글로벌 ICT 표준 컨퍼런스 2023

Global ICT Standards Conference 2023

(세션3) 미래 모빌리티: 새로운 이동 생태계

자율주행 레벨 국제표준화 동향 및 주요 이슈

차홍기 (표준전문위원, ETRI)

주최 과학기술정보통신부 Ministry of Science and ICT
특허청 Korean Intellectual Property Office
주관 국립전파연구원 National Radio Research Agency
TTA IITP KEA kista ETRI

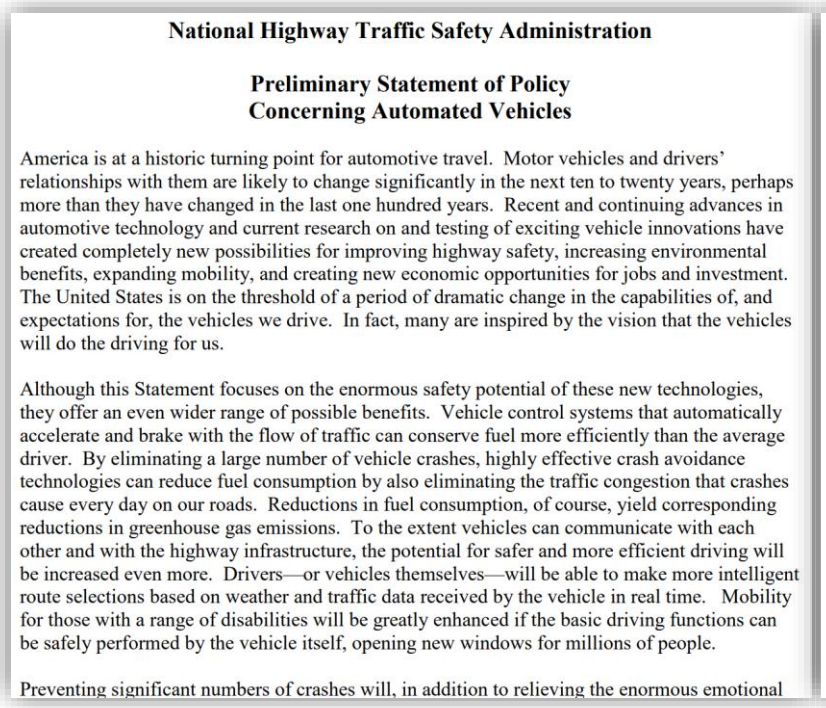
00. 배경

Preliminary Statement of Policy Concerning Automated Vehicles

NHTSA (National Highway Traffic Safety Administration, 미국도로교통안전국)

2013년, NHTSA는 총 5단계
(레벨 0 ~ 4)의 자율주행 레벨 정의

2014년, SAE International (이하, SAE)는 총 6단계(레벨 0 ~ 5)의 자율주행 레벨을 분류하고 관련 용어를 정의하는 SAE J3016 표준 제정



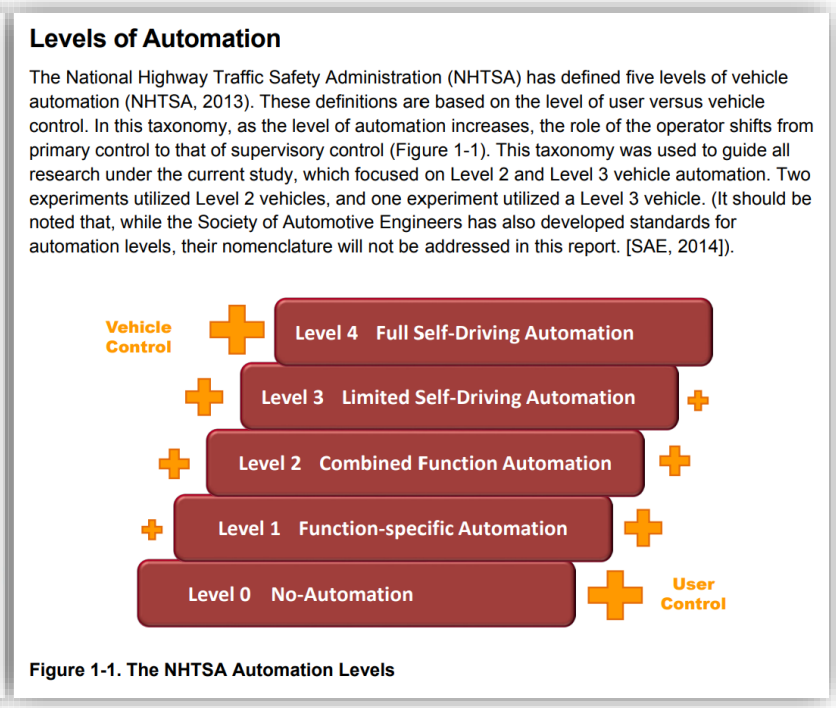
National Highway Traffic Safety Administration

Preliminary Statement of Policy
Concerning Automated Vehicles

America is at a historic turning point for automotive travel. Motor vehicles and drivers' relationships with them are likely to change significantly in the next ten to twenty years, perhaps more than they have changed in the last one hundred years. Recent and continuing advances in automotive technology and current research on and testing of exciting vehicle innovations have created completely new possibilities for improving highway safety, increasing environmental benefits, expanding mobility, and creating new economic opportunities for jobs and investment. The United States is on the threshold of a period of dramatic change in the capabilities of, and expectations for, the vehicles we drive. In fact, many are inspired by the vision that the vehicles will do the driving for us.

Although this Statement focuses on the enormous safety potential of these new technologies, they offer an even wider range of possible benefits. Vehicle control systems that automatically accelerate and brake with the flow of traffic can conserve fuel more efficiently than the average driver. By eliminating a large number of vehicle crashes, highly effective crash avoidance technologies can reduce fuel consumption by also eliminating the traffic congestion that crashes cause every day on our roads. Reductions in fuel consumption, of course, yield corresponding reductions in greenhouse gas emissions. To the extent vehicles can communicate with each other and with the highway infrastructure, the potential for safer and more efficient driving will be increased even more. Drivers—or vehicles themselves—will be able to make more intelligent route selections based on weather and traffic data received by the vehicle in real time. Mobility for those with a range of disabilities will be greatly enhanced if the basic driving functions can be safely performed by the vehicle itself, opening new windows for millions of people.

Preventing significant numbers of crashes will, in addition to relieving the enormous emotional



Levels of Automation

The National Highway Traffic Safety Administration (NHTSA) has defined five levels of vehicle automation (NHTSA, 2013). These definitions are based on the level of user versus vehicle control. In this taxonomy, as the level of automation increases, the role of the operator shifts from primary control to that of supervisory control (Figure 1-1). This taxonomy was used to guide all research under the current study, which focused on Level 2 and Level 3 vehicle automation. Two experiments utilized Level 2 vehicles, and one experiment utilized a Level 3 vehicle. (It should be noted that, while the Society of Automotive Engineers has also developed standards for automation levels, their nomenclature will not be addressed in this report. [SAE, 2014]).

Figure 1-1. The NHTSA Automation Levels

출처(좌): 'Preliminary Statement of Policy Concerning Automated Vehicles' NHTSA, 2013.05
출처(우): 'Human Factors Evaluation of Level 2 and Level 3 Automated Driving Concepts' NHTSA, 2015.08

01. SAE J3016

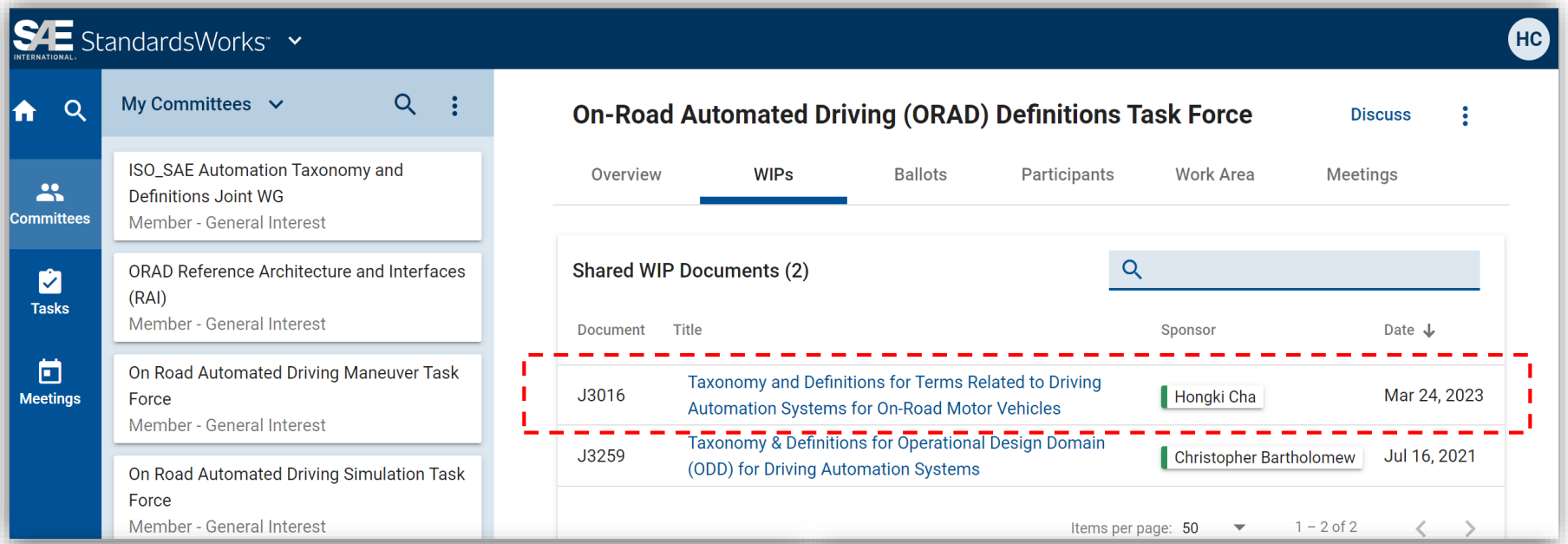
Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles

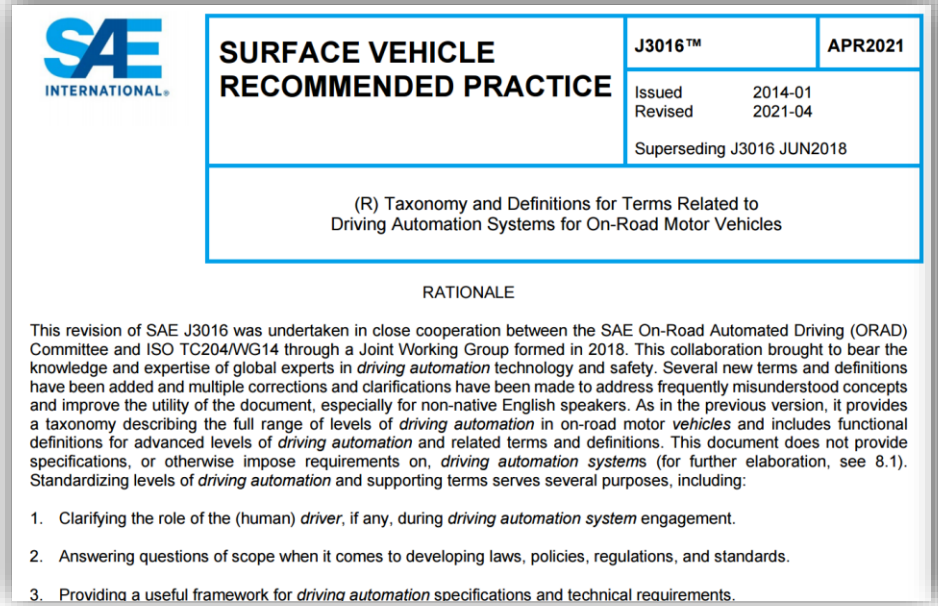
2014년 제정 후 2016년, 2018년 및 2021년 개정

SAE ORAD Committee 산하 Definitions TF에서 개발

SAE J3016 스폰서: 차홍기

2024년 목표로 개정 추진





SAE INTERNATIONAL

SURFACE VEHICLE RECOMMENDED PRACTICE

J3016™ APR2021

Issued 2014-01
Revised 2021-04

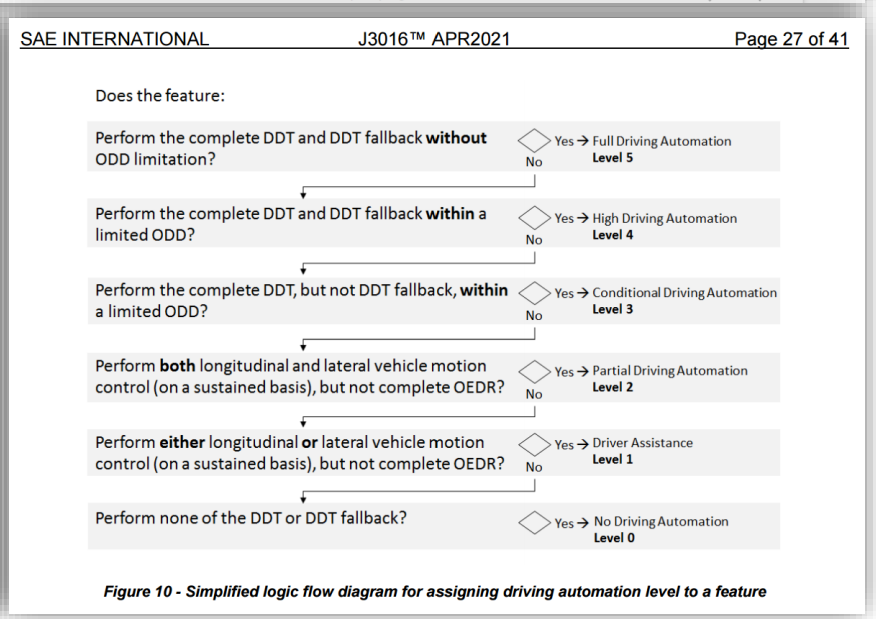
Superseding J3016 JUN2018

(R) Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles

RATIONALE

This revision of SAE J3016 was undertaken in close cooperation between the SAE On-Road Automated Driving (ORAD) Committee and ISO TC204/WG14 through a Joint Working Group formed in 2018. This collaboration brought to bear the knowledge and expertise of global experts in *driving automation* technology and safety. Several new terms and definitions have been added and multiple corrections and clarifications have been made to address frequently misunderstood concepts and improve the utility of the document, especially for non-native English speakers. As in the previous version, it provides a taxonomy describing the full range of levels of *driving automation* in on-road motor *vehicles* and includes functional definitions for advanced levels of *driving automation* and related terms and definitions. This document does not provide specifications, or otherwise impose requirements on, *driving automation systems* (for further elaboration, see 8.1). Standardizing levels of *driving automation* and supporting terms serves several purposes, including:

1. Clarifying the role of the (human) *driver*, if any, during *driving automation system* engagement.
2. Answering questions of scope when it comes to developing laws, policies, regulations, and standards.
3. Providing a useful framework for *driving automation* specifications and technical requirements.



SAE INTERNATIONAL J3016™ APR2021 Page 27 of 41

Does the feature:

Perform the complete DDT and DDT fallback **without** ODD limitation? Yes → Full Driving Automation **Level 5**; No

Perform the complete DDT and DDT fallback **within** a limited ODD? Yes → High Driving Automation **Level 4**; No

Perform the complete DDT, but not DDT fallback, **within** a limited ODD? Yes → Conditional Driving Automation **Level 3**; No

Perform **both** longitudinal and lateral vehicle motion control (on a sustained basis), but not complete OEDR? Yes → Partial Driving Automation **Level 2**; No

Perform **either** longitudinal **or** lateral vehicle motion control (on a sustained basis), but not complete OEDR? Yes → Driver Assistance **Level 1**; No

Perform none of the DDT or DDT fallback? Yes → No Driving Automation **Level 0**

Figure 10 - Simplified logic flow diagram for assigning driving automation level to a feature

01. SAE J3016

주요 개정 내용

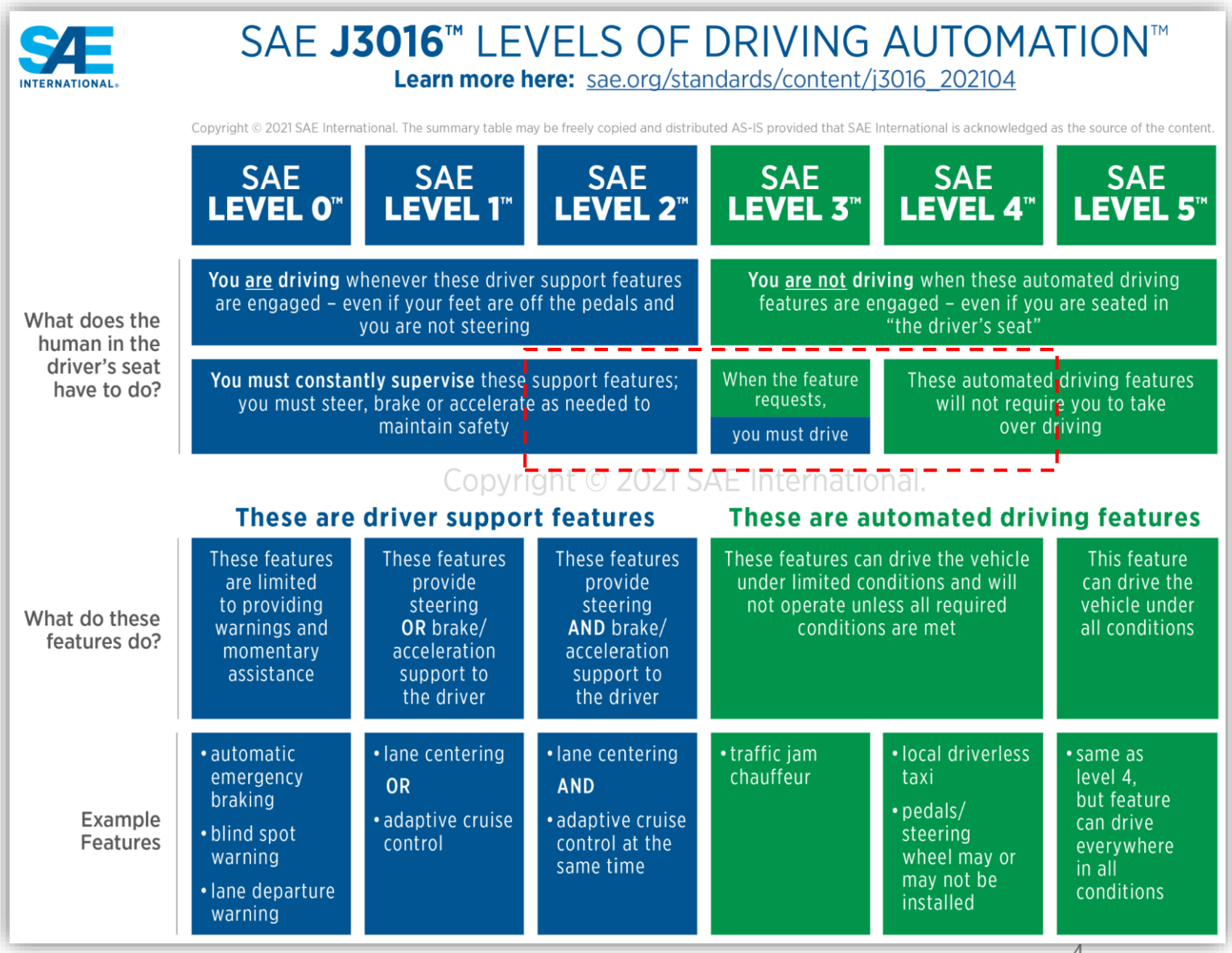
SAE 레벨 3과 SAE 레벨 4의 차이에 대한 추가적인 설명

"remote assistance" 및 "remote driving" 신규 용어 정의

레벨 1 및 레벨 2 에서 "Driver Support" 표현 사용

"failure mitigation strategy" 용어 정의

등



출처: 'SAE Levels of Driving Automation™ Refined for Clarity and International Audience' SAE, 2021.05

01. SAE J3016

미국 교통부(USDOT), SAE J3016 채택

2016년, 미국 교통부는 'Federal Automated Vehicles Policy (FAVP)'를 발간하고, SAE J3016에서 정의한 자율주행 레벨 채택

이후 해당 분류법은 자율주행 산업에서 가장 많이 인용되는 사실상(de facto) 표준으로 통용

C. Overview: DOT's Vehicle Performance Guidance

Figure I provides the framework for DOT's Vehicle Performance Guidance. It is the manufacturer or other entity's responsibility to determine their system's AV level in conformity with SAE International's published definitions. (NHTSA will review manufacturers' automation level designations and advise the manufacturer if the Agency disagrees with the level assigned by the manufacturer.) The figure identifies the key areas to be addressed by manufacturers and other entities prior to testing or deploying the vehicle on public roadways.

Figure I: Framework for Vehicle Performance Guidance

Scope & Process Guidance

- Test/Production Vehicle
- FMVSS Certification/ Exemption
- HAV Registration

Guidance Applicable to All HAV Systems on the Vehicle

- Data Recording and Sharing
- Privacy
- System Safety
- Vehicle Cybersecurity
- Human-Machine Interface
- Crashworthiness
- Consumer Education and Training
- Post-Crash Vehicle Behavior
- Federal, State and Local Laws
- Ethical Considerations

Guidance Specific to Each HAV System

Describe the ODD (Where does it operate?)	Object and Event Detection and Response	Fall Back Minimal Risk Condition
Geographic Location	Normal Driving	Driver / System
Roadway Type	Crash Avoidance - Hazards	
Speed		
Day/Night		
Weather Conditions		
Other Domain Constraints		

- Testing and Validation
  - Simulation
  - Track
  - On-Road

01. SAE J3016

미래 모빌리티 시장, 기술, 및 정책을 제대로 파악하려면 자율주행 레벨 이해가 필수

SAE J3016는 레벨 2+, 레벨 2.5 등 사용을 지양할 것을 권고

EV9 오너들 목빠질라… '레벨3 자율주행' 더 미뤄진다

입력 2023.10.12 16:15 수정 2023.10.12 16:20 편은지 기자 (silver@dailian.co.kr)

고속 도로 자율주행 'HDP' 도입 당장 어려워
"실도로 주행서 변수 많아… 추가 테스트 필요"

대한민국정부 보 도 자 료 대한민국 대전환 한국판뉴딜

2021년 3월 24일(수) 석간부터 보도하여 주시기 바랍니다.
(인터넷, 방송, 통신은 3. 24(수) 오전 6시 이후 보도 가능)

배포일시	2021. 3. 23.(화)	담당부서	산업통상자원부 미래자동차산업과
담당과장	산업통상자원부미래자동차산업과장 서길원 과장(044-203-4340)	담 당 자	김상효 사무관(044-203-4342)
	과기정통부 디지털포용정책팀 김준동 팀장(044-202-6150)		황선영 사무관(044-202-6152)
	국토교통부 첨단자동차과 이창기 과장(044-201-3847)		이정규 사무관(044-201-3852)
	경찰청 교통운영과 김한철 과장(02-3150-2753)		이창민 경정(02-3150-2751)

자율주행 레벨 4+ 상용화 앞당긴다!
– 「자율주행기술개발혁신사업단」 공식 출범 –
– '27년까지 총 1.1조원 투입, 융합형 Lv 4+ 자율주행차 상용화 기반 완성 목표 –

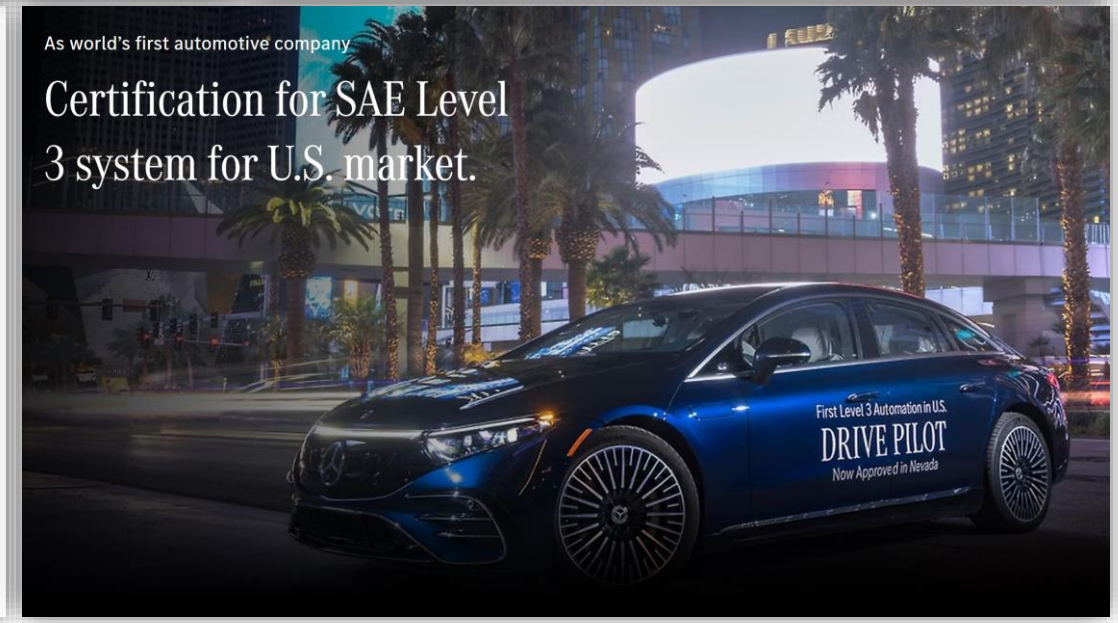
과학기술정보통신부 보 도 자 료 대한민국 대전환 한국판뉴딜

보도 일시	2022. 4. 6.(수) 12:00 (2022. 4. 7.(목) 조간)	배포 일시	2022. 4. 6.(수) 09:00
담당 부서	과학기술정보통신부 과학기술정보분석과	책임자	과 장 김영은(044-202-6960)
		담당자	주무관 김정우(044-202-6966)

과기정통부, 『단계(레벨) 4 이상 자율주행의 미래』 책자 발간
– 2021년 기술영향평가 결과, 전문가와 시민들이 함께 한 정책제언 –

□ 과학기술정보통신부(장관 임혜숙, 이하 '과기정통부')는 2021년 기술영향평가 결과*를 담은 '레벨 4 이상 자율주행의 미래' 책자를 발간하였다.

* 기술영향평가위원회, 시민포럼, 온라인 의견 창구 등을 통해 도출한 기술영향평가 결과



02. ISO/SAE PAS 22736

SAE 및 ISO의 공동작업을 통한 단일 표준 개발

SAE 및 ISO/TC 204/WG 14이 공동으로 단일 표준 개발

2021년, SAE J3016 개정본 및 ISO/SAE PAS 22736 표준 발간

현재, SAE ORAD Committee 및 ISO/TC 204/WG 14 산하 JWG에서 ISO/SAE TS 22736을 목표로 개정 추진

대한민국, 미국, 캐나다, 영국, 일본, 독일 및 SAE 전문가들(대표: 차홍기)

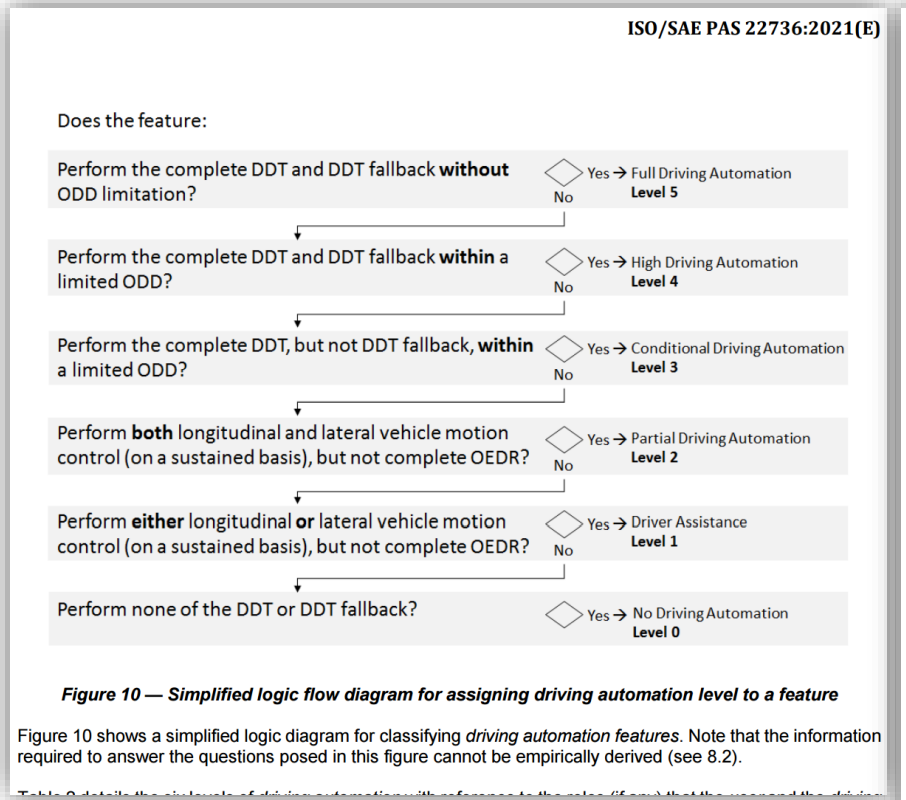
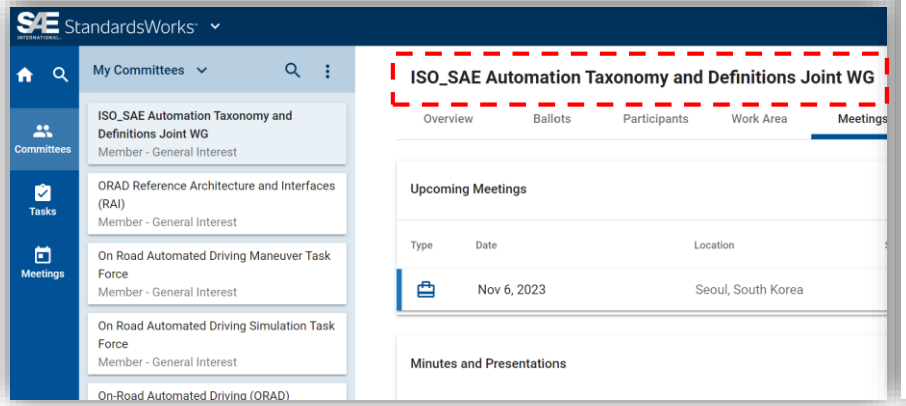
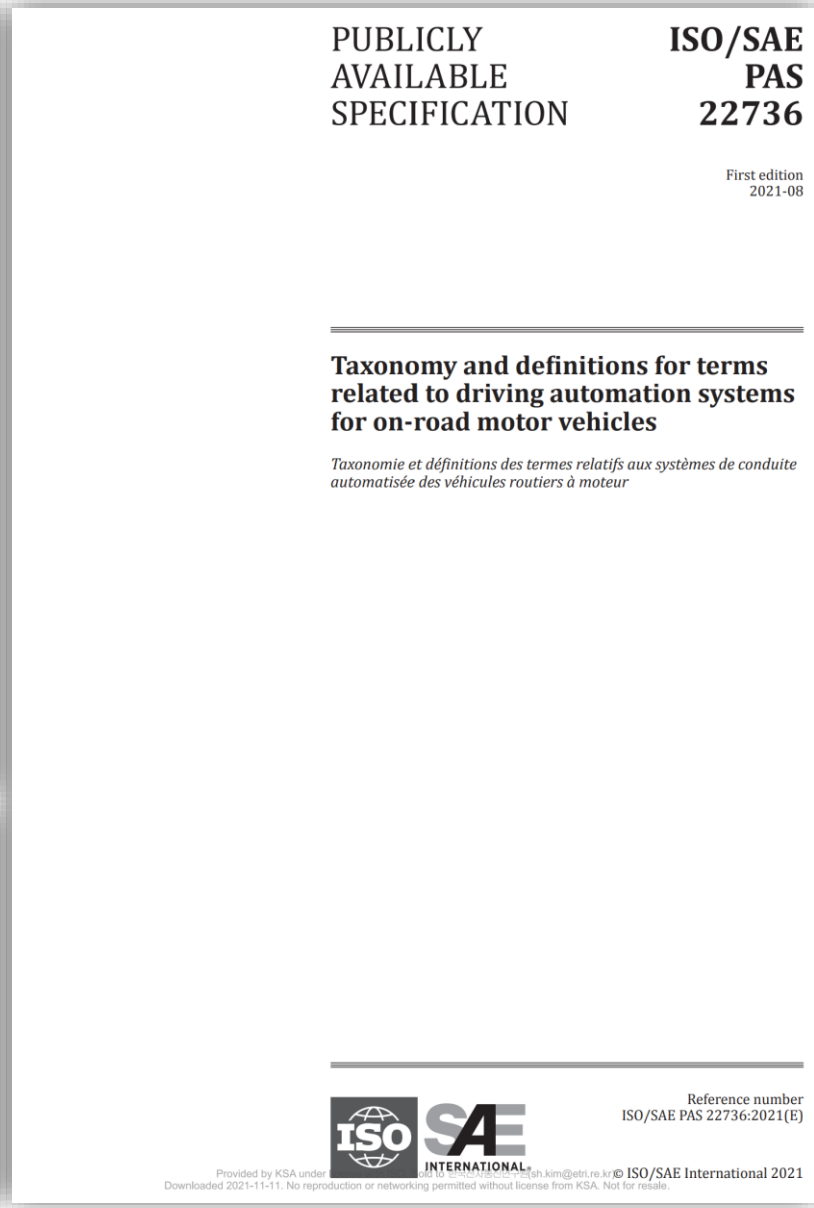


Figure 10 — Simplified logic flow diagram for assigning driving automation level to a feature

Figure 10 shows a simplified logic diagram for classifying *driving automation features*. Note that the information required to answer the questions posed in this figure cannot be empirically derived (see 8.2).





03. KR R ISO/SAE PAS 22736

도로 차량 운전자동화 시스템의 분류와 용어 정의

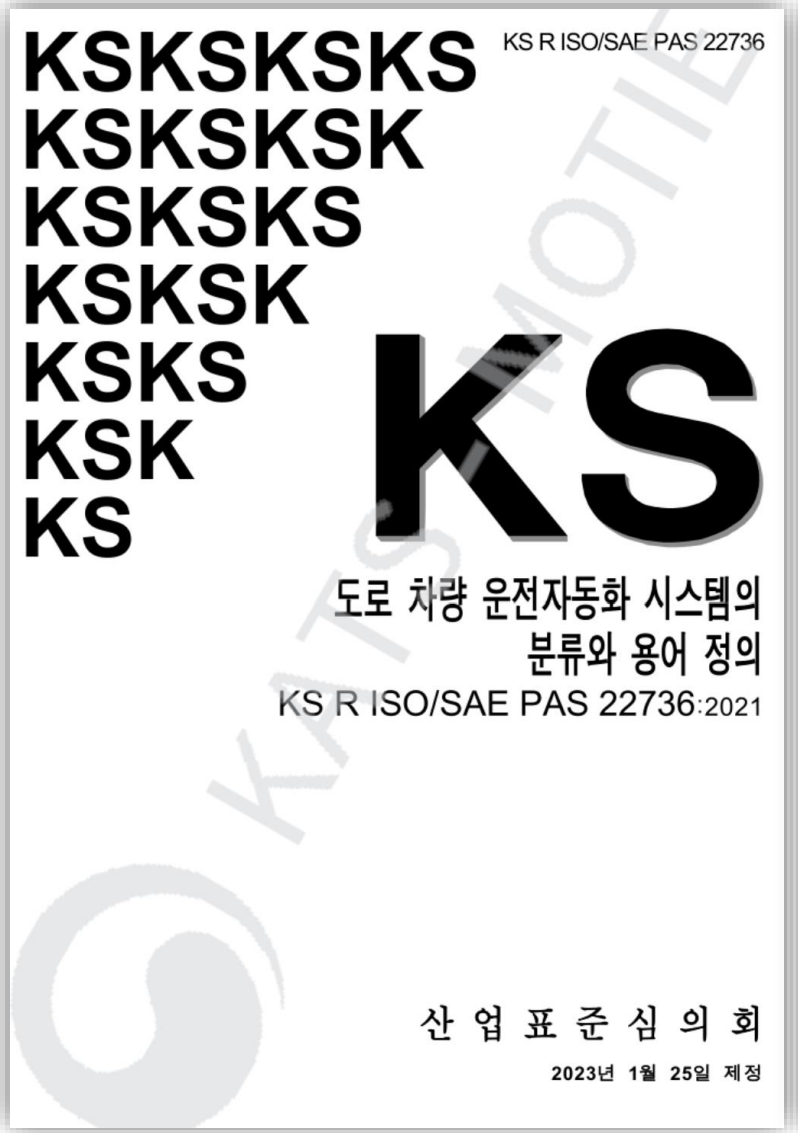
ISO/SAE PAS 22736를 기반으로 개발

SAE J3016 및 ISO/SAE PAS 22736을 더 빠르고 쉽게 이해 가능

국내 현재 산업계에서 사용하는 용어를 사용하되, 국내외 관련 표준 및 법규에서 사용하는 용어와 통일성 지향

표준 해설서 포함

문서 작성 시 주요 용어를 우리말로 쉽게 번역 가능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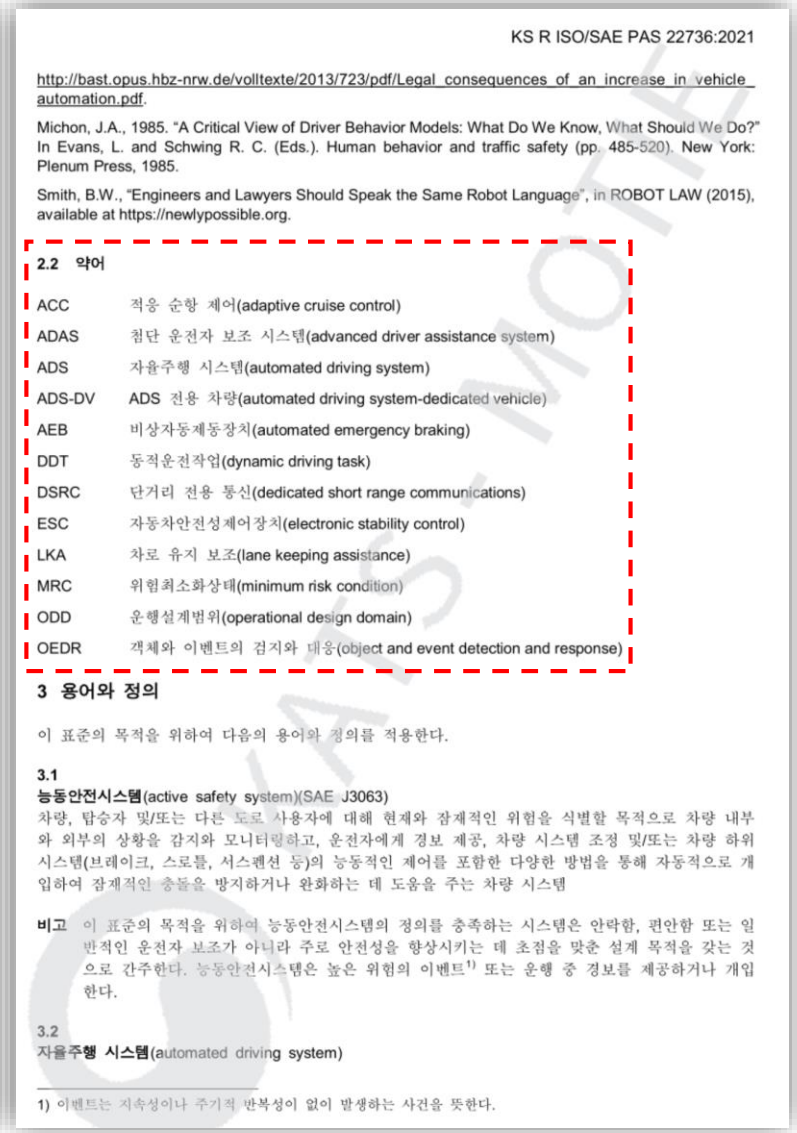
도로 차량 운전자동화 시스템의 분류와 용어 정의

KS R ISO/SAE PAS 22736:2021

산 업 표 준 심 의 회

2023년 1월 25일 제정


KS R ISO/SAE PAS 22736:2021

http://bast.opus.hbz-nrw.de/volltexte/2013/723/pdf/Legal_consequences_of_an_increase_in_vehicle_automation.pdf.

Michon, J.A., 1985. "A Critical View of Driver Behavior Models: What Do We Know, What Should We Do?" In Evans, L. and Schwing R. C. (Eds.). Human behavior and traffic safety (pp. 485-520). New York: Plenum Press, 1985.

Smith, B.W., "Engineers and Lawyers Should Speak the Same Robot Language", in ROBOT LAW (2015), available at https://newlypossible.org.

2.2 약어

ACC	적응 순항 제어(adaptive cruise control)
ADAS	첨단 운전자 보조 시스템(advanced driver assistance system)
ADS	자율주행 시스템(automated driving system)
ADS-DV	ADS 전용 차량(automated driving system-dedicated vehicle)
AEB	비상자동제동장치(automated emergency braking)
DDT	동적운전작업(dynamic driving task)
DSRC	단거리 전용 통신(dedicated short range communications)
ESC	자동차안전성제어장치(electronic stability control)
LKA	차로 유지 보조(lane keeping assistance)
MRC	위험최소화상태(minimum risk condition)
ODD	운행설계범위(operational design domain)
OEDR	객체와 이벤트의 검지와 대응(object and event detection and response)

3 용어와 정의

이 표준의 목적을 위하여 다음의 용어와 정의를 적용한다.

3.1
능동안전시스템(active safety system)(SAE J3063)
차량, 탑승자 및/또는 다른 도로 사용자에 대해 현재와 잠재적인 위험을 식별할 목적으로 차량 내부와 외부의 상황을 감지와 모니터링하고, 운전자에게 경보 제공, 차량 시스템 조정 및/또는 차량 하위 시스템(브레이크, 스로틀, 서스펜션 등)의 능동적인 제어를 포함한 다양한 방법을 통해 자동적으로 개입하여 잠재적인 충돌을 방지하거나 완화하는 데 도움을 주는 차량 시스템

비고 이 표준의 목적을 위하여 능동안전시스템의 정의를 충족하는 시스템은 안락함, 편안함 또는 일반적인 운전자 보조가 아니라 주로 안전성을 향상시키는 데 초점을 맞춘 설계 목적을 갖는 것으로 간주한다. 능동안전시스템은 높은 위험의 이벤트[1] 또는 운행 중 경보를 제공하거나 개입한다.

3.2
자율주행 시스템(automated driving system)

1) 이벤트는 지속성이나 주기적 반복성이 없이 발생하는 사건을 뜻한다.

03. SAE, ISO, 한국, 일본 및 중국

출처(1): '自動車用運転自動化システムのレベル分類及び定義 (TP-18004-22)', 2022.03
출처(2): '汽车驾驶自动化分级 (GB/T 40429-2021)', 2021.08

	SAE	ISO	한국	일본(1)	중국(2)
레벨 0	No Driving Automation	No Driving Automation	운전자동화없음	運転自動化なし (운전자동화없음)	应急辅助 (응급보조)
레벨 1	Driver Assistance	Driver Assistance	운전자보조	運転支援 (운전지원)	部分驾驶辅助 (부분조종보조)
레벨 2	Partial Driving Automation	Partial Driving Automation	부분운전자동화	部分的運転自動化 (부분적운전자동화)	组合驾驶辅助 (조합조종보조)
레벨 3	Conditional Driving Automation	Conditional Driving Automation	조건부운전자동화	条件付き運転自動化 (조건부운전자동화)	有条件自动驾驶 (유조건자동조종)
레벨 4	High Driving Automation	High Driving Automation	고도운전자동화	高度運転自動化 (고도운전자동화)	高度自动驾驶 (고도자동조종)
레벨 5	Full Driving Automation	Full Driving Automation	완전운전자동화	完全運転自動化 (완전운전자동화)	完全自动驾驶 (완전자동조종)

04. UNECE FRAV

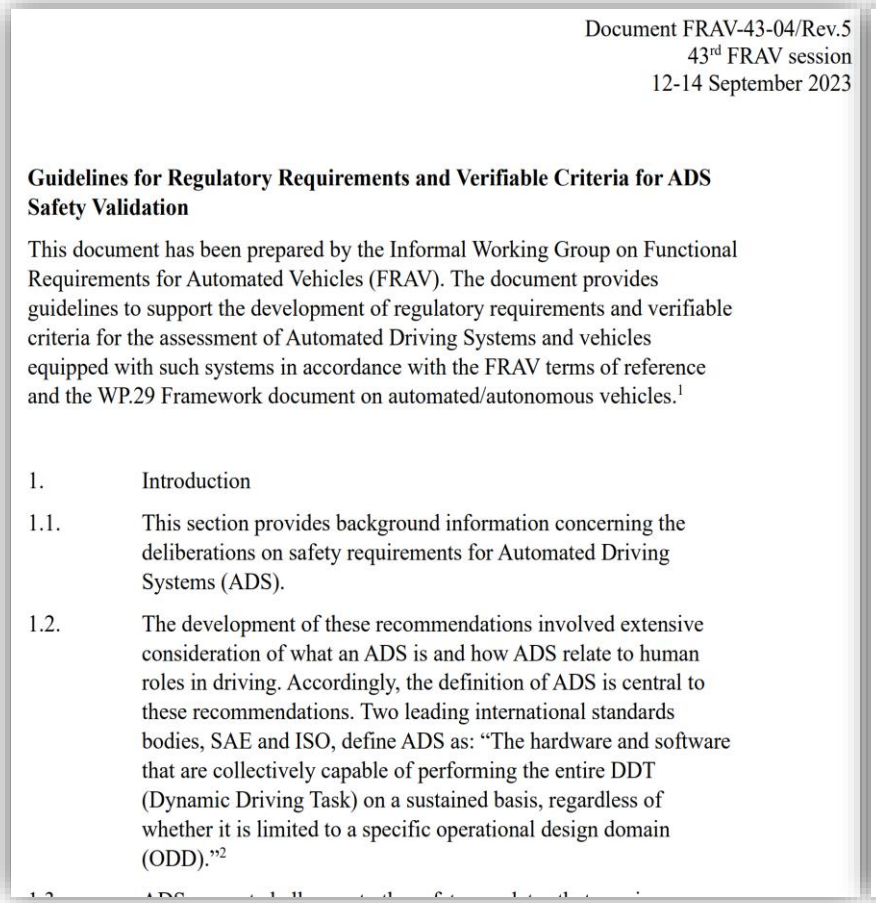
Guidelines for regulatory requirements and for verifiable criteria for ADS safety validation

World Forum for Harmonization of Vehicle Regulations (WP.29) 산하

Working Party on Automated/Autonomous and Connected Vehicles (GRVA) 산하

FRAV Informal Working Group (IWG)에서 Informal document 로 작업

약 70% 정도의 용어는 SAE J3016에서 정의한 용어 정의와 동일하고, 나머지는 일부 수정



Document FRAV-43-04/Rev.5
43rd FRAV session
12-14 September 2023

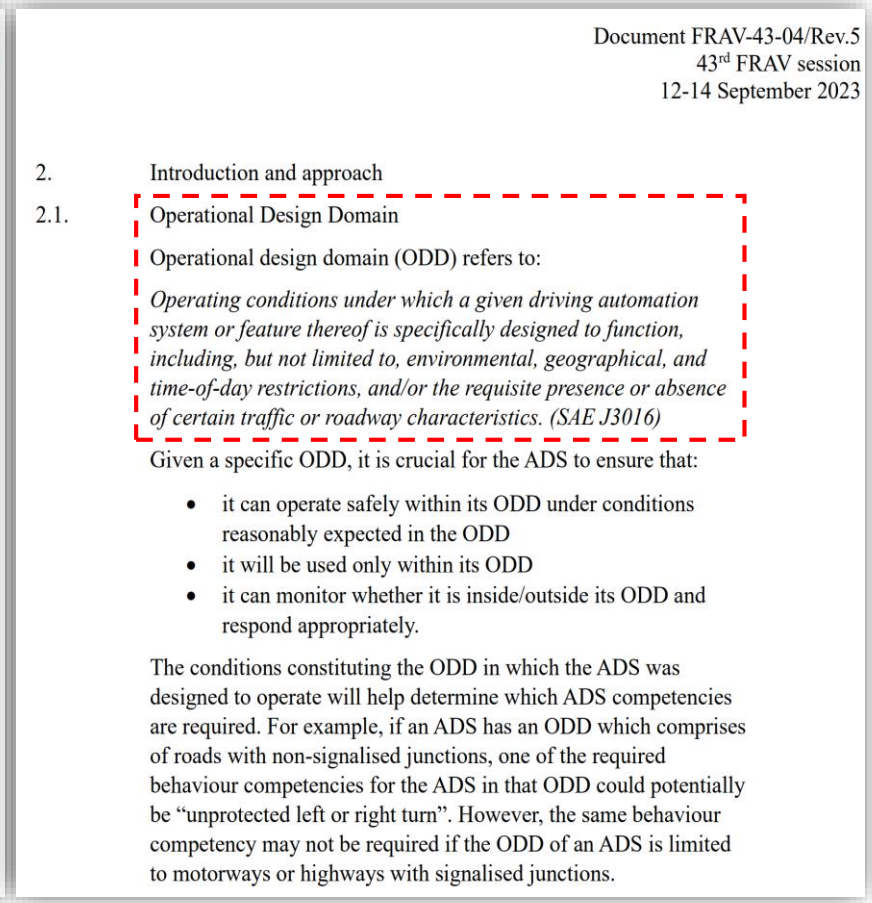
Guidelines for Regulatory Requirements and Verifiable Criteria for ADS Safety Validation

This document has been prepared by the Informal Working Group on Functional Requirements for Automated Vehicles (FRAV). The document provides guidelines to support the development of regulatory requirements and verifiable criteria for the assessment of Automated Driving Systems and vehicles equipped with such systems in accordance with the FRAV terms of reference and the WP.29 Framework document on automated/autonomous vehicles.[1]

1. Introduction

1.1. This section provides background information concerning the deliberations on safety requirements for Automated Driving Systems (ADS).

1.2. The development of these recommendations involved extensive consideration of what an ADS is and how ADS relate to human roles in driving. Accordingly, the definition of ADS is central to these recommendations. Two leading international standards bodies, SAE and ISO, define ADS as: "The hardware and software that are collectively capable of performing the entire DDT (Dynamic Driving Task) on a sustained basis, regardless of whether it is limited to a specific operational design domain (ODD)."[2]



Document FRAV-43-04/Rev.5
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2. Introduction and approach

2.1. Operational Design Domain

Operational design domain (ODD) refers to:

Operating conditions under which a given driving automation system or feature thereof is specifically designed to function, including, but not limited to, environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics. (SAE J3016)

Given a specific ODD, it is crucial for the ADS to ensure that:

- it can operate safely within its ODD under conditions reasonably expected in the ODD
- it will be used only within its ODD
- it can monitor whether it is inside/outside its ODD and respond appropriately.

The conditions constituting the ODD in which the ADS was designed to operate will help determine which ADS competencies are required. For example, if an ADS has an ODD which comprises of roads with non-signalised junctions, one of the required behaviour competencies for the ADS in that ODD could potentially be "unprotected left or right turn". However, the same behaviour competency may not be required if the ODD of an ADS is limited to motorways or highways with signalised junctions.

05. SAE J3016 배우기: 주요 용어 및 정의

3.2 AUTOMATED DRIVING SYSTEM (ADS)

The hardware and software that are collectively capable of performing the entire *DDT* on a *sustained* basis, regardless of whether it is limited to a specific *operational design domain* (*ODD*); this term is used specifically to describe a Level 3, 4, or 5 *driving automation system*.

3.2
자율주행 시스템(automated driving system)
ADS
특히 레벨 3, 레벨 4 또는 레벨 5의 운전자동화시스템을 기술할 목적으로 사용하는 용어로, 특정한 운행설계범위(ODD)에 대한 제한 여부와 상관없이 지속적으로 DDT 전체를 집합적으로 수행할 수 있는 하드웨어와 소프트웨어

3.10 DYNAMIC DRIVING TASK (DDT)

All of the real-time *operational* and tactical functions required to *operate* a *vehicle* in on-road traffic, excluding the strategic functions such as *trip* scheduling and selection of destinations and waypoints, and including, without limitation, the following subtasks:

1. Lateral *vehicle* motion control via steering (*operational*).
2. Longitudinal *vehicle* motion control via acceleration and deceleration (*operational*).
3. Monitoring the driving environment via object and event detection, recognition, classification, and response preparation (*operational* and tactical).
4. Object and event response execution (*operational* and tactical).
5. Maneuver planning (tactical).
6. Enhancing conspicuity via lighting, sounding the horn, signaling, gesturing, etc. (tactical).

3.10
동적운전작업(dynamic driving task)
DDT
트립 일정, 목적지와 경유지 선택과 같은 전략적인 기능은 제외하며 다음을 포함하나 이에 한정되지는 않는, 도로 위 차량 운행에 필요한 모든 실시간 운행과 전술적인 기능

1) 조향을 통한 횡방향 차량 운동 제어(운행)
2) 가속과 감속을 통한 종방향 차량 운동 제어(운행)
3) 객체와 이벤트 검지, 인식, 분류 및 응답 준비를 통해 주행 환경 모니터링(운행과 전술)
4) 객체와 이벤트 응답 실행(운행과 전술)
5) 거동 계획(전술)
6) 조명, 경적 울림, 신호, 제스처 등을 통해 시인성 개선(전술)

3.19 OBJECT AND *EVENT* DETECTION AND RESPONSE (OEDR)

The subtasks of the *DDT* that include monitoring the driving environment (detecting, recognizing, and classifying objects and events and preparing to respond as needed) and executing an appropriate response to such objects and events (i.e., as needed to complete the *DDT* and/or *DDT fallback*).

3.19
객체와 이벤트의 검지와 대응(object and event detection and response)
OEDR
주행 환경 모니터링(객체와 이벤트 검지, 인식 및 분류, 필요시 응답 준비)을 포함하고, 이러한 객체와 이벤트(즉, DDT 및/또는 DDT 폴백 완료에 필요한 경우)에 대한 적절한 대응을 포함하는 DDT의 하위 작업

3.21 OPERATIONAL DESIGN DOMAIN (ODD)

Operating conditions under which a given *driving automation system* or *feature* thereof is specifically designed to function, including, but not limited to, environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics.

3.21
운행설계범위(operational design domain)
ODD[1)]
주어진 운전자동화시스템 또는 그 기능이 환경적, 지리적, 시간적(time-of-day) 제약 및/또는 특정 교통이나 도로 특성의 필요 유무를 포함하여 작동하도록 특정되어 설계된 운행 조건

05. SAE J3016 배우기: 자율 주행 레벨

06. 결론

미래 모빌리티 시장, 기술, 및 정책을 제대로 파악하려면 자율주행 레벨 이해가 필수

SAE J3016 및 ISO/SAE TS 22736, 2024년 하반기 개정 추진

SAE ORAD Definitions Task Force – J3016 Working Group: 격주 개최(새벽 4시)

SAE ORAD Committee: 매월 개최(새벽 4시)

ISO/TC 204/WG 14 산하 JWG: 격월 개최

운전 자동화의 단계적 구분

	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
레벨 구분						
	운전자 보조기능			자율주행 기능		
명칭	無 자율주행 (No Automation)	운전자 지원 (Driver Assistance)	부분 자동화 (Partial Automation)	조건부자동화 (Conditional Automation)	고도 자동화 (High Automation)	완전 자동화 (Full Automation)
자동화 항목	없음 (경고 등)	조향 or 속도	조향 & 속도	조향 & 속도	조향 & 속도	조향 & 속도
운전 주시	항시필수	항시필수	항시필수 (조향핸들 상시잡고 있어야함)	시스템 요청시 (조향핸들 잡을필요X, 제어권 전환시만 잡을 필요)	작동구간 내 불필요 (제어권 전환X)	전 구간 불필요
자동화 구간	–	특정구간	특정구간	특정구간	특정구간	전 구간
시장 현황	대부분 완성차 양산	대부분 완성차 양산	7~8개 완성차 양산	1~2개 완성차 양산	3~4개 벤처 생산	없음
예시	사각지대 경고	차선유지 또는 크루즈기능	차선유지 및 크루즈 기능	혼잡구간 주행 지원 시스템	지역(Local) 무인택시	운전자 없는 완전 자율주행

출처: '레벨 4 이상 자율주행의 미래' 과학기술정보통신부, 2022.04

감사합니다.

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