



# SAE J3016™ LEVELS OF DRIVING AUTOMATION™

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	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	

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## 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
	<ul style="list-style-type: none"> <li>• automatic emergency braking</li> <li>• blind spot warning</li> <li>• lane departure warning</li> </ul>	<ul style="list-style-type: none"> <li>• lane centering OR</li> <li>• adaptive cruise control</li> </ul>	<ul style="list-style-type: none"> <li>• lane centering AND</li> <li>• adaptive cruise control at the same time</li> </ul>	<ul style="list-style-type: none"> <li>• traffic jam chauffeur</li> </ul>	<ul style="list-style-type: none"> <li>• local driverless taxi</li> <li>• pedals/steering wheel may or may not be installed</li> </ul>
Example Features					

# Automated Driving Sae

**L Darling-Hammond**



## **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>

*Handbook Assisted and Automated Driving* Hermann Winner, Klaus C. J. Dietmayer, Lutz Eckstein, Meike Jipp, Markus Maurer, Christoph Stiller, 2026-03-19 This open access book explains in detail systems and technologies for assisted and automated driving It also provides an overview of the limitations of such systems concerning development processes and test tools This description covers today's advanced driver assistance systems with environment perception in passenger cars commercial vehicles and motorcycles This includes functional principles as well as embodiments of the components required for this purpose such as sensors actuators mechatronic subsystems and actuating elements Additionally data fusion concepts environment representations and user friendly designs of the human machine interface between the assistance system and driver are presented New priorities are also presented concerning the development of automated driving Although automated driving is based on the technology of advanced driver assistance systems removing humans from the responsibility of driving induces entirely new challenges that also go beyond series technology The variety of necessary innovative approaches is presented in example applications The content Fundamentals of Advanced Driver Assistance System Development Virtual Development and Test Environments for ADAS Test Methods Sensors for ADAS Data Fusion and Environment Representation Digital Infrastructure Actuation for ADAS Human Machine Interfaces for ADAS ADAS on Guidance and Navigation Level Automated Driving The target groups Automotive development and application engineers Students of automotive electrics electronics mechatronics Students of mechanical engineering automotive technology Students of electronics informatics information technology The Editors Prof Dr rer nat Hermann

Winner headed the Department of Automotive Engineering at the Technical University of Darmstadt FZD until 2021 Prof Dr Ing Klaus Dietmayer is Director of the Institute of Measurement Control and Microtechnology at the University of Ulm Prof Dr Ing Lutz Eckstein is Director of the Institute for Automotive Engineering ika at RWTH Aachen University Prof Dr Meike Jipp is Divisional Board Member Energy and Transport German Aerospace Center DLR Prof Dr Ing Markus Maurer is Head of the Institute for Control Engineering at the Technical University of Braunschweig Prof Dr Ing Christoph Stiller is Head of the Institute of Measurement and Control Technology MRT at the Karlsruhe Institute of Technology

**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

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> *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> *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 **Cellular V2X for Connected Automated Driving** Mikael Fallgren,Markus Dillinger,Toktam Mahmoodi,Tommy Svensson,2021-04-15 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 [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>

*Road Vehicle Automation 2* Gereon Meyer, Sven Beiker, 2015-06-30. This paper collection is the second volume of the LNMOB series on Road Vehicle Automation. The book contains a comprehensive review of current technical, socio-economic, and legal perspectives written by experts coming from public authorities, companies, and universities in the U.S., Europe, and Japan. It originates from the Automated Vehicle Symposium 2014, which was jointly organized by the Association for Unmanned Vehicle Systems International (AUVERSI) and the Transportation Research Board (TRB) in Burlingame, CA, in July 2014. The contributions discuss the challenges arising from the integration of highly automated and self-driving vehicles into the transportation system, with a focus on human factors and different deployment scenarios. This book is an indispensable source of information for academic researchers, industrial engineers, and policy makers interested in the topic of road vehicle automation.

*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.

*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 Issues Regarding Communication of Automated Vehicles with Other Road Users* Sven Beiker,2020-11-30 The focus of this SAE EDGE Research Report is to address a topic overlooked by many who choose to view automated driving systems and AVs from a 10 000 foot perspective how automated vehicles AVs will actually communicate with other road users Conventional human driven vehicles bicyclists and pedestrians already have a functioning system of understating each other while on the move Adding automated vehicles to the mix requires assessing the spectrum of existing modes of communication both implicit and explicit biological and technological and how they will interact with each other in the real world The impending deployment of AVs represents a major shift in the traditional approach to ground transportation its effects will inevitably be felt by parties directly involved with the vehicle manufacturing and use and those that play roles in the mobility ecosystem e g aftermarket and maintenance industries infrastructure and planning organizations automotive insurance providers marketers telecommunication companies *Unsettled Issues Regarding Communication of Automated Vehicles with Other Road Users* brings together the multiple scenarios we are likely to see in a future not too far away and how they are likely to play out in practical ways Click here to access the full SAE EDGETM Research Report portfolio <https://doi.org/10.4271/EPR2020023> **Guidelines for Safe On-road Testing of SAE Level 3, 4, and 5 Prototype Automated Driving Systems (ADS)**. ,2015 *Unsettled Issues Concerning Semi-Automated Vehicles* Francesca Favaro,2020-02-28 Across the span of the SAE International defined Levels of Driving Automation human drivers occupy a diverse range of responsibilities and authority on the vehicle movement and the monitoring of the outside environment From both a technological and a regulatory perspective there is a gap that divides lower levels of automation L1 through L3 and higher levels of automation L4 and L5 For those vehicles that require the cooperation between a human driver and the autonomous technology it is important to ascertain the safety consequences of such a design choice It is also important to understand what the transition between automated driving and manual driving entails for the human driver as well as for the surrounding traffic This SAE EDGE Research Report investigates unsettled issues concerning what is commonly referred to as semi automation including an overview of the role of human drivers the quantification of the transition to manual problem the role played by L3 toward full automation and regulatory and moral considerations surrounding the deployment of these vehicles 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/EPR2020001> **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.

**Fundamentals of Connected and Automated Vehicles** Jeffrey Wishart, Yan Chen, Steven Como, Narayanan Kidambi, Duo Lu, Yezhou Yang, 2022-01-20 The automotive industry is transforming to a greater degree that has occurred since Henry Ford introduced mass production of the automobile with the Model T in 1913. Advances in computing, data processing, and artificial intelligence (deep learning in particular) are driving the development of new levels of automation that will impact all aspects of our lives, including our vehicles. What are Connected and Automated Vehicles (CAVs)? What are the underlying technologies that need to mature and converge for them to be widely deployed? **Fundamentals of Connected and Automated Vehicles** is written to answer these questions, educating the reader with the information required to make informed predictions of how and when CAVs will impact their lives. Topics covered include: History of Connected and Automated Vehicles; Localization; Connectivity; Sensor and Actuator Hardware; Computer Vision; Sensor Fusion; Path Planning and Motion Control; Verification and Validation; and Outlook for the future of CAVs.

**Human Factors Definitions for Automated Driving and Related Research Topics**, 2016

**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>

**Autonomous Driving Changes the Future** Zhanxiang Chai, Tianxin Nie, Jan Becker, 2020-07-22 This book systematically discusses the development of autonomous driving, describing the related history, technological advances,

infrastructure social impacts international competition China's opportunities and challenges and possible future scenarios This popular science book uses straightforward language and includes quotes from ancient Chinese poems to enhance the reading experience The discussions are supplemented by theoretical elaborations presented in tables and figures The book is intended for auto fans upper undergraduate and graduate students in the field of automotive engineering

**Autonomous Vehicles for Safer Driving** Ronald K Jurgen, 2013-04-16 Self driving cars are no longer in the realm of science fiction thanks to the integration of numerous automotive technologies that have matured over many years Technologies such as adaptive cruise control forward collision warning lane departure warning and V2V V2I communications are being merged into one complex system The papers in this compendium were carefully selected to bring the reader up to date on successful demonstrations of autonomous vehicles ongoing projects and what the future may hold for this technology It is divided into three sections overview major design and test collaborations and a sampling of autonomous vehicle research projects The comprehensive overview paper covers the current state of autonomous vehicle research and development as well as obstacles to overcome and a possible roadmap for major new technology developments and collaborative relationships The section on major design and test collaborations covers DARPA contests and the USDOT and the Crash Avoidance Metrics Partnership Vehicle Safety Communications CAMP VSC2 Consortium The final section presents seven SAE papers on significant recent and ongoing research by individual companies on a variety of approaches to autonomous vehicles This book will be of interest to a wide range of readers engineers at automakers and electronic component suppliers software engineers computer systems analysts and architects academics and researchers within the electronics computing and automotive industries legislators managers and other decision makers in the government highway sector traffic safety professionals and insurance and legal practitioners

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## Automated Driving Sae Introduction

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