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A taxonomy for autonomous vehicles for different transportation modes

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Abstract. To be autonomous, systems must be able to capture, perceive, analyse, plan, make decisions and act without human intervention. These characteristics are very important and should be carried out in real time. This is what creates the challenge for autonomous systems to come out and become established players in real world. Different autonomous vehicles that are used in different environments, constrained or not, like roads, rails, overwater, underwater, air, need to have different capabilities and characteristics and in addition pose different kind of challenges that need to be overcome. Therefore, there exists many taxonomies that have been proposed by researchers with different backgrounds in order to address the needs of their specific systems in the most effective way. However, there is some common base between the different taxonomies that are proposed for various vehicles and it would be beneficial to try and learn from the experience of the approaches proposed. In this paper, we try to compare the most frequently proposed taxonomies in autonomous vehicles operating in different modes and help the readers find the similarities and differences amongst them.

1. Introduction

Autonomous and unmanned ships have received much interest the last few years, not the least with the presentation of the world's first ever autonomous, unmanned container ship with zero emission, the "Yara Birkeland" [1]. The ship is expected to be delivered in 2020 and will gradually move from manned operation to autonomous by 2022.

However, autonomous ships are not the first means of transportation that are moving from manned to unmanned operations. All new technologies in communication and robotics have had a substantial influence on our daily lifestyle of which transportation is no exception. The first general purpose mobile ground system dates back in 1960's, and was called "Shakey the robot" [2], which was able to reason its own actions, and had the ability to perceive and reason about its surroundings. New and more powerful technologies give a definitive increase in the number and types of autonomous transport technology. In academic circles ground vehicle autonomy may be a research subject on its own, but in general, it is a tool that aims to reduce crashes, energy consumption, pollution, and congestion while at the same time increasing transport accessibility [3]. The same goals apply to autonomous vehicles in other types of transportation like railways, airplanes, as well as ships and inland vessels.

All autonomous vehicles that operate in mixed traffic, i.e. together with conventionally manned vehicles, need to satisfy some important criteria with safety being the most crucial amongst them [4]. This is because they need to guarantee that the probability of harming its own passengers or other people in their vicinity, is negligible. This is a difficult proposition, both in determining what exactly "negligible" is and in proving that the safety level of the vehicle satisfies this criterium. A general rule



can be that for a safe system, the current and future risk is below a threshold accepted in society [5]. A main problem is to get a sufficiently good overview of what the potential hazards are and the associated risks, particularly with respect to new hazards that may evolve from the development of increased autonomy.

One way to improve our knowledge and understanding of autonomous vehicles is to pool the knowledge from the different modes. This research however comes with some challenges. Different classes of vehicles can have significant differences regarding their safety requirements and putting them into a cost effective operational concept can be hard. Ships, light trains and airplanes are relatively large systems with high value and will in most cases be supervised from a remote control centre and have in addition supervision from the authorities like Vessel Traffic Services for ships or Air Traffic Control for airplanes. On the other hand, passenger cars must likely be based on intervention from the passenger, when and if necessary, while autonomous buses end up in a category in between. The traffic situation is also very different with an almost fully controlled environment for light rail and mining trucks, a controlled environment with some traffic challenges when it comes to large ships and airplanes to a fully uncontrolled environment for passenger cars in normal traffic. The potential damage is also very different with inherently close to negligible for small underwater craft to very high for fast moving autonomous cars in mixed traffic.

There is some controversy related to the general term "autonomous" and, e.g. the Society of In Automotive Engineers (SAE) has suggested to depreciate it in favor of the term "driving automation". However, in the current paper the term autonomous is used in order to describe a vehicle that can make decisions by itself and can operate independent of a human operator. Therefore, autonomous is an engineering system able to make its own decisions about its actions while performing different tasks, without the need for involvement of an exogeneous system or an operator. This human machine interaction and operation can be expressed by "levels of autonomy" which specify the different level to which a task is automated [6].

This paper will develop a simple classification system for autonomous vehicles that may make it easier to compare knowledge and experience from the different transportation modes. In this paper we will focus on the comparison of levels of autonomy (LoA) in the different modes. Section 2 will briefly give an overview of the relationship between loA and safety hazards. Section 3 describes some different vehicle types and their LoA classifications.

2. Level of Autonomy and safety

Most classifications of levels of autonomy (LoA) look only on the division of responsibility between human and automation. This will be discussed in section 4. The focus on responsibility divisions is natural as the Human-Automation Interface (HAI) may be a significant source of safety hazards in operation of semi-autonomous systems [7]. This means that there are three related hazard types one needs to consider in autonomous systems control:

- a) The capabilities of the automation system to handle all relevant problems in the operations and environment
- b) The capabilities of the human to handle any tasks that are delegated to the operator
- c) How well human and autonomous systems can cooperate with each other.

In [7] it is argued that the latter problem should not be underestimated and that it is likely to be more apparent especially in the cases when the systems need to execute complex tasks or operate in complex environments.

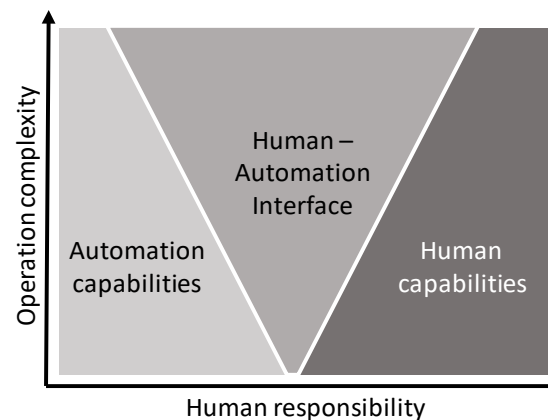


Figure 1: HAI related hazard groups

Figure 1 illustrates this problem. From the perspective of cross-modal safety learning, this also makes the LoA classifications and the relevant characterizations of the modes relevant.

As we will see in the next section, most LoA are generally modelled on the pipeline model of human decision making that was proposed in [8] and illustrated in Figure 2. In addition to the four steps in the original model, we have added an extra step, number 5 named execution, in order to illustrate that someone must initiate the execution of the decision.

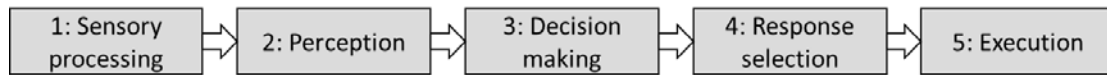


Figure 2: Human decision pipeline – modified

Table 1: Sheridan versus pipeline level

Sheridan’s LOA / Pipeline level	1	2	3	4	5
human does the whole job up to the point of turning it over to the computer to implement					
computer helps by determining the options					
computer helps to determine options and suggests one, which human need not follow					
computer selects action and human may or may not do it					
computer selects action and implements it if human approves					
computer selects action, informs human in plenty of time to stop it					
computer does whole job and necessarily tells human what it did					
computer does whole job and tells human what it did only if human explicitly ask					
computer does whole job and decides what the human should be told					
computer does the whole job if it decides it should be done, and if so, tells human, if it decides that the human should be told					

This model is also closely related to the well-known 10 LoA taxonomy initially proposed by Sheridan and Verplank [9], and a simplified cross-reference between the two is illustrated in Table 1. The shaded cells illustrate the responsibilities of the computer and the unshaded cell those of the human. The lightly shaded cells show various degrees of split responsibility.

There are also other ways to classify levels of automation or autonomy, e.g. as a layered structure where increasingly higher levels of decisions are left to the computer, e.g. starting at simple locomotion, increasing with object detection and object avoidance, then planning for exploration etc. [10]. Other approaches also take, e.g. the complexity of operations or environment into consideration when classifying level or degree of autonomy [11].

3. Types of vehicles and challenges for autonomous usage

In the current paper we use some specific types of autonomous systems as an example. We try to analyse the challenges that need to be faced and not all systems experience the same challenges when it comes to autonomous operations. There are different aspects that make the general public or the authorities sceptical to different systems and we give an overview of the problems that need to be faced when such a system is launched.

3.1. Autonomous cars

Autonomous cars seem like a promise that is here, almost here, and still not happening for years and years. The statement is obviously true because there are different “levels” of autonomy. Different challenges have been applied and are connected to autonomous driving cars especially after the last accidents that have caused the death of pedestrians, the public started again being sceptic about them. The main challenges that need to be faced include the cars' safety when perception and decision-making capabilities are concerned. The challenge is to build an autonomous car that will have a better perception of the road than the best human driver has. In addition, usefulness is another aspect that comes into the equation. That means a system that can make reasonable decisions, such as how fast to drive and when

should it change lanes. I can be completely safe if I don't drive or if I drive very slowly," "but then I'm not useful, and society will not want those vehicles on the road" [12].

Finally, the last challenge is to create a cost-effective car, so consumers are willing to switch to driverless. In the near term, with the technology still at tens of thousands of dollars, only a ride-hailing business will be financially sustainable. In that context, "you are removing the driver from the equation, and the driver costs more than tens of thousands of dollars" [12]. Another challenge to be solved is the fact that it is still unclear how autonomous cars will be able to handle extreme and unexpected events including their moral aspects. Six levels of autonomy are proposed by NHTSA for autonomous cars as they are presented below.

Table 2: Official Autonomous Vehicle Classification System Established by National Highway Traffic Safety Administration (NHTSA), United States

Level of Autonomy	Description
LoA0	No automation. Zero autonomy, the driver performs all driving tasks.
LoA1	Driver assistance. Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.
LoA2	Partial Automation. Vehicle has combined automated functions, like acceleration and steering, but the driver must always remain engaged with the driving task and monitor the environment.
LoA3	Conditional Automation. Driver is a necessity, but it is not required to monitor the environment. The driver must always be ready to take control of the vehicle with notice.
LoA4	High automation. The vehicle can perform all driving functions under certain conditions. The driver may have the option to control the vehicle.
LoA5	Full automation. The vehicle can perform all driving functions under all conditions. The driver may have the option to control the vehicle.

3.2. Light Rail/Metro

Railway transportation is the simplest to be automated because of the simple environment that they operate on. However, the amount of the trains/metros around the world that run in autonomous mode is quite low. This is due to different factors. When it comes to suburban trains a great challenge that we need to overcome are the safe management of train door closures in the station without negatively impacting operations. In addition, in inter-urban a variety of rolling stock that can limit performance gains, analysis of efficiency is performed on the transport system. The stopping distance for these systems is far superior to road systems: for TGV 300km/h, stopping distance: 3,000m in emergency brake and 9,000m in service brake and for RER 80km/h – 300m in emergency brake and 500m in service brake [13]. Therefore, actions in order to overcome the above-mentioned challenges need to be considered for an increase in the usage of autonomous railway systems to become a reality.

Amongst the different and various taxonomies that exist it seems that the most commonly taxonomy used for these types of autonomous systems consists of 5 levels of autonomy and is described as follows:

Table 3: Levels of Autonomy for light rail and metros

LoA	Description
LoA0	No automation
LoA0+	The system controls the speed.
LoA1	The system allows for a movement authority and a requested speed profile. External systems can detect non-railway related risks (lateral winds) and the modification of speed is communicated to the driver by these systems.
LoA2	Operation system is interfaced with the onboard and ATP/supervisor equipment. The speed modification is communicated by the non-railways risk detection systems to the ATO.
LoA3	The driver becomes an on-board attendant and intervenes only when necessary.
LoA4	The train drives itself without the presence of an onboard agent.

3.3. Trams

Trams differ from light rail and metros in that they operate in less controlled environments, where other traffic may disturb operations and also pedestrians are present. As far as autonomous tram systems are concerned, their presence in the world is quite limited. The reason for that is twofold. Firstly, because there is a limited market comparing with the R&D costs for the adaptation of such an autonomous vehicle technology. Furthermore, additional complexity in security validation if Deep Learning is used (opacity of the algorithms, error rate, incompleteness of data, instability). Moreover, there is a tradeoff between safety and availability of the service/overall performance of the system: an imperative for a tram which cannot leave its guideway and change itinerary to compensate for the loss of speed or regularity as an autonomous shuttle can do. Another challenge is the stopping distance that is required that is far superior than road vehicles (wheel rail contact and no belted passengers): 50 km/h, stopping distance: 100 m, which is 3 times more than for a car. Finally, is the problem that can be caused by the departure of the train in the station with the presence of many pedestrians in front of the train. A commonly used taxonomy that is used when it comes to autonomous trams includes 6 LoA and is presented in Table 4.

Table 4: Levels of Autonomy for trams

LoA	Description
LoA0	No automation
LoA0+	The system controls the speed (with a gentle and progressive sanction mode)
LoA1	The system helps the driver to drive better (speed setpoint, passive driving aids)
LoA2	The driver assists the system to be driven (control and speed control by the system, acti initiated either by the driver or by the system...)
LoA3	The driver becomes an attendant and intervenes when necessary
LoA4	The tram drives itself, without the presence of any onboard agent

3.4. Mining trucks

As far as mining trucks are concerned there is a different philosophy than cars and trams mostly because they have a completely different area of operation. Mining trucks operate mostly in environments that are rugged, (dust, moisture, extreme weather conditions), dynamic and often unpredictable, unstructured, difficult to sense and costly to incorporate integrity. In addition, for this case it is quite difficult to build simple, effective and robust models and there is a significant interaction with manned machines. In general, the challenges in mining automation become increasingly formidable as the level of autonomy increases. Automation technologies will only flourish after the evolution of the real-time, whole-of-mine, information systems take place. Such systems are virtually mandated where autonomous equipment is to interact with other equipment (manned or autonomous) by providing the framework for managing the interaction.

The proposed taxonomy for mining trucks consists of 5 LoA and is in accordance with the National Highway Traffic Safety Administration in the USA and is presented in Table 5.

Table 5: Official Autonomous Vehicle Classification System Established by National Highway Traffic Safety Administration (NHTSA), United States

LoA	Description
LoA0	No automation. The driver is in complete and sole control of the primary vehicle controls – brake, steering, throttle, and motive power – at all times.
LoA1	Function-specific Automation. Automation at this level involves one or more specific control functions. Examples include electronic stability control or precharged brakes, where the vehicle automatically assists with braking to enable the driver to regain control of the vehicle or stop faster than possible by acting alone.

LoA2	Combined Function Automation. This level involves automation of at least two primary control functions designed to work in unison to relieve the driver of control of those functions. An example of combined functions enabling a Level 2 system is adaptive cruise control in combination with lane centring.
LoA3	Limited Self Driving Automation. Vehicles at this level of automation enable the driver to cede full control of all safety-critical functions under certain traffic or environmental conditions and in those conditions to rely heavily on the vehicle to monitor for changes in those conditions requiring transition back to driver control. The driver is expected to be available for occasional control, but with sufficiently comfortable transition time. The Google car is an example of limited self-driving automation
LoA4	Full Self-Driving Automation. The vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Such a design anticipates that the driver will provide destination or navigation input, but is not expected to be available for control at any time during the trip. This includes both occupied and unoccupied vehicles.

3.5. UAV – small

UAVs fly over the air and in that case the challenges that they need to encompass different to some extent to the ones that are encountered by the ground systems. First of all, it is difficult to regulate flying of small drones. Thousands of small drones are sold every year to private buyers. Even a small drone can possibly pose high safety risks to large planes and ground installations like fuel depots. There are occasional instances where operators lose control of their UAV during the flight. The insurance aspect is not fully defined and developed. There are privacy risks to people. Drones can fly high and record visible parts of a private property. It can be used to look inside homes through windows [14].

As far as the levels of autonomy that are proposed regarding small drones it seems that this can vary according to the desired application, the area of flight etc. However, NATO WG defines four levels to classify the autonomy of a UAV system and is the one presented below.

Table 6: UAVs autonomy levels

LoA	Description
LoA1	Remotely Controlled System - System reactions and behaviour depend on operator input
LoA2	Automated System - Reactions and behaviour depend on fixed built-in functionality (preprogrammed).
LoA3	Autonomous non-learning system - Behaviour depends upon fixed built-in functionality or upon a fixed set of rules that dictate system behaviour (goal-directed reaction and behaviour)
LoA4	Autonomous learning system with the ability to modify rules defining behaviors - Behavior depends upon a set of rules that can be modified for continuously improving goal directed reactions and behaviors within an overarching set of inviolate rules/behaviors.

3.6. Small AGV (St Olav type)

Cost-effective AGVs run through production paths, which can be very narrow at times, without posing a risk to persons, machines and transport goods. Reliability and safety are the most important issues to be faced, since customers want systems to operate safely in environments with humans that in many cases are not aware of the existence of the device [24]. In addition, buyers are not willing to reconstruct their buildings in order to accommodate an AGV system and therefore some flexibility in their technology is needed in order to be able to satisfy different needs for different applications to various environments.

Normally, AGVs are not autonomous agents. This means that all vehicles of a fleet are guided by a centralized system which supervises the overall transport process. The agent's autonomy is limited to safety actions to ensure a safe overall process. A more flexible solution would lead to more data to process and higher computational costs [25]. This additional data would not be manageable in real-time by a centralized system, as the bandwidth and the computational costs would be too high. As a result, control must be distributed, and agents have to gain more autonomy in making decisions. However, autonomous agents are not well accepted in industrial applications and therefore a balance has to be struck among demands, flexibility and control.

3.7. Autonomous ships (MASS)

There is no generally accepted definition of levels of autonomy for ships. The International Maritime Organization (IMO) has selected a relatively arbitrary four *degrees* of autonomy for their regulatory scoping exercise, but this is not intended as a final classification:

Table 7: IMO's degrees of ship autonomy for scoping exercise

LoA	
AD1	Ship with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control..
AD2	Remotely controlled ship with seafarers on board: The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions..
AD3	Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.
AD4	Fully autonomous ship: The operating system of the ship is able to make decisions and determine actions by itself.

Several class societies (Class NK, LR, DNV GL, BV) have published their own definition of levels which are summarized in the below table.

Table 8: Comparison of class societies definitions

General description	Class NK [19]	LR [20]	DNV GL [21]	BV [22]
Human operated/Manual	-	AL0	M	0
Decision support on ship, manual		AL1		
Decision support on/off ship, manual		AL2	DS	1
Human directed, active human in the loop when needed	I	AL3	DSE	2
Human delegated, human on the loop	II	AL4	SC	3
Autonomous, sometimes human supervised		AL5		
Fully autonomous. Limited operational domain	III			
Fully autonomous	IV	AL6	A	4

This comparison is not 100% accurate, but it illustrates the general approach in the sector.

3.8. Autonomous inland vessels

Inland vessels operate in a domain in between trucks, with relatively well-defined lanes and ships, with less problems of unexpected events. The Rhine Commission is responsible for navigational safety in large parts of the European inland waterways and have also proposed a definition [23] that is presented in the below table.

Table 9: CCNR proposed definition

LoA	Description
LoA0	No automation, e.g. navigation with support of radar

LoA1	Steering assistance, e.g. rate of turn controller or track-pilot.
LoA2	Partial automation, certain parts of steering and propulsion is automated. Boat-master performs additional duties.
LoA3	Conditional automation: All navigational tasks supported by automation, including collision avoidance. Boat-master intervenes when necessary.
LoA4	High automation: Full automation and fallback handling of all situations under well defined condition, e.g. passage between locks. Additional situations handled by boat-master.
LoA5	Full automation: No human required to operate boat.

This proposed definition is very similar to the one used for cars.

4. Comparing vehicle types

One aim of this paper is to compare the levels of autonomy for different vehicle types and suggest how it is possible to use experience from one transport mode in analysis of others. The focus is on safe operation and, e.g. accident statistics is important to reuse over modes, if possible. However, the implementation of autonomous differs much over the modes and one reason for this is that the different modes face different challenges. The first part of this section defines the comparison criteria and the second summarizes the modes we analysed in the previous section.

4.1. Taxonomy components

Human-automation interface (HAI)

How the different modes make use of human backup or support is a major difference between modes. Some vehicles are designed for full autonomy with no humans in the loop while others in almost all cases rely on an operator somewhere in the system. The reasons for this are varied, but some important factors are briefly described below:

- *Size of vehicle:* High value vehicles like large ships will normally tend to be less autonomous than smaller and cheaper vehicles. This is mainly because the relative cost and human supervision is very small compared to possible losses, but also because damage potentials are much higher for larger vehicles and this warrants closer supervision.
- *Passengers on board:* Transporting passengers will normally require presence of trained personnel onboard to handle emergencies and possible evacuations. Safe boarding and disembarking of passengers are also a challenge.
- *Suitability for good HAI solutions:* The type of interaction between human and automation is also very different between modes. Ships move slowly and operate in a relatively controlled environment compared to cars, in terms of traffic or human presence without notice around them. This gives the operator more time to achieve situational awareness when his or her attention is required, and it is generally easier to design the HAI for such systems.

Environmental complexity

Some autonomous vehicles operate only in controlled environments. Examples are mining trucks and light rail systems where the operational area is expected to be empty of other vehicles that are not part of the system and other obstacles that can move around of free will, e.g. larger animals or humans.

In this case, the complexity of operations is relatively low, and any unexpected object that is detected can be handled by just stopping the vehicle and call for an operator or other person to assist. In other cases, complexity increases by adding more uncertainty to the vehicle's environment:

- *Object detection complexity:* How easy it is to implement an object detection system? Environmental factors like daylight/night, snow/rain/sleet, may affect the detection distance which is important for safety reasons. Also, how dense are the obstacles that need to be avoided, is another question. This is related to vehicle speed: Faster vehicles or objects need faster detection. Expected obstacle behaviour is also an issue. Other ships are expected to follow the

collision avoidance regulations, but pedestrians on a sidewalk can enter the in a street at any time.

- *Availability of maps*: Can the vehicle rely on a pre-mapped environment or not? Maps will greatly simplify operations as voyage plans can be made early and just adjusted in case obstacles appear. Maps can also be used as backup to, e.g. satellite positioning systems.
- *Traffic lanes*: The use of defined traffic lanes will also simplify the environment in which autonomous systems operate. It increases the predictability of other traffic and lowers need for complex anti-collision systems.

System complexity

The type of autonomous vehicle will also vary in complexity. Ships are created as self-sustained units for long voyages of up to several months. Light rail will be close to repair facilities at any time and need not the same durability as ships. The main factors determining system complexity are:

- *Physical size and complexity*: The larger the vehicle is, the more complex its systems are. This is related to damage potential as well as size. Size will have significant impact on energy consumption systems and actuators.
- *Voyage duration*: The other main factor is voyage duration. Long voyages far from repair facilities require more self-sustained systems in the vehicle.

Societal acceptance

Different types of autonomous vehicles can expect to get different level of societal acceptance. By societal acceptance we refer how well the society at large will tolerate the deployment of such vehicles and, ultimately, how well the society will tolerate any accidents related to the use of the vehicles. Societal acceptance is built on several factors and varies according to the previous knowledge that the general public has for each autonomous systems family [26]. This section describes through some factors that are used in this analysis.

- *Damage potential – Hazards severity*: Autonomous vehicles have different potential for causing damage. The potential will typically be a function of the size of the vehicle, the speed and the operational environment. Also, the number of autonomous vehicles in operation will be a factor. Thus, a mass-produced autonomous car will have a very high damage potential as several may fail due to, e.g. a systematic error in software. A large ship obviously has a high damage potential, but as there will be relatively few of them and as they generally move in relatively uncluttered environments, it can be characterized as medium to high hazard severity.
- *Perceived usefulness*: Another factor is how useful the autonomous vehicle is perceived to be, normally for the society at large. High usefulness will to some degree offset, e.g. high damage potentials.
- *Exposure of "innocent" people*: If the autonomous vehicle mainly poses a danger to professional personnel, this will also tend to reduce the weight on the damage potential. Examples of this are mining trucks that operate in controlled environments where only professional personnel is at risk.
- *Familiarity to the public*: One can also expect that autonomous vehicles that are familiar to the public, such as autonomous cars, will get a lower acceptance for any dangerous situations or accidents as many in the public will feel that this is more likely to affect themselves.

4.2. Comparing the modes

Table 10 summarises the characteristic factors for the investigated vehicle types and a rough overview of their main characteristics.

Table 10: Characteristics of transport modes

General description	Car	Metro	Truck	Small AV	AGV	MASS	IWW
HAI	Shared	Supervised	Supervised	Autonomous	Automatic	Supervised	Shared

Env. complexity	High	Low	Medium	Medium	Medium	Medium	Medium
System complexity	Medium	Medium	Medium	Low	Low	High	High
Societal acceptance	Low	High	High	High			

There are significant differences and the one which stands most out may be the autonomous car, due to its possible problem with societal acceptance.

Regarding the levels of autonomy used by the different modes, these are relatively similar. The exception here may be the MASS where there is still a discussion on the model to be used and where the argument is that the pipeline model may not work due to problems with hand over between automation and remote operations center (ROC), which is very likely that the MASS will have. One may argue that the focus on the LoA in the MASS domain is driven by this focus on the ROC and the problems of providing a good HAI for the ROC operators.

5. Summary and conclusions

The current paper summarizes some characteristics of different transport modes and what level of automation principles they employ. The authors have tried to compare different types of transport vehicles and compare the taxonomy that is commonly used in each different transportation mode. It seems that the decision on what type of taxonomy to be used in each mode depends on multiple decisions like the application itself, the environment to be used, the complexity, the security factors and the societal acceptance by the population. The authors tried to summarize and compare the different proposed taxonomies trying to find similarities and differences between them in order to help the readers understand which one suits better for their purposes.

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