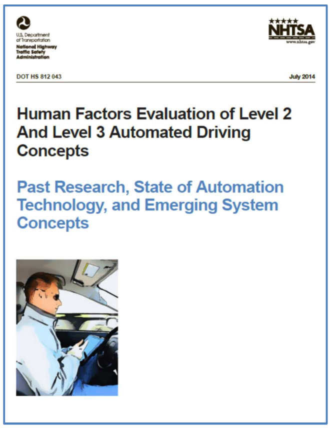
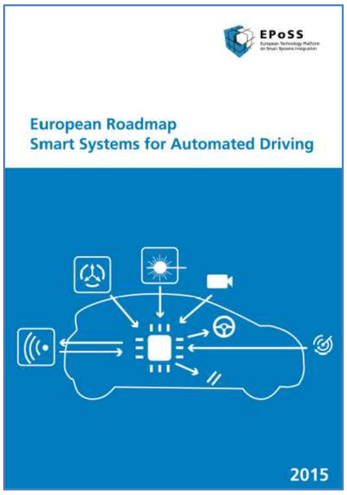
Key publications on automated driving

Automated Driving Roadmap (ERTRAC) : This document provides an overview on the current status for Automated Driving technologies with regard to implementation in Europe. The ERTRAC roadmap is based on available documents for automated driving. The overall objective is to identify challenges for implementation of higher levels of automated driving functions. A lot of work has been done on this topic by various stakeholders and multi-stakeholders platforms (e.g. iMobility Forum, EUCAR, CLEPA, ERTICO, EPoSS) and in European research projects. Therefore, it is essential to avoid any duplication of activities and concentrate on the missing items, concerns and topics for future implementation.

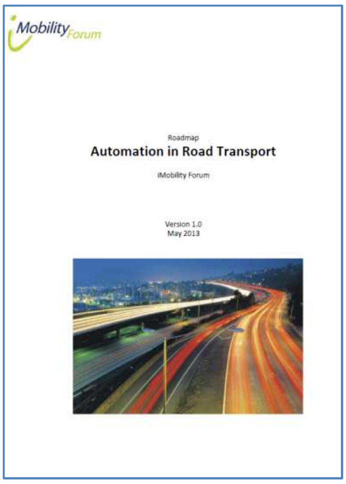
Verslag Kennisagenda Automatisch Rijden (RWS): Door RWS is een werkbijeenkomst georganiseerd om te bespreken wat we in Nederland inmiddels al weten en wat we nog willen weten om automatisch rijden mogelijk te maken op de openbare weg en wat op de korte termijn voor de testperiode nodig is (en wat we in die periode moeten/willen leren). Op 14 april 2015 waren daartoe 125 deelnemers van overheden, bedrijfsleven en kennisinstellingen bij elkaar in een werkbijeenkomst bij Connekt in Delft. De uitkomst van deze bijeenkomst is opgenomen in deze notitie die een aanzet is voor de kennisagenda voor automatisch rijden in Nederland.



Human Factors Evaluation of lv2&3 automated driving concepts (NTSHA): Within the context of automation Levels 2 and 3, this report documents the proceedings from a literature review of key human factors studies that was performed related to automated vehicle operations. This document expands and updates the results from a prior literature review that was performed for the US DOT. Studies both directly addressing automated driving, and those relevant to automated driving concepts have been included. Additionally, documents beyond the academic literature, such as articles, summaries, and presentations from original equipment manufacturers and suppliers, have been researched. Information from both United States and international projects and researchers is included. This document also identifies automated-driving relevant databases in support of future research efforts.



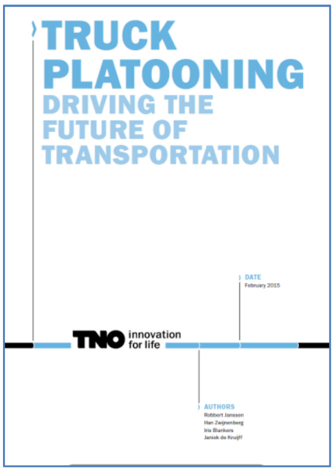
European Roadmap Smart Systems for Automated Driving (EPoSS): This roadmap is based on surveys and consultations among major European automotive manufactur-ers and suppliers. Starting from an analysis of goals and challenges towards the introduction of auto-mated driving (AD) and a description of the state-of-the-art technologies, technology roadmaps that provide information about content and timescales of actions in Research and Innovation (R&I) on technology and in framework conditions, are presented. These roadmaps are organized along mile-stones for implementation of highly automated driving. The text contains names of projects, initiatives and mentions trademarks or manufacturer's names. This document shall allow private and public stakeholders, particularly the European Commission and Member States authorities to determine what actions have to be taken when and for what reason. Besides, this document is meant as a contribution of the smart systems community to a broader strategy development process involving e.g. EUCAR, CLEPA, iMobility Forum and EPoSS, under the um-brella of ERTRAC, and the JTI ECSEL as well as the EGVI PPP.



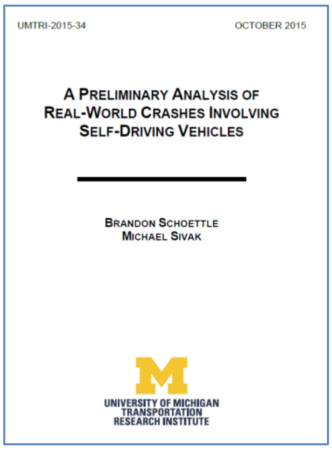
Automation in Road Transport (iMobility): The Working Group was created under the iMobility Forum after the successful workshop organized by the European Commission, DG INFSO in October 2011. This workshop commenced the three SMART studies, executed in 2011 for the European Commission, DG INFSO specifically focusing on automation, the future of internet and the connected car and during the workshop a clear need was identified to further discuss and guide the research, development and deployment of automation for road traffic and road transport systems.

Chauffeur aan het stuur? (KiM): Zelfrijdende auto's kunnen onze maatschappij ingrijpend veranderen. Of dat gebeurt hangt af van hoeveel de auto daadwerkelijk zelf kan maar ook van wat de consument wil. Worden auto's een tweede luxe huiskamer of blijft een bestuurder noodzakelijk? Ook de deeleconomie is van invloed. Als veel mensen zelfrijdende voertuigen en ritten gaan delen verandert dit het verkeer- en vervoersysteem radicaal.

Dit zijn een aantal conclusies uit het rapport 'Chauffeurs aan het stuur?- Zelfrijdende voertuigen en het verkeer en vervoersysteem van de toekomst' van het Kennisinstituut voor Mobiliteitsbeleid (KiM). In dit rapport worden vier scenario's voor een toekomstig verkeer- en vervoersysteem met zelfrijdende auto's beschreven. Deze beelden verschillen van elkaar op het vlak van techniek en acceptatie (oftewel hoe 'automatisch' wordt de zelfrijdende auto?) en in de mate waarin consumenten willen delen (van autobezit en van ritten).

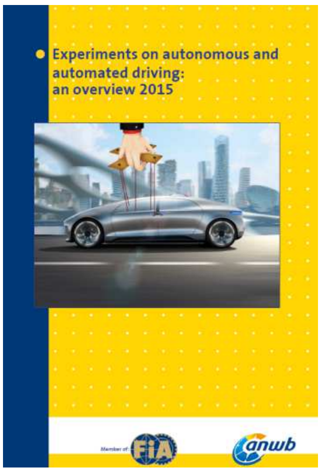


Truck platooning (TNO): Developments in the underlying Cooperative Adaptive Cruise Control (CACC) technology have been ongoing for years, yet widescale deployment of truck platooning is a system-wide innovation challenge that requires a concerted approach of all stakeholders in society. Right now the political and economic climate is positive for a broad deployment of platooning as initial legislation amendments are proposed to allow testing and experimentation on Dutch roads. For this system-wide innovation, we suggest to establish an Shared Innovation Programme, based on open innovation principles. In the programme, we can jointly work towards commercial deployment of platooning to implement a safe, reliable and efficient two-truck platooning concept by 2020.



Real-world crashes involving self-driving vehicles (UMTRI): This study performed a preliminary analysis of the cumulative on-road safety record of self-driving vehicles for three of the ten companies that are currently approved for such vehicle testing in California (Google, Delphi, and Audi). The analysis compared the safety record of these vehicles with the safety record of all conventional vehicles in the U.S. for 2013 (adjusted for underreporting of crashes that do not involve a fatality). Two important caveats should be considered when interpreting the findings. First, the distance accumulated by self-driving vehicles is still relatively low (about 1.2 million miles, compared with about 3 trillion annual miles in the U.S. by conventional vehicles). Second, self-driving vehicles were thus far driven only in limited (and generally less demanding) conditions (e.g., avoiding snowy areas). Therefore, their exposure has not yet been representative of the exposure for conventional vehicles.

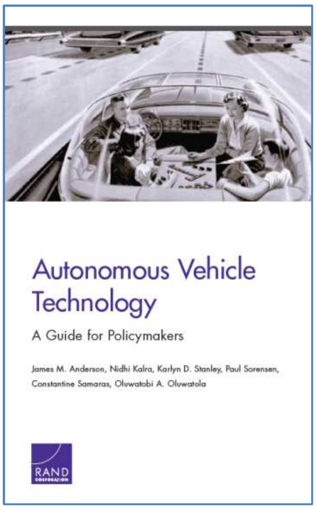
With these caveats in mind, there were four main findings. First, the current best estimate is that self-driving vehicles have a higher crash rate per million miles travelled than conventional vehicles, and similar patterns were evident for injuries per million miles travelled and for injuries per crash. Second, the corresponding 95% confidence intervals overlap. Therefore, we currently cannot rule out, with a reasonable level of confidence, the possibility that the actual rates for self-driving vehicles are lower than for conventional vehicles. Third, self-driving vehicles were not at fault in any crashes they were involved in. Fourth, the overall severity of crash-relat ed injuries involving self-driving vehicles has been lower than for conventional vehicles.



Experiments on autonomous and automated driving (ANWB): Autonomous and automated driving will be happening in the near future. Today, manufacturers like Audi, Mercedes and Volvo are developing and testing new vehicles for future use. And new players like Google and Apple have also arrived on the scene. Governments need to be involved in these developments because testing on the road means changing existing legislation. This was the reason for ANWB to collect information about all such activities and to create an overview of what activities are happening all around the world. What tests have already been conducted in other countries and how can the Netherlands be of additional value? The collected information in this report has been combined with information provided by the clubs and collected from websites and reports like ‘The pathway to driverless cars’ by the UK Department for Transport and VRA’s ‘Regulatory needs and solutions for deployment of vehicle and road automation’.

Autonomous Vehicle Implementation Predictions (VTPI): This report explores the impacts that autonomous (also called *self-driving*, *driverless* or *robotic*) vehicles are likely to have on travel demands and transportation planning. It discusses autonomous vehicle benefits and costs, predicts their likely development and implementation based on experience with previous vehicle technologies, and explores how they will affect planning decisions such as optimal road, parking and public transit supply. The analysis indicates that some benefits, such as independent mobility for affluent non-drivers, may begin in the 2020s or 2030s, but most impacts, including reduced traffic and parking congestion, independent mobility for low-income people (and therefore reduced need to subsidize transit), increased safety, energy conservation and pollution reductions, will only be significant when autonomous vehicles become common and affordable, probably in the 2040s to 2060s, and some benefits may require prohibiting human-driven vehicles on certain roadways, which could take longer.

Tem de robot auto (Rathenau Instituut): De digitalisering van de auto leidt tot een explosie van gegevens en nieuwe toepassingen. Denk aan autofabrikanten die onderhoud op afstand verzorgen door updates via wifi te installeren. En verzekeraars houden proeven met track-en-trace-modules die het rijgedrag van bestuurders volgen. Maar hoe zit het met het eigenaarschap van data en voor welke doelen mogen data wel of niet voor worden gebruikt? Maatschappelijk verantwoorde innovatie op dit terrein vraagt om een heldere beleidsvisie, die alleen maar met de inbreng van burgers en maatschappelijke organisaties tot stand komen. De ontwikkeling van de zelfsturende auto is een complex technisch, economisch en politiek-bestuurlijk proces waarvan de uitkomst onzeker is. Met de studie *Tem de robotauto* wil het Rathenau Instituut tijdig bijdragen aan het debat over de toekomst van de zelfsturende auto en data-gedreven mobiliteit.



Autonomous Vehicle Technology (RAND): Autonomous vehicle (AV) technology offers the possibility of fundamentally changing transportation. Equipping cars and light vehicles with this technology will likely reduce crashes, energy consumption, and pollution—and reduce the costs of congestion. This technology is most easily conceptualized using a five-part continuum suggested by the National Highway Traffic Safety Administration (NHTSA), with different benefits of the technology realized at different levels of automation. Careful policymaking will be necessary to maximize the social benefits that this technology will enable, while minimizing the disadvantages. Yet policymakers are only beginning to think about the challenges and opportunities this technology poses. The goal of this report is to assist policymakers at the state and federal levels to make wise policy decisions in this rapidly evolving area.

Selected scientific articles:

Banks, V. A., & Stanton, N. A. (2015). Keep the driver in control: Automating automobiles of the future. *Applied ergonomics*.

Beller, J., Heesen, M., Vollrath, M. (2013) Improving the driver-automation interaction: an approach using automation uncertainty. Hum. Factors 55, 6: 1130-1141

Hancock, P.A. (2015) Automobility: The coming use of fully-automated on-road vehicles. In IEEE Int. Inter-Disc. Conf. Cogn. Meth. in Sit. Awar. Dec. Support (CogSIMA), 137-139.

Korber, M., Schneider, W., & Zimmermann, M. (2015, June). Vigilance, boredom proneness and detection time of a malfunction in partially automated driving. In *Collaboration Technologies and Systems (CTS), 2015 International Conference on* (pp. 70-76). IEEE.

Kountouriotis GK; Wilkie RM; Gardner PH; Merat N (2015) Looking and thinking when driving: The impact of gaze and cognitive load on steering, Transportation Research Part F: Traffic Psychology and Behaviour, 34, pp.108-121. doi: 10.1016/j.trf.2015.07.012

Merat N; Jamson A; Lai F; Daly M; Carsten O (2014) Transition to manual: Driver behaviour when resuming control from a highly automated vehicle, Transportation Research Part F: Traffic Psychology and Behaviour, 27, pp.274-282. doi: 10.1016/j.trf.2014.09.005

Merat, N., & Lee, J. D. (2012). Preface to the Special Section on Human Factors and Automation in Vehicles: Designing highly automated vehicles with the driver in mind. Human Factors: The Journal of the Human Factors and Ergonomics Society, 54(5), 681–686.

Merat N; de Waard D. (2014) Human factors implications of vehicle automation: Current understanding and future directions, Transportation Research Part F: Traffic Psychology and Behaviour, 27, pp.193-195. doi: 10.1016/j.trf.2014.11.002

Schieben, A., Temme, G., Köster, F., Flemisch, F. (2011). How to interact with a highly automated vehicle. In Human Centered Automation, D. de Waard, N. Gérard, L. Onnasch, R. Wiczorek, D. Manzey (Eds.). Shaker Publ., Maastricht, the Netherlands, 251-266.

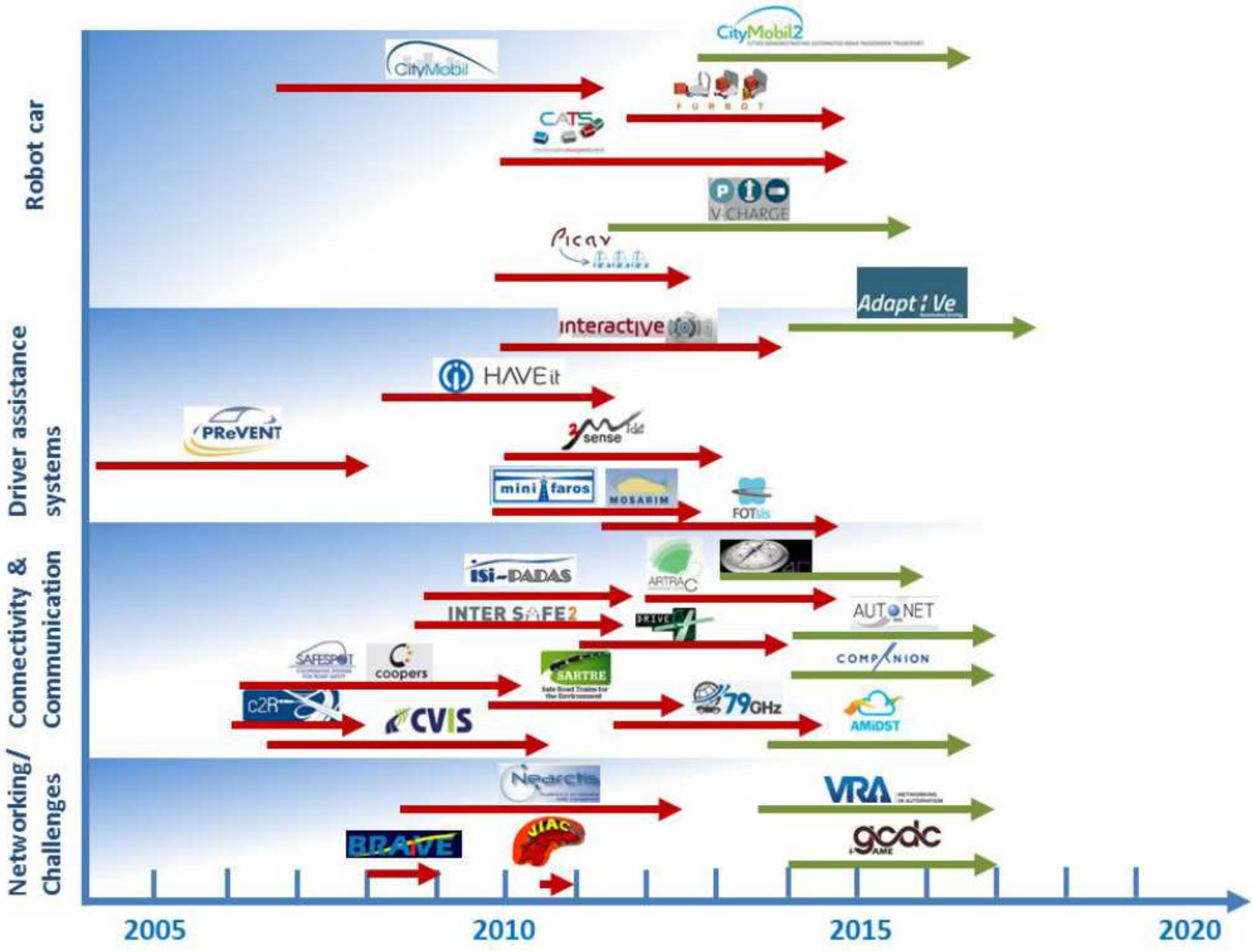
De Waard, D., Kruizinga, A., & Brookhuis, K. A. (2008). The consequences of an increase in heavy goods vehicles for passenger car drivers' mental workload and behaviour: A simulator study. Accident Analysis and Prevention, 40(2), 818-828. 10.1016/j.aap.2007.09.029

De Waard, D., Dijksterhuis, C., & Brookhuis, K. A. (2009). Merging into heavy motorway traffic by young and elderly drivers. Accident Analysis and Prevention, 41(3), 588-597. 10.1016/j.aap.2009.02.011

De Winter, J.C.F., Happee, R., Martens, M.H., Stanton,N.A. (2014). Effects of adaptive cruise control and highly automated driving on workload and situation awareness: A review of the empirical evidence. Transport Res F-Traf, 27: 196-217.

Key EU-projects on automated driving

An overview of the EC funded projects that support the development of automated driving. The analysis has been done for the period of the last ten years. With red arrows, completed projects are shown and with the green ones, the pro-jects that are still running (from EPoSS European roadmap on automated driving; see appendix 1). Additionally a Marie Curie project Human Factors in automated Driving started in 2014 (13PhDs and 1 Postdoc).



Appendix I: EU Projects List

Category	Acronym	Name	Duration	Purpose / Keywords
Robot car	**CityMobil**	Towards Advanced Road Transport for the Urban Environment	02/2004-01/2008	Safety applications and technologies: safe speed and safe following, lateral support, inter-section safety, active 3D sensor technology for pre-crash and blind spot surveillance
	PICAV	Personal Intelligent City Accessible Vehicle	08/2009-07/2012	Passenger transport, urban traffic, car sharing, networking, assisted driving, vulnerable road users
	CATS	City Alternative Transport System	01/2010-12/2014	Robotic driverless electric vehicle, passenger transport, transport management, urban transport
	V-Charge	Automated Valet Parking and Charging for e-Mobility	06/2011-09/2015	Autonomous valet parking, EVs coordinated recharging, smart car system, autonomous driving, multi-camera system, multi-sensor sys-tems
	FURBOT	Freight Urban RoBOTic vehicle	11/2011-10/2014	Fully electrical vehicle for freight transport in urban areas, robotics
	CityMobil2	Cities demonstrating automated road passen-ger transport	09/2012-08/2016	Automated road transport system, automated vehicle, driverless, urban transport, safety, infrastructure, legislation
Driver assistance systems	**PReVENT**	Preventive and Active Safety Application	02/2004-01/2008	Development and demonstration of preventive safety applications and technologies (advanced sensor, communication and positioning technol-ogies); subproject Response 3
	HAVEit	Highly Automated Vehi-cles for Intelligent Transport	02/2008-07/2011	Automated assistance in congestion, temporary auto-pilot
	MiniFaros	Low-cost Miniature La-serscanner for Environ-ment Perception	01/2010-12/2012	Develop and demonstrate innovative low-cost laserscanner
	MOSARIM	MOre Safety for All by Radar Interference Mitiga-tion	01/2010-12/2012	Interference mitigation, automotive short-range radars
	2WideSense	WIDE spectral band & WIDE dynamics multi-functional imaging SEN-Sor ENabling safer car transportation	01/2010-12/2012	Development and testing of next generation imaging sensors, new camera systems
	interactIVe	Accident avoidance by active intervention for intelligent vehicles	02/2010-06/2013	Development of safety systems supporting the driver (joint steering and braking actuators)
	AdaptIVe	Automated Driving Appli-cations and Technologies for Intelligent Vehicles	01/2014-06/2017	Automated driving, cars, trucks, motorways, transport in cities, close-distance manoeuvres; subproject Response 4 (beyond ADAS)

Category	Acronym	Name	Duration	Purpose / Keywords
Connectivity & Communication	**COM2REACT**	Cooperative Communication System to Realise Enhanced Safety and Efficiency in European Road Transport	01/2006-12/2007	Road and in-car communication systems, cooperative system, involvement of two-way communication systems: V2V and V2I, contribution for standardization and harmonization throughout Europe
	SAFESPOT	Cooperative Systems for Road Safety	02/2006-01/2010	Implementation and demonstration of V2V-based technology, Local Dynamic Maps, multi-sensor data fusion
	COOPERS	Co-operative Networks for Intelligent Road Safety	02/2006-01/2010	Development of intelligent transport systems (ITS), I2V technology, co-operative traffic management
	CVIS	Cooperative Vehicle-Infrastructure Systems	07/2006-06/2010	Development of a technology platform that provides wide-ranging functionality for data collection, journey support, traffic and transport operations and driver information.
	Intersafe2	Cooperative Intersection Safety	06/2008-05/2011	Development of a Cooperative Intersection Safety System (CISS) – detection of static and dynamic components of the traffic environment.
	ISI-PADAS	Integrated Human Modelling and Simulation to Support Human Error Risk Analysis of Partially Autonomous Driver Assistance Systems	09/2008-08/2011	Joint Driver-Vehicle-Environment Simulation Platform, prediction of driver errors in realistic traffic scenarios, driver modelling, Human Error Risk Analysis
	SARTRE	Safe Road Trains for the Environment	09/2009-10/2012	Development of strategies and technologies allowing vehicle platoons to operate on public highways – introduction of the vehicle platoons concept
	DRIVE2X	DRIVing implementation and Evaluation of C2X communication technology in Europe	01/2011-12/2013	Creation of harmonized Europe-wide testing environment for cooperative systems, promotion of cooperative driving
	FOTsis	European Field Operational Test on Safe, Intelligent and Sustainable Road Operation	04/2011-09/2014	Intelligent transport systems, electronic stability control, cooperative I2V & V2I technologies, emergency management, safety incident management, intelligent congestion control, dynamic route planning, infrastructure safety assessment
	ARTRAC	Advanced Radar Tracking and Classification for Enhanced Road Safety	11/2011-10/2014	Generic detection system, detect low-friction road sections, automatic braking, VRU safety technologies, radar hardware, software and performance-related algorithms

Category	Acronym	Name	Duration	Purpose / Keywords
Connectivity & Communication	**79GHz**	International automotive 79 GHz frequency harmonization initiative and worldwide operating vehicular radar frequency standardization platform	07/2011-06/2014	Global harmonization, 79GHz band, automotive short-range radars
	Compass4D	Cooperative Mobility Pilot on Safety and Sustainability Services for Deployment	01/2013-12/2015	Forward collision warning (FCW), red light violation warning (RLVW), energy efficient intersection service (EEIS), cooperative system, standardization cooperation
	AMiDST	Analysis of Massive Data STreams	01/2014-12/2016	Big data, stream processing, software development, automotive
	COMPANION	Cooperative dynamic formation of platoons for safe and energy-optimized goods transportation	10/2013-09/2006	Application of platooning on heavy-duty vehicles; concepts development for platoon applications in daily transport operations (off- a on-board systems for coordinated platooning, multimodal user interfaces)
	AutoNet2030	Co-operative Systems in Support of Networked Automated Driving by 2030	11/2013-10/2016	Development and testing of a co-operative automated driving technology with a time-horizon between 2020 and 2030.
Networking/ Challenges	**BRAiVE**	BRAin-drIVE	2008	A prototype vehicle development by VisLab, designed for the testing of concepts, sensors and specific HMIs. The prototype was also used for the design of new ADAS.
	Nearctis	Network of Excellence for Advanced Road Cooperative Traffic Management in the Information Society	07/2008-06/2012	Academic network for traffic management and optimization with focus on cooperative systems able to cope with safety, energy consumption, environmental impacts and congestion.
	VIAC	VisLab Intercontinental Autonomous Challenge	07/2010-10/2010	Challenge conceived by VisLab as an extreme test for automated vehicles.
	VRA	Support action for Vehicle and Road Automation network	07/2013-12/2016	Should create a collaboration network of experts and stakeholders working on deployment of automated vehicles and its related infrastructure.
	GCDC	Grand Cooperative Driving Challenge	10/2013-10/2016 (annually)	Is arranged by the i-GAME project that is aiming at speeding up real-life implementation and interoperability of wireless communication based automated driving.