

SAE J3016™ LEVELS OF DRIVING AUTOMATION

		SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
What does the human in the driver's seat have to do?		You are driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			You are not driving when these automated driving features are engaged – even if you are seated in “the driver’s seat”		
		You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
		These are driver support features			These are automated driving features		
What do these features do?		These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/acceleration support to the driver	These features provide steering AND brake/acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met		This feature can drive the vehicle under all conditions
Example Features		• automatic emergency braking • blind spot warning • lane departure warning	• lane centering OR • adaptive cruise control	• lane centering AND • adaptive cruise control at the same time	• traffic jam chauffeur	• local driverless taxi • pedals/steering wheel may or may not be installed	• same as level 4, but feature can drive everywhere in all conditions

For a more complete description, please download a free copy of SAE J3016: https://www.sae.org/standards/content/J3016_201806/.

Automated Driving Sae

**Christine Eisenmann, Dennis
Seibert, Torsten Fleischer, Ayako
Taniguchi, Takashi Oguchi**

Automated Driving Sae:

SAE J3016 as a Learning Device for the Driving Automation Community TC Eley IV, John Leslie King, Kalle Lyytinen, Jeffrey V. Nickerson, 2024-12-12 It is the tenth anniversary of SAE International's Surface Vehicle Recommended Practice effort SAE J3016 to establish a nomenclature standard for driving automation systems and levels of automation While not exhaustive this report covers motivation initiation and continued development of J3016 regarding driving automation systems noting that J3016 evolved as a learning device that facilitated the evolution of driving automation systems It initially worked by establishing common terminology for the technical learning in the field but over time J3016 expanded to recognize the human roles in driving automation systems with later iterations considering broader transportation ecosystems including fleet operations and remote assistance centers SAE J3016 as a Learning Device for the Driving Automation Community Technical Socio technical and Systemic Learning emphasizes ongoing learning to integrate diverse insights about technical social and socio technical challenges of driving automation systems It also addresses briefly the struggle to accommodate hybrid visions of driving automation systems It provides a brief history and describes how J3016 changed over time to reflect and support driving automation community learning as lessons for driving automation whether focused on road or off road concluding with a summary of driving automation challenges and tasks 9781468608977 9781468608984 <https://doi.org/10.4271/EPR2024029>

Unsettled Topics Concerning Automated Driving Systems and the Development Ecosystem Rahul Razdan, 2020-03-17 With over 100 years of operation the current automobile industry has settled into an equilibrium with the development of methodologies regulations and processes for improving safety In addition a nearly 2 trillion market operates in the automotive ecosystem with connections into fields ranging from insurance to advertising Enabling this ecosystem is a well honed tiered supply chain and an established development environment Autonomous vehicle AV technology is a leap forward for the existing automotive industry now the automobile is expected to manage perception and decision making tasks The safety technologies associated with these tasks were presented in an earlier SAE EDGE Research Report Unsettled Technology Areas in Autonomous Vehicle Test and Validation In a later SAE EDGE Research Report Unsettled Topics Concerning Automated Driving Systems and the Transportation Ecosystem senior executives from the automotive ecosystem explored the impact of AV technology as they faced the prospect of this disruptive technology entering their marketplace Interestingly stable use models and market penetration were all gated primarily by the demonstration of AV safety Building on these previous verification and validation V V related reports Unsettled Topics Concerning Automated Driving Systems and the Development Ecosystem explores the open issues in the shift of the development and supplier environment toward a new AV enabled future NOTE SAE EDGE Research Reports are intended to identify and illuminate key issues in emerging but still unsettled technologies of interest to the mobility industry The goal of SAE EDGE Research Reports is to stimulate discussion and work in the hope of promoting and speeding resolution of

identified issues SAE EDGE Research Reports are not intended to resolve the challenges they identify or close any topic to further scrutiny Click here to access the full SAE EDGETM Research Report portfolio <https://doi.org/10.4271/EPR2020004>

Autonomous Vehicles and Civil Liability in a Global Perspective Hans Steege, Ilaria Amelia Caggiano, Maria Cristina Gaeta, Benjamin von Bodungen, 2024-04-30 In the automotive sector digitalisation connectivity and automation are rapidly expanding In tomorrow's vehicles human beings will merely be passengers which raises a host of complex legal issues regarding accidents involving self driving vehicles This book is the first to offer a comprehensive global overview of civil liability regimes for all levels of vehicle automation in jurisdictions that represent some of the most important markets for the automotive industry After a technical introduction to how self driving cars work the individual chapters analyse the liability for driving automation at SAE J3016 levels 0 through 5 from a country specific perspective All chapters were written by experts in the field and follow a uniform legal structure Hence the book offers an essential comparative analysis of similarities and differences in the jurisdictions examined while also providing suggestions for future legislative changes at the national and international level The book is not only relevant for legal scholars and practitioners but will also be of particular interest to anyone involved in the design manufacture distribution and operation of self driving vehicles

Unsettled Technology Areas in Autonomous Vehicle Test and Validation Rahul Razdan, 2019-06-12 Automated driving system ADS technology and ADS enabled operated vehicles commonly referred to as automated vehicles and autonomous vehicles AVs have the potential to impact the world as significantly as the internal combustion engine Successful ADS technologies could fundamentally transform the automotive industry civil planning the energy sector and more Rapid progress is being made in artificial intelligence AI which sits at the core of and forms the basis of ADS platforms Consequently autonomous capabilities such as those afforded by advanced driver assistance systems ADAS and other automation solutions are increasingly becoming available in the marketplace To achieve highly or fully automated or autonomous capabilities a major leap forward in the validation of these ADS technologies is required Without this critical cog helping to ensure the safety and reliability of these systems and platforms the full capabilities of ADS technology will not be realized This paper explores the ADS validation challenge by reviewing existing approaches and examining the effectiveness of those approaches presenting critical techniques required to bring safe and effective solutions to market discussing unsettled topics and suggesting next steps for industry stakeholders to consider as they work to advance the ADS ecosystem NOTE SAE EDGE Research Reports are intended to identify and illuminate key issues in emerging but still unsettled technologies of interest to the mobility industry The goal of SAE EDGE Research Reports is to stimulate discussion and work in the hope of promoting and speeding resolution of identified issues SAE EDGE Research Reports are not intended to resolve the issues they identify or close any topic to further scrutiny Click here to access the full SAE EDGETM Research Report portfolio <https://doi.org/10.4271/EPR2019001> [Unsettled Topics Concerning Automated Driving Systems and the](#)

Transportation Ecosystem Rahul Razdan,2019-11-05 Over the last 100 years the automobile has become integrated in a fundamental way into the broader economy A broad and deep ecosystem has emerged and critical components of this ecosystem include insurance after market services automobile retail sales automobile lending energy suppliers e g gas stations medical services advertising lawyers banking public planners and law enforcement These components which together represent almost 2 trillion of the U S economy are in equilibrium based on the current capabilities of automotive technology However the advent of autonomous vehicles AVs and technologies like electrification have the potential to significantly disrupt the automotive ecosystem The critical cog governing the rate and pace of this shift is the management of the test and verification of AVs In this SAE EDGE report six senior industry leaders in the impacted ecosystems essay articles which describe sectors of the current automotive ecosystem and the manner in which AV technology can potentially reshape them providing a mosaic of the massive infrastructure shifts which will be required to absorb AV technologies NOTE SAE EDGE Research Reports are intended to identify and illuminate key issues in emerging but still unsettled technologies of interest to the mobility industry The goal of SAE EDGE Research Reports is to stimulate discussion and work in the hope of promoting and speeding resolution of identified issues SAE EDGE Research Reports are not intended to resolve the issues they identify or close any topic to further scrutiny Click here to access the full SAE EDGETM Research Report portfolio <https://doi.org/10.4271/EPR2019005>

Knowledge Graph-Based Methods for Automated Driving Rajesh Kumar Dhanaraj,M. Nalini,Malathy Sathyamoorthy,Manar Mohaisen,2025-04-11 The global race to develop and deploy automated vehicles is still hindered by significant challenges with the related complexities requiring multidisciplinary research approaches Knowledge Graph Based Methods for Automated Driving offers sought after specialized know how for a wide range of readers both in academia and industry on the use of graphs as knowledge representation techniques which compared to other relational models provide a number of advantages for data driven applications like automated driving tasks The machine learning pipeline presented in this volume incorporates a variety of auxiliary information including logic rules ontology informed workflows simulation outcomes differential equations and human input with the resulting operational framework being more reliable secure efficient as well as sustainable Case studies and other practical discussions exemplify these methods promising and exciting prospects for the maturation of scalable solutions with potential to transform transport and logistics worldwide Systematically covers knowledge graphs for automated driving processes Includes real life case studies facilitating an understanding of current challenges Analyzes the impact of various technological aspects related to automation across a range of transport modes networks and infrastructures

Characterizing the Safety of Automated Vehicles Juan Pimentel,2019-03-07 Safety has been ranked as the number one concern for the acceptance and adoption of automated vehicles since safety has driven some of the most complex requirements in the development of self driving vehicles Recent fatal accidents involving self driving vehicles have uncovered issues in the way some automated vehicle

companies approach the design testing verification and validation of their products Traditionally automotive safety follows functional safety concepts as detailed in the standard ISO 26262 However automated driving safety goes beyond this standard and includes other safety concepts such as safety of the intended functionality SOTIF and multi agent safety Characterizing the Safety of Automated Vehicles addresses the concept of safety for self driving vehicles through the inclusion of 10 recent and highly relevant SAE technical papers Topics that these papers feature include functional safety SOTIF and multi agent safety As the first title in a series on automated vehicle safety each will contain introductory content by the Editor with 10 SAE technical papers specifically chosen to illuminate the specific safety topic of that book Shaping Automated Driving to Achieve Societal Mobility Needs Peter Moertl, Bernhard Brandstaetter, 2024-03-14 This edited book describes novel human systems integration approaches to improve acceptance safety and comfort of automated vehicles Each chapter analyses different aspects in the development of automated driving systems such as assessing needs and opportunities of specific user populations i.e. elderly drivers and truck drivers creating fluid human systems interactions in the vehicle to answer specific driver needs developing an automated driving tutoring application and identifying benefits of including road infrastructure sensors to support automated driving predictability A detailed description of the assessment of the above described solutions in real world situations is also included Written by both researchers and professionals this book offers timely and practice oriented information concerning the development of automated driving systems that better adapt to the users needs

Safety-Relevant Guidance for On-Road Testing of SAE Level 3, 4, and 5 Prototype Automated Driving System (ADS)-Operated Vehicles On-Road Automated Driving (ORAD) Committee, 2019 This document provides safety relevant guidance for on road testing of vehicles being operated by prototype conditional high and full Levels 3 to 5 ADS as defined by SAE J3016 It does not include guidance for evaluating the performance of post production ADS equipped vehicles Moreover this guidance only addresses testing of ADS operated vehicles as overseen by in vehicle fallback test drivers IFTD These guidelines do not address Remote driving including remote fallback test driving of prototype ADS operated test vehicles in driverless operation Note The term remote fallback test driver is included as a defined term herein and is intended to be addressed in a future iteration of this document However at this time too little is published or known about this type of testing to provide even preliminary guidance Testing of driver support features i.e. Levels 1 and 2 which rely on a human driver to perform part of the dynamic driving task DDT and to supervise the driving automation feature s performance in real time Refer to SAE J3016 Closed course testing Simulation testing except for training purposes Component level testing This document provides general safety relevant guidance for testing prototype automated driving systems ADS equipped on test vehicles operated in mixed traffic environments on public roads hereafter prototype ADS operated vehicles This document is being substantially updated in order to incorporate lessons learned based on accumulated field experience in testing prototype ADS operated vehicles on public roads and to make it compatible with

related SAE documents It is assumed that the prototype ADS operated vehicles that are the subject of this guidance have been developed using standardized methods for safer product development including but not limited to A systems engineering approach i e V model Adherence to a recognized functional safety process such as ISO 26262 for identifying hazards and implementing strategies for mitigating them Implementation of an electrical electronic E E architecture system hardware software levels capable of implementing hazard mitigation concepts and strategies Analysis and testing of identified hazard mitigation strategies hardware and software Prototype ADS operated vehicles that are based on existing production vehicles rely on the existing vehicle s E E architecture as adapted for ADS Prototype ADS technology provided via added hardware and software modules that are not integrated according to the vehicle manufacturer s specifications should be checked to ensure that they do not interfere with base vehicle hardware or software systems As such they should abide by the following general principles All hardware and software interfaces between production and development level hardware and software should be analyzed and tested for operational integrity including analysis of failure modes and effects All developmental software added to a vehicle including that equipped on added hardware modules should be monitored and or include self diagnostics for safety critical functions which should be verified for efficacy prior to on road testing Proper test program operations management plays a key role in helping to maintain safety while conducting on road testing of prototype ADS operated vehicles Unexpected behaviors including incidents should be reported accurately and consistently for later root cause analysis and resolution A manager in charge of prototype ADS operated vehicle testers should explain to them the organization s specific rules about testing and documentation as well as any hardware software updates that impact the performance of the ADS operated vehicles Novice testers should be paired with more experienced testers to learn the appropriate reactions in various situations Real time calibration tuning of ADS software during testing should be allowed only after evaluation by qualified personnel e g development engineer lead calibrator and or designated safety engineer indicating that the change does not pose unacceptable risk for on road testing

User Experience Design in the Era of Automated Driving Andreas Riener, Myoungsoon Jeon, Ignacio Alvarez, 2022-01-01 This book is dedicated to user experience design for automated driving to address humane aspects of automated driving e g workload safety trust ethics and acceptance Automated driving has experienced a major development boost in recent years However most of the research and implementation has been technology driven rather than human centered The levels of automated driving have been poorly defined and inconsistently used A variety of application scenarios and restrictions has been ambiguous Also it deals with human factors design practices and methods as well as applications such as multimodal infotainment virtual reality augmented reality and interactions in and outside users This book aims at 1 providing engineers designers and practitioners with a broad overview of the state of the art user experience research in automated driving to speed up the implementation of automated vehicles and 2 helping researchers and students benefit from various perspectives and approaches to generate

new research ideas and conduct more integrated research Cellular V2X for Connected Automated Driving Mikael Fallgren, Markus Dillinger, Toktam Mahmoodi, Tommy Svensson, 2021-04-19 CELLULAR V2X FOR CONNECTED AUTOMATED DRIVING A unique examination of cellular communication technologies for connected automated driving combining expert insights from telecom and automotive industries as well as technical and scientific knowledge from industry and academia Cellular vehicle to everything C V2X technologies enable vehicles to communicate both with the network with each other and with other road users using reliable responsive secure and high capacity communication links Cellular V2X for Connected Automated Driving provides an up to date view of the role of C V2X technologies in connected automated driving CAD and connected road user CRU services such as advanced driving support improved road safety infotainment over the air software updates remote driving and traffic efficiency services enabling the future large scale transition to self driving vehicles This timely book discusses where C V2X technology is situated within the increasingly interconnected ecosystems of the mobile communications and automotive industries An expert contributor team from both industry and academia explore potential applications business models standardization spectrum and channel modelling network enhancements security and privacy and more Broadly divided into two parts introductory and advanced material the text first introduces C V2X technology and introduces a variety of use cases and opportunities requiring no prerequisite technical knowledge The second part of the book assumes a basic understanding of the field of telecommunications presenting technical descriptions of the radio system aspects and network design for the previously discussed applications This up to date resource Provides technical details from the finding of the European Commission H2020 5G PPP 5GCAR project a collaborative research initiative between the telecommunications and automotive industries and academic researchers Elaborates on use cases business models and a technology roadmap for those seeking to shape a start up in the area of automated and autonomous driving Provides up to date descriptions of standard specifications standardization and industry organizations and important regulatory aspects for connected vehicles Provides technical insights and solutions for the air interface network architecture positioning and security to support vehicles at different automation levels Includes detailed tables plots and equations to clarify concepts accompanied by online tutorial slides for use in teaching and seminars Thanks to its mix of introductory content and technical information Cellular V2X for Connected Automated Driving is a must have for industry and academic researchers telecom and automotive industry practitioners leaders policymakers and regulators and university level instructors and students Additional resources available at the following site Cellular V2X for Connected Automated Driving 5GCAR

Designing Interaction and Interfaces for Automated Vehicles Neville Stanton, Kirsten M. A. Revell, Patrick Langdon, 2021-03-10 Driving automation and autonomy are already upon us and the problems that were predicted twenty years ago are beginning to appear These problems include shortfalls in expected benefits equipment unreliability driver skill fade and error inducing equipment designs Designing Interaction and Interfaces for Automated Vehicles User Centred

Ecological Design and Testing investigates the difficult problem of how to interface drivers with automated vehicles by offering an inclusive human centred design process that focusses on human variability and capability in interaction with interfaces This book introduces a novel method that combines both systems thinking and inclusive user centred design It models driver interaction provides design specifications concept designs and the results of studies in simulators on the test track and in road going vehicles This book is for designers of systems interfaces interactions UX Human Factors and Ergonomics researchers and practitioners involved with systems engineering and automotive academics _ In this book Prof Stanton and colleagues show how Human Factors methods can be applied to the tricky problem of interfacing human drivers with vehicle automation They have developed an approach to designing the human automation interaction for the handovers between the driver and the vehicle This approach has been tested in driving simulators and most interestingly in real vehicles on British motorways The approach called User Centred Ecological Interface Design has been validated against driver behaviour and used to support their ongoing work on vehicle automation I highly recommend this book for anyone interested or involved in designing human automation interaction in vehicles and beyond Professor Michael A Regan University of NSW Sydney AUSTRALIA [Unsettled Topics Concerning User Experience and Acceptance of Automated Vehicles](#) Amine Taleb-Bendiab,2020-06-29 This SAE EDGE Research Report addresses the unsettled topic of user acceptance of automated driving analyzing the user experience for a more intuitive and safe driving experience Unsettled Topics Concerning User Experience and Acceptance of Automated Vehicles examines the requirements for safer driver user engagement with driving for the various SAE automation levels It analyzes consumer sentiment toward automated driving both consumer excitement about the perceived benefits and dislikes or concerns about the technology The findings from surveys about drivers experience with advanced driving assistance technologies and its application to automated driving is also brought to the surface of the discussion together with driver profiles observed during a user centric experience in an immersive automated driving cockpit Unsettled Topics Concerning User Experience and Acceptance of Automated Vehicles proposes through a trust pyramid representation a means of gradually increasing user trust through careful human machine interface HMI delivery with appropriate levels of information that communicate safe driving Ultimately the goal is to build up user confidence levels in safe automated driving so that their time can be spent on entertainment or other non driving tasks Click here to access the full SAE EDGETM Research Report portfolio <https://doi.org/10.4271/EPR2020012> **Guidelines for Safe On-road Testing of SAE Level 3, 4, and 5 Prototype Automated Driving Systems (ADS).** ,2015 **The Safety of Controllers, Sensors, and Actuators** Juan Pimentel,2019-03-07 Safety has been ranked as the number one concern for the acceptance and adoption of automated vehicles since safety has driven some of the most complex requirements in the development of self driving vehicles Recent fatal accidents involving self driving vehicles have uncovered issues in the way some automated vehicle companies approach the design testing verification and validation of their products Traditionally

automotive safety follows functional safety concepts as detailed in the standard ISO 26262. However, automated driving safety goes beyond this standard and includes other safety concepts such as safety of the intended functionality (SOTIF) and multi-agent safety. The Safety of Controllers, Sensors, and Actuators addresses the concept of safety for self-driving vehicles through the inclusion of 10 recent and highly relevant SAE technical papers. Topics that these papers feature include risk reduction techniques in semiconductor-based systems, component certification, and safety assessment and audits for vehicle components. As the fifth title in a series on automated vehicle safety, this contains introductory content by the Editor with 10 SAE technical papers specifically chosen to illuminate the specific safety topic of that book.

Autonomous, Connected, Electric and Shared Vehicles UMAR ZAKIR ABDUL HAMID, 2022-10-28

We are at the beginning of the next major disruptive cycle caused by computing. In transportation, the term Autonomous, Connected, Electric, and Shared (ACES) has been coined to represent the enormous innovations enabled by underlying electronics technology. The benefits of ACES vehicles range from improved safety, reduced congestion, and lower stress for car occupants to social inclusion, lower emissions, and better road utilization due to optimal integration of private and public transport. ACES is creating a new automotive and industrial ecosystem that will disrupt not only the technical development of transportation but also the management and supply chain of the industry. Disruptions caused by ACES are prompted by not only technology but also by a shift from a traditional to a software-based mindset embodied by the arrival of a new generation of automotive industry workforce. In *Autonomous, Connected, Electric, and Shared Vehicles: Disrupting the Automotive and Mobility Sectors*, Umar Zakir Abdul Hamid provides an overview of ACES technology for cross-disciplinary audiences including researchers, academics, and automotive professionals. Hamid bridges the gap among the book's varied audiences, exploring the development and deployment of ACES vehicles and the disruptions, challenges, and potential benefits of this new technology. Topics covered include: Recent trends and progress stimulating ACES growth and development; ACES vehicle overview; Automotive and mobility industry disruptions caused by ACES; Challenges of ACES implementation; Potential benefits of the ACES ecosystem. While market introduction of ACES vehicles that are fully automated and capable of unsupervised driving in an unstructured environment is still a long-term goal, the future of mobility will be ACES, and the transportation industry must prepare for this transition. *Autonomous, Connected, Electric, and Shared Vehicles* is a necessary resource for anyone interested in the successful and reliable implementation of ACES. ACES are destined to be game changers on the roads, altering the face of mobility. Daniel Watzenig, Professor, Graz University of Technology, Austria.

Unsettled Topics Concerning the Field Testing of Automated Driving Systems Bob McQueen, 2019-12-19

Automated driving systems (ADS) have the potential to revolutionize transportation. Through the automation of driver functions in the application of advanced technology within the vehicle, significant improvements can be made to safety, efficiency, user experience, and the preservation of the environment. According to the US Department of Transportation [1], there are more than 1,400 cars, trucks, buses, and other vehicles being

tested by more than 80 companies across the USA Implementation of ADS technology is well advanced with many sites across the USA incorporating automated vehicles AVs into wider programs to apply advanced technology to transportation Discussions with the public sector s implementing agencies suggest that one of the barriers to faster progress lies in the lack of consistent and standardized field testing protocols This report looks at the state of the art of field testing for ADS and identifies areas for improved consistency and standardization It will define the problem to be addressed by AVs and the challenges associated with the introduction of such vehicles and open road situations In particular the report will look at the possibilities for big data and analytics to enable the sharing of lessons learned and convergence on standard field testing approaches NOTE SAE EDGE Research Reports are intended to identify and illuminate key issues in emerging but still unsettled technologies of interest to the mobility industry The goal of SAE EDGE Research Reports is to stimulate discussion and work in the hope of promoting and speeding resolution of identified issues SAE EDGE Research Reports are not intended to resolve the issues they identify or close any topic to further scrutiny Click here to access the full SAE EDGETM Research Report portfolio <https://doi.org/10.4271/EPR2019009> *Models and Technologies for Smart, Sustainable and Safe Transportation Systems* Stefano de Luca,Roberta Di Pace,Chiara Fiori,2021-07-28 Innovative and smart mobility systems are expected to make transportation systems more sustainable inclusive and safe Because of changing mobility paradigms transport planning and design require different methodological approaches Over twelve chapters this book examines and analyzes Mobility as a Service MaaS travel behavior traffic control intelligent transportation system design electric connected and automated vehicles and much more *Characterizing the Safety of Automated Vehicles* Juan R. Pimentel,2019 **Human Factors Definitions for Automated Driving and Related Research Topics** ,2016

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