human body modelling conferences and workshops.

Communication is the core strategy:

Following some initial projects on HBM evaluations, SAFER project funding was used to recruit one senior researcher and two doctoral students at Chalmers in 2009. The strategy is to have close communication between the key people at all SAFER partners actively working with HBMs and jointly connect to international research groups. Research questions are defined based on needs of all partners and focus strategic areas that complement other international efforts, such as modelling of muscle activity for pre-crash and applied injury prediction capabilities. Close international collaborations ensure access to validation data to assess HBM biofidelity and updated knowledge transfer to the SAFER partners.

Measurable results:

• One Docent, three Ph.D., more than five Lic.Eng.
• Numerous publications and presentations.
• 1st price in the recognized international STAPP car crash conference student paper award.
• HBM enhancements for adult pedestrian and occupant, as well as child occupant.
• A world-first open-source female HBM is being developed.

Funding: 11 MSEK SAFER internal (cash and inkind) and almost 60 MSEK external

Partners: AB Volvo, Autoliv, Chalmers, Royal Institute of Technology (KTH), Sahlgrenska University Hospital (VGR), Umeå University, Volvo Cars, VTI, ÅF

Funders: FFI, VR, EU, Folksams forskningsfond

Period: 2006 - ongoing

Oct 2015
SAFER SUCCESS STORY: Naturalistic data platform

"SAFERs platform for naturalistic driving data is used in our global projects in Sweden, US and China. The platform plays an important role when analysing and understanding driver behaviour, and is used in the development of our active safety systems."

John-Fredrik Grönvall, Senior Research Manager, Field data
Volvo Car Corporation

The objective was to develop a secure, world-class, platform for handling naturalistic data from data collection over data storage and processing to analysis to gain control of the quality of data and results, and to maintain the world-class level over the years.

SAFER was technically challenged by being the first in Europe to develop such a platform, and administratively challenged on how to finance the platform over the years.

Benefit to the project partners and impact on society:

• Common world class infrastructure for naturalistic data (ND) collection, secure data storage and analysis
• SAFER chosen as Central Data Centre in the largest ND study in Europe
• Cross-Atlantic Connected Analysis Centres with remote access developed and tested at SAFER and UMTRI
• The platform almost self-financed through projects since the start
• Data Protection Concept developed for all stages in data handling
• Tools for collection of naturalistic data from vulnerable road users (pedestrians and bicyclists)

The challenge was approached using eight key strategies:

Develop our own infrastructure from data collection over data storage to data analysis to learn the process, gain control of the quality and understand the challenges; Collaborate with UMTRI, to learn from their expertise in naturalistic data handling; Develop a strategy for the financing of the platform over time; Investigate data protection issues due to personal privacy and Immaterial Property Rights together with the four Swedish OEMs; Capitalise on the knowledge among the SAFER partners for the development of the ND platform; Implement support for a variety of ND data types (continuous and event based, and cooperative systems data); Develop a remote access method, where researchers can access data globally, using remote desktop.

Measurable results:

• SAFER has developed a set of common data management principles, hardware and tools, supporting the complete chain from collecting data in vehicles, to analysis of data.
• SAFER has established good relations with many data providers, and access to several important ND databases globally.

(See also SAFER Success Story
Naturalistic Driving Data)

Funding: 11 MSEK SAFER internal (cash and inkind) and over 113 MSEK external
Partners: AB Volvo, Autoliv, Chalmers, City of Gothenburg, If, Lindholmens Science Park, Saab Automobile, Scania, SP, Swedish Transport Administration, TÖI, University of Gothenburg, Viktoria Swedish ICT, Volvo Cars, VTI, AF
Funders: Chalmers (SOT), EU, National Academy of Sciences, Swedish Transport Administration, VINNOVA, VR
Period: 2007 - ongoing
The challenge is to better understand the interaction between the driver/rider, the vehicle and the environment including other road users and thereby understand incidents and accidents causation as well as how different vehicle systems enhance safety. The objective is to reduce the number of fatalities and seriously injured in road traffic.

Benefit to the project partners and impact on society:

- Network including the most prominent researchers in the area from the US, Europe, Australia, Japan and China
- Mobile phone use policy in Sweden influenced through SAFER researchers
- Naturalistic driving data integrated and used in the courses at Chalmers
- Data processing and analysis methods developed for naturalistic data, resulting in scientific papers and reports
- Data Protection Concept developed, ranging from data collection, storage, analysis and re-use of data
- Founder of the Driver Distraction and Inattention conference, held three times at SAFER attracting the best researchers
- 3rd International Cycling Safety Conference (ICSC 2014) held at SAFER (record high attendance)
- Information exchange on naturalistic data topics with SHRP2 based on an agreement (MoU) between TRB, VINNOVA and Swedish Transport Administration

The challenge was approached using seven key strategies:

Provide initial SAFER funding for early start-up: networking, travel, lead in proposal writing; Learn from the best, starting with UMTRI and continuing with expertise in key areas such as statistics and human behaviour; Build a complete data handling infrastructure consisting of data collection equipment, database structures and analysis tools, to gain control of the quality and understand the challenges; Use all competences within SAFER and be open-minded as the area is new, complex, and a large variety of competences are needed; Develop a world class worldwide network to get access to vital competences and form strong consortiums; Form a vision of the area in 2016 to create energy to achieve world class; Produce quality results to attract renewed funding.

Measurable results:

- One of three consortiums awarded US analysis projects on the world’s largest ND dataset SHRP2
- Numerous scientific papers and reports based on methods for and results from analysis using naturalistic data
- Founder of the Driver Distraction and Inattention conference, held three times at SAFER attracting the best researchers

(See also SAFER Success Story Naturalistic Data Platform)
Neck injuries (often called whiplash injuries) can occur in all collision types, and is one of the most challenging injury types in safety research and developments, mainly due to difficulties to diagnose. They account for 64% of all disabling car occupant injuries in Swedish. The aim is to identify injury mechanisms and develop assessment methods and guidelines that allow industry to develop effective protection.

SAFER SUCCESS STORY: Neck injury prevention

“The BioRID dummy with its human-like response to low speed rear collisions has been key to our safety ratings and has promoted vehicle seats with demonstrably fewer real world injuries.”

Adrian K. Lund, President, Insurance Institute for Highway Safety

- As the BioRID II dummy creators, taking the lead in setting the future directions in the area, exemplified by the development of the world-first mid-size female dummy model
- State-of-the-art real world data analyses providing important input to regulation, standard development and car design
- Research results confirm the in house developed neck injury criterion NIC providing best correlation to neck injury risk
- Ongoing work on a new female human body model for neck injury assessment in rear impact to be delivered open source

Neck injuries (often called whiplash injuries) can occur in all collision types, and is one of the most challenging injury types in safety research and developments, mainly due to difficulties to diagnose. They account for 64% of all disabling car occupant injuries in Swedish. The aim is to identify injury mechanisms and develop assessment methods and guidelines that allow industry to develop effective protection.

Benefit to the project partners and impact on society:

- SAFER research has significantly contributed to occupant dummies and models, starting with the mid-size male dummy, BioRID, in 1998 followed by mathematical models of BioRID and a mid-size female counterpart, EvaRID, in 2011.
- Development and validation of the most recognized neck injury criterion for rear-end impacts, the NIC.
- Key contributor in the development of international rear-end impact assessment methods, exemplified by EuroNCAP.
- Joint research activities resulted in world-first protection systems by Volvo and Saab in 1997, SAFER research has shown these systems to be state-of-the art still.
- Hypothesized and partly corroborated a completely new injury mechanism and injury site (pressure induced cervical dorsal root ganglion injuries), providing important input both to the engineering and medical society.
- Currently developing a new average female size Human Body Model (HBM) with a detailed neck. First focus being neck injury assessment in rear impacts.

Approach:

This effort involved several SAFER partners, starting in the 1980ies, and is still ongoing. During the SAFER period in total eight projects are performed involving varying partner constellations. The projects include accident data analyses, accident reconstructions, experimental biomechanics, dummy development, seat testing and computer modeling. Results are shared internationally, enabling independent evaluations and wide implementation tools and criteria. This approach was proven successful making the BioRID and NIC world standard and used globally for car developments. The same approach is used for the continued work, mainly focusing protection for females and development of human body models, as well as the experimental work on injury mechanisms.

Measurable results:

- In total about 10 PhD examinations, whereof two during 2006-2015
- One Post-Doc period
- Numerous journal and conference papers

Funding: Approx. 2.5 MSEK SAFER internal (cash and inkind), and 18 MSEK external

Partners: Autoliv, Chalmers, University of Gothenburg, Epsilon (ÅF), Folksam, Saab Automobile, Swedish Transport Administration, Volvo Cars, VTI

Funders: VINNOVA, FFI, EU

Period: 2006-ongoing, joint research history back to 1985
Virtual testing methods are increasingly important for automotive product development. The QUADRA project developed mathematical models of drivers’ behaviour in critical traffic situations, to allow computer simulation of driver interaction with active safety systems in the final seconds leading up to a crash (or its avoidance). The challenge, at the time when the project was decided, was that driver behaviour modelling was a new and highly unproven topic. SAFER decided to push this emerging area by supporting an academic PhD student in collaboration with an industrial PhD student funded by FFI.

Benefit to the project partners and impact on society:
- Mathematical models of driver behaviour in selected crash scenarios – “virtual crash test dummies with a brain”
- Computer simulations allowing system evaluation at an unprecedented level of detail (e.g. effects for individual drivers, or for specific real-world crashes)
- Several concrete ideas for system improvements, including one patent application
- Models and evaluation methodology are influencing product development processes and tool chains at both Volvo Cars and AB Volvo
- Several novel ideas and findings that connect driver modelling with state of the art neuroscience, potentially game changing for future driver modelling research
- Models and evaluation methodology are influencing product development processes and tool chains at both Volvo Cars and AB Volvo
- Strengthened international collaboration through a Scientific Advisory Board with leading researchers from Europe and the US
- Several novel ideas and findings that connect driver modelling with state of the art neuroscience, potentially game changing for future driver modelling research
- Extensive media coverage for one of the findings (taken up by more than 100 news outlets worldwide)

Approach:
One key decision, agreed upon in a pre-study for the project, was to constrain the driver modelling very tightly to a few well-defined applied scenarios. In this way, it was possible to look very deeply into each separate scenario, and reach across the full cross-disciplinary chasm from vehicle dynamics and safety systems, via psychology all the way to neuroscience. Thus, the modelling could keep a high scientific level, while at the same time remaining in touch with the intended application. Furthermore, since driver modelling was a relatively new area for all of the project partners, interactions with leading international experts were established in the form of a Scientific Advisory Board.

Measurable results:
- Two PhDs graduated
- Numerous publications and presentations
- One patent application

Funding: 2.3 MSEK SAFER internal (cash and inkind), more than 21. MSEK external
Partners: AB Volvo, Chalmers, Volvo Cars, VTI
Funding: FFI
Period: 2010-2014
Human Body Models (HBMs) are state-of-the-art tools for injury biomechanics research and occupant protection system development. HBMs are mathematical models of human bodies. Developments of active safety technologies (e.g., braking, steering) call for human models functioning both in a pre-crash and the crash phase, why the effect of occupant postural and reflexive responses must be accounted for in HBMs by the addition of neuromuscular control schemes.

**Benefit to the project partners and impact on society:**

- A unique FE-HBM with active muscle control has been developed and validated by SAFER partners, called the SAFER A-HBM.
- Up to date, the SAFER A-HBM has been used to study the effect of reversible seat belt pre-tension on occupant pre-crash posture during braking events.
- Recently, the pre-crash functionality of the SAFER A-HBM has been connected to the crash functionality of the model, enabling study of a whole sequence of pre-crash braking with a following frontal crash. This is a first of its kind FE-model.
- Industrial implementations in product development processes are ongoing.
- Through a number of research projects, collaborations with internationally renowned researchers within the field of neuromuscular control have been established.
- Long term research project plan established (for a total period of over 10 years), aiming at advances addressing complex events in multiple directions involving control of muscle activation.

**Approach:**

Based on SAFER partner needs, an existing HBM was further enhanced by the addition of a model package containing muscles and a neuromuscular control scheme. The model is validated using data derived from large volunteer studies performed to study car occupant muscle responses to autonomous and driver braking interventions. In close collaboration with the industry partners, academic research staff carried out complex volunteer tests with state-of-the-art measurement methods in real vehicles driving in almost naturalistic conditions.

**Measurable results:**

- 1 Ph.D., 2 Lic. Eng.
- 6 journal articles in high level journals
- Several conference presentations
- 1st price in the recognized international STAPP car crash conference student paper award

**Funding:**

- 3.6 MSEK SAFER internal (cash and inkind), approx. 22.6 MSEK external
- **Partners:** AB Volvo, Autoliv, Chalmers, Saab Automobile, Umeå University, Volvo Cars
- **Funders:** FFI
- **Period:** 2009 – ongoing

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**SAFER SUCCESS STORY: SAFER A-HBM (Active - Human Body Model)**

"With this unique SAFER-developed tool, advanced integrated (passive and active) safety systems for occupant protection are developed to save even more lives and reduce even more injuries."

*Bengt Pipkorn*

Director, Simulation and Active Structures, Autoliv

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**Oct 2015**
The aim is to enhance both safety and energy efficiency in the transport system through a holistic approach. New, energy-efficient vehicles can be made safe and affordable if all desired properties are considered from the very beginning and the context in which they exist is integrated in the analysis. SEVS, Safe Efficient Vehicle Solutions, is an explorative project addressing complex societal and technological challenges related to the future transport of people and goods and at the same time shaping efficient tools and methods for dealing with such complexity and uncertainty involving experts from many different organizations.

Benefit to the project partners and impact on society:

• SEVS has developed a generic method for how to work efficiently in cross-disciplinary explorative projects and perform analysis of complex societal development.
• The project provides a “smorgasbord” of results and insights of possible future societies and the different driving forces that influence the shaping of the future transport system. These methods and insights prevent errors commonly made when analyzing the future.
• SEVS has built a community of researchers, vehicle engineers, planning experts in society and industry and others that now share a common understanding of a scenario-based approach.

Approach:

The approach is to organize stakeholders in a workshop based process. Between workshops in-depth studies are conducted. One core activity is to agree on the most uncertain influencing factors and define scenarios based on this. The consequences for different use cases in the transport system are then explored. Since complexity by definition cannot be divided into smaller separate pieces, SEVS developed methods and tools enabling a holistic analysis. The participating experts should have a high degree of diversity and span over fields like social sciences, vehicle technologies, city traffic administration, and resource analysis. SAFER as an Open Innovation Platform facilitated and strengthened the trust among people.

Measurable results:

• Four complementary scenarios of the future society has been developed
• Seven vehicle concepts (desktop studies) to illustrate effects on vehicles based on scenarios
• Creation of a driving force model which describes driving forces, their relations and how they shape the future transport system
• A generic method to analyze which transport solution the user will select, based on the scenarios and selected use cases
• About 100 seminars and workshops with multi-disciplinary teams and about ten dissemination seminars
• Deeper understanding of mega cities challenges, using Shanghai as the study case
• Several reports e.g. “Electro Mobility in Norway - Experiences and Opportunities with electric vehicles”, The SEVS Way and about 20 sub-reports (not public), the SEVS Brochure and the Exhibition
• Input to more than six new projects; e.g., Balancing active and passive safety, Urban Personal Vehicle, and applications e.g. Multi-purpose Urban Mobility Solution (UDI)
The aim was to benefit from SAFERs multi-disciplinary scope and combine research in HMI with research in dependable systems to increase system safety in vehicles and define the connections between behavioural science and dependable systems. The scope was later enlarged to encompass knowledge of the relation between drivers and vehicle automation.

**Benefit to the project partners and impact on society:**
- A novel method to assess the safety of transitions from automated to manual driving when vehicle automation fail
- Development of driving simulator methodology (design of experiment and measures such as ‘point-of-no-return’)
- Strategies to improve driver controllability in situations where technical failures occur
- Implications for design of driver HMI
- Further knowledge on the consequences of introducing driver assistance systems and automation in cars
- Enhanced knowledge of drivers’ experiences of using assistance systems in everyday life
- Successful multi-disciplinary collaboration
- Strengthening of national competitiveness through collaboration; (industry/academia/institutes) and coordination of driving simulator equipment and methodology

**Approach:**
Recruit Ph.D. students with a human factors and an engineering background respectively; Make use of the broad competence base in institutes and academy; Carry out the project with a co-research approach (simultaneous and integrated rather than parallel activities); Apply a mixed methods approach to research activities; Secure involvement and input from industrial partners.

**Measurable results:**
- Two Ph.D.;
- Two master theses;
- A number of journal and conference papers;
- One invited book chapter;
- Several prominent presentations for national and international audiences, including academia as well as OEMs;
- VTI simulator software implemented in Chalmers’ simulator.

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**SAFER SUCCESS STORY: System Safety through the Combination of HMI and Dependable Systems I and II**

“The opportunity to recruit a PhD with unique knowledge in automated driving is a result of the SHADES project that provides Volvo Cars with key competence for the development of self-driving cars.”

Mikael Kjellgren, Manager, Active Safety Sensor & Systems A&V Volvo Car Corporation

**Unique knowledge on drivers’ ability to handle technical system failures**

The opportunity to recruit a PhD with unique knowledge in automated driving is a result of the SHADES project that provides Volvo Cars with key competence for the development of self-driving cars.”

Mikael Kjellgren, Manager, Active Safety Sensor & Systems A&V Volvo Car Corporation

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**Funding:** 13.2 MSEK SAFER internal (cash and inkind)

**Partners:** AB Volvo, Chalmers, Saab Automobile, SP, Volvo Cars, VTI

**Funders:** SAFER

**Period:** 2008-2011; 2011-2014

Oct 2015
SAFER started to form Competence Areas as a way to create communities gathering experts within the partner organizations. Vehicle Dynamics started in 2008 with core partners from Chalmers, KTH, Scania, Volvo, Volvo Cars and Saab Automobile. In 2009, Saab Automobile contributed a first test vehicle (as in-kind to SAFER) to Vehicle Dynamics Competence Area. That vehicle has been used in many research projects and courses. It has been the embryo for fostering a flourishing experimental vehicle research. The build-up of workshop facilities enabled to expand with a Volvo S60 and, through another SAFER project, a truck converter dolly. This encouraged SAFER to spend resources on a pre-study for a full-scale vehicle laboratory that should enable independent research and education experimentation for active safety systems and automated driving. In November 2015 the result is a laboratory at Lindholmen, ReVeRe, with two new test vehicles - a Volvo XC90 and a Volvo FH tractor 6x2. In the overall context with the unique test track AstaZero close to SAFER, this lifts the automotive research significantly.

Benefit to the project partners and impact on society:

- SAFER’s researchers have the capacity to perform experimental complete vehicle tests, primarily on AstaZero test track but also in real traffic. This leads to innovative cutting edge research.
- Complete vehicle experiments
  - help to find the right problems, bringing in real life aspects of imperfect tyre/road, sensors/actuators, traffic, driver, weather and other road users, and bringing in integration aspects in a vehicle.
  - are valuable for development and validation of computer simulations and results from driving simulators.
  - bring researchers together to cooperate with a common test object.
  - enhance the learning experience for students.

Approach:

The strategy for vehicle and laboratory expansion has been to be responsive to the needs in projects and education. The Competence Area strategy is to be as collaborative as possible and to create a welcoming community. The regular meetings are thus moved between the partners’ different geographical sites. A common road map for competence development is openly shared. Open seminars in collaboration with other stakeholders have been held on a yearly basis.

Measurable results:

- The first Saab 93 is still alive and used in research and education.
- The ReVeRe full-scale vehicle laboratory is inaugurated.
- The infrastructure contains Volvo S60, Volvo, XC90, a converter dolly for semi-trailers, a Volvo FH tractor and a driving simulator.

Funding: 14.5 MSEK SAFER internal (cash and inkind) and 64.6 MSEK external

Partners: AB Volvo, Autoliv, Chalmers, CPAC Systems, Kapsch TrafficCom, KTH, Mälardalen University, NEVS, Parator, Region Västra Götaland, Parator, Saab Automobile, SP, Swedish Hybrid Center, Swedish ICT, Swedish Transport Administration, Volvo Cars, VTI, ÅF

Funders: SAFER, VGR, FFI, VINNOVA

Period: 2008-ongoing

Oct 2015
The aim is to build world-class academic competence in key areas of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications. The SAFER project Physical Layer Techniques for Vehicle-to-Vehicle Communications served as a critical springboard in this, and has allowed prof. Erik Ström and his co-workers to establish Chalmers as a leader in vehicular communication research. The purpose is to gain fundamental knowledge of vehicular radio channels and to devise novel design and analysis methods for the physical layer of a V2V communication system. This knowledge is vital for enabling real-time, reliable, scalable, low-delay V2V communications, which needed for challenging traffic safety applications. The knowledge is used to increase the competitiveness of the SAFER partners and the academic status of Chalmers.

Benefit to the project partners and impact on society:

- Established Chalmers as an internationally attractive partner for research on vehicular communications as evidenced by, e.g., invitations to join EU projects such as METIS (FP7) and HIGHTS (H2020) and prof. Erik Ström’s appointment as Co-Chair of the Topical Working Group on Vehicular Environment in the EU COST action IC1004 Cooperative Radio Communications for Green Smart Environments.

- Established Chalmers as an academic leader in the field of vehicular communications, indicated by, e.g., prof. Erik Ström’s appointment as guest editor for the prestigious journal Proceedings of the IEEE special issue on Vehicular Communication, external examiner of Ph.D. theses in Germany, Austria, France, and South Africa, and invited speaker at national and international scientific conferences.

The approach:

Generic research problems were identified through interaction with the SAFER partners and the international academic community. Problems suitable for a PhD student were defined and Wanlu Sun was recruited after a very competitive selection process. Her work has proven to be of excellent quality and has led to many highly regarded publications. International recognition of Chalmers as a leader in vehicular communication was established by engaging in the academic community by, e.g., co-chairing a COST Action (European Cooperation in Science and Technology) working group and taking initiatives for special sessions at conferences and special journal issues. Industrial relevance was ensured by interaction with SAFER partners. More funding was acquired and the number of Ph.D. students and senior researchers engaged in vehicular communications has increased. This positive spiral was kick-started by the SAFER project Physical Layer Techniques for Vehicle-to-Vehicle Communications.

Results as a direct consequence of the SAFER project:

- 1 Lic. Eng.
- 5 conference and 1 journal papers in prestigious journals
- Service to academic community
- Numerous invited talks at national and international events

“Chalmers, with their deep knowledge of communication technologies and worldwide research network, contributes with excellence towards Volvo Cars’ research and development of connected safety systems.”

Mikael Nilsson, Technical Expert
Volvo Car Corporation

SAFER SUCCESS STORY: Vehicular communication research

Visibility and impact on the international academic community
Academic excellence through publications and invited talks
Establishing critical mass of researchers in vehicular communication