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Road Traffic Safety (RTS) — Guidance on ethical considerations relating to safety for autonomous vehicles

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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 241, *Road traffic safety management systems*.

A list of all parts in the ISO 39000 series can be found on the ISO website.

Introduction

0.1 General

A long established and commonly held view is that the single most significant factor in road traffic safety are the actions of the driver. It must however be emphasized that the road transport system is a complex socio-technical system which places high demands on humans to negotiate. Crashes occur since human beings due to finite cognitive capacity and physiological limitations cannot always cope with these demands. To increase road safety the road transport system therefore has to be designed to support the road user to cope with this complexity and to mitigate the effects of crashes when this is not possible. When technology exceeds human capability autonomous vehicles have the potential to replace the human driver and to further increase road safety

Autonomous vehicles have the potential to replace the human driver and to increase road safety by reducing the opportunity of poor decision making and improper conduct in daily operations. This will probably take a long time and in the meantime the capabilities of technology and humans should be combined and integrated in such a way that the strengths of both are utilized efficiently. Important safety improvements were made over the last century, but AD technology provides new opportunities to improve safety even further.

Autonomous vehicles (AV) are unlikely to gain widespread acceptance until the travelling public feels assured of their safety and security, not only of passengers but also other vehicles and vulnerable road users. This includes a behaviour of the AV according to the desires and requirements of society. However, despite contemporary expectations and a very optimistic view on technology, humans have an extremely valuable faculty that machines will probably never possess -- ethical decision making and judgement. For real traffic situations the human does not always have the prerequisites to take a rational decision based on ethics since the time frame is often too narrow. For that reason, many “decisions” are made instinctively without the possibility of making a well-reasoned and balanced ethical decision. Defining this element and imparting it on machines is critical for the success of autonomous vehicles. This can only be achieved by ensuring that autonomous vehicles are equipped with driving rules that align with the general ethical beliefs, needs, and desires of humanity on a global level, subject to local specific nuances.

To achieve the imprint of global and local ethical considerations in AV design, there is a need for a framework of ethics involving the necessary stakeholders of different areas. To that objective’s end, it is important to develop standards for AV behaviour. The objective is to ensure that these vehicles are designed to minimize risk and behave in all circumstances in a way that is aligned with universal expectations of a fair society. While there are few standards available, or under development, that address the engineering and technological aspects of autonomous vehicles, there are no international standards that address aspects concerning the general topics of driving policy and ethical behaviour, which are also important. By driving policy we mean a general approach of how an AV makes a decision and performs manoeuvres. Ethical relevant behaviour represents positive or potentially negative impact on road users and especially the vulnerable ones as well as the public space at large.

The objective of this work is to lay out a framework for the development of a standard for ethical and societally accepted driving policy (e.g., those relating to fairness and equity with respect to other road users, the public space, and the environment).

0.2 The Concept of Autonomous Vehicles

Autonomous vehicles have the objective to substitute driver, including tasks, decisions, and responsibilities. Hence the driver behaviour model proposed by Michon (1985) and applied to autonomous vehicles by Ulbrich and colleagues (2013) (Figure 1) can be a start to design and operate autonomous vehicles. The driving task consists of three levels: the strategic level concerned with the higher-level trip goals (e.g., route choice), the tactical level concerned with the maneuvering decisions, including negotiations and interactions with other vehicles, and operational level concerned with the execution of these tactical and operational behaviours at the level of vehicle control. There is no strictly hierarchical relationship among these levels.

Figure 1 — Hierarchical model of driving task (source Ulbrich et al., 2013)

Beside this consideration which has a timely sequence, the autonomous vehicle must be designed thoroughly to ensure safe and secure operation, the decision base for the desired behavior need to be established. Therefore, all necessary information needs to be available, situation needs to be captured and understood while different perspectives will support the final decision.

Hence a functional decomposition into six layers (Amersbach, Winner, 2017) (Figure 2) can provide the first step into solution space.

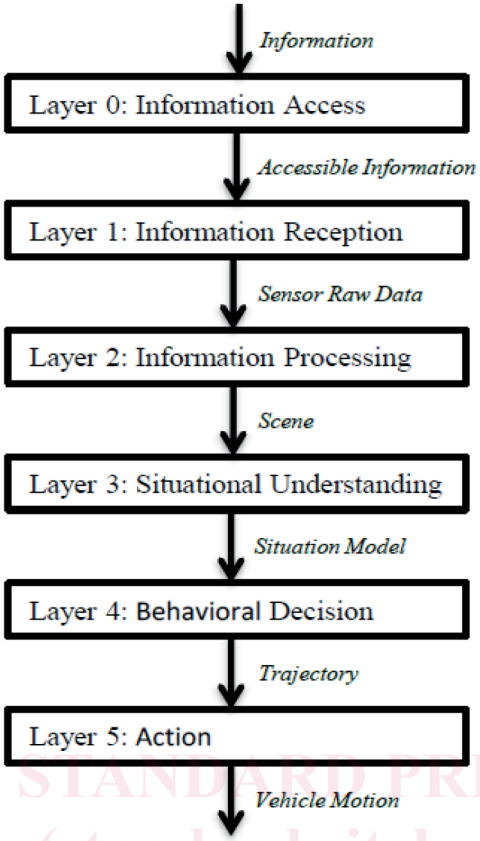

Figure 2 — Decomposition Layers (source Amersbach, Winner, 2017)

— Information access

  Information needs to be available and accessible

— Information reception

  All necessary information can be captured

— Information processing

  Captured information need to contain all required classification and identification for further process

— Situational understanding

  Based on information, situation need to be captured and understood

— Behavioral decision

  Based on designed or trained situational awareness, the desired behavior needs to be chosen

— Action

  Vehicle transforms whished behavior into action

Within this framework, technical realization can differ while the focus of the situation decision will be comprehensible, accountable, and comparable among different designs. A thoroughly development will benefit transparency for action and taken decision. The work described in this standard focuses primarily on Layer 4 – behavioral decision

0.3 The Concept of Ethical considerations for autonomous vehicles

Philosophy helps people question, understand and make sense of the world so they can act properly in it. This means that decisions and actions are not only intrinsically fair, but that they are also performed in a way that is *balanced* with respect with other's needs, the societal needs and humanistic values, as well as with respect to the physical world around us. It is widely accepted that philosophy can be divided into theoretical philosophy and practical philosophy. Theoretical philosophy is concerned with understanding and making sense of the world and includes topics such as ontology, epistemology, and meta-ethics amongst others. Practical philosophy focuses on topics such as human agency, practices, values, as well as ethical dimensions of (human) behaviour and conduct.

Within practical philosophy there are two main branches: Normative and applied ethics. Normative ethics is the study of ethical action and determining standards for decision making and conduct (e.g. deontology, virtue ethics, etc. - see Annex B). Applied ethics is the application of standards of ethics to real life situations (e.g. biomedical ethics, AI ethics, political ethics, etc. - see Annex B). In this document, ethics refers to both normative and applied ethics but not to meta-ethics (which is more concerned with the nature and basis of ethical concepts and the underlying reasoning and assumptions behind moral theories).

Applied ethics is a flexible and practical way to address ethical considerations in the development of new technologies because an applied ethics field, such as AV ethics, can borrow from more than one normative school of ethics. Therefore, the framework offered in this document, although based on "a principle-based approach, can use ideas from deontology and virtue ethics, for example, to help solve problems. This is a balanced approach; it does not condone one type of normative ethics over another, it offers a range of perspectives that will help the designer/developer in choosing the best (or better) decision possible for specific situations.

In summary, ethics is the study of how to choose to act in situations. To make decisions, we need clarity on what matters and to understand what is considered good, bad, right, and wrong. Therefore, ethics may be viewed as a tool that helps us create the difference between a "good" decision and a "bad" one. This is of great importance in the development of autonomous vehicles because choices made during the design and development of AV systems determine its "driving behaviour" and how it caters for its passengers and interacts with other road users (e.g., vulnerable road users). "Driving behaviour" is what was designed for and programmed into the machine, "conduct" is what actually transpires as a consequence of applying the driving behaviour to the real world.

This document offers a particular framework for AV ethics which is intended to support the practical integration of ethics into the AV development process. The framework we suggest builds upon Socrates conception of the hierarchical nature of philosophy for practical use which has three levels (See Figure 3). The base level is the conduct that transpires as a consequence of decision and actions (behaviour), the second level is how these behaviours are governed. Namely what kind of policy and arrangements are in place to make decisions. The top level is Purpose, which Behaviour and Conduct must align with, in order to achieve the goals and objectives of the entire endeavour. Finally, knowledge is the "tool" for making sure that the purpose is reasonable and balanced and that the governance and behaviour/conduct are indeed feasible and appropriate.

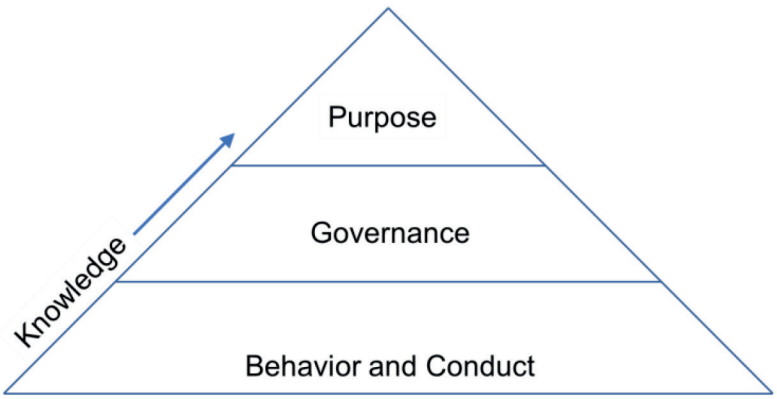

Figure 3 — Socrates' hierarchical nature of philosophy

Figure 4 is a graphical depiction of the framework advocated here for AV ethics. It shares similarities with other ethical approaches for emerging technologies, it is also unique as it has been created specifically for the AV context. Essentially, the AV ethics framework provides guidance for reflective and critical decision making and is composed of four main elements: purpose, values, principles, and process. The framework approach provides structure and guidance, yet it is flexible enough to accommodate multicultural perspectives.

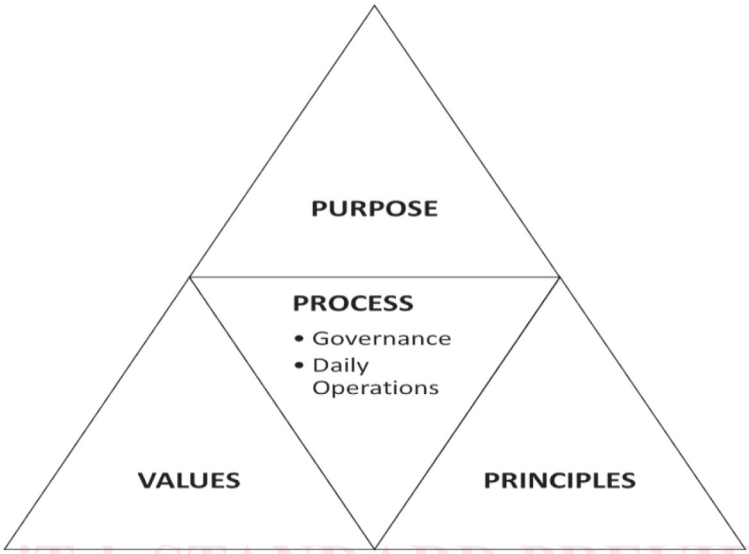

Figure 4 — The AV Ethics framework for the integration of ethical considerations into the design and development of AVs

The *purpose* element refers to the overall goal of integrating ethics into AV design and development. The purpose is the "why" aspect of the framework or the reason for the existence of this standard. Purpose offers high level (or meta) guidance when decision making - i.e. will a particular decision lead to an increase in road traffic safety or not. As this is an international standard, the *values* element provides guidance on what is important to the world's population. Therefore, universal values such as the UN universal values (e.g. human dignity) are recommended in this framework. The *principles* element gives more detailed guidance on decision making by identifying the boundaries of a good decision and a bad one as well as directing the attention to specific areas (fairness in AV behaviour and conduct in the context of other vehicles). The *process* element refers to two levels of process activities, governance, and daily operations, which are required to integrate ethics into AV development. Table 1 summarises these four elements.

Specific examples for the values, principles, and process elements are provided in the AV ethics framework section. The *purpose* is not an example but a strong recommendation as it contributes to the overall goal of the ISO traffic management safety series of standards. The *values*, *principles* and *processes* presented here are relevant and universally acceptable examples but may be changed according to the requirements and needs of specific countries, societies and organizations. The users of this standard must decide on which values, principles and processes they will use for their work. Finally, we acknowledge that an ethics framework is only useful if it is adhered to by all involved and is well integrated into the AV system development process.

Table 1 — Framework elements and recommended designations

Purpose	Overarching goal: increase safety in road traffic systems for all traffic participants (ISO TC 241)
Values	Value set: UN universal values recommended
Principles	Principle set: Artificial Intelligence for People principles recommended (with other options listed)

Table 1 *(continued)*

Process	Governance (e.g. integration of AV ethics into existing governance measures)
	Daily operations (e.g. ethical evaluations, operationalization of principles)

Road Traffic Safety (RTS) — Guidance on ethical considerations relating to safety for autonomous vehicles

1 Scope

This document gives guidance on ethical considerations with regards to road traffic safety of autonomous vehicles.

This document is applicable to vehicles in Level 5 mode according to international Society of Automotive Engineers (SAE J3016) in 2014, as part of its Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems report.

This document does not apply to the technical method used to control the decision-making process, nor does it give any guidance on the desired outcomes of those decisions; it gives guidance on ethical aspects for consideration in the design of decision-making process.

This document is not a management system standard or technical standard, and it does not set requirements for the outcomes of ethical decisions, nor does it offer guidance on methodology. It only details aspects of the behaviour of autonomous vehicles that require considerations to be made by the designer/manufacturer to ensure that key aspects are not overlooked or disregarded.

This document does not offer the technical precision to prescribe the required controls but would, rather, offer a set of "protocol guidelines" that a vehicle manufacturer could choose to self-certify against to assure that the desired necessary ethical considerations were addressed during design and effectively controlled.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 39001, *Road traffic safety (RTS) management systems — Requirements with guidance for use*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 39001 and the following apply. ISO and IEC maintain terminological databases for use in standardization at the following addresses:

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

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

3.1
Autonomous vehicle (AV)
Vehicles equipped with ADS

3.2
Automated Driving System (ADS)
System, that allows a vehicle to fulfil the requirements for a SAE J3016 level 5 vehicle

3.3
Conventional vehicle
A vehicle designed to be operated by a conventional driver during part or all of every trip.

3.4
Dynamic Driving Task (DDT)
as per SAE J3016

3.5
AV Ethics
A branch of applied ethics specific to the ethics of autonomous vehicles (AVs). It is concerned with the ethical decision-making process of the designers and developers of AVs while creating and programming AVs. Further, it helps designers and developers of AVs define the conditions of a good choice and determine which of the options available is the most appropriate one.

3.6
Ego Vehicle
Subject connected and/or automated vehicle, the behaviour of which is of primary interest in testing, trialling or operational scenarios.

4 External factors affecting autonomous vehicle safety

4.1 General

There are 7 categories of external factors relevant to autonomous vehicle safety:

1) Other fully Autonomous Vehicles (SAE Level 5)
2) Other highly or partially Autonomous Vehicles (SAE Level 4 and below)
3) Other Conventional Vehicles
4) Other mechanical transportation
5) Vulnerable road users
6) Animals
7) Road traffic environment

Note For definition of categories 1 to 3 see SAE J3061

4.2 The road environment

In addition to road users and vehicle factors, road and environment conditions are also considered as contributing factors to crashes. Hence, it is important for autonomous vehicles to be aware of environmental factors such as road and topographical conditions and road type (e.g. single-or dual carriageway, etc.) throughout the entire journey route.

Attention should be given, but not limited to:

1. Road conditions:
   - road surface (e.g., potholes, slippery, greasy),
   - geometric features (e.g., sag curves, crest curves, lane width), and,
   - road construction work.
2. Road furniture along the route (e.g., type of guardrail used, road signage, road markings.
3. Road environment:
   - topographical condition (e.g., flat, undulating, hilly, mountainous),

— signage (e.g., inadequate, confusing or blocked road signages),

— lighting,

— haze,

— thick fog,

— weather condition (e.g., snow, ice, heavy rain, flood, landslide, crosswind),

— animal crossing, and,

— parked vehicles and potential impact on sightlines.

4. Traffic volume and condition (e.g., during peak hours, festive seasons).

   The nature and magnitude of traffic plying on the road plays a significant role and gives rise to a number of problems if traffic is not properly regulated and controlled due to non-adherence to the traffic rules which are common features in many developing countries. Therefore, an understanding of traffic characteristics is a key component to build into autonomous driving systems. If traffic is allowed to mix with non-motorized traffic (NMT), it would be difficult to ensure that there would not be any likelihood for occurrence of road crashes. There are many complex issues like the presence of NMT in the traffic stream to be addressed in a holistic manner in context of ethic consideration for autonomous vehicles

5 Stakeholders in AV design and operations

There are four entities that are stakeholders involved in the design and operations of AVs. Each one is examined below.

5.1 Producers – Manufacturers; designers and their suppliers

Manufacturers of autonomous vehicles designing the vehicle carry responsibility toward the users of the vehicle as well as and towards other road users (vulnerable road users, bystanders, other drivers) for the product and toward the regulator and operational agencies such as the Department of Motor Vehicles[1)]. Manufacturers share this responsibility with their suppliers. This document, which discusses ethical considerations in the design of the autonomous vehicle behaviour, provides guidance to manufacturers and their suppliers as to how they develop ethical relevant components (e.g., vehicle behaviour, interaction with other road users) and how to document the decision process and decisions accordingly. In particular, the focus is on ethical considerations in designing vehicle behaviours and decision making.

5.2 Distribution chain – Distributors; Sellers

The role of a distributors is to facilitate the bulk transfer of completed vehicles from manufacturers to sellers. They should address the safety ethical considerations and the guidance within this document and ensure that no part of the distribution process can compromise any safety features or design of the vehicle, as manufactured.

The role of a seller is to facilitate the sale of vehicles to users. They should be responsible for ensuring that all vehicles they sell address the guidance within this document and that the prospective purchasers are made aware of the relevance of meeting the guidelines in this document (e.g. education about L5 AV technology and its societal impact).

1) See Appendix C.1 for a discussion of the concept of responsibility and accountability in AV design