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Intelligent transport systems — Vehicle/roadway warning and control systems — Report on standardisation for vehicle automated driving systems (RoVAS)/Beyond driver assistance systems

Systèmes intelligents de transport — Systèmes d'alerte et de commandes des véhicules/chaussées — Rapport sur la normalisation des systèmes de conduite automatisée des véhicules (RoVAS)/systèmes d'aide à la conduite

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Foreword

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This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

Introduction

In recent years, rapid progresses of sensing and computational technologies have promoted research and development on automated driving systems. Some systems have already been commercialized and have begun to be installed in production vehicles. Standardization activities for automated driving systems have been advanced as well. Amid ongoing practical implementation of the systems, standardization for automated driving systems should be stimulated.

In the future, various automated driving systems will be increasingly introduced in the automotive industry. For appropriate usage of these systems by general users, it is important for us to make a distinction between a vehicle's functions and the driver's role to avoid confusion. Therefore, several International Standards should be established that can be shared widely. However, from current perspective, it seems to be not clear which items should be standardized. Nevertheless, since more advanced systems for automated driving systems will be introduced in the near future, standardization will widely consider and assess candidates for standardization to ensure covering not only the functions of an automated driving system itself, but also contributing or enabling issues for each system.

Therefore, this document outlines potential standardization areas and items and marshal them in a systematic manner to distinguish potential standardization for various automated vehicle systems. It is also intended to cover the need for standardization on the usage of automated driving systems in a heterogeneous traffic condition (where not all vehicles are automated). This document does neither determine the area of standardization body, where the work should be performed, nor the recommendation of specific standardization.

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This document should be helpful for those who consider and/or develop standards for automated driving systems. Use case of this document may be as follows; to share common perceptions of standardization, to clarify perspectives of standardization, to take standardization items, to estimate coverages and priorities of items, and to consider feature of technologies or products.

Intelligent transport systems — Vehicle/roadway warning and control systems — Report on standardisation for vehicle automated driving systems (RoVAS)/Beyond driver assistance systems

1 Scope

This document provides the results of consideration on potential areas and items of standardization for automated driving systems. In this document, automated driving systems are defined as systems that control longitudinal and lateral motions of the vehicle at the same time.

Potential standardization areas and items are widely extracted and marshalled in a systematic manner to distinguish potential standardization for various automated vehicle systems. When, what, and by whom the standardization activities are actually done are discussed separately.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Extracting potential areas for standardization

4.1 Principles

4.1.1 General

This clause presents basic concepts for items related to automated driving systems for standardization. Examples of basic architectures have been considered and potential areas for standardization, based on these examples have been derived. Aside from this, items based on actual standardization activities and other important issues have been extracted.

4.1.2 Issues based on architectures

4.1.2.1 General

It is effective to extract areas for standardization based on architecture. This section suggests an example of notional architecture based on automated driving systems. This is not a proposal for a standard, but intended for use when for considering potential standardization items systematically.

It might be suggested that areas for standardization are standards for each entity and interface between entities. Functional transitions are especially important in the architecture of automated driving systems.

4.1.2.2 Functional architecture

An automated driving system as a whole is given as an example of the notional functional architecture of systems in Figure 1.

Under normal driving, a driver recognizes the driving environment (S1: on) and operates a vehicle (S5: on). Under automated driving, operation is entrusted to the in-vehicle system (S4: on). Additionally, the system shows its condition to the driver and he/she may adjust the system as needed (S2: on). The vehicle may be operated by the driver and the in-vehicle system also (S4: on and S5: on). Under fully automated driving, there is no need for the driver to be involved in operation. The driver does not need to recognize the environment (S1: off) nor monitor the in-vehicle systems (S2: off).

Alternatively, there are two types of automated driving modes: the non-connected (autonomous) type and the connected type. The non-connected type does not communicate with infrastructure and/or other vehicles (S3: off). The connected type communicates with infrastructure and/or other vehicles (S3: on). The connected type receives external information from infrastructure and/or other vehicles and transmits its own information to them also.

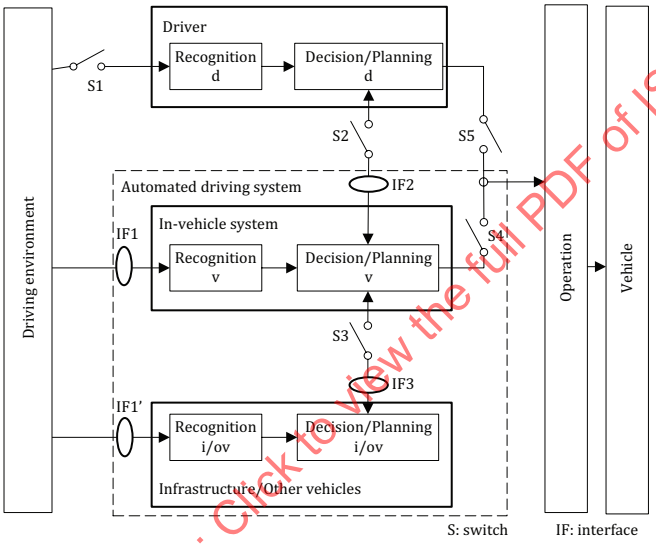

Figure 1 — Example of notional functional architecture

There might be a need to develop standards for the functional requirements of recognition, decision and planning, requirements for interfaces between elements, and standards for designing automated driving systems that can adapt to changes of switch positions. For future introduction, on behalf of users, of its design for systems that is widely shared, International Standards need to be established.

4.1.2.3 Physical architecture

An example of notional physical architecture is shown in Figure 2. This is not a proposal for a standard, but intended for use when for considering potential standardization items systematically.

Standards for each entity and interfaces between entities may be subjects of standardization. However, physical architecture and functions differ depending on the implementation of each system. Therefore, the specifications of physical elements and their standard are not discussed in this document, although those might be subject to international standards.

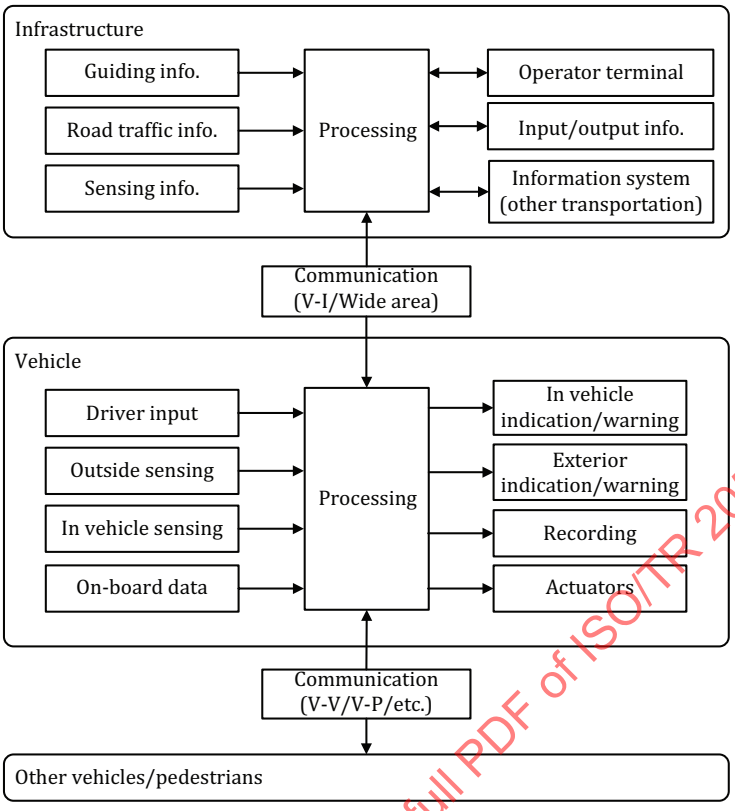

Figure 2 — Example of notional physical architecture

4.1.3 Issues based on activities

In addition, areas for standardization are extracted, considering the activities for standardizing automated driving systems as described in Annex A.

It is suggested that areas for standardization be definitions of levels of automated driving systems, terms, and testing issues.

4.1.4 Other important issues for automated driving systems

Several important potential standardization items that are not shown in the architecture are proposed.

For instance, standards might be developed for safety, reliability, security, recording (event data recorder), principle of privacy, test methods and distinguishing automated driving systems from non-automated driving systems.

4.2 Proposal of standardization items

4.2.1 Classification

Potential standardization areas and items are extracted in the previous section. In this section, potential areas of standardizations are classified in three categories: common items, basic functional requirements and other items.

NOTE Items are mapped and listed in Annex B.

4.2.2 Common items

a) Terminology

Today, automated driving systems are being discussed in various countries and regions. However, there is no common International Standard for definitions of terms of automated driving systems. As a result, different groups use terms in different ways. For instance, one word may have different meanings, or several words may be used to express the same idea.

To prevent confusion among users and to share a common understanding among stakeholders, terms for automated driving systems might be potential standardization areas.

For instance, the concept of automated driving systems might be a potential standardization item because it has a wide range of meanings.

b) Levels of automation

As shown in A.6, several institutions, including SAE, NHTSA and BASt, define automation levels. However, their definitions differ in terms of descriptions and criteria.

There is a need to standardize automation levels to prevent misunderstandings among users and to have a shared understanding among stakeholders.

The name of each level, which is easy to understand, and description of each level including examples of use, are needed.

The definitions of automation levels in A.6 are based on the following elements:

— the subject of control by systems;

— division of authority between driver and systems [driver's presence, response to faults and failures (override, etc.) transition time, driver's position, monitoring environment, monitoring systems, control operations, start/stop];

— operating environment (time, place, weather, road conditions, road structures, traffic conditions, speed, etc.).

c) Automated driving system reference architecture

There are many systems that can be used for automated driving systems. Having a common understanding of systems might be a potential standardization area. To define reference architecture would be useful to discuss and consider functions for automated driving systems.

For example, the communication protocol field has reference architectures such as the OSI model to promote a common understanding by everyone. It is a layered model of communication functions, which provides a common understanding when discussing communication protocols and systems.

4.2.3 Basic functional requirements

a) System requirements of each automation level

Requirements for automated driving systems at each automation level may include recognition, decision and planning of automated driving system's area and requirements of on/off switching conditions of S1, S2 and S3, which are connections of interfaces under the notional functional architecture in Figure 1.

For instance, standardizing recognition of driving status (positioning, static or dynamic condition of status such as maps and traffic jam information), sensing targets and area, control performance (responsive and control area), checks of status and information to driver might be considered.

b) Functional allocation between system and driver at each automation level

Requirements for functional allocation between system and driver at each automation level may be considered. They relate interface IF2 between driver and in-vehicle system under the notional functional architecture in Figure 1.

For instance, standardization of requirements for monitoring/estimating driving state and system operation, requirements for driver to recover driving might be considered.

c) Requirements regarding transition of functions between system and driver at each automation level

Requirements regarding transition of functions between system and driver of each automation level may be considered. They include transition of on/off switching condition of S1, S2, S4 and S5, and interface IF2 under the notional functional architecture in Figure 1.

For instance, for standardizing information provided by a system, time requirements for control change, interaction with driver, and HMI might be considered.

d) Requirements regarding system transition between automation levels

Requirements regarding system transition between levels may be considered. They include transition of on/off switching conditions of S1, S2, S4 and S5, and interface IF2 under the notional functional architecture in Figure 1.

For instance, for standardizing information provided by a system, time requirements for control change, interaction with driver, and HMI might be considered.

e) Requirements in case of system malfunction at each automation level

Requirements of system operation in case of system malfunctions (recognition and decision/planning) at each level may be considered.

They include interface IF2 between driver and in-vehicle system on/off switching conditions of S1 and S2, on/off switching and transition conditions of S4 and S5 under the notional functional architecture in Figure 1.

For instance, standardizing requirements for system operation (processing principle in case of system malfunctions at each automation level) might be considered.

f) Elements of V2X communication requirements under cooperative systems

Requirements for a driver under cooperative systems may include interface IF3 between in-vehicle system and infrastructure/other vehicles if S3 is “on”, then a vehicle cooperates with infrastructure or other vehicles under the notional functional architecture Figure 1. V2X communication is required for automated parking known as “Automated valet parking system”, which does not need a vehicle to be driven by a human driver but may offer operating and monitoring from outside the vehicle.

For instance, standardization of requirements for message sets, data (contents, accuracy, etc.), latency, capacity, V2X communication range and security if a vehicle communicates with infrastructure or other vehicles might be considered.

g) Basic concepts regarding using combinations of information from in-vehicle sensors and V2X communications

Requirements for external information from infrastructure or other vehicles obtained from cooperative systems should be considered. A vehicle cooperates with infrastructure or other vehicles under the notional functional architecture in Figure 1, when S3 is “on”.

In case there are inconsistencies between the information received from in-vehicle sensors and V2X communications, data fusion approaches should be considered, weighing the different information based on the level of confidence in the accuracy of each. Basic concepts or requirements on these issues may be considered for standardization.

For instance, discrimination information to identify origin and/or characteristics (e.g. in cases of information that are given from different source are inconsistent) might be considered.

4.2.4 Other items

This clause intends to cover potential standardization items broadly. The advisability and availability of standardizations will be discussed and estimated from now on.

a) Reliability requirements

Requirements for reliability of automated driving systems may be considered for standardization.

For instance, there is a need to consider standardization of the following items:

— fault tolerance (capability that enables the system to continue normal operation if part of the systems fails);

— fail-safe (capability that makes the system emphasize safety to minimize harm if part of the system fails);

— fool proof (capability designed to ensure no harm results even if users operate it in the wrong way).

These items need to be considered in engineering automated driving systems. However, international standardization may be difficult due to differences in situation in various countries.

b) Security requirements

Security requirements may be considered for standardization.

For example, data security, cyber security requirements, requirements for preventing manipulation of sensors might be potential standardization items.

c) Requirements for event data recorder

Requirements for recording data in the operation of systems may be considered for standardization.

For example, there is a need to consider standardization of an event data recorder (When, what and how to record data) and principle of privacy handling (identifying personal information by tracking data, personal information dispersed by network).

d) Testing procedures

Requirements related to testing basic functional requirements, reliability, security, and recording system operation should be considered for standardization.

For instance, there may be a need to standardize for functional tests (test scenarios, etc.), safety analysis, hazard analysis, safety and reliability tests (test scenarios, test conditions, test use cases) and test methods (driving simulators, test tracks, desk check, emulation and condition of their combination).

e) Requirements for standard related certification

Requirements for permissions of automated driving systems may be considered for standardization.

For instance, there may be a need to standardize certification-related issue of systems (vehicles, on-board equipment and roadside equipment), testing method, system diagnostics (checklists before driving, etc.) and permission to operate automated driving systems on highways.

These items and related issues need to be considered in engineering automated driving systems. However, international standardization may be difficult due to differences in situation and rules in various countries.

f) Visible interfaces with other vehicles and pedestrians

The behaviour of automated driving systems may differ from that of vehicles driven by humans. Therefore, visible interfaces with other vehicles and pedestrians may be considered for standardization.

For instance, requirements for display of under automated driving, display of under platooning and interfaces that replace eye contact with other drivers and pedestrians may be considered.

NOTE Examples of analogous items are shown in Annex C.

5 Approach to standardization

5.1 Standards organizations

These are the standards development organizations related to automated driving systems:

— ETSI;

— SAE.

Discussions will be needed on the division of work by these organizations and cooperative work on standardization.

ISO/TC 204 will actively work on standardization activities for automated driving systems.

On the other hand, standardization of automated driving systems might be closely related to standards already developed or in the process of being developed. There may be a need to refer to their standards or to add automated driving system-related subjects in the next revision.

5.2 Priority

Priority should be considered for promoting standardization work focusing on the following viewpoints.

— Give priority to common and generic items, such as definitions of terms and automation levels.

— Give priority to items that will be introduced early.

The standards for each system should be prepared for individual situations. In addition, more investigation and discussions are needed for considering standardization for each entity and interfaces.

Annex A
(informative)

Related activities on standards for automated driving systems

A.1 General

This Annex provides an overview of activities related to the standardization of automated driving systems.

Various organizations in different countries and areas have started working on standardization activities. Standards and regulations based on standardization are also being discussed. As a result, International Standards for development need to be immediately established.

There are many examples of rules or regulations being established based on standards. For instance, some rules and regulations were established based on Lane Departure Warning Systems (see ISO 17361) and Lane Keeping Assist Systems (see ISO 11270).

To define automated driving systems, related issues are discussed in not only standard development organizations but other organizations or projects. Some examples of activities considering the levels of automated driving are shown in A.6.

A.2 Activities in North America

In North America, there are activities for standardizing automated driving systems and some rules and regulations are under consideration.

For instance, these are the following activities.

a) National Highway Traffic Safety Administration (NHTSA) defined automation levels. The NHTSA considers it premature at this time to establish rules for automated driving systems.

b) Society of Automotive Engineers (SAE) defined automation levels derived from the BASt levels. It has standardized requirements for testing automated driving systems also.

c) Institute of Electrical and Electronics Engineers (IEEE) is considering the standardization in relation to automated driving systems. Standards Coordinating Committee on Transportation (IEEE SCC 42 Transportation) was established to promote transportation standard, facilitate adoption and increase interoperability including automation fields.

d) Several states and the District of Columbia have authorized the testing of automated driving systems (e.g. Nevada, California, Washington DC, etc.).

e) California has already defined the regulations for the manufacturers testing of automated driving systems on public roads, and is in the process of defining the regulations for general users' operation of automated driving systems on public roads.

A.3 Activities in Europe

In Europe, several organizations are discussing standardization, regulation or definitions of automation levels, and are considering roadmaps for future applications of automated driving systems.

For instance, these are the following activities.

a) SMART64 (SMART 2010/0064) project defined automation levels in 2011. It also defined the requirements for automated vehicles and infrastructure, and roadmaps for implementing automated driving systems.

b) Automated Driving Applications and Technologies for Intelligent Vehicles (AdaptIVe) project is conducting research and development on automated driving systems. It is discussing legal issues at sub-project 2, Response 4.

c) The working group on automation of iMobility forum researched definitions for automation levels and terms, as well as the efficiency of automated driving systems. It is also discussing the need for standardizing automated driving systems.

d) European Telecommunications Standards Institute (ETSI) is paying attention to standardizing automated driving systems. It has started pre-standardization on two automation systems, CACC and platooning.

e) Verband der Automobilindustrie: German Association of the Automotive Industry (VDA) has established a coordination group on "Connected Automated Driving" that works comprehensively in all concerned areas of automated driving.

f) Bundesanstalt für Strassenwesen: Federal Highway Research Institute of Germany (BASt) defined automation levels in 2012. It is now discussing issues from legal perspectives.

g) In the United Kingdom, a Code of Practice for on-road testing of level 3-5 as per SAE levels of automation has been published. The UK government has provided funding to field trials of vehicle automation technology in 4 cities: Coventry, Milton Keynes, Greenwich and Bristol. The trials include studies on technological developments and also on human perception of the technology.

h) The Vehicle and Road Automation (VRA) project has a discussion group for standardization and certification needs. They discuss the approach towards standardization and certification, the needs and steps towards healthy market conditions. It aims to create an international network for collaboration with other areas, and to share its knowledge and research technologies with other organizations in European countries.

i) INnovative Testing of Autonomous Control Techniques (INTACT) project funded by the UK government is focused on testing and evaluating autonomous control systems in a safe, repeatable, controlled and scientifically rigorous environment.

A.4 Activities in Asia-Pacific region

In the Asian-Pacific region, several organizations are considering standardization for automated driving systems.

For instance, these are the following activities.

a) The Cross-Ministerial Strategic Innovation Promotion Program (SIP) conducted by the Japanese Cabinet Office announced it would promote research on automated driving systems as one project of SIP. The research project aims to conduct demonstrations to develop technologies for automated driving systems, to reduce casualties from traffic accidents and also to reduce traffic congestion, as well as apply automated driving systems to the introduction of next-generation transport systems. It also aims to encourage international cooperation. It plans to work on standardizing automated driving systems.

b) Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) of Japan has established a study group on auto-pilot systems (automated driving systems). It is discussing the requirements for automated driving systems to introduce in the future. It is also working on standardizing automated driving systems.

c) Japan Automobile Manufacturers Association (JAMA) has established a committee on automated driving systems, and it is discussing standardizing automated driving systems.

A.5 Other worldwide activities

International organizations are working on standards and regulation activities for automated driving systems.

For instance, these are the following activities.

a) ISO/TC 22 (Road vehicles) is discussing standardization of the human-machine interface (HMI) for automated driving systems.

b) United Nations Economic Commission for Europe (UNECE) is considering regulations for automated driving systems.

c) UNECE, Inland Transport Committee, Working Party 1 (Road Traffic Safety) is considering revisions to the articles of the Convention on Road Traffic (Vienna Convention) related to automated driving systems.

d) UNECE, Inland Transport Committee, Working Party 29 (World Forum for Harmonization of Vehicle Regulations) reached a basic agreement on the principles for automated driving systems, which is to be submitted to UNECE/ITC/Working Party 1 as a proposal.

e) UNECE Regulation No. 79 (Steering equipment) is under consideration as a revision to be adopted for automated driving systems.

f) International Organization of Motor Vehicle Manufacturers (OICA) is discussing terms and levels of functionality of automated driving systems.

A.6 Activities to define automated driving systems/levels

As described previously, levels of automated driving systems have been discussed in several organizations. Example of activities to define automated driving systems/levels are shown in Table A.1.

Table A.1 — Example of activities to define automated driving systems/levels

Organization/project	Related document
National Highway Traffic Safety Administration (NHTSA, US)	— Preliminary Statement of Policy Concerning Automated Vehicles, 2013 — Human Factors Evaluation of Level 2 and Level 3 Automated Driving Concepts: Concepts of Operation, 2014
Society of Automotive Engineers (SAE, US)	— J3016 Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems, 2014 — J3018 Guidelines for Safe On-Road Testing of SAE Level 3, 4, and 5 Prototype Automated Driving Systems (ADS)
SMART64 (EU)	— Definition of necessary vehicle and infrastructure systems for automated driving (SMART 2010/0064), 2011
Bundesanstalt für Strassenwesen (BASt, Germany)	— Legal consequences of an increase in vehicle automation, 2013
Cross-Ministerial Strategic Innovation Promotion Program (SIP, Japan)	Related documents are shown in the following website. The documents might be provided in Japanese only. http://www8.cao.go.jp/cstp/gaiyo/sip/iinkai/jidousoukou.html
Autopilot System meeting (MLIT, Japan)	Related documents are shown in the following website. The documents might be provided in Japanese only. http://www.mlit.go.jp/road/ir/ir-council/autopilot/

Annex B
(informative)

Mapping and table of potential standardization items

B.1 General

This annex summarizes potential standardization items shown in 4.2 diagrammatically to be identified at a glance. The description repeats 4.2 in order to summarize items touched on in the section and to enhance usability.

B.2 Item mapping

Figure B.1 shows a map of potential standardization items.

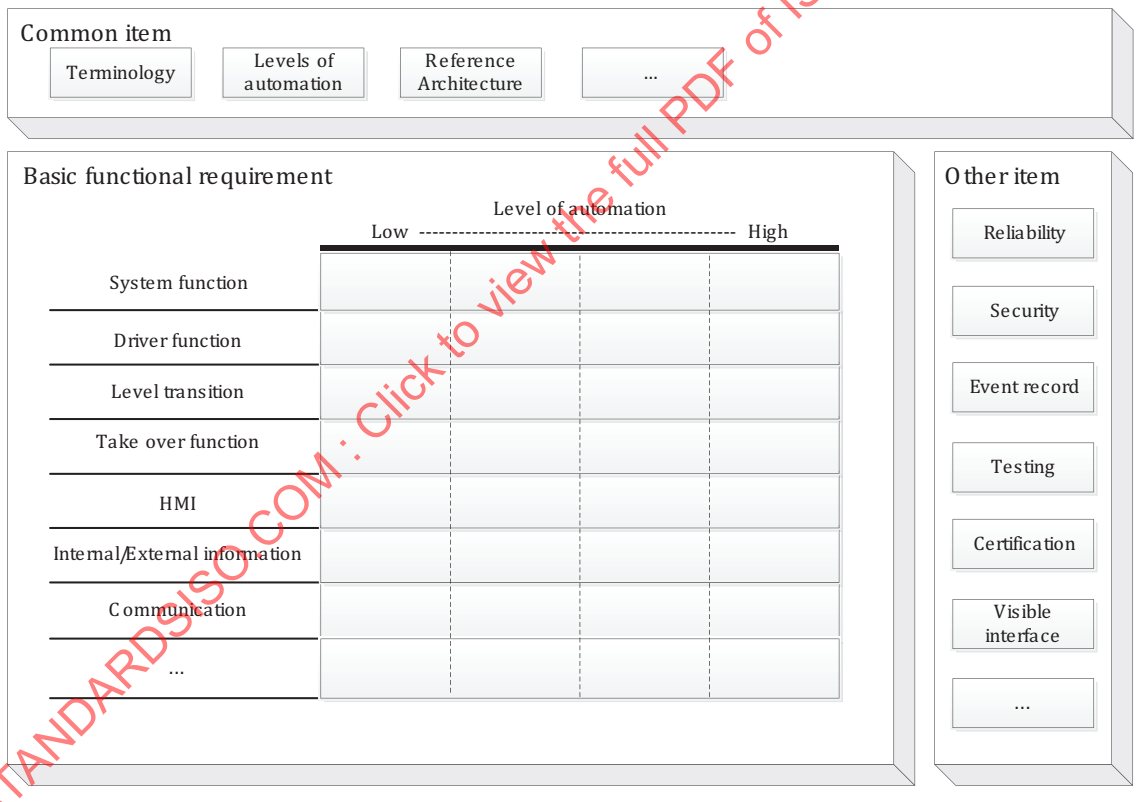

Figure B.1 — Item mapping

B.3 Table of items

Table B.1 shows a list of example potential standardization items.