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# AUTOMATED VEHICLES RISK ASSESSMENT AND EVALUATION

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## ABSTRACT

Statistics show that the number of passenger cars is increasing significantly, which will have a negative impact on social, economic and environmental sustainability, and it will cause severe problems for the next generations. Automated Vehicles represent an innovation in automotive technology. They have become a global concern because of their importance in smart traffic systems as well as their significant impact on safety, supposing that traffic will be more efficient and longer travel distance will not be a problem. They will become more acceptable since they will encourage living in suburbs and leaving noisy and polluted cities behind. Drivers will be more relaxed and in comfort while enjoying travel time and some extra privileges that they may have, for example, the chance for spending time more productively and efficiently at non-driving times inside the vehicle. Automated Vehicles are also beneficial for the environment. In fact, it is expected that in the next few years these cars in general will provide a solution for many problems. Researchers and planners of transportation systems are facing many challenges in the field of autonomous vehicles, as the level of safety and mobility involves such elements and circumstances which may cause that the operated travel will be less efficient than expected. The aim of the article is to discuss the challenges, threats, vulnerability, impacts and likelihood of failure faced in the development of Automated Vehicles by studying information security risk management standard process, and explaining how to apply the process of International Organization for Standardization. The concept of applying ISO to Automated Vehicles will be discussed here through certain processes.

## KEY WORDS

autonomous vehicles, risk management, risk assessment, transportation, safety and security

## CLASSIFICATION

JEL: O10, Q55

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## INTRODUCTION

Autonomous vehicles (AVs) are vehicles which are capable of driving themselves as well as recognizing, handling and sensing their environment. In order to do this, these vehicles should make decisions about where it is safe and desirable to move without the need for human supervision, control or operation. Everyone in the car could be a passenger, or it could even drive with no occupants at all. Automated vehicles are becoming a global phenomenon and expected to have various social, economic and environmental benefits. In fact, they are designed so that in the future they will be the solution for transportation systems, because of their high priority in achieving safety, not to mention other potential benefits. In the domain of Automated Vehicles there have been many different studies recently. Transport researchers generally focus on the implementation of intelligent transport systems (ITS), for example, how to construct and develop roads and traffic for a transport automation system with partially or fully autonomous vehicles, which will have a strong impact on the automotive industry and on the whole transportation system. Moreover, in the near future, self-driving cars will fundamentally reformulate road transportation inducing technological and socio-economic developments and requiring adaptation of the applicable laws as well as social acceptance. The framework is continuously changing over time, i.e. the future transportation design has to take into consideration technical, economic, legal, and social aspects simultaneously [1]. Software in AVs has various roles: engine control, external communications, car safety and security, and from the point of security the primary aim is to build a cyber-safe system with regard to the vehicles, vehicle systems and the intelligent infrastructure within the intelligent transport system [2]. The implementation of AVs will produce safer roads by removing human error from the driving equation, cleaner, healthier environment, new culture of sharing rides, which could reduce the need for new roads or parking areas and the expansion of existing roads, creating the potential to construct space for uses such as businesses, green space, walking and bicycling infrastructure. In addition, AVs will significantly improve traffic behaviour, as drivers will be more relaxed and enjoying travel time. Some expected benefits of exploiting non-driving time in vehicles in a productive way, transport accessibility to be widened for those previously unable to drive and it will improve access to certain jobs.
With a shift towards autonomous technology and away from human operators, vehicles are autonomously restored to the system state of minimal risk. From a technical point of view, the greatest challenge lies in the complete absence of a human supervisor, who knows the system's limits, recognizes its faults and, where needed, switches the vehicle into a safe state. But first, the meaning of a safe state must be defined, and whether it is possible for a driver take control within the exact needed time. Especially on highways these questions need to be further tested, analysed and assessed to identify the impact [3]. Special attention must be paid to the discussion of safety challenges that a self-driving electrical car project can encounter, and the main outcomes and future research possibilities for development [4]. Also, motor insurance companies, and related parties may change dramatically. There would be a greater need for the expertise of data analysts to understand why an autonomously operated vehicle failed in the event of an accident, and other potential negative impacts cannot be neglected. For example, who will take liability and blame for accidents, what happens to those millions who will be out of work, especially unskilled people. Therefore, the consequences of the use of this technology must be further studied. On the other hand, strategies must ensure that all adapted policies must be for the benefit of the whole community to create a better future for transportation, rather than focus narrowly on serving only vehicles. From an environmental point of view, it is known that Europe's primary sources for obtaining electricity rely heavily on coal, oil, gas and nuclear energy, and the goal should be to look for new energy sources (renewable and /or non-fossil sources) and to invest in better management and technologies

to reduce pollution. Since the energy consumption of the transportation sector is continuously increasing, more efficient and modern strategies are required in order to reduce its negative impact. It will have direct and indirect impact on transportation infrastructure and its environmental dimensions of sustainability for the coming generations. Whether the outcomes are positive or negative, it will depend on how policy frameworks guide the introduction of this rapidly evolving technology. The structure of the article is the following: the first part contains the literature review, it addresses the sustainability of using AVs with emphasize on positive and negative sustainability dimensions, impacts, risk management and assessment. The second part of this article describes the methodology of the research and introduces the concept of AV with risk management and risk assessment according to International Standardization. The final part includes the conclusions and recommendations.

## LITERATURE REVIEW

New technology always come with new risks, and the fear of autonomous vehicles is quite significant. However, increased safety, efficiency and improvements in quality of life and work are worth the effort, for instance globally, 93 % of road traffic accidents are caused by human error, with 1,3 million fatalities and 50 million injuries every year. By replacing the fallible human driver with a sufficiently capable technology, it is thought that collision rates will substantially decrease, with significant implications on safety. The potential for change is great, and yet, at the same time, this must be balanced against the practicalities of implementation, and the achievement of adequate safety standards to mitigate the new risks that come with the new technology. The lengthy considerations that would have to lead to reworking laws, systems and infrastructure should not be underestimated, nor should public mistrust of putting lives in the hands of technology.

### TRANSPORTATION SUSTAINABILITY

Sustainability in general is gaining balance between three main pillars: the economic, environmental and social health of a community. However, sustainability from transportation perspective, as reviewed in most literatures, is the future capacity to enhance mobility needs of a society to be less harmful for the environment with respect to the mobility needs for the generations to come. The European Council of Ministers of Transport (ECMT) defines a sustainable transportation system as one that meets the following: -

1. Allows the basic access needs of individuals and societies to meet safely and in a manner consistent with human and ecosystem health, and with equity within and between generations.

2. Affordable, operates efficiently, offers choice of transport modes, and supports a vibrant economy.

3. Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, re-uses and re-cycles its components, and minimizes the use of land and the production of noise.

### AVS AND SUSTAINABILITY DIMENSIONS

By applying the definitions of a sustainable transportation system on AVs according to (ECMT) most of the elements to reach sustainability have been achieved.

### THE SOCIAL DIMENSION

Many advantages have been associated with AVs recently. Handicapped or disabled people consider such cars as blessings. It will bring the chance for minors to move on road without adults joining them. They will enrich the travel experience and bring excitement and release people who do not like driving from this burden, as the car's intelligent system will choose the most optimal route decreasing highway traffic jams. All of these and more needed to be analysed to inform decision makers and to support risk responses [5]. Studies show that more than 90 % of automobile related fatalities are attributable to human error, either negligence, distraction, incapacitation or other human factors. Therefore, safer transportation with no human error is the most significant benefit, since the ability to control the flow of traffic will greatly increase. It is also worth to mention that a major strength of automated driving is that stress would no longer be a part of daily life and the morning commute to work would be relaxing.

### THE ECONOMIC DIMENSION

There will be indirect impacts on the economy, because autonomous cars will cause cities to expand and they will reduce parking lots, which will make valuable land available for development and allow cities to grow. Furthermore, longer travel distance will not be a problem, on the contrary, it will be more acceptable and it will encourage living in suburbs and leaving noisy and polluted cities behind, which will increase prosperity of such areas for the benefit of the economic dimension of both cities and suburbs.

### THE ENVIRONMENTAL DIMENSION

The preparation to shift towards another system of transportation could also become the perfect opportunity to incorporate more electric technology into automobiles, thus reducing carbon-emissions. From an optimistic point of view, the positive result is that using renewable energy sources for electricity generation will result in an over 25 percent reduction in emissions. It is shown by statistics that emissions of electric vehicles are falling. With declining percentage of electricity generated by coal power and increasing renewable resources, as well as with continued improvements in vehicle technologies the emissions reduction benefits of EVs will continue to grow. By 2050, much greater deployment of renewable energy sources could lower global warming emissions even further. Studies include electricity produced from renewable sources, under which scenario, emission intensity will be reduced. Also, driving at more consistent speeds, with less accelerating and braking, as well as more efficiently chosen routes could result in lower carbon emissions from driving. On the other hand, the initial concern and fear should be replaced by complete reliance on technology, and since driving can be a very dangerous task, it should be let under the control of an automated system. The infrastructure should also be made ideal for such fully automated vehicles, and it will take long to develop such an ideal infrastructure. A massive amount of data needs to be collected and tested via field before implementation. Other questions will come to surface related to various situations, for example, the liability of accidents, whether is it the responsibility of the car owner or the manufacturer, how the insurance company will deal with it, whether for the priority of safety the vehicle will take the right decision, and there will be an enough time for the driver to interfere, as well as many other questions. Also if we want the system to operate efficiently, there must be a single, ultimate network on which these vehicles communicate and operate with one another, since the cars are essentially computers on wheels, they do face cybersecurity threats. Many concerns about privacy and personal information security will arise not to mention the passengers' location which can be tracked. All of these are considered as weakness points and threats, and, at the same time, many parties will be affected either directly or indirectly, for example, but not limited to, auto manufacturers, oil companies, labour sectors, job seekers, etc.

## METHODOLOGY

As the process of research in automated transportation is a combine of an unlimited set of operational scenarios encountered in public traffic with the absence of human supervision, it needs the highest demands regarding functional safety throughout the development of these systems. To ensure safety, a risk assessment must be carried out, with analysis and evaluation as well.

## RISK MANAGEMENT AND ASSESSMENT PROCESSES

It is a fact that in recent research special attention has been paid to the discussion of the safety challenges that a self-driving electrical car project can encounter, the main outcomes and future research and development possibilities [4]. Hence, risk management is brought to surface in this research as it aims to make the transportation system more secure in terms of traffic accidents, protection against theft, security of software systems against malfunctions and external attacks. Software in AVs has various roles: engine control, external communications, car safety and security, and to build a cyber-safe system with regard to the vehicles, vehicle systems and intelligent infrastructure within the intelligent transport system [2].The main challenges in the field of autonomous vehicles rest in the fact that it will result in "Improving road safety by removing human error from the driving equation, through testing and validation processes for new autonomous systems and features and through developing cost and time efficient methodologies" [6]. There are continuous changes in the fields of research over time, i.e. future transportation design has to take into consideration technical and economic aspects as well as, legal rules and regulations, financial, insurance policies, socio-economic benefits, and other necessary factors [1]. The concept of applying NIST SP 800-30 and International Organization for Standardization (ISO)/ International Electro Technical Commission (IEC) 27005 to AV will also be discussed [5]. By implementing the risk assessment process, threats and vulnerabilities and their impact will be studied, and the analysis of risks will be followed by evaluation, whether they should be accepted or treated, and each step will be compatible and correlative with monitoring, acceptance, communication and consultation steps, as it is show in Table 1 and 2 below.

## RISK ASSESSMENT

Risk assessment does not only depend on ideal design system and modern technology implementation but also on seeking for information and data from different realistic studies. With the help of all possible assistance from transportation researchers and planners, the risk assessment process must be identified, analysed and evaluated, and each step in the assessment process must be implemented. This article supports the general concepts specified and designed as guidelines for security risk management and to define the approach to the risk management process as seen in the Tables below [5]. The assessment processes for risks will be as follows.

### Risk Identifications

Self-driving vehicles are not yet completely present in the traffic streams, with the exception of a few test vehicles. It is difficult to reliably predict future consumer demand. Any outcomes are just theoretical at this point since the fully self-driving technology is not available on the streets, the expectations of using self-driving cars are still not clear depending on how and when people will use self-driving vehicles [7]. This is why different risk studies are associated with the self-driving vehicles technology and each must be carefully assessed and taken into account [4].

### Risk Analysis

If any interruption occurs to an AV’s system, this will lead to high economic, environmental and social damages and leave the whole system in huge danger [8].

**Table 1.** Risk analysis.

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|---|---|
| **Resource and Assets** | Automated vehicles are not yet involved in the traffic and passenger demands are still ambiguous and uncertain, whether it will increase or decrease. To solve such problems and to make people more trusted in such technology, the following must be tested, assessed and evaluated; infrastructure readiness with existing as well as modern technology, and smart systems, in addition to the information and data implementation. |
| **Threats** | It is a very important to analyse in order to predict the needed processes to apply to the whole automated system, and to identify the types of threats that will surface first, the threats on infrastructure itself should be examined, because at present, there is no separated automation infrastructure, so automated vehicles should be made alert to their surroundings, other objects, cars, infrastructure and electric system, and their security aspects against direct or indirect contacts. At the same time, the operational and functional system safety in the car itself is a very important and vital element, since it is mainly concerned about hardware failures and software bugs [4]. To solve such problems and to analyse such threats the impact of cyber security must be taken into consideration, because these vehicles will be increasingly connected with smartphones and tablets. Even now, cars already have computerised units, so it is better to be worked by isolated systems, not networked, and therefore at less risk and less hacker attacks to access personal data. |
| **Vulnerability and Impact** | Analysis of the expected vulnerability and impacts include: -<br>1. Direct and indirect interruption or deliberate corruption occurred and how it will lead to severe economic, social and environmental damages and leave the whole system at risk 2. Battery charging safety and vehicle maintenance, 3. Operation and training and 4. With the identification of priority areas according to risk degree, in order to rearrange risks to an acceptable risk degree [4]. |
| **Likelihood of Failure** | "Every type of sensor has weaknesses, for example the weather condition has a strong effect on the visual capability of the video-based sensors. From another aspect, disturbances can also be simulated by region dependent road types or traffic signs" [6]. |

## Risk Evaluations

By using certain electronic systems and sensors to observe the environment and for mapping, localisation and navigation, such as a Vehicle-to-Everything platform, a vehicular communication system that incorporates other more specific types of communication as (Vehicle-to-Infrastructure), (Vehicle-to-Vehicle), (Vehicle-to-Pedestrian) or other users such as cyclists or a Wi-Fi network by providing automatic warning to prevent an accident, (Vehicle-to-Device), (Vehicle-to-Grid), or any other entity that may affect the vehicle [4].

The behaviour of pedestrians or a person around the car is difficult to predict in order to react properly. "In case of a sudden reaction of a person, the system must be able to react and remain in a safe state. This holds also for people lying on the ground or small animals. After all, these are not imaginary but fully realistic situations; in case a collision occurs, the system has to be able to stop so that no injury occurs" [4].

**Table 2.** Monitoring, acceptance, communication and consultation.

| | |
|---|---|
| **Monitoring Risk and Risk Treatment** | This can be achieved by testing the self-driving functions of the vehicles within a controlled area as a "Smart City". A "Smart City" would be "a place where connected car features and smart traffic control systems could monitor and test the conventional traffic stakeholders, as well as the automated vehicles using the controlled, partially public road.<br>The modified regulation of the traffic could be time dependent and it would be dynamically changeable to meet the safety objectives at all times" [6]. |
| **Risk Acceptance** | Risk can be at an acceptable rate if the followings are maintained: -<br>1. Comfort, safety, velocity and traffic density, 2. Increased productivity (transport capacity), 3. Decreased or even eliminated traffic jams with efficient and intelligent traffic control systems, 4. Reduced number of accidents and 5. Reduced emission of harmful materials, where the smart city transport can be conceived as an advanced ITS system [2]. |
| **Risk Communication and Consultation** | If self-driving cars could approach people whenever and wherever needed, it would lead to less car parks and less ownership of private cars. Safety and productivity are also added to socio-economic benefits, including sharing. This, however, will require public acceptance and usage before experiencing the benefits, and users will create the demand that will determine the size of market development. "The advent of autonomous vehicles could be truly transformative" [7].<br>Academic and non-academic sources have discussed the numerous advantages of AVs and how they will reduce the cost of travel, allow minors to travel without the presence of adults, enhance travel experience, travel more safely, or choose the route more optimally. But the questions arise, how other transportation modes, such as travel by Traditional Vehicles (TVs) or no travel at all, will be aff ected by such innovation, what eff ects it will have on the labour force, how the role of motor insurance companies can be determined, as losses may not be associated with one particular party, etc. [9].<br>In addition, in case of an accident, it must be determined who will take the risk and accept liability: the manufacturing company, the software provider or others, and how these vehicles could be protected from hackers and severe attackers [10]. |
| **Risk Monitoring and Review** | Automated Vehicles AV will be able to move with the help of an intelligent driving system that will replace human driving, and this will raise a number of issues. For example, initiative studies must be made for empty AVs from central to external parking in the morning, and vice versa in the evening, as traffic is expected to increase with the introduction of AVs, but this will not necessarily cause congestion. In fact, it will reduce traffic accidents and increase safety. "Create smoother traffic flow and unlock existing capacity on roadways which means less road works" [7]. |

## CONCLUSIONS AND RECOMMENDATIONS

When an Information Security Management System (ISMS) is applied to Automated Vehicles AV with risk management in a systematic way, the following social, economic and environmental dimensions will be achieved to maintain welfare for the whole society. It will change the lifestyle of driving and passengers, as it will change many people's habits by making life easier, saving time and removing many obstacles and burdens, as it promotes travelling for long distances, allows minors to travel without the presence of adults. It will relieve busy people, elderly and people who are afraid of driving from the burden of driving,

Reduced costs of parking and other costs as compared to travelling by traditional vehicles will make people accept longer travel distances in exchange for larger and more comfortable family residences, which will increase the total size of residential land that was previously considered to be too far away.

People will travel more safely, choose the route more optimally, increase highway usage and this will enrich travel experience.

In addition, cities will change, urban and rural planning will proceed in a different direction to be compatible with the latest developments in the traffic and transportation technology using appropriate infrastructure. Less parking space will be needed especially in downtowns, as daytime parking will become unnecessary, which allows the use of urban land that was dedicated to parking.

The size and density of economic activity will grow, causing increase in productivity.

Although traffic is expected to increase, this will not necessarily cause more congestion, as AVs are expected to operate more efficiently.

For further research in the future it is recommended to adopt creative and initiative studies for empty AVs in the morning because the reverse traffic will be made by mostly empty AVs and vice versa in the evening.

As long as Traditional Vehicles and Automated Vehicles travel together the risk will be higher, which means that governments should adopt more traffic control systems and encourage car sharing for AVs in all possible ways, especially in rush hour periods.

Threats related to cyber security must be considered for further innovative studies, and it is better to work in isolated safe systems, not networked, so that hacker attacks cannot access personal data or take control of the AV system.

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