Internal

i4Driving Project Glossary

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i4Driving
integrated 4D driver modelling under uncertainty

Deliverable

Project Acronym	Grant Agreement #	Project Title
I4Driving	101076165	Integrated 4D Driver Modelling under Uncertainty

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Project Glossary

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Executive Summary

The present document is the deliverable D.8.1 - "Project Glossary" of the i4Driving project, funded by the European Commission's Climate, Infrastructure and Environment Executive Agency (CINEA), under its Horizon Europe programme.

The main objective of the deliverable is to develop a project glossary which contains a summary of all main acronyms, terms and definitions relevant for the project. This is linked to task 8.2

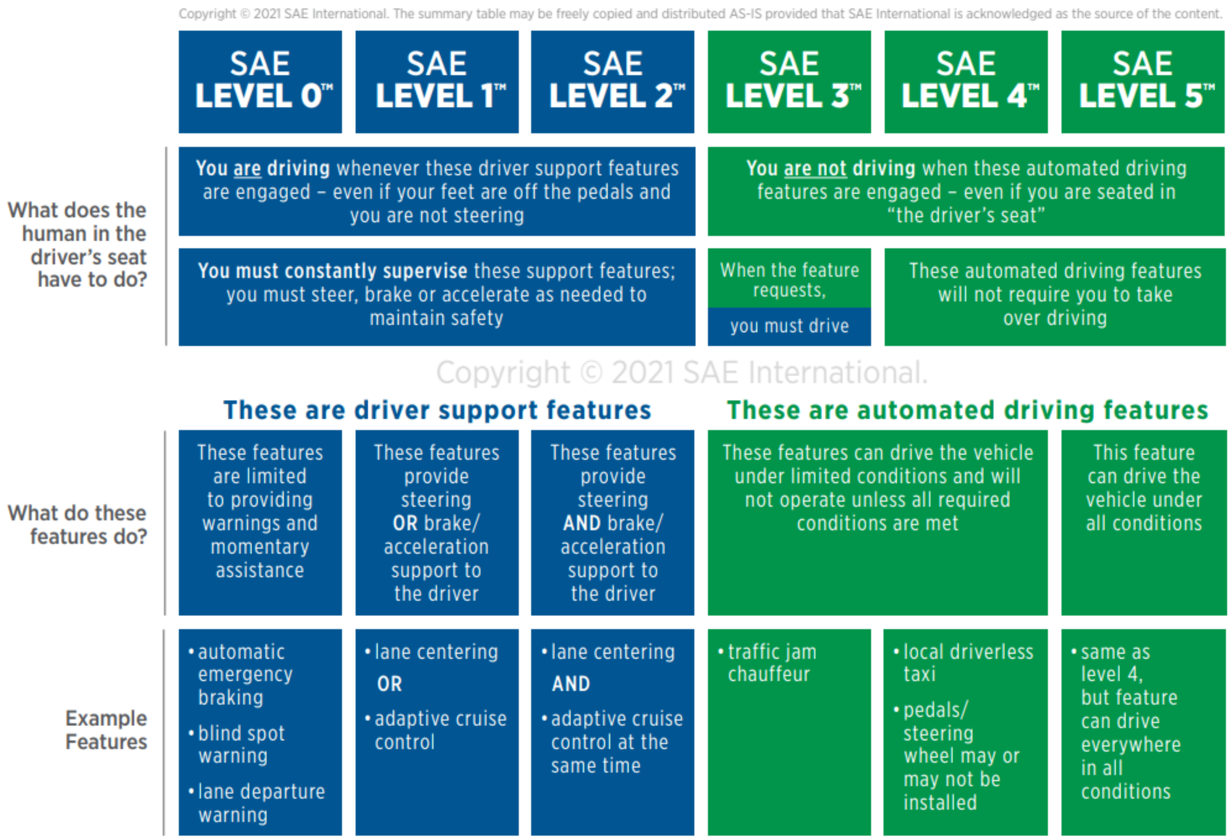
The Project Glossary will be updated again in the month 24 of the project.

Contents

Summary of all main acronyms, terms and definitions

Term	Definition
2 and 3D spaces	2 and 3D virtual worlds (driving simulator experiments, metaverses).
2 and 3D traffic simulation	Simulation of a traffic environment in a 2 or 3D space.
Abstract scenario	An abstract scenario is a formalized, machine readable, declarative description (constraints on the happenings) of a traffic scenario focusing on complex relations, particularly on causal relations (link).
Aleatory uncertainty	Uncertainty that comes from a random process. Flipping a coin and predicting either HEADS or TAILS is aleatory uncertainty. In other words, the uncertainty we are observing is random, it is part of the natural processes of what we are observing. Aleatory uncertainty refers to the inherent uncertainty due to the probabilistic variability. This type of uncertainty is Irreducible, in that there will always be variability in the underlying variables. These uncertainties are characterized by a probability distribution (link).
ART forum	Automated Road Transport Forum
ASAM	Association for Standardization of Automation and Measuring Systems
Automated driving systems (ADS)	The hardware and software that are collectively capable of performing some or all of the entire Dynamic Driving Task within its specific Operational Design Domain, if any. This term is used specifically to describe a Level 3, Level 4, or Level 5 driving automation system as defined in SAE J3016 as revised periodically (see below) (link).
Level 0 (no driving automation)	A motor vehicle designed and constructed to move autonomously for certain periods of time without continuous driver supervision but on which the driver intervention is still expected or required (link). Vehicles at this level have no autonomous capabilities, meaning the driver is in complete control of the vehicle at all times, even if it is equipped with warning and intervention systems, including obstacle avoidance and emergency braking systems. There are no bells and whistles here, just your ordinary cruise control to help with long-distance driving and minimize the risk of a speeding ticket from a lead foot. Those enhanced driver safety systems are excluded from the automation categoric system as they do not perform part or all of the DDT (Dynamic Driving Task) on a sustained basis; instead they provide brief intervention during potentially hazardous situations.
Level 1 (driving assistance)	Level 1 is the most basic type of autonomy and safety, where one element of the driving process is taken over in isolation, using data from sensors and cameras, but the driver is very much still in charge. Here we can find adaptive cruise control and lane-keep assist technology to help with driving fatigue. Adaptive cruise control will maintain a safe distance between you and the vehicle ahead of you by utilizing radars and/or cameras to automatically apply braking when traffic slows and resume speed when traffic clears. Lane keep assist may also be present and will help nudge you back into the lane should the vehicle start to veer out of it.
Level 2 (partial control)	Although the driver must have hands on the wheel and be ready to take control at any given moment, level 2 automation can assist in performing rudimentary tasks. The driver still needs to perform tactical manoeuvres such as responding to traffic signals, changing lanes and scanning for hazards. Vehicles at this level are typically equipped with advanced driving assistance systems (ADAS) that can take over steering, acceleration, and braking in specific scenarios. These systems are beneficial in stop-and-go traffic scenarios by maintaining the distance between you and the vehicle in front of you while also providing steering assistance by centering the car within the lane.
Level 3 (conditional automation)	A specific mode that handles all aspects of driving but the driver must be ready to respond to a request to intervene. Autonomous vehicles at this level are capable of driving themselves, but only under ideal conditions and with limitations, such as limited-access divided highways at certain speeds. A human driver is still required to take over should road conditions fall below ideal. Some vehicles at this level have "environmental detection" capabilities and can make informed decisions for themselves, such as accelerating past a slow-moving vehicle.
Level 4 (high automation)	At Level 4, the vehicle's autonomous driving system is fully capable of monitoring the driving environment and handling all driving functions for limited routes and conditions defined within its operational design domain (ODD). A steering wheel and pedals remain at this level but no human input or oversight is required except under certain conditions, such as road type or geographic area, poor weather and other unusual environments. The driver might manage all driving duties on surface streets then become a passenger as the car enters a highway. The vehicle may alert the

Term	Definition
	driver that it is reaching its operational limits if those conditions dictate human intervention, such as heavy snow. If the driver does not respond, it will secure the vehicle automatically within specified safety parameters, including slowing down to a full stop.
Level 5 (full driving automation)	Vehicles at Level 5 are fully autonomous, meaning a driver is not required to perform all driving tasks. Autonomous vehicles at this level are not bound by geofencing nor affected by weather and can transport human beings comfortably and efficiently. Only the destination is the sole requirement to get from point A to point B. In fact, vehicles in this category may not come outfitted with steering wheels or gas/brake pedals. Passengers simply enter voice commands for onboard systems, such as entertainment, air-conditioning and video calling.



(Link)

Term	Definition
CARLA	An open source simulator for autonomous driving research. CARLA has been developed from the ground up to support development, training, and validation of autonomous driving systems. In addition to open-source code and protocols, CARLA provides open digital assets (urban layouts, buildings, vehicles) that were created for this purpose and can be used freely. The simulation platform supports flexible specification of sensor suites, environmental conditions, full control of all static and dynamic actors, maps generation and much more.
Catapult	The Catapult Open Innovation Vehicle Platform is an autonomous capable vehicle used to support research and development of Connected and Autonomous Vehicle products and services.
CCAM	Cooperative, connected and automated mobility: In many respects today's vehicles are already connected devices. However, in the very near future they will also interact directly with each other as well with the road infrastructure and other road users. This interaction is the domain of Cooperative Intelligent Transport Systems (C-ITS), which will allow road users to share information and use it to coordinate their actions. This cooperative element is expected to significantly improve road safety, traffic efficiency and comfort of driving, by helping the driver to take the right decisions and adapt to the traffic situation.
Car-Following models	Models which describe how drivers follow each other within the same lane. By considering the drivers' reaction times, the vehicles' speeds, and distances between preceding vehicles (PVs) and following vehicles (FVs), in addition to desired inter-vehicle spacing and other factors, these models try to reproduce real-world following dynamics of human -driven or automated vehicles (link).

Term	Definition
Clustering	Clustering is a Machine Learning technique that involves the grouping of data points. Clustering aims to discover meaningful structure, explaining the underlying process, descriptive attributes, and groupings in the selected set of examples. The categorization can use different approaches and algorithms depending on the available data and the required sets (link).
Collision-free CF models	A class of car following models within which rear-end collisions do not occur when the preceding vehicle suddenly brake (link).
CommonRoad	CommonRoad is a collection of composable benchmarks for motion planning on roads, which provides researchers with a means of evaluating and comparing their motion planners. Composable benchmarks for motion planning on roads (CommonRoad) are proposed so that numerical experiments are fully defined by a unique ID; all information required to reconstruct the experiment can be found on the CommonRoad website. Each benchmark is composed by a vehicle model, a cost function, and a scenario (including goals and constraints).
Concrete scenario	A single scenario describing exactly one specific scenery and chain of events with fixed parameters. This can, for example, be written as OpenDrive + OpenSCENARIO (link). Also useful: https://arxiv.org/pdf/1905.03989.pdf

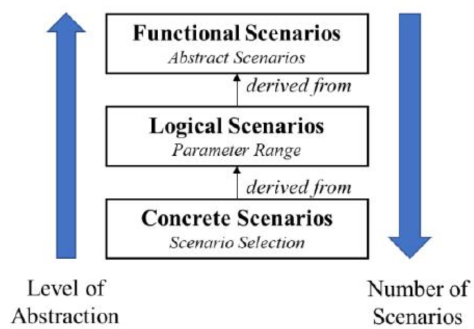
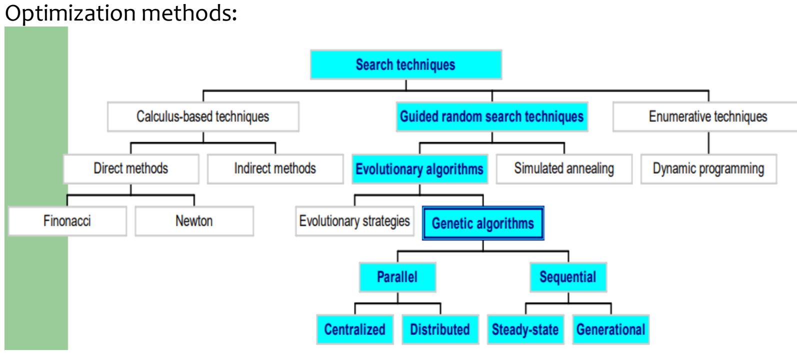


Figure 1. Scenario Development Process.

Conventional Human Driver	A human [natural] person who manually exercises in-vehicle braking, accelerating, steering, and transmission gear selection input devices in order to operate a vehicle (link).
Credibility	The "quality to elicit belief or trust" – is the simulation credible enough to be used in the verification and validation process to ensure whether a real test can be replaced by a virtual one (link).
Critical driving situations / Safety-Critical Operational Situation	Traffic conditions (within the ODD), where a hazard is very likely to propagate to a harm. // Scenarios that cause potential risks of harm, which need explicit consideration for risk investigation and potential mitigation measures (link).
Data mining techniques	Data mining is the process of finding anomalies, patterns and correlations within large data sets to predict outcomes // the process of sorting through large data sets to identify patterns and relationships that can help solve specific research problems.
DNSH assessment documents	Do No Significant Harm
DOE analysis	Design of experiments (DOE) is a systematic, efficient method that enables scientists and engineers to study the relationship between multiple input variables (aka factors) and key output variables (aka responses).
Driver behaviour heterogeneity	Variations in the individual's driving styles during routine driving. Heterogeneity is an important characteristic of car-following behaviour and can be defined as the differences between car-following behaviours of driver/vehicle combination under comparable conditions (link) (link).
Dynamic driving task (DDT)	Real-time operational and tactical functions required to operate a vehicle safely in on-road traffic (link).
Elastic net regression	Elastic net is a combination of the two most popular regularized variants of linear regression: ridge and lasso. Ridge utilizes an L2 penalty and lasso uses an L1 penalty. With elastic net, you don't have to choose between these two models, because elastic net uses both the L2 and the L1 penalty. A problem with linear regression is that estimated coefficients of the model can become large, making the model sensitive to inputs and possibly unstable. Ridge and lasso are the two most popular variations of linear regression which try to make it a bit more robust (link).

Term	Definition
Epistemic uncertainty	Epistemic uncertainty refers to the part of uncertainty deriving from a lack of knowledge about the system or the environment and representing a potential inaccuracy in any phase or activity of the modelling process. As such, it can potentially lead to a strong bias of results i.e., systematic deviation of model outputs from the true states of a system. It was also called ignorance, incertitude or subjective uncertainty. It can be reduced by collecting more data or information, increasing the measurement techniques, the model structure, the resolution method, the numerical precision, etc. Usually, it is not naturally defined in a probabilistic framework (link).
Estimation errors	The difference between an estimated value and the true value of a parameter or, sometimes, of a value to be predicted (link).
Euro NCAP	The European New Car Assessment Programme is a European voluntary car safety performance assessment programme.
Falsification techniques	The Falsification Principle (Karl Popper) is a way of demarcating science from non-science. It suggests that for a theory to be considered scientific it must be able to be tested and conceivably proven false. For example, the hypothesis that "all swans are white," can be falsified by observing a black swan (link). A hypothesis or model is called falsifiable if it is possible to conceive of an experimental observation that disproves the idea in question. That is, one of the possible outcomes of the designed experiment must be an answer, that if obtained, would disprove the hypothesis (link).
First order correlations	A partial correlation in which the effects of only one variable are removed (held constant) (link).
FOT data	Field Operational Test data – ADS technologies need to go through field operational tests or FOTs — where a certain number of participants are recruited to try a novel system or service for a few months or years before it enters the market (link).
FRAV groups	Functional Requirements for Automated and Autonomous Vehicles (FRAV). The Informal Working Group develops functional (performance) requirements for automated/autonomous vehicles, in particular, the combination of the different functions for driving: longitudinal control (acceleration, braking and road speed), lateral control (lane discipline), environment monitoring (headway, side, rear), minimum risk manoeuvre, transition demand, HMI (internal and external) and driver monitoring. This work item should also cover the requirements for Functional Safety. Also, should do this in line with the following principles/elements a. System safety, b. Failsafe Response, c. HMI / Operator information d. OEDR (Functional Requirements) described in document ECE/TRAN/WP29/2019/34.
Functional Scenario	A non-formal, human readable, behaviour-based description of a traffic scenario, possibly containing a visualization (link).
Genetic Algorithm model	Genetic algorithm is a part of heuristic optimization approaches. Optimization: search for the "best" configuration of a set of variables to achieve some goals. Optimization methods:  Heuristic approach: Faster than mathematical optimization (branch & bound, simplex, etc.). Genetic algorithm (GA): a type of evolutionary algorithm that can compute solutions to general problems which humans do not know how to solve directly. The machine is tasked with generating a working computer program from a high-level implementation of the problem. The idea is to randomly generate thousands of computer programs and use Darwinian natural selection to evolve the programs until the population converges to a global maxima/minimum. It is often used in the field of Machine Learning to determine relationships between features in data. Link and link and link.
Generalized linear mixed effect models	Generalized linear mixed models (or GLMMs) are an extension of linear mixed models to allow response variables from different distributions, such as binary responses. GLMMs are an extension

Term	Definition
	of generalized linear models (e.g., logistic regression) to include both fixed and random effects. GLMMs can answer specific research questions OR be used to understand sources of random variability in outcomes. In addition, GLMMs are useful for experimental data because they can include all sources affecting the responses in a model with fixed or random effects, and the distribution of responses is not limited to a normal distribution (link).
Global sensitivity analysis	Sensitivity analysis is the measure of how sensitive a model is to changes in parameters, i.e. how much the output changes given a change in the input. Global sensitivity analysis is the process of apportioning/allocating the uncertainty in outputs to the uncertainty in each input factor over their entire range of interest. I.e. how does the output of a model generally change with a change in the input? (link).
Hierarchical Bayesian networks	Bayesian Networks are one of the most popular formalisms for reasoning under uncertainty. Hierarchical Bayesian Networks (HBNs) are an extension of Bayesian Networks that can deal with structured domains, using knowledge about the structure of the data to introduce a bias that can contribute to improving inference and learning methods (link).
Human factors (HF)	An applied, scientific field of study to understand the relationship between devices and systems and their users, with the capabilities and limitations of human beings as the central focus (link).
Human in the Loop Machine Learning	Human-in-the-loop machine learning is the practice of uniting human and machine intelligence to create effective machine learning algorithms. It's a blend of supervised machine learning and active learning. Humans are involved in both the training and testing stages of building an algorithm, which creates a continuous feedback loop that allows the algorithm to produce better results each time (link).
Human road safety baseline	The minimum level of safety that an automated driving system should have - as a starting point in the roadmap to zero fatalities it has been established that an ADS shall be equally safe or safer than a current human driven vehicle/ a "reference" human driver – the so-called "skilled and attentive human driver". The safety baseline is given by the range of critical conditions that can be prevented by a human driver model (so-called "preventable" scenarios).
Human-driven vehicles	Vehicles that are controlled/driven by a human with 0 automation.
IEEE	IEEE (Institute of Electrical and Electronics Engineers) is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity.
Integrated lane changing models	The transfer of a vehicle from one lane to adjacent lane is defined as lane change. Lane changing has significant impact on traffic flow. Lane changing models are therefore an important component in microscopic traffic simulation Modelling the behaviour of a vehicle within its present lane is relatively straightforward, as the only considerations of any importance are the speed and location of the preceding vehicle. Lane changing, on the other hand, is more complex, because of the decision to change lanes depends on several objectives. Integrated models are those which integrate mandatory (occurs when a driver must change lane to follow a specified path) and discretionary lane changes 9 occurs when a driver changes to a lane perceived to offer better traffic conditions, such as to achieve desired speed, avoid following trucks, avoid merging traffic, etc.) in a single framework, include an explicit target lane choice in the decision process and incorporate various types of lane-changing mechanisms, such as cooperative lane changing and forced merging. Aim is to provide a more complete and integrated representation of drivers' behaviours (link). Examples: LMRS (Lane change Model with Relaxation and Synchronization), MOBIL (Minimizing Overall Braking Induced by Lane Changes), GIPPS (from 198 - constructed a new model for the response of the following vehicle based on the assumption that each driver sets limits to his desired braking and acceleration rates).
Inter-driver heterogeneity	Variability in the behaviour of the same driver (link).
Intra-driver heterogeneity	Variability in the behaviour of different drivers (link).
ISO Standards	ISO standards are internationally agreed by experts. ISO 22737 sets the standards for Intelligent transport systems — Low-speed automated driving (LSAD) systems for predefined routes — Performance requirements, system requirements and performance test procedures.
ITF	International Transport Forum
ITS	Intelligent Transport Systems
Ko-HAF	The Ko-HAF project - cooperative highly automated driving - aims at the next essential step towards autonomous driving, highly automated driving at higher speeds.

Term	Definition
LASSO regression	Lasso regression is a regularization technique. It is used over regression methods for a more accurate prediction. This model uses shrinkage. Shrinkage is where data values are shrunk towards a central point as the mean. The lasso procedure encourages simple, sparse models (i.e. models with fewer parameters) (link).
Logical scenario	A parameterized representation of a set of scenarios, where influencing factors are described by means of parameter ranges and distributions – enables parameter variation (link).
Microscopic mixed traffic simulation	Microscopic traffic simulation models traffic networks, typically with advanced traffic control and ITS systems. They represent networks in detail and simulates individual vehicle movements using car following, lane changing, and traffic signal responding logic (link). Mixed traffic: describes any form of mixture of road users that interact on the road with each other. That can be a mix of human driven and autonomous vehicles, a mix of connected or non-connected vehicles etc.
Model validation	Model validation is the process of checking that the model is representative, not only of the data used for model calibration but also, in more general terms, of the traffic system to be analysed. (link).
Model verification	Model verification is the process in which the constructed simulation model is checked for logical errors. In other words, the analyst verifies that the model is functioning as intended by e.g. software error checking, Input coding error checking, animation review, etc. (link).
Modelling of the modelling process	Modelling of the modelling process is a strategy inspired by sensitivity auditing whereby a modeller retraces her steps in the construction of the model, and replaces crisp assumptions with actionable choices, then propagate the uncertainty through all these choices using a Monte Carlo approach.
Naturalistic driving data	Naturalistic data can be defined as data that make up records of human activities that are neither elicited by nor affected by the actions of social researchers. In the context of this project, it provides continuous recording of driving information using advanced instrumentation under real-world driving conditions. Naturalistic driving (ND) is a research method that provides insight in everyday driver behaviour. Typically, in an ND study vehicle are equipped with several small cameras and sensors, which continuously and inconspicuously register vehicle manoeuvres, driver behaviour, and external conditions. This allows observation and analysis of the interrelationships between driver, vehicle, road, and other traffic in normal situations, conflict situations, and crashes (link).
Naturalistic driving studies (NDS)	Refers to studies undertaken using unobtrusive observation when driving in a natural setting. In Naturalistic Driving Studies (NDS), the driver is unaware of the observation as the data collection is organised as discreet as possible and preferably drivers use their own vehicles (link).
Naturalistic field operational test (n-fot)	A Field Operational Test is a study undertaken to evaluate a function, or functions, under normal operating conditions in environments typically encountered by the host vehicle(s) using quasi-experimental methods. EC officials define Field Operational Tests (FOT) as large-scale testing programmes aiming at a comprehensive assessment of the efficiency, quality, robustness and acceptance of ICT solutions used for smarter, safer and cleaner and more comfortable transport solutions, such as navigation and traffic information, advanced driver assistance - and cooperative systems (link).
Near-critical conditions	Near critical conditions for an AV would be all the driving conditions for which the AV has not been trained for. Therefore, to enhance safety resilience of AV, it is necessary to define all the near critical conditions that may on the road (link).
ODDs	Operational design domain(s) means a description of the specific domain or domains in which an automated driving system is designed to properly operate, including types of roadways, ranges of speed, weather, time of day, and environmental conditions (link). Operational Design Domain: Operating conditions under which a given ADS or AD feature thereof is specifically designed to function [6]. It contains the set of all the influential factors and the possible combinations of these factors (link).
OEMs	Original equipment manufacturer (link).
OpenX standards	ASAM's OpenX standards describe the domain of road traffic. They cover concepts like road infrastructure, traffic participants, and scenarios for driving simulations. The standards play an increasing role in the automotive and driving Simulation industries. All OpenX standards come from the same domain - road traffic (link).
OTS	OpenTrafficSim aims to bring traffic simulation to a new level by: • Combining micro-simulation, macro-simulation and meta-simulation in a single environment • Combining all traffic modes (private car, buses, trains, bicycles, pedestrians, airlines, etc.) in a single simulator

Term	Definition
	• Providing options to link to external code, driving simulators, and data sources
Parsimonious models	A parsimonious model is a model that accomplishes a desired level of explanation or prediction with as few predictor variables as possible (link).
PEARS	Prospective Effectiveness Assessment for Road Safety: an open consortium (established in 2012 as Harmonization Group) in which engineers and researchers from the automotive industry, research institutes and academia join with the objective to develop a comprehensible, reliable, transparent, and accepted methodology for quantitative assessment of crash avoidance technology by virtual simulation. The focus of P.E.A.R.S. is on the development of an ISO standard for the prospective assessment of traffic safety for vehicle-integrated active safety technologies by means of virtual simulation (link).
Pegasus	PEGASUS project of the German Federal Ministry of Economic Affairs and Energy (methods for the testing and development of automated driving systems) (link).
Plausibility	The authenticity of data, i.e. node-centric trust, is ensured by authentication protocols defined in the IEEE 1609.2 [1], but detecting the correctness of data broadcasted remains an open challenge. This is also known as data-centric trust, where the detection is focused on verifying data accuracy mainly thanks to plausibility and consistency checks *(17) (PDF) Integrating Plausibility Checks and Machine Learning for Misbehavior Detection in VANET*. Available from: https://www.researchgate.net/publication/330472657_Integrating_Plausibility_Checks_and_Machine_Learning_for_Misbehavior_Detection_in_VANET [accessed Oct 26 2022] (link).
Prospective safety analyses	The safety effectiveness assessment of the technology before its market introduction is aimed by the prospective assessment approaches. Basically, four different approaches are known. These are: field operational test (FOT), user studies in a controlled environment (driving simulator or test track), accident analysis and computer simulations (link).
Regularized regression tools	(e.g., LASSO, elastic net)
SAE	Society of Automotive Engineers
Safety critical scenarios	Refers to unsafe driving. A safety-critical event can be a crash (where measurable contact is made between the subject vehicle and an object), a near-crash (where a crash would have transpired had a rapid evasive maneuver not been made) and a crash-relevant conflict (which is a conflict that is less severe than a near-crash, but more severe than normal driving) (link).
Scenario	The temporal development between several scenes in a sequence of scenes (link).
Sensitivity auditing	Sensitivity auditing is an extension of sensitivity analysis for use in policy-relevant modelling studies. Its use is recommended when a sensitivity analysis (SA) of a model-based study is meant to demonstrate the robustness of the evidence provided by the model, but in a context where the inference feeds into a policy or decision-making process'.
Structural equation modelling (SEM)	SEM involves the construction of a model, to represent how various aspects of an observable or theoretical phenomenon are thought to be causally structurally related to one another. The structural aspect of the model implies theoretical associations between variables that represent the phenomenon under investigation (link) The structural equation model (SEM) provides a means for measuring the relationship between multiple variables at the same time (link).
Surrounding-Aware Manoeuvre Recognition	Recognition of manoeuvres, which takes into account the context of present surrounding vehicles with their dynamic features of motion in relation to other vehicles, to roads topology and features, occupancy grids for gaps estimations and available free space, possible dynamic and static obstacles and/or occlusions.
Task demand (FDTD)	Fundamental Diagram of Task Demand: FDTD is defined as the functional relationship between a task depicted by a measurable variable, such as headway, speed, etc, and the cognitive demand that the task has on a driver as a function of the presumed variables (link).
TRA	Transport Research Arena Conference
TRB conference	Transportation Research Board Annual Meeting
Turing test	Turing test is a test of a machine's ability to exhibit intelligent behaviour equivalent to, or indistinguishable from, that of a human (link). The use of AI for advanced driver assistance systems (ADAS) or within Self-Driving Systems (SDS), Automated Driving Systems (ADS) or Automated Vehicles (AV) is considered for reducing road fatalities (link).

Term	Definition
Type-approval	'type-approval' means the procedure whereby an approval authority certifies that a type of vehicle, system, component or separate technical unit satisfies the relevant administrative provisions and technical requirements (link).
Uncertainty	Any deviation from the unachievable ideal of completely deterministic knowledge of the relevant system (link).
UNECE VMAD	'Validation Method for Automated Driving' VMAD is an informal group in GRVA-UNECE which is responsible for developing methods to assess the safety of the driving performance for automated driving systems that fulfil the role of the human driver when undertaking driving tasks, including safe responses to the environment as well as safe behaviour towards other road users by December 2020 (link).
V-model	The V-model is a graphical representation of a systems development lifecycle. It is used to produce rigorous development lifecycle models and project management models. The left side of the "V" represents the decomposition of requirements, and creation of system specifications. The right side of the "V" represents integration of parts and their validation.