Methodological framework document – initial version

Vehicles and automated transport systems:

First principles and questions for the definition of the ODD

1. Introduction

The objective of this document is to propose principles for defining the "*operational design domain*" (ODD) based on existing work and taking into account the different application frameworks in which this concept, founding but broad, is used.

The "*operational design domain*" is defined in SAE J3016 as "the operating conditions under which an automated driving system is designed to operate, including (but not limited to) environmental, geographic and time specifications, and/or the required presence or absence of certain traffic or flow characteristics"[1].

In addition, the concept of ODD is used in the UN R157 regulation known as the "ALKS" regulation: "the system […] has been designed and developed to operate in such a way as to be free from unreasonable risks for the driver, passengers and other road users within the functional design domain and declared boundaries"[2].

These two examples, both normative and regulatory, show that it is up to the notion of functional design domain of an automated driving system, to use the terms of French decree no. 2021-873 of June 29, 2021, reflected in the international definition.

Based on the literature review carried out by the PRISSMA project[3] as well as by the SAM project[4] as a PFA-SAM position, it appears that the concept of ODD is widely shared on the international scene, although no standard exists at this point. The works presented are based, for the most part, on the definition given by the J3016 standard or attempt to define the concept of ODD as a starting point for the definition of descriptors.

This 2018 standard is itself based on the USDOT definition which attempts to define the ODD as of 2016: "*Description of the specific Operating Domains(s) in which an automated function or system is designed to properly operate , including but not limited to roadway types, speed range, environmental conditions (weather , daytime / nighttime, etc.) and other domain constrains"*.

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[1] *An ODD is defined as operating conditions under which an ADS is designed to function, including (but not limited to) environmental, geographical, and time-of- play restrictions, and/or the requisite presence or absence of certain traffic or roadway features.*

[2] *Operational Design Domain (ODD) of the automated lane keeping system defines the specific operating conditions (eg. environmental, geographic, time-of- day, traffic, infrastructure, speed range, weather and other conditions) within the boundaries fixed by this regulation under which the automated lane keeping system is designed to operate without any intervention by the driver.*

[3] [L8.9] *Operational design domain* , ODD – State of the art, PRISSMA, 2021

[4] Deliverable 2.2-2. ODD: Definition & Description framework. Chrono number ISX-SAM-LIV-1219. SAT. 2021

The USDOT goes further by even defining obligations for manufacturers[5] and specifies that the NHTSA will produce specific standards and performance tests to define safe ODD[6].

In 2017, the NHTSA published the following assertions, subsequently reused in most existing international and normative reference documents: "*Entities are encouraged to define and document the Operational Design Domain (ODD) for each ADS available on their vehicle(s) as tested or deployed for use in public roads, as well as document the process and procedure for assessment, testing, and validation of ADS functionality with the prescribed ODD. The ODD should describe the specific conditions under which a given ADS or feature is intended to function. The ODD is the definition of where (such as what roadway types and speeds) and when (under what conditions, such as day / night, weather limits, etc.) an ADS is designed to operate".*

This methodological document reports on the different approaches to describing the ODD proposed in international works and attempts to bring out proposals for ordering the attributes that emerge from these works.

At this preliminary stage, the attributes are not set in stone, nor exhaustive and the proposed classification is intended to be advisory and to evolve given the deepening of international work and with the French ecosystem.

NB: this methodological document has no scope in terms of defining the responsibility between the automated driving system and the driver, in particular with regard to the following legislative and regulatory provisions:

a) obligation to request control of the automated system (see " *when its operating state no longer allows it to exercise dynamic control of the vehicle or when the conditions of use are no longer met or when it anticipates that its conditions of use will probably no longer be met during the execution of the maneuver"* - cf. article L319-3 of the traffic rules)

b) definition of highly or totally automated driving (cf. " *being able to respond to any traffic hazard or failure, without exercising a request to regain control during a maneuver carried out in its functional design domain"* – cf. article R. 311-1 of the traffic rules).

[5] *The manufacturer or other entity should define and document the Operational Design Domain (ODD) for each highly automated vehicle system available on their vehicle as tested for use on public roadway . The ODD should describe the specific operating domain (s) in which the highly automated vehicle system is designed to properly operate.*

[6] *Manufacturers and other entities should develop testing and verification methods to assess their HAV systems' capabilities to ensure a high level of safety. In the future, as DOT develops more experience and expertise with HAV systems, NHTSA may promulgate specific performance tests and standards.*

2. ODD descriptors: summary and common points of different approaches

The characterization elements of the ODD[7] presented in this document are based on a state of the art including in particular the work carried out by the NHTSA [8]and the Korea Institute on intelligent transport services[9], on the literature review on the of the attributes of the ODD carried out within the framework of the PRISSMA project and on the contributions of the SAM project[10]. (Some French actors propose in this context to rely on the notion of safe employment conditions, which comes to revisit the concept of ODD - cf. appendix).

Overall, it emerges from the work carried out in different national or international frameworks (see appendix) different approaches for the definition of ODD descriptors:

- Common elements, ie axes of description common to all approaches: these axes relate essentially to the static description of the traffic environment, typically the geometry of the road

- Elements that may vary depending on the approaches, ie descriptors that may or may not be considered as defining the ODD[11]. These elements include:
    - Visibility conditions
    - Traffic conditions (density)
    - Traffic rules (e.g. maximum speed; weight and size restrictions)
    - Road sharing signs and equipment
    - Static masks
    - Vehicle behavior (nominal or in response to events)
    - Connectivity needs / capabilities (message content; coverage; reliability)
    - Behavior of third-party users

3. ODD concept: links with the French safety demonstration framework for automated road transport systems (ARTS).

The national regulatory framework (French decree no. 2021-873 of June 29, 2021) defines:

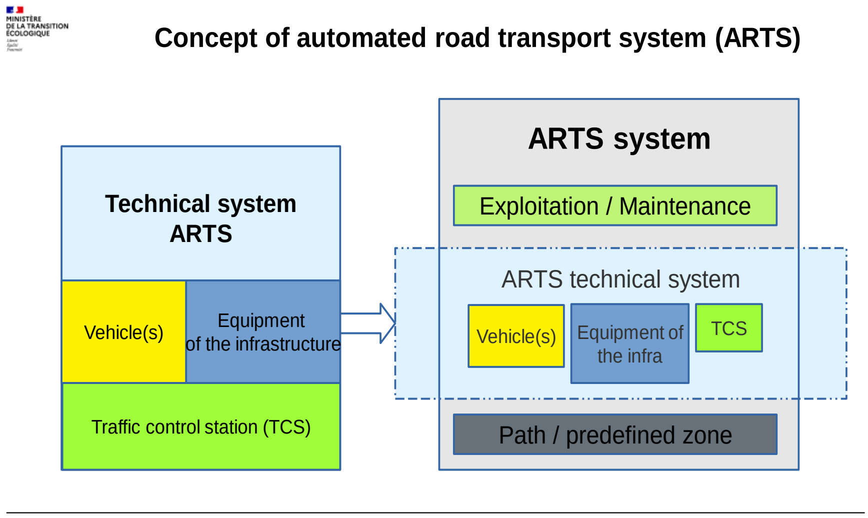
- The functional design domain of an automated driving system: conditions including geographic, weather, time, traffic, traffic and infrastructure under which an automated driving system is specifically designed to exert and inform dynamic control of the vehicle the driver ;

- The technical design domain of the automated road transport technical system: operating conditions under which this system is specifically designed to operate;

- The field of use of an automated technical road transport system: conditions of use associated with specific routes or traffic areas and respecting its technical design field.

[7] In the rest of this document and by misuse of language vis-à-vis the definitions of decree no. 2021-873 of June 29, 2021, the term ODD refers to the field of functional design of the automated driving system.
[8] *A framework for automated driving system testable cases and scenarios*. Thorn , Eric , et al. DOT No. HS 812 623. United States. Department of Transportation. National Highway Traffic Safety Administration, 2018
[9] *Operational Design Domain for Testing of Autonomous Shuttle on Arterial Road*. The Journal of The Korean Institute of Intelligent Transport Systems, 19(2), pp.135-148. Kim, H., Lim, K., Kim, J., and Son, W., 2020
[10] Deliverable 2.2-2. ODD: Definition & Description framework. Chrono number ISX-SAM-LIV-1219. SAT. 2021
[11] The list described in no way predicts the elements that will indeed be integrated into the ODD. This is an exhaustive list taken from the state of the art on what may or may not appear in the ODD.

In relation to these definitions, the ODD can thus relate to the functional design domain of an automated driving system on board a vehicle or to the concept of the technical design domain of a system integrating vehicles with which installations are associated. techniques, or to the field of employment, integrating elements specific to the course conditioning the performance of the systems.



It is important that the concept of ODD makes it possible to cover these different nested notions of systems, and to ensure correspondence between these layers. In particular, it is important to take into account:

a) of the ODD which can either be provided by the "system" layer (in particular via the exported connectivity and supervision constraints)
b) the need to match ODD descriptors in a "vehicle-centric" approach and journey descriptors, with their specificities, in order to ensure that the system design domain and the employment domain represented by the course and its specificities, are consistent.

Furthermore, it is important that the observability requirements of the ODD limits apply to the different nested systems (either to the system considered, or to its constraints exported vis-à-vis another system).

4. Objectives and challenges of ODD definitions

Two main issues emerge from the different approaches to define ODD:

i) ***the system to which it applies*** , with two sub-questions: that of constraints exported from one system to another system and that of degraded performance levels;
ii) ***the objective of using the ODD in the validation of systems*** , with, schematically, two sub-objectives:
   - ensure the correspondence between the SDGs defined at the generic level of the system, and their instantiation in a route or a circulation zone;
   - pre-define an envelope of hazards[12] that the system is supposed to be able to address, and which will have to be verified (based on scenarios), either at the generic level, or at the level of the zone or the traffic route instantiated.

Nevertheless, it should be noted that the ODD is refined throughout the system validation process.

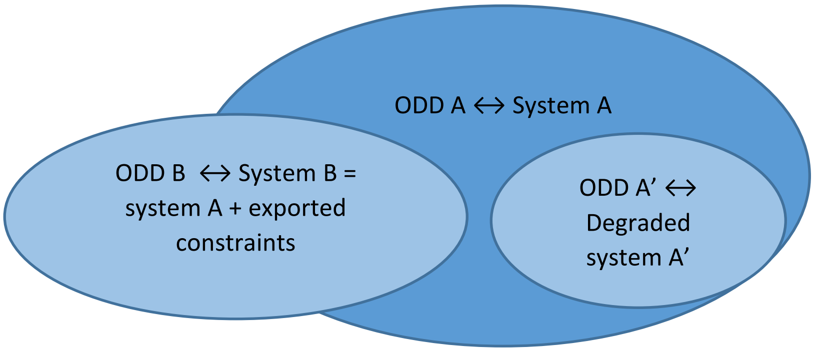
[12] The term "hazard" here does not refer to the potential interactions of the system but to the description of the hazards that the system is able to detect and recognize.

a) ODD description, performance description and exported constraints

ODD description derived from the idea that the system must be able to check and validate at any time whether the traffic environment in which it is located ensures that its operation is safe: this definition defines the ODD from the performance *("capabilities")* of the system, which seems consistent with the notion of functional design domain, but subjects the SDG descriptors to an "endogenization" constraint with respect to the capabilities of the systems, which can make any exercise difficult standardization of ODD descriptors.

In this order of ideas, the description of the ODD can be derived either from degraded performances (linked for example to potential malfunctions of the system), or from increased performances, for example thanks to the connectivity between the road infrastructure and the vehicle or supervision.

In the remainder of the document, it is assumed that the ODD is attached to a system, whether the latter is a) attached to the vehicle or attached to a system with constraints exported from the vehicle to the off-vehicle; b) attached to nominal operation or to one or more degraded operations.



b) ODD description, path and hazard scenarios

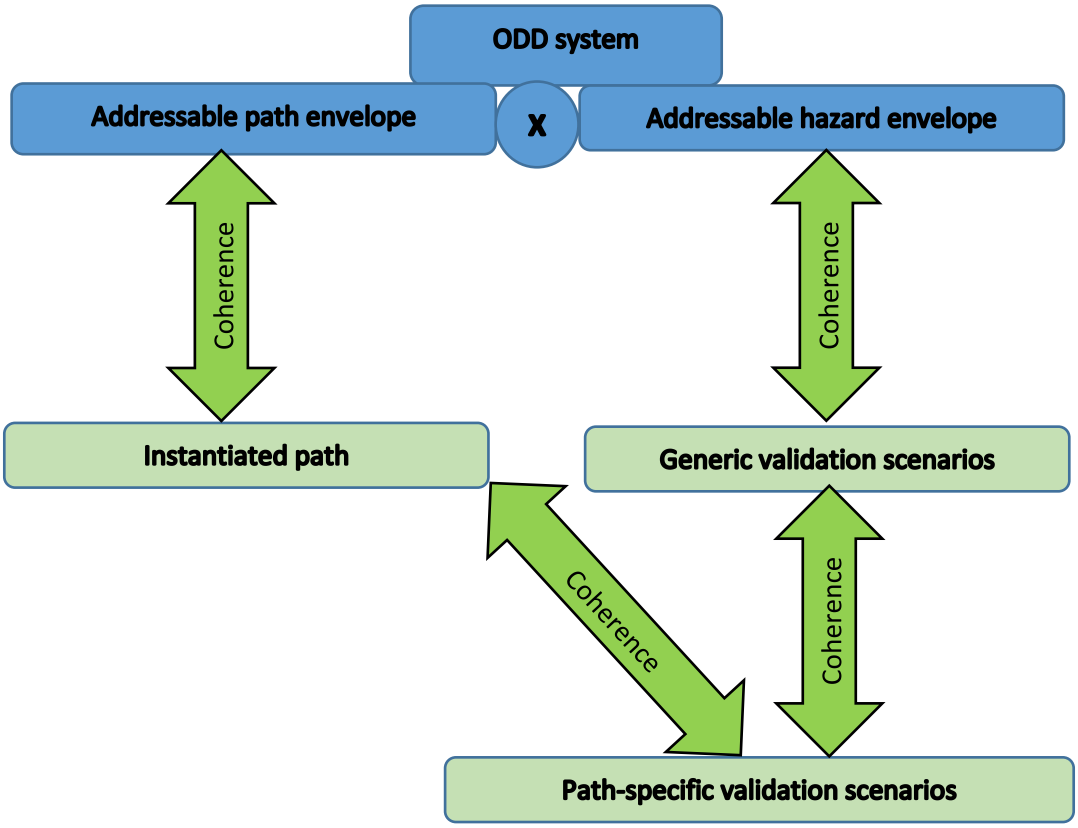
The main objective of the ODD concept is to define the elements to be detected to ensure a safe system. It is also about being able to ensure that the instantiated traffic environment conforms to what the system is designed for. This leads a priori to searching for all the descriptors of a traffic route that can affect safety, and therefore to a diversity of descriptors.

It may be useful here to distinguish two families of objectives within this main objective.

I. Ensure a correspondence between the attributes of the traffic environments which will have been defined at the level of the vehicle, those which will have been defined at the level of a system[13] (vehicle(s) + constraints exported outside vehicles[14]), and those which will characterize a route;

II. Describe hazard envelopes that can be addressed by the system, allowing in particular to develop design and then security demonstration scenarios.

[13] This is a technical system, by abuse of language it will be called system in the rest of the document.
[14] To use the terms of the decree, we are talking about a vehicle equipped with its technical installations.



With regard to the objective of correspondence between the generic ODD and the "instantiated" traffic environments at the level of the journey, the underlying "interoperability" issue is to define a list of descriptors making it possible to ensure the correspondence between:

- related to the traffic environment used to define performance (ie system responses to hazards and failures);
- the attributes used to describe a particular traffic environment, and, among these environments, the specific routes attached to an automated road transport system.

Within this objective of being able to match attributes linked to the performance of the systems and others linked to the "performance" of the routes, we conceive that:

- the descriptors must be sufficiently detailed, taking into account all the possible attributes of a traffic environment relevant to safety;
- the descriptors can probably be designed in a "nested" way, starting from generic descriptors that can be detailed or instantiated when one arrives at the level of a type of circulation environment, a particular circulation environment, or a specific course;
- as mentioned above, the descriptors must be measurable and observable by the system or, failing that, its exported constraints[15].

[15] This consideration thus implies defining only what the system is able to detect and recognize; are therefore excluded from the ODD the attributes that would be outside the scope of the detection and recognition capabilities of the system.

With regard to the objective of describing the hazards that can be addressed by the system ("safely" to use the terms of the original definition), the challenge of the ODD descriptors is first of all to characterize these hazards in order to unfold the OEDR approach[16].

The question of the definition of objects or events recognizable by the system raises a specificity linked to this dimension of the ODD: its strong dependence on the capacities or performances of the system:

- the hazards that can be addressed by the system must be able, by definition, to be recognizable and measurable by the detection and recognition capabilities of the system (example: nature, speed and size of vulnerable users);
- the addressable risks thus defined therefore reveal the detection and recognition capabilities, which are probably the most sensitive data from the point of view of industrial secrecy;
- the dimensions making it possible to characterize a hazard in order to prepare the system's response can be specific to each system (example: a vulnerable user can be recognized more by his speed than by his size);
- the assumption that these "ODD border" objects are recognized unequivocally, is linked to "nominal" operating assumptions of perception, which is not the case in practice, either in the event of a failure or in the event of changes in visibility (fog, rain, brightness);
- by extension, the detection capacity depends on static masks or on the quality of the horizontal or vertical signaling, specific to a route;
- similarly, the ability to detect and recognize may depend on the density of objects around the ego vehicle, with objects representing masks for each other.

The attributes of environmental visibility and "density" of objects (traffic, or accumulation of vulnerable users) of the ODD thus appear useful to meet the objective of ensuring correspondence between a generic ODD attached to the vehicle (ex : day / night) and traffic environments (e.g. fog) and or specific routes (e.g. visibility of signs, static masks) (see below on the application of the ODD to the route).

The ability to recognize particular objects or "targets" (vulnerable users or other vehicles) appears to come under the approach by driving scenarios[17], which should then address the question of the possible standardization of the descriptors of these objects or "targets".

The question of integrating the system's response into the description of the ODD is even more delicate than that of integrating the characteristics of “targets” that can be addressed by the system.

In theory, if we retain the "pure" definition of the SDG, it should consist of the envelope of scenarios of traffic hazards (or even hazards and malfunctions) to which the system responds without damage. unacceptable. However, we see that this definition goes a long way and makes it essential to have carried out a detailed analysis of the scenarios before defining an SDG.

Moreover, this definition deviates from the “ mainstream ” of international work (although certain descriptors from the literature actually characterize the system's responses).

All in all, the scenario-based approach appears more conducive to tackling the sensitive issue of hazards and system responses. This approach by scenarios is the subject of work elsewhere, in which the question of descriptors also arises. It is therefore important that the choice of descriptors can ensure the passage between the definition of the ODD and the validation by the driving scenarios.

[16] *Object and event detection and response,* a concept defined in the NHSTA approach.
[17] See methodological document on driving scenarios mentioned above.

The French doctrine for developing scenarios[18] is based on an organization of descriptors into 5 layers for the design of a scenario:

1. **Static traffic environment (e.g. geometric configuration of the infrastructure)**
2. **Rated driving maneuver**
3. **Hazards (collision precursor events; system malfunctions)**
4. **System Response**
5. **Hazards affecting the response of the system (combination of hazards; visibility)**

The component of the ODD corresponding to the addressable paths resulting from the J3016 standard is composed mainly of the elements of the static elements of layers 1. and 5. of the approach presented above.

In particular, all the elements and attributes that belong to the dynamic characterization of the scenario (hazards and responses) are not a priori part of this component of the ODD.

This document therefore proposes to set aside, in the description of the ODD, the contingencies and the responses of the system. This choice seems common to all the approaches referenced in the literature.

This choice appears consistent with the French regulatory definitions of highly or fully automated driving *("being able to respond to any traffic hazard or failure, without making a request to regain control during a maneuver carried out in its functional design domain")* and of the functional design domain *("conditions including geographic, weather, time, traffic, traffic and infrastructure under which an automated driving system is specifically designed to exert dynamic control of the vehicle and inform the driver thereof")* .

These definitions lead to separating: a) the definition of static and visibility attributes (axes 1 and 2 of the description of the scenarios defined in the methodological guide DGITM cited above) and b) the hazards and the responses (axes 3 and 4 of the description of the scenarios). If the hazards and the responses were to integrate the definition of the ODD in the sense of the functional design domain, one could arrive at the paradox that the system would be "highly automated" for certain hazards and "partially automated" for others. In other words, the driver should expect the system to give back control in an unpredictable way depending on whether the traffic hazard is part of the ODD or not. However, it seems very ambitious to anticipate that a driver will be able to know traffic hazards in sufficient detail (ie concretely, the "targets" and their dynamics), that the system may or may not be able to manage. (From the perspective of extending the use cases, it appears even less viable to require the driver to know the list of manageable contingencies for the different systems he is likely to use). Integrating hazards into the definition of the SDGs would therefore be likely to generate vagueness in terms of responsibility.

The rest of this document is based on this bias by focusing primarily on the ODD description to the exclusion of the detailed and dynamic description of the hazards faced by the ego vehicle as well as the responses expected by the ego.

However, on closer inspection, a number of SDG descriptors de facto include elements indirectly related to hazards and the system's response capacity. This is the case with visibility attributes, which affect the detection and recognition capabilities of the system[19]. The same is true of traffic conditions (density, speed), which could be qualified as indicators of "density of collision precursor hazards". The following section comes back to this category of descriptors, which we sense are "on the fringes" of the choice to exclude hazards and responses from the description of the ODD.

[18] Safety demonstration of automated road transport systems: Expected contributions of driving scenarios, Methodological report, DGITM, 2022

[19] This is in particular what is taken into account in the OEDR approach and detailed below.

c) ODD description and traffic rules

One of the questions raised by certain approaches to describe the ODD lies in the consideration of traffic rules.

The question arises, for example, for the speed limit authorized on a section of traffic: is it a descriptor of the ODD? In fact, the automated system is characterized by traffic speeds which are basically responses of the system to its driving environment and traffic rules. The traffic limit speeds do not therefore constitute a priori an element allowing the system to identify whether it is in its field of operation: the vehicle must comply with the most demanding between the traffic rules and its field of operation. Speed is therefore a system capability and not primarily an ODD descriptor. However, the maximum traffic speed can become an ODD descriptor in the sense that it would reflect the behavior of third-party vehicles and therefore the ability of the ego vehicle to detect and then respond to such behavior. Nevertheless, we must ask ourselves the question of the real relevance of a descriptor of maximum authorized speed to characterize the ODD: the scenario approach militates rather to seek the capacity of the system to respond to speed behaviors of other road users that we can consider as extreme but conceivable, that is to say, offending behaviour. This militates against making the maximum authorized speed an ODD descriptor.

Similarly, the ability of the system to recognize and respond to the orders of the police or the priorities of priority vehicles appears difficult to integrate into the notion of ODD, except to consider that this ability would depend on the traffic environment.

Similarly, traffic restrictions (weight and dimensions, ZFE) and their zoning (geofencing) do not appear to be specific to the automated driving system and it does not appear a priori justified to make them SDG descriptors.

Finally, to make the link with the previous part on recognition, the signage does not appear to have to constitute a descriptor in itself (the automated system is supposed to recognize any horizontal or vertical signage). Signaling only becomes a determinant of the ODD insofar as it can be crossed with elements affecting its readability (weather, luminosity, masks) or with a functional dysfunction of the system (degradation of the capacities of perception – recognition). On this point, it is theoretically appropriate to define the level of functional degradation which makes the identification of the safety signaling impossible, and which may depend on the redundancies of the system.

In other words, as soon as the system (and its possible redundancies) is able to recognize the safety signaling, it has no reason to be described in the ODD. As soon as the system (even with its redundancies) is no longer able to recognize the safety signaling, it must be considered out of its field of use.

The question of fixed safety signage therefore appears to have to be dealt with, either through the "visibility" section of the field of use, or via the ODD of the system increased by connectivity capacities, if this replaces visibility. One can nevertheless conceive that the signaling attributes which contribute to the positioning (white lines) or the temporary or dynamic signaling, can be useful to describe in the ODD to define the traffic environments addressable by the system.

5. Priority ODD description for further ARTS work

This part proposes a subset of the possible axes of ODD description centered on the most relevant descriptors for the application of the ARTS safety demonstration framework, and in particular the issue of correspondence between the generic ODD defined at the level of the vehicles. or technical systems, and the traffic areas affected by these systems. As argued above, this approach leaves aside the attributes attached to the hazards and to the responses of the systems, which in particular pose problems related to their very endogenous character to the systems. In other words, the benefits of a work of detailed description of the components of the ODD which characterize the traffic environments, appear clearer than those of an identical work on the hazards and especially, the responses, which it seems pointless to wish to standardize (a common description of the hazards, in the form of minimum lists of collision precursor events, nevertheless appears relevant in the scenario approach, to meet the objective of completeness targeted in the scenario approach)

The proposals for ODD descriptors in this part come from the considerations above on the priorities, and from a literature review (in particular from the PRISSMA project and the SAM project).

The proposed organization of the descriptors is thus based on the state of the art around the ODD but does not seek to adhere in all respects to these approaches. The methodological bias leading to favoring the correspondence between the generic ODD and the characteristics of the specific course prevails in the ordering of the levels of description of the ODD.

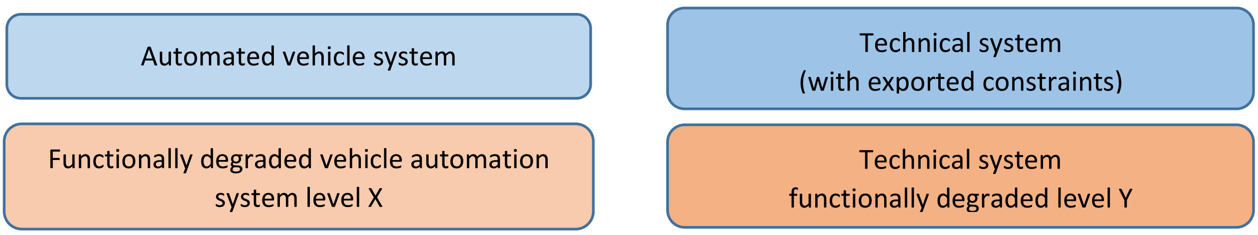
This approach leads to considering several levels of description for the SDG, based on the principles presented above:

a) Systems to which ODD are attached:

As indicated above, it seems important not to generate confusion between three concepts:

- ODD (characteristics of the traffic environments in which the system is intended to operate);
- Exported constraints (from the vehicle to a system);
- Nominal and degraded operation.

This would lead to favoring an approach in which different ODD are described, for different systems integrating either exported constraints or dysfunctions:



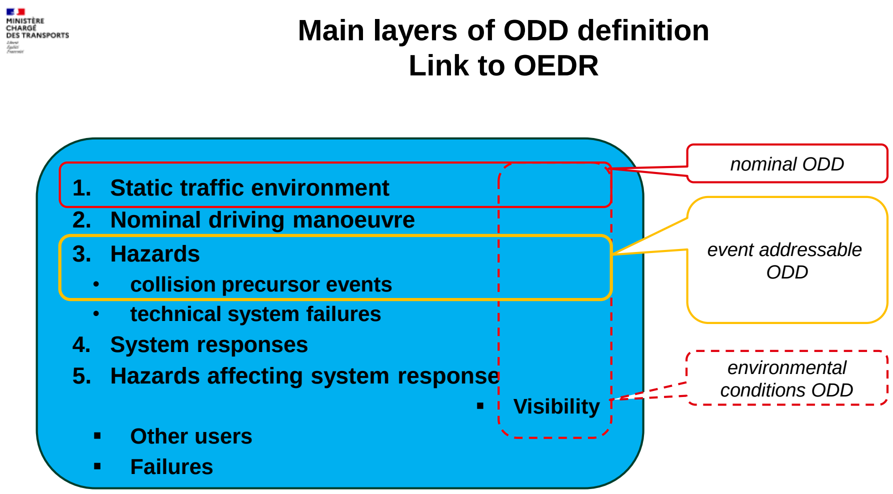
b) Priority families of ODD description attributes for ARTSs

The organization of the descriptors proposed here is based both on the international inventory (in particular recalled in the PRISSMA report[20]), on the productions of the actors of the sector (SAM project), and on the first works of description of the scenarios for the security demonstration.

This organization strives to stick as closely as possible to the fundamental concept according to which the ODD must make it possible to describe all the attributes of a traffic environment making it possible to say that the capacities of an automated system allow it to behave in a safe manner.

However, this concept, taken literally, would become very encompassing by focusing on the envelope of hazards that can be addressed by the system. However, this concept of envelope of addressable scenarios does not appear to be easily manipulated with a view to implementing systems in areas or traffic routes, a view that underlies the regulatory framework of the ARTSs. A partial concept of ODD should be preferred, favoring a priori static descriptors (ie excluding hazards) of traffic environments. This concept would lead to distinguish three main "sub-layers" in ODD definition:

- A layer linked to the essentially static attributes of the infrastructure: this layer of definition of the ODD makes it possible in particular to ensure the correspondence between a generic or "coarse" description that could be made at the level of the vehicle or the system technique, and a finer characterization at the level of routes or traffic areas.
- A layer related to events addressable by the system (in the sense of collision precursor events): this layer is particularly useful for defining the validation scenarios to be used within the limits of the ODD; this layer can be translated into " proxies " characterizing routes, thus also making it possible to make the link between generic attributes at the vehicle or system level and a finer characterization at the level of routes or traffic areas: typically, a density traffic or vulnerable users can characterize object recognition limits specified at the system level, and useful to know for the implementation on zones or routes.
- A layer related to environmental conditions (visibility, grip), partly usable to assess the correspondence between the generic ODD at vehicle or technical system level, and the route or implementation area.



[20] [L8.9] *Operational design domain* , ODD – State of the art, PRISSMA, 2021

ODD definition, centered on static attributes and environmental and traffic conditions, which emerges from this approach is summarized in the table below.

Static attributes
Geometric static attributes (e.g. number of lanes, widths, curvature, cant, shoulders)
“Lane usage” attributes (reserved lanes, authorized traffic)
Elements of infrastructure generating collision hazards (intersections, roundabouts, exits)
Infrastructure-related elements, collision hazard generators (e.g. schools)
Singular points (ex: tunnels, canyons)
Visibility attributes
Luminosity – environmental visibility (fog, rain, glare,…)
Minimum angles or fields of vision
Signaling-related attributes
Temporary or dynamic signaling
Signaling Connectivity
Adhesion related attributes
Ice, rain, snow
Attributes related to traffic conditions
Administrative typology of road and area
Authorized speed limit
Meeting areas, pedestrians, sidewalks
Protection from adjacent roads and traffic of vulnerable users

More specifically, the attributes could cover the following descriptors, to be refined in the work to follow:

Static attributes

- Geometric static attributes
  - curvature , cant
  - number and width of lanes
  - hard shoulder and/or type of shoulders
- “Lane usage” attributes
  - reserved lanes
  - insertion/divergent pathways
  - devices + restraint devices
  - *NB: temporary or dynamic uses are considered “static” at the time of use by an automated driving system; the question of the change of status refers to dynamic signaling – cf. below*
- Elements of infrastructure generating collision hazards
  - intersections , roundabouts
- Infrastructure-related elements, collision hazard generators
  - list (e.g. sports, recreational, cultural, educational centres, car parks, delivery areas, etc.)
  - devices or geometry
- Singular points
  - tunnels
  - geo-positioning canyons
  - work areas

Visibility attributes

- Brightness – environmental visibility
  - Day Night
  - Fog, rain, snow
  - Grazing light
- Minimum angles or fields of vision
  - *NB: these descriptors are intended to make the link with the “mask” type attributes of the routes*

- *NB: concerns in particular intersections or car park exits… as well as vertical signage (possibly horizontal)*
- *NB: these descriptors are very close to system performance indicators, without revealing the detection capabilities of objects / targets / third-party users*

Signaling-related attributes

- Temporary or dynamic signaling
  - NB: these descriptors are intended to characterize the system's ability to recognize temporary or dynamic signals whose design may be less unambiguous than "static" safety signals
- Signaling Connectivity
  - NB: this is formally an exported constraint or a capacity of the system; describing it in the ODD can generate confusion, except to design this attribute in the design phase of a system;
  - NB: in this category of descriptors, could possibly be included the need for connectivity of priority vehicles and law enforcement, if the system turns out to be incapable of visual recognition; idem, this inclusion is rather a phase of designing a system, the system having to recognize the injunctions and priorities.

Adhesion related attributes

- Ice, rain, snow
  - NB: these are formally attributes linked to the mechanical performance of the vehicle, their inclusion in the attributes of the ODD does not appear to be a priority.

Attributes related to traffic conditions

NB: these attributes are in fact “proxies” for exposure to traffic hazards

- Administrative typology of road and area (urban, peri-urban, rural, mountain, etc.)
  - NB: these are presumed "proxy" descriptors of standard traffic conditions
- Authorized speed limit
  - Lane traveled and adjacent/intersected lanes
- Meeting areas, pedestrians, sidewalks
- Protection from adjacent roads (including vulnerable user traffic areas)

This conception of the ODD does not encompass all the dimensions of the concept of safe working conditions (see above). It can be seen as the subset of ODD descriptors particularly useful for ensuring the correspondence between a generic ODD (at the level of a system – ADS or technical system) and a route or an area.

The table below illustrates the possibilities, through the proposed attributes, of matching a functional design domain of an automated driving system and a traffic environment (which, for an automated road transport system, is a journey or a zone).

Attributes	***Vehicle***	***System***	***Path***
Static attributes			
Geometric static attributes			
“Lane usage” attributes			
Elements of infrastructure generating collision hazards			
Infrastructure-related elements, collision hazard generators			
Singular points			
Visibility attributes			
Brightness – environmental visibility			
Minimum angles or fields of vision			
Signaling-related attributes			
Temporary or dynamic signaling			
Signaling Connectivity			
Adhesion related attributes			
Ice, rain, snow			
Attributes related to traffic conditions			
Administrative typology of road and area			
Authorized speed limit			
Meeting areas, pedestrians, sidewalks			
Protection from adjacent roads and traffic of vulnerable users			

In total, the descriptors or families of descriptors proposed in this document, centered on static attributes and environmental or traffic conditions affecting detection and recognition capabilities, deserve as a priority to give rise to a standardization of descriptors and metrics for the application of the ARTS regulatory framework (without predicting that all the descriptors will be used for any system / course).

This proposal for priority descriptors remains consistent with the approach to safe employment conditions, and retains two salient features:

a) the fact that the descriptors retained to decline the axes must be observable by the system or, failing that, its exported constraints;
b) the fact of being able to apply to any system: ADS of the vehicle or technical system or system deployed on a route , possibly through the constraints exported from one to the other.

This proposal of descriptors also makes it possible to approach different levels of operation of the system, by characterizing for example one or more degraded systems when the system is not in its nominal operation.

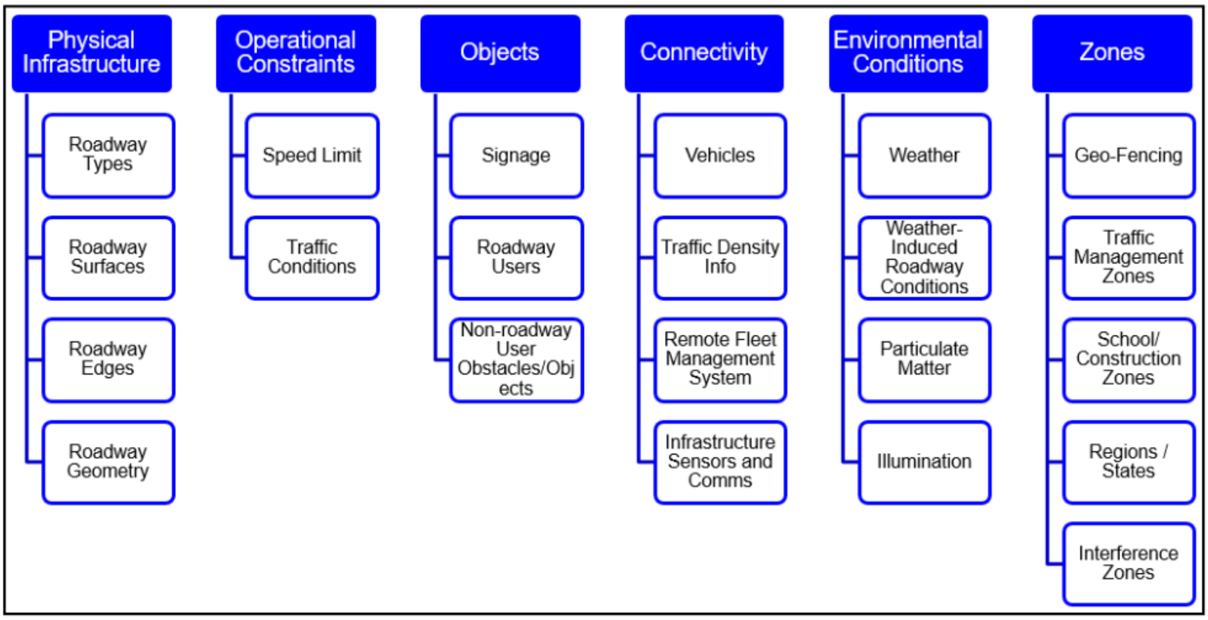
The attributes proposed above constitute a first proposal, based on existing work. This proposal aims to prioritize standardization work on descriptors and associated metrics.

These lists of attributes may evolve subject to feedback and mainly the ability of this list to ensure correspondence between a "generic" description of the ODD centered on the vehicle (with or without its constraints exported on a system) and the characterization of a specific course.

Appendices: descriptors proposed in international works

1. **NHTSA**

A framework for automated driving system testable cases and scenarios. Thorn , Eric , et al. DOT No. HS 812 623. United States. Department of Transportation. National Highway Traffic Safety Administration , 2018.



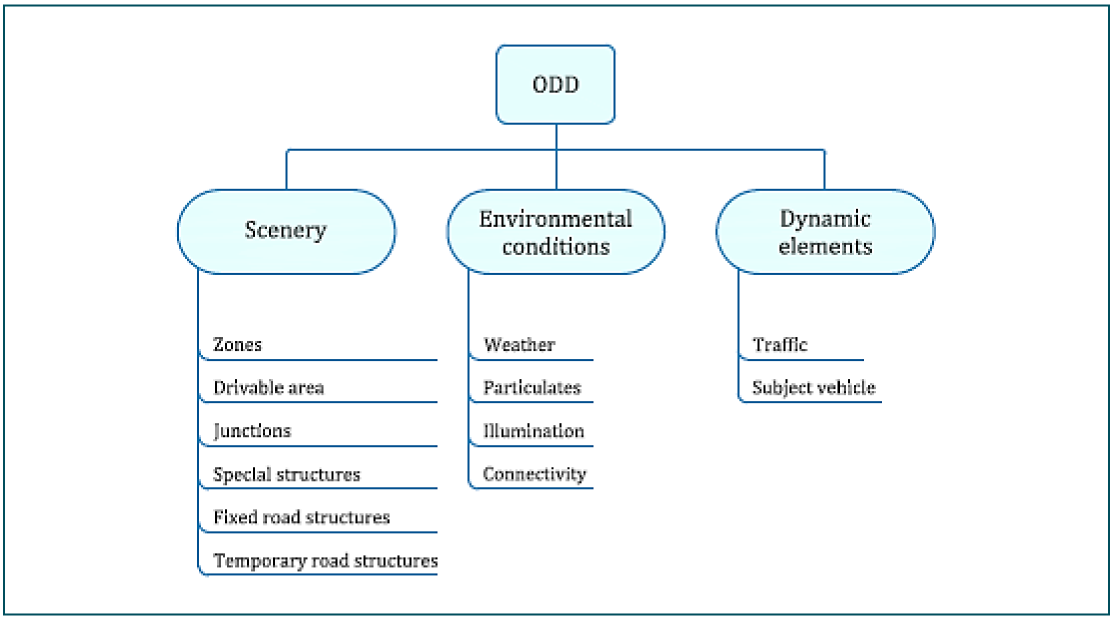
2. Korea Institute of Intelligent Transportation Systems:

Operational Design Domain for Testing of Autonomous Shuttle on Arterial Road. The Journal of The Korea Institute of Intelligent Transport Systems , 19(2), pp.135-148. Kim, H., Lim, K., Kim, J. and Son, W., 2020

Classification		Definition	Kind	Impact
Geometry Factors	Link	- Influence on the driving performance of autonomous driving system as a representative factor of traffic features	Urban and Suburban Highways (Type 1, 2, 3) Highway Urban Highway Highway Underground Roadway Overpass Ramp	Autonomous Driving System
	node	- Whether the right to pass can be clearly communicated when changing directions and geometric factors that can minimize confusion in the direction of travel	Three-way Intersection Four- way Intersection Over Five- way Intersection Roundabout	Autonomous Driving System
	road Surface	- Impact on acceleration and deceleration of autonomous driving system	Asphalt Concrete Unpaved Road break road	Autonomous Driving System
	Number Of Lane	- Impact on traffic environment according to the characteristics of autonomous driving service	One- way two way three way Four- way Over Five- way	road Environment
Operational Factors	Traffic Signal	- Influence on the information collection technology for judging the right of autonomous vehicles according to the way of providing signal information at intersections	Provision of information we communicate network use Unable to provide information on communication network use	Autonomous Driving System
	road Operation	- Impact on safety of pedestrians and transportation vulnerable in the area due to the entry of autonomous driving system	General Road Section Senior Area School Zone Area 30 Illegal Parking Area	road Environment
	Traffic Condition	- Influence on the external environmental perception performance of autonomous driving system to recognize and respond to the situation at the site according to the congestion	LOS AF	Autonomous Driving System
Environmental Factors	Time Period	- Influence of external environment detection performance of autonomous driving system due to changes in illuminance according to time period	Morning Peak Non Peak Afternoon Peak midnight	Autonomous Driving System
	Weather	- Influence of external environment detection performance of autonomous driving system due to changes in illuminance according to weather condition	Sunny Rain fog Snow	Autonomous Driving System

3. Standard BSI

PAS 1883:2020 Operational Design Domain (ODD) taxonomy for an automated driving system (ADS) – Specification . The British Standards Institution 2020



4. Wise approach

Source: Czarnecki , K.: WISE Requirements Analysis Framework for Automated Driving Systems , Operational World Model Ontology for Automated Driving Systems Part 1/Part 2 (2018)

Top Level	2nd Level
Road structure	road type and capacity
	road surface type and quality
	road geometry
	cross-section design
	traffic Control devices
	pedestrian crossing facilities
	cycling facilities
	junctions
	railroad level crossings
	bridges
	tunnels
	driveways
	temporary road structure

Top Level	2nd Level
Road users	ground vehicles, including their occupants
	animal riders
	pedestrians
	traffic control persons
Animals	small
	medium-size
	large
Other obstacles	-
Environ-mental conditions	atmospheric conditions
	lighting conditions
	road surface conditions

5. SAE-AVCS approach

Source: SAE ITC: AVSC00002202004: AVSC Best Practice for Describing an Operational Design Domain: Conceptual Framework and Lexicon (2020)

Top Level	2nd Level	3rd Level
Weather-related Environmental Conditions	Temperature	-
	Precipitation Types	10
	Haze	-
	Sky condition	-
	Illuminance	-
	Sun angle	-
	Wind	-
Road Surface Conditions	State of Repair	5
	Quality of Road Markings	-
	Road Surface Obscurants	7
	Transient Roadway Obstacles	-
Operational Constraints	Rush Hour	-
	Intended Operational Times	-
	Zones	2
Road Users	-	10
Non-Static Roadside Obj.	-	-
Connectivity	Fleet Management	-
	Obstructions	-

Top Level	2nd Level	3rd Level
Roadway Infrastructure	Road Network	-
	Road Network	-
	(Roadway) Sight Distance	-
	(Roadway) Grade	-
	(Roadway) Superelevation	-
	(Road) Vertical Curvature	-
	(Road) Horizontal Curvature	-
	Ramps	-
	Intersections	-
	Geofenced Area	-
	Traffic Control Devices	-
	Design Elements	7
	Lane	4
	Shoulder	-
	Curb	-
	Weaving Section	-
	On-Street Parking	-

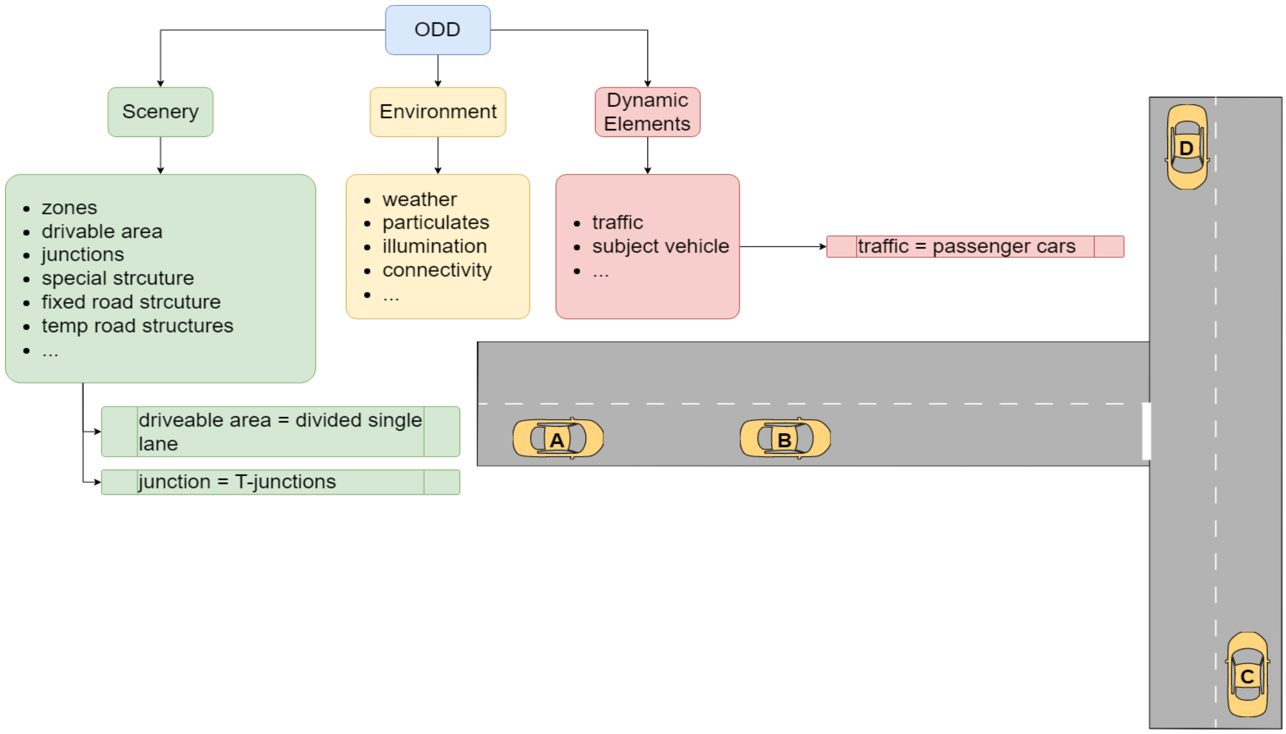
6. OpenODD

OpenODD (https://www.asam.net/standards/detail/openodd/) presents itself as an open approach to define ODDs by the user, according to his needs. OpenODD explicitly makes the link with the scenarios approach:

"It is important to emphasize that although the SDGs and the scenarios are related, they are not identical.

An ODD essentially defines the operating environment for which a system is designed. It can also be viewed from the perspective of the end user (e.g. local authority) as the operating environment in which a system must be able to operate safely. It is essential that there is an overlap between the two perspectives of the ODD, the manufacturer (or system designer) and the end user to ensure the safe deployment of automated and connected vehicles.

A scenario defines the behavior of the different actors and entities of an ODD. Below, the difference between scenario and ODD is highlighted graphically. A simple scenario with passenger cars describes a scenario that illustrates the behavior of vehicles in the ODD. In summary, once the behavior of actors is defined in part of an ODD, it becomes a scenario. This has no bearing on whether a scenario is a stand-alone entity regardless of the ODD definition and can therefore be defined independently"



6. *Concept of safe working conditions*

The concept of ***conditions of safe use*** of a system is based on the initial definition of the ODD *("operating conditions in which an automated driving system is designed to operate"*). This concept leads to distinguish:

- the conditions of safe employment provided;
- actual safety conditions of employment.

This notion thus recalls a fundamental principle: the boundary of the conditions provided for safe use must be measurable and observable in real conditions, so that the system can ensure at all times that it remains under the conditions provided. The requirement to observe the boundaries of the employment conditions then relates either to the system stricto-sensu, or to its constraints exported to other systems).

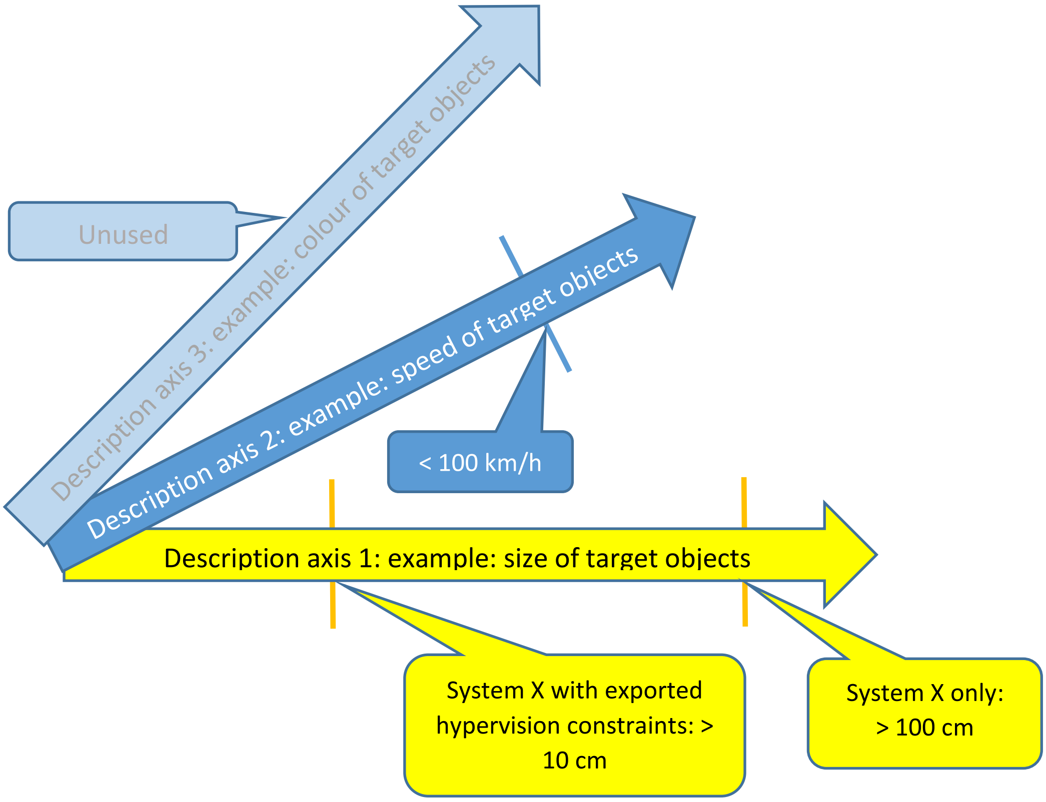
This notion also has the advantage of being able to be applied to different nested systems: the automated system at the vehicle level (ADS); the technical system; the system deployed on a route: each of these systems has its safety conditions of use.

The concept of safe employment conditions is broken down into 7 categories of descriptors:

0. Use of transportation
1. Physical / road infrastructure
2. Operational constraints
3. Objects
4. Connectivity
5. Environmental conditions
6. Geographic area

The approach then consists, within these different categories, in harmonizing the content of descriptors, the system designers remaining in control of using this or that descriptor and, within this descriptor, what level, to characterize its conditions of use. The conditions of use are then deemed to be defined unequivocally by the fact that an attribute is outside the ODD (ie prohibited) or in the ODD (ie compulsorily addressed in a secure manner by the system). The approach is intended to be flexible, in the sense that not all the ODD descriptors are necessarily filled in (cf. example of the " OpenODD " approach above).

Appendix: optional nature of certain hazard description axes within the SDGs: illustration



Description example of the attribute relating to the size of objects/targets detectable by a system with optional nature of certain attributes and taking into account increased capacities