International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Autonomous Vehicles in India: Evaluating the Need for Legislative Action

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Submitted:14/03/2024 **Revised**: 29/04/2024 **Accepted**: 06/05/2024

Abstract: The rapid development of autonomous vehicle (AV) technology necessitates comprehensive legislative action in India to address various challenges and opportunities. This evaluation highlights the critical need for a robust regulatory framework to manage the deployment and operation of AV. Technological readiness in India is progressing, yet it requires clear guidelines to foster innovation. The country's vast road infrastructure and city planning demands significant upgrades for safe AV integration. A dedicated legal framework is essential to establish standards for testing, liability, correctness and Safety concerns must be addressed through stringent testing and continuous monitoring to build public trust. Additionally, the AVs with EV benefits to eco-friendly environments, AV robust concept for reduce accidents and reduce of traffic congestion require policies to sustainable urban planning adaptations. Recommendations include formulating a dedicated AV policy, creating a regulatory body, fostering public-private partnerships, and promoting pilot projects. Legislative action is crucial for navigating the technological, infrastructural, and societal challenges, ensuring AVs contribute positively to India's transportation landscape and sustaining the country as global manufacturer of AVs in future mobility.

Keywords: autonomous vehicle producers, autonomous vehicles, driverless car & liabilities, laws for autonomous Vehicles, legal provisions for driverless cars, legality of driverless cars.

1. Introduction

Autonomous vehicles (AVs), or self-driving cars, are revolutionizing transportation by enabling vehicles to navigate and operate without human intervention. These vehicles use an array of advanced technologies, including sensors (such as radar, and cameras), artificial intelligence (AI), and machine learning algorithms, to perceive their environment and make driving decisions in real-time. The Society of Automotive Engineers (SAE) categorizes AVs into six levels of automation, from Level 0 (no automation) to Level 5 (full automation). At the highest level, AVs can perform all driving tasks under all conditions without human input. The benefits of AVs are substantial. They promise to enhance road safety by reducing accidents caused by human error, such as distracted or impaired or drunken driving. AVs can optimize traffic flow, reduce congestion, and improve fuel efficiency, contributing to environmental sustainability. Additionally, they offer increased mobility for those unable to drive, such as the elderly and people with disabilities, thus improving their quality of life. Despite their potential, AVs face significant challenges. Technical hurdles include ensuring reliable and safe operation in complex real-world environments. Regulatory frameworks need to be developed to address issues of liability, insurance, data privacy, and safety standards. Infrastructure improvements, such as better road conditions and updated traffic systems, are essential for supporting AV deployment. Building public trust through transparent communication about the safety and benefits of AV technology is also crucial. Overall, autonomous vehicles represent a transformative leap in transportation, with the potential to greatly improve safety, efficiency, and accessibility, provided that technical, regulatory, and societal challenges are adequately addressed.

Though the benefits of AVs are considerable, there are some lacuna in adopting these innovative technology for real time roads and traffics. These include developing a robust regulatory framework to initiate AVs policies, upgrading infrastructure to support new technologies,and overcoming public skepticism regarding safety and reliability. Effective policies, public-private partnerships, and continued innovation will be key to successfully integrating autonomous vehicles into transportation landscape, paving the way for a safer and more efficient future. However, AVs can significantly reduce the high number of traffic accidents caused by human error, addressing a major public safety issue. AVs can also streamline traffic flow in densely populated urban areas, reducing travel times and pollution levels. Additionally, AVs hold the promise of increased mobility for individuals who are unable to drive, such as the elderly and people with disabilities, thereby enhancing their quality of life.

1.1. Abbreviations and Acronyms

Autonomous Vehicle (AV), Electric Vehicle (EV), The Society of Automotive Engineers (SAE), Artificial Intelligence (AI), Autonomous Electric Vehicles (AEV), Department of Transportation (DOT) , AV START Act (American Vision for Safer Transportation through Advancement of Revolutionary Technologies Act),

Master in Technology Law

National Highway Traffic Safety Administration (NHTSA), United States of America (U.S), Automated Vehicle Transparency and Engagement for Safe Testing (AV TEST), National Platform for Future Mobility (NPM), Highly Automated Vehicles (HAVs), Automated Driving Systems (ADS), Strategic Innovation Promotion Program (SIP),

Advanced Smart Mobility Co-Creation Initiative (ASIC), United Nations Economic Commission for Europe (UNECE), International Organization for Standardization (ISO)., Centre for Connected and Autonomous Vehicles (CCAV), United Kingdom Research and Innovation (UKRI)

1.2. Background

Autonomous vehicle (AV) development is advancing rapidly worldwide, led by countries like the United States, Germany, and Japan. Major tech companies and automakers, including Google's Waymo, Tesla, and BMW, are at the forefront, conducting extensive testing and deploying pilot programs. Europe and China are also making significant strides, with robust regulatory support and infrastructure investments. Governments are establishing regulatory frameworks to ensure safety and integration, while fostering innovation. Collaboration between industry, academia, and policymakers is crucial, aiming to revolutionize transportation with safer, more efficient, and environmentally friendly mobility solutions. The integration of AVs can stimulate economic growth by creating new jobs in technology development, data analysis, cybersecurity, and vehicle maintenance. AVs, particularly electric ones, can contribute to reducing carbon foot print and greenhouse gas emissions. With rapid advancements in AV technology globally, The world lacks in a United and Comprehensive legal framework to govern AV deployment. Proactive legislative action is necessary to establish clear guidelines for testing, liability, data privacy, and cybersecurity, providing certainty for manufacturers and users.

AVs can provide enhanced mobility for individuals who are unable to drive, such as the elderly and people with disabilities. This can improve their quality of life and ensure greater exclusivity in society. It examines the current state of AV technology, infrastructure, regulatory frameworks, and societal impacts, identifying critical gaps and proposing recommendations for effective legislative measures. Legislative support can facilitate the adoption of cleaner technologies, promoting environmental sustainability. Understanding the specific needs and challenges can help tailor these technologies for AV manufacturing company's use of Artificial Intelligence (AI) for ensuring safety and efficiency. This study evaluates the need for legislative action regarding the integration of autonomous vehicles (AVs) across the globe. India has one of the highest rates of road accidents globally, largely and most of the fatal accidents are due to human errors likely in alcohol influences or rash driving. AVs have the potential to significantly reduce these incidents by eliminating driver-related mistakes, thus saving lives. India's urban areas are plagued with severe traffic congestion. AVs can optimize traffic flow through real-time data processing and communication, leading to smoother and more efficient transportation networks and ultimately guiding policymakers in creating a conducive environment for the adoption of this transformative technology.Conducting this study is crucial to address these multifaceted aspects and lay the groundwork for a future where autonomous vehicles can be safely and effectively integrated into world's reliable transportation system.

1.3. Purpose

The ultimate goal of this research is to Develop comprehensive regulations to ensure the safe and ethical deployment of AVs, addressing issues such as liability, data privacy, cybersecurity, and standards for testing and certification, Though the deployment of AV may affect the employment of the drivers or Spur job creation in emerging fields related to AV technology. However the AV technology create a smarter, safer, and more sustainable transportation system that enhances the quality of life for all citizens. Achieving this goal requires a collaborative effort between government, industry, and academia to address technological, infrastructural, and regulatory challenges, paving the way for a future where autonomous vehicles are seamlessly integrated into the daily lives of Indians.

1. To Implement mandatory safety protocols that AVs must follow, including fail-safe mechanisms, redundancy systems, and real-time diagnostics to ensure operational safety at all times.

2. To Develop new insurance models tailored to AVs, which may include coverage for cyber incidents, software malfunctions, and data breaches, alongside traditional vehicle insurance.3. To Invest in smart infrastructure that can support AV technology. This includes upgrading roadways with sensors, communication systems for V2X (vehicle-to-everything) interactions, and dedicated lanes for AVs in urban areas. 4. To Ensure the availability of charging stations for electric AVs and maintenance facilities equipped to handle the specialized needs of AV technology. 5. To Develop ethical guidelines for the decision-making algorithms used by AVs. This includes addressing moral dilemmas that AVs may encounter, such as prioritizing between the safety of passengers and pedestrians in critical situations. 6. To Launch public education campaigns to inform citizens about the benefits and safety features of AVs. Building public trust is essential for the acceptance and widespread adoption of AVs. 7. To Support pilot programs and real-world testing of AVs in controlled

environments to gather data, identify challenges, and refine regulations accordingly .8..To Collaborate with international regulatory bodies to develop global standards for AVs. This ensures consistency and interoperability across different regions and markets.

2. METHODS

The accomplishment of a legal framework for autonomous vehicles involves a multi-faceted approach that covers safety standards, liability, data privacy, infrastructure, ethical considerations, public engagement, and international collaboration. By addressing these areas comprehensively, the framework can ensure that AVs are integrated safely, ethically, and efficiently into the transportation ecosystem, ultimately enhancing mobility and contributing to societal well-being. The establishment of a comprehensive legal framework for autonomous vehicles (AVs) is critical to ensure their safe, efficient, and ethical integration into the transportation system. This framework must address a variety of technical, legal, and societal aspects.

2.1. Classification of Autonomous Vehicles & Testing of AVs

The Society of Automotive Engineers (SAE) has defined six levels of autonomy for vehicles, ranging from Level 0 (no automation) to Level 5 (full automation). These levels indicate the degree of autonomy and human involvement in driving tasks, with higher levels of autonomy requiring less human intervention.

SAE Level	Description	Key Features
Level 0	No Automation	- Driver controls all aspects of driving.- No automated assistance systems.
Level 1	Driver Assistance	- Basic driver assistance systems.- Examples: Adaptive Cruise Control, Lane-keeping Assistance.
Level 2	Partial Automation	- Vehicle controls both steering and acceleration/deceleration simultaneously under certain conditions.- Driver must remain engaged and be ready to take over.
Level 3	Conditional Automation	- Vehicle can perform all driving tasks under specific conditions and environments.- Driver must be present but can disengage from driving tasks.- System prompts driver to intervene when necessary.
Level 4	High Automation	- Vehicle can perform all driving tasks under specific conditions and environments.- No driver intervention required.-
Level 5	Full Automation	- Vehicle can perform all driving tasks under all conditions and environments.- No driver intervention required

AVs have the potential to significantly reduce accidents caused by human error, which is a leading cause of road accidents worldwide. By eliminating human factors such as distraction, fatigue, and impaired driving, AVs can improve road safety and save lives. *Transport Authority has to establish clear guidelines for the testing and certification of AVs. This includes defining the requirements for different levels of autonomy (as per SAE levels), ensuring that AVs meet stringent safety and performance standards before they can be deployed on public roads.*

2.2. Guidelines for the testing and certification of autonomous vehicles {AVs)

The steps involved for testing and certification of AVs are crucial to ensure their safety, reliability, and compliance with regulatory standards. These guidelines help establish a structured approach for manufacturers, regulators, and testing agencies to assess the performance of AVs throughout their development and deployment phases.

Step 1: Safety Standards and Protocols		
Establish comprehensive safety standards and protocols that AVs must adhere to during testing and operation	Define criteria for assessing the vehicle's ability to detect and respond to various hazards, including pedestrians, cyclists, and other vehicles	Ensure that AVs have fail-safe mechanisms and redundancy systems to handle malfunctions and unexpected events
Step 2: Performance Metrics		
Define performance metrics for evaluating the capabilities of AVs across different driving scenarios, environments, and conditions.	Include parameters such as accuracy of sensor data, response time to stimuli, adherence to traffic laws, and ability to navigate complex road geometries.	

Step 3: Testing Environments	
Identify and create diverse testing environments that simulate real-world driving conditions, including urban, suburban, and rural settings.	Develop test tracks, closed-course facilities, and simulated environments where AVs can undergo controlled testing under various scenarios.
Step 4: Simulation and Modeling	
Utilize simulation and modeling techniques to augment real-world testing efforts, allowing for the rapid evaluation of AV performance in virtual environments.	Develop realistic simulation scenarios that replicate challenging driving situations, enabling manufacturers to validate AV algorithms and behaviors.
Step 5: Data Collection and Analysis	
Implement robust data collection and analysis processes to gather information on AV performance, failures, and incidents during testing.	Use telemetry data, onboard sensors, and external monitoring systems to track the behavior of AVs and identify areas for improvement.

Step 6: Certification Process		
Define a clear certification process that outlines the steps and requirements for obtaining approval for commercial deployment.	Establish independent certification bodies or regulatory agencies responsible for reviewing and verifying compliance with safety and performance standards.	Ensure transparency and accountability throughout the certification process, with opportunities for public input and review.

Step 7: Regulatory Compliance	
Ensure that testing and certification guidelines align with existing regulatory frameworks and standards for vehicle safety and operation.	Collaborate with regulatory agencies to develop harmonized guidelines that facilitate the approval and deployment of AVs across different jurisdictions.

2.3. Derive the Liabilities

Upon implementing comprehensive guidelines for testing and certification, stakeholders can mitigate risks, build public trust, and accelerate the adoption of autonomous vehicles, ultimately realizing their full potential to define the liability in case of accidents involving AVs by classifying the responsibility of manufacturers, software developers, vehicle owners, operator and insurance company and the consumers, I-e, the passengers in the vehicle or the person who faces injury and get compensation to the insured person in case of any accident.

2.4. Steps in Creating New Policies in India for AVs

Creating new policies for autonomous vehicles (AVs) requires a systematic and collaborative approach involving multiple stakeholders, including government agencies, industry representatives, academia, and civil society.

Step 1: Identify Related Authorities for Engagement and Collaboration	
Identify key Person, including Legislative, Law Commission of India, Legal Experts, Traffic Police authorities, related government departments, regulatory bodies, automotive manufacturers, technology companies,academic institutions, urban planners, and community representatives.	Understand the AV developments and Policies and Law across the world for AVs and, do necessary collaboration to ensure that all relevant perspectives are considered during policy development.
Step 2: Policy Goal Setting	
Define clear and measurable policy goals that align with national priorities, such as improving road safety, reducing traffic congestion, promoting innovation, and enhancing mobility for all citizens.	Establish a timeline for policy development and implementation, taking into account technological advancements and market trends.
Step 3: Drafting Policy Framework	

Develop a draft policy framework that addresses key areas such as testing and certification requirements, safety standards, liability and insurance, infrastructure development, data privacy, cybersecurity, and ethical considerations.	Consult with Traffic Police Department, Lawyers and Law commission of India and other government authorizes to gather feedback and refine the draft policy framework based on their inputs and recommendations.
Step 4; Regulatory Impact Assessment	
Conduct a regulatory impact assessment to evaluate the potential costs, benefits, and unintended consequences of the proposed policies.	Identify any regulatory barriers or loopholes that may hinder the effective implementation of the policies and develop strategies to address them.
Step 5: Public Consultation & Revisions	
Seek input from the public through consultation sessions, public hearings, surveys, and online platforms to gauge public opinion, concerns, and preferences regarding AVs.	Consider public feedback when finalizing the policy framework to ensure that it reflects the needs and interests of all stakeholders.
Step 6: Policy Adoption and Implementation	

Present the final policy framework to the appropriate government authorities for review, approval, and adoption through legislative or regulatory channels.	Develop an implementation plan that outlines specific actions, timelines, and responsibilities for implementing the new policies.	Allocate resources, establish monitoring mechanisms, and develop capacity-building initiatives to support the effective implementation of the policies.

Step 7: Regularly review and update the policies in response to technological advancements, changing market conditions, and evolving societal needs.

By following these steps, policymakers can develop robust and responsive policies that promote the safe, sustainable, and equitable deployment of autonomous vehicles in India, contributing to the country's transportation transformation and economic development.

3. Literature Review

A self-driving automobile, also known as an autonomous vehicle (AV), is a vehicle that is able to move between locations without the need for a human driver by utilizing a mix of sensors, cameras, radar, and artificial intelligence. Autonomous vehicles (AVs), also known as self-driving cars or driverless vehicles, are vehicles equipped with advanced technologies that enable them to operate and navigate without human intervention. The concept of AVs revolves around the idea of vehicles being capable of sensing their environment, interpreting data, making decisions, and navigating routes autonomously, without the need for human drivers. AVs are equipped with various sensors, including cameras, radar, lidar (light detection and ranging), GPS, and ultrasonic sensors, which continuously monitor the vehicle's surroundings. These sensors provide real-time data on road conditions, traffic, obstacles, pedestrians, and other vehicles.

3.1 Autonomous Vehicles: Concept, Meaning and Evolution

AVs use AI algorithms and machine learning techniques to process sensor data, interpret information, and make driving decisions. AI algorithms analyze sensor data to detect objects, identify obstacles, predict behavior, and plan safe and efficient routes. AVs are equipped with sophisticated control systems that translate decisions made by AI algorithms into vehicle actions, such as steering, acceleration, and braking. These control systems ensure that AVs can navigate complex environments and respond appropriately to changing road conditions and traffic situations. AVs rely on high-definition maps and localization technology to understand their precise location and surroundings. Mapping data provides detailed information about roads, lanes, traffic signals, and landmarks, enabling AVs to navigate accurately and safely.

AVs can enhance mobility for individuals who are unable to drive due to age, disability, or other reasons. They offer convenient and accessible transportation options for people with limited mobility, improving their independence and quality of life. AVs can optimize traffic flow, reduce congestion, and improve fuel efficiency by minimizing unnecessary stops, accelerating and braking smoothly, and avoiding traffic jams and bottlenecks. This can lead to

shorter travel times, lower fuel consumption, and reduced emissions. AVs enable passengers to use travel time more productively, whether for work, leisure, or relaxation. Passengers can engage in activities such as reading, working, or watching movies while the vehicle handles the driving tasks, increasing productivity and convenience. Overall, the concept of autonomous vehicles holds great promise for revolutionizing the future of transportation, offering safer, more efficient, and more accessible mobility solutions for people and goods. However, the widespread adoption of AVs also presents technical, regulatory, ethical, and societal challenges that must be addressed to realize their full potential.

3.2 Common Obstacles for Autonomous Vehicles

Although there has been great development in technology, there are still a number of general difficulties that need to be overcome before autonomous vehicles may be fully integrated into everyday life. These problems cover a wide range of concerns, including those pertaining to technology and regulations. This section will thus, discuss the obstacles for autonomous vehicles.

3.2.1. Lack of Regulatory Frame Works:

The lack of comprehensive regulatory frameworks governing the testing, deployment, and operation of AVs is a significant obstacle. Unclear regulations regarding liability, insurance, data privacy, cybersecurity, and infrastructure requirements create legal uncertainties and hinder investment in AV technology.

3.2.2. Safety Concerns:

Ensuring the safety of autonomous vehicles and their passengers is paramount. AVs must be capable of navigating complex environments and unpredictable situations safely. Concerns about the reliability of AV technology and the potential for accidents or malfunctions pose significant obstacles to adoption.

3.2.3. Ethical and Social Implications:

AVs raise complex ethical questions, such as how to prioritize passenger safety versus the safety of pedestrians and other road users in the event of an unavoidable accident. Addressing ethical dilemmas and societal implications related to AV technology requires careful consideration and dialogue among stakeholders.

3.2.4. Technological Limitations:

Despite rapid advancements in AV technology, there are still technical limitations that need to be addressed. Challenges such as sensor accuracy, environmental variability, edge cases, and real-time decision-making in complex scenarios pose obstacles to achieving fully autonomous driving capabilities.

3.2.5. Data Privacy and Security:

AVs collect and process vast amounts of data, raising concerns about data privacy and security. Protecting sensitive information, preventing unauthorized access, and ensuring data integrity are critical challenges that need to be addressed to build trust and confidence in AV technology.

3.2.6.Infrastructure Readiness:

AVs require infrastructure support, including high-definition mapping, communication networks, and dedicated lanes or facilities. The lack of standardized infrastructure and communication protocols poses challenges for AV deployment and operation in real-world environments.

3.2.7.Public Acceptance:

Building public trust and acceptance of AV technology is crucial for its successful adoption. Many people are skeptical or apprehensive about autonomous driving, citing concerns about safety, reliability, job displacement, and loss of control. Addressing these concerns and educating the public about the benefits of AVs are essential for overcoming this obstacle.

3.2.8. Cost and Affordability: The initial cost of AV technology, including sensors, computing hardware, and software, can be prohibitively expensive. Lowering the cost of AV technology and making it more affordable for consumers and businesses is essential for driving adoption and market penetration.By overcoming these obstacles, autonomous vehicles have the potential to revolutionize transportation and improve mobility for people and goods.

3.3 New Trend - Autonomous Electric Vehicles (AEV)

Autonomous Electric Vehicles (AEV) represent a groundbreaking trend in the automotive industry, combining the advancements of electric propulsion and autonomous driving technologies. AEVs leverage the synergies between electric propulsion and autonomous driving systems, offering vehicles that are both environmentally friendly and capable of autonomous operation. By utilizing electric power trains, AEVs produce zero tailpipe emissions, contributing to cleaner air and reduced carbon footprint. This aligns with global efforts to combat climate change and promote sustainability.Autonomous driving systems in AEVs prioritize safety, reducing the risk of accidents caused by human error. These vehicles are equipped with sensors, cameras, and AI algorithms that enable them to perceive and respond to their surroundings, enhancing road safety for passengers and pedestrians.

AEVs offer a convenient and comfortable travel experience. With autonomous capabilities, passengers can relax or engage in other activities during their journey, while the vehicle takes care of the driving tasks. AEVs hold immense potential for transforming urban mobility. They can be integrated with ride-sharing and on-demand mobility

services, offering efficient and flexible transportation solutions for urban residents. Rapid advancements in electric and autonomous technologies are driving the development of AEVs. Innovations in battery technology, AI, and sensor technology are making AEVs more practical and cost-effective. The market for AEVs is experiencing rapid growth, with increasing investments and partnerships from automotive manufacturers, tech companies, and startups. This indicates a growing interest and confidence in the potential of AEVs to reshape the future of transportation. Overall, Autonomous Electric Vehicles represent a new frontier in automotive innovation, offering a glimpse into a future where transportation is not only sustainable and efficient but also safer and more convenient than ever before.

3.4 New Laws & Regulations across the world for Autonomous Vehicles

Across the world, various countries and regions are implementing new laws and regulations to govern the testing, deployment, and operation of autonomous vehicles (AVs). These laws aim to address safety, liability, data privacy, cybersecurity, infrastructure requirements, and other key considerations related to AV technology.

3.4.1.New Laws and Regulations in United States for AVs

The United States has been at the forefront of developing laws and regulations to govern the testing and deployment of autonomous vehicles (AVs) within its borders. United States is taking a multi-faceted approach to regulating autonomous vehicles, balancing safety, innovation, and collaboration. As AV technology continues to evolve, U.S. regulators are expected to adapt and refine their regulatory frameworks to address emerging challenges and opportunities in the autonomous driving ecosystem. The U.S. Department of Transportation (DOT) issued the Federal Automated Vehicle Policy in 2016 to provide guidance for the testing and deployment of AVs. This policy outlines a voluntary framework for AV manufacturers, developers, and states, addressing safety, regulatory compliance, ethical considerations, and public engagement.

The AV START Act (American Vision for Safer Transportation through Advancement of Revolutionary Technologies Act) was introduced in the U.S. Congress to establish a federal regulatory framework for AVs. Although the bill did not pass in its entirety, certain provisions related to AV testing and safety standards were incorporated into other legislative initiatives. The National Highway Traffic Safety Administration (NHTSA) has issued guidelines and technical standards for AV manufacturers and developers. These guidelines cover areas such as vehicle performance, cybersecurity, data sharing, and human-machine interface design. NHTSA also provides safety assessments for AV manufacturers to demonstrate compliance with federal safety standards. Several U.S. states have enacted legislation specifically addressing AV testing and deployment within their jurisdictions. States such as California, Michigan, Arizona, and Florida have established regulations governing AV testing permits, insurance requirements, reporting of incidents, and liability frameworks.

The U.S. government collaborates with industry stakeholders, research institutions, and academia to advance AV technology and address regulatory challenges. Initiatives such as the Automated Vehicle Transparency and Engagement for Safe Testing (AV TEST) Initiative and the Automated Vehicle Proving Grounds Program support research, testing, and demonstration of AV technology.Some states and local governments have issued executive orders to promote AV testing and deployment. These executive orders may provide funding, establish task forces, or create regulatory sandboxes to support innovation and collaboration in the AV ecosystem.

3.4.2. New Laws and Regulations in Germany for AVs

Germany is taking proactive steps to create a conducive regulatory environment for autonomous vehicles, balancing innovation with safety, privacy, and ethical considerations. As AV technology continues to advance, Germany's regulatory framework is expected to evolve to address emerging challenges and opportunities in the autonomous driving ecosystem. Germany passed the Autonomous Driving Act in May 2021. This legislation provides a legal framework for the operation of AVs on public roads in certain defined scenarios. It allows AVs to operate without a human driver under specific conditions, such as on designated test routes or in automated valet parking systems. The Act outlines requirements for AV technology, safety measures, data protection, liability, and insurance. Germany has established test fields and pilot projects across the country to facilitate the testing and validation of AV technology. These test fields provide controlled environments where AV developers can conduct experiments, trials, and demonstrations of their autonomous driving systems. Examples include the Digital Test Field Autobahn and the Berlin-Brandenburg Test Area for Automated and Connected Driving.

The German government is collaborating with industry partners, research institutions, and other stakeholders to promote innovation and development in the field of autonomous driving. Initiatives such as the German National Platform for Future Mobility (NPM) and the German Aerospace Center are fostering collaboration and knowledge exchange among stakeholders involved in AV research and development. Germany is also aligning its AV regulations with European Union directives and regulations governing connected and automated mobility. This includes

efforts to harmonize technical standards, safety requirements, and legal frameworks for AVs across EU member states.

3.4.3. New Laws and Regulations in Japan for AVs

Japan enacted the Act for Securing the Safety of Highly Automated Vehicles in 2017. This legislation establishes a legal framework for the testing and operation of highly automated vehicles (HAVs), which are AVs capable of operating without human intervention under certain conditions. The Japanese government has issued guidelines for ensuring the safety of automated driving systems (ADS). These guidelines provide technical standards, testing procedures, and safety requirements for ADS used in autonomous vehicles. They address topics such as sensor performance, system redundancy, fail-safe mechanisms, and human-machine interfaces.

Japan's government launched the Cross-ministerial Strategic Innovation Promotion Program (SIP) to promote research, development, and deployment of autonomous driving technology. SIP funds collaborative projects between government agencies, industry partners, and research institutions to advance AV technology and address regulatory challenges. Japan has established test beds and demonstration projects across the country to facilitate AV testing and validation. These test beds provide controlled environments where AV developers can conduct experiments, trials, and demonstrations of their autonomous driving systems. Examples include the Automated Driving Systems Experimentation Area in Shin-Tomei Expressway and the Advanced Smart Mobility Co-Creation Initiative (ASIC) in Okinawa. Japan is collaborating with international partners to harmonize AV regulations and standards. The Japanese government participates in international forums and working groups, such as the United Nations Economic Commission for Europe (UNECE) and the International Organization for Standardization (ISO), to develop global guidelines for AVs.

3.4.4. New Laws and Regulations in England for AVs

Automated and Electric Vehicles Act 2018 is enacted in 2018 by United Kingdom, sets out a framework for the insurance of AVs in the UK. It establishes a single insurer model where an insurer is liable for accidents caused by an AV when it is driving autonomously. This Act aims to ensure that victims of accidents involving AVs are adequately compensated. The UK government established the Centre for Connected and Autonomous Vehicles to coordinate policy and regulatory initiatives related to AVs. CCAV works in partnership with industry stakeholders, research institutions, and local authorities to support the development and deployment of AV technology. The United Kingdom Department for Transport has issued a Code of Practice for the testing of AVs on public roads. This code provides guidance for AV developers and testers on safety standards, testing procedures, and reporting requirements. It outlines best practices for conducting AV tests and ensures compliance with regulatory requirements.

The UK government has established regulatory sandboxes to support the testing and development of AV technology. These sandboxes provide a controlled environment where AV developers can conduct experiments, trials, and demonstrations of their autonomous driving systems under regulatory supervision. The UK collaborates with international partners, including other European Union member states, to harmonize AV regulations and standards. Efforts are underway to develop common technical standards, safety requirements, and legal frameworks for AVs across Europe and beyond. The UK government provides funding and support for research and innovation in AV technology through initiatives such as the United Kingdom Research and Innovation (UKRI) program and Innovate UK. These initiatives aim to accelerate the development and commercialization of AV technology and promote UK leadership in the field.

3.4.5. New Laws and Regulations in Dubai for AVs

In 2017, the Dubai government launched the Dubai Autonomous Transportation Strategy, with the goal of transforming 25% of total transportation in Dubai to autonomous mode by 2030. This strategy aims to enhance mobility, reduce congestion, and improve the efficiency of transportation systems through the use of AVs. The Smart Dubai initiative aims to make Dubai the happiest and smartest city in the world by leveraging advanced technologies such as AI, IoT, and AVs. Smart Dubai initiatives include the Dubai Autonomous Mobility Strategy, which focuses on the development and deployment of AVs for public transportation, logistics, and smart city services.

The Dubai Autonomous Mobility Strategy outlines plans for the gradual introduction of AVs on Dubai's roads. This strategy includes pilot projects, test beds, and regulatory sandboxes to facilitate the testing and validation of AV technology in real-world environments. It also addresses regulatory, legal, and infrastructure challenges related to AV deployment. Dubai's government has established regulatory sandboxes to support the testing and development of AV technology. These sandboxes provide a controlled environment where AV developers can conduct experiments, trials, and demonstrations of their autonomous driving systems under regulatory supervision. Dubai collaborates with industry partners, research institutions, and technology companies to advance AV technology and address regulatory challenges. Partnerships with companies such as Tesla, Uber, and Waymo facilitate the testing and deployment of AVs in Dubai's urban environment.

3.5 Demand for AV & AEV Manufacturing Base

The demand for Autonomous Vehicles (AVs) and Autonomous Electric Vehicles (AEVs) is driving the need for manufacturing bases to meet growing market demands. Consumers are increasingly interested in AVs and AEVs due to their potential for enhanced safety, convenience, and environmental sustainability. This growing demand is prompting automakers to invest in the production of these vehicles. Governments around the world are implementing policies and incentives to promote the adoption of AVs and AEVs. This includes funding for research and development, subsidies for buyers, and regulatory support, which encourages manufacturers to establish production facilities.

Stringent environmental regulations are pushing automakers to shift towards electric vehicles (EVs), including AEVs, to reduce greenhouse gas emissions. This shift in consumer preferences towards cleaner vehicles is driving the demand for manufacturing bases to produce EVs. Rapid advancements in autonomous and electric vehicle technologies are making AVs and AEVs more feasible and cost-effective. As these technologies mature, automakers are ramping up production to capitalize on the growing market opportunities. The demand for AVs and AEVs is not limited to domestic markets but extends globally. Establishing manufacturing bases in strategic locations allows automakers to cater to international demand and expand their market reach.

There are world class manufacturers like Tesla (USA), Waymo (USA),Zoox (USA), Volkswagen (Germany), Toyota (Japan), Nissan (Japan), Cruise (USA), Daimler/ Mercedes-Benz (Germany), BMW (Germany),Volvo (Sweden), Nuro (USA), Mobil eye (Israel),Baidu (China), Aurora (USA), Motional (USA) are investing in Autonomous Vehicle and these companies may looking for manufacturing base across the world. The establishment of manufacturing bases for AVs and AEVs creates jobs and stimulates economic growth in the regions where they are located. This includes jobs not only in manufacturing, research and development but service and maintenance industries and more. There may be chance for Automotive Revolution and much co-relation to the IT revolution -2k.

3.6 Obstacles Related to the Legal Provisions Regarding Autonomous Vehicles in India

Current laws do not clearly define the liability of manufacturers, software developers, vehicle owners, or operators in autonomous driving scenarios, leading to legal ambiguity and potential disputes.In India, the Motor Vehicles Act of 1988, does not provide any provisions for autonomous vehicles in any capacity, including the testing of autonomous vehicles on Indian roads in accordance with the regulations that are now in place. In accordance with this, this section will discuss the legal challenges that are associated with autonomous vehicles in India.

AVs collect and process vast amounts of data, including sensitive personal information about passengers and their travel patterns. The absence of robust data privacy laws and regulations raises concerns about the unauthorized access, misuse, and exploitation of this data. AVs are vulnerable to cyber-attacks and hacking due to their reliance on interconnected systems and communication networks. Weak cybersecurity measures and the absence of regulatory standards for securing AVs pose significant risks to passenger safety and data integrity.India's infrastructure, including roadways, traffic management systems, and communication networks, may not be adequately prepared to support the safe and efficient operation of AVs. The lack of standardized infrastructure and communication protocols poses challenges for AV deployment.

3.7 Research Gap

This section will outline the research gap obtained after critically analyzing the various aspects and concerns of the Grey areas. It will provide what the prior researchers have failed to address through their research frameworks. The section will summaries all the works of literature reviewed in this module to draw this dearth.

The process of formulating and implementing new regulations for AVs in India may be slow and bureaucratic, leading to delays and uncertainty for manufacturers and investors. A lack of clear timelines and regulatory guidance hampers innovation and investment in AV technology.Many people in India are unfamiliar with AV technology and may harbor skepticism or apprehension towards autonomous driving. Building public awareness and trust in AVs is essential for their acceptance and adoption.

India currently lacks comprehensive regulations specifically tailored to autonomous vehicles. Existing legal frameworks do not adequately address issues such as liability, insurance, data privacy, cybersecurity, and infrastructure requirements for AVs.Several obstacles related to legal provisions regarding autonomous vehicles (AVs) exist in India, hindering their widespread adoption and deployment.Determining liability in the event of accidents involving AVs is a complex legal issue. Addressing these obstacles requires collaborative efforts from policymakers, industry stakeholders, academia, and civil society to develop comprehensive legal frameworks that balance innovation with safety, privacy, and societal concerns. Clear and transparent regulations, robust data privacy laws, cybersecurity standards, and investment in infrastructure are essential to unlock the full potential of autonomous vehicles in India.

4.0 Conclusion:

Though Ministry of Road Transport and Highways released draft guidelines for the testing and certification of AVs in India in 2019 but these guidelines outlines has not significantly supports the procedures for testing AVs on public roads, including safety standards, data protection measures, and reporting of incidents during testing. Several Indian states have initiated their own efforts to promote AV testing and deployment within their jurisdictions. For example, Karnataka launched the Karnataka Innovation Authority Sandbox in Bengaluru to facilitate the testing of emerging technologies, including AVs, in a controlled environment.

As AV technology continues to evolve, India's regulatory framework is expected to evolve in parallel to support innovation and ensure the safe and responsible deployment of AVs in the country. The Motor Vehicles (Amendment) Act, 2019, introduced amendments to the existing motor vehicle laws in India to accommodate emerging technologies such as AVs. While the act primarily focuses on aspects like road safety, traffic management, and driver accountability, it lays the groundwork for future regulations related to AVs.India is in the early stages of developing a regulatory framework for AVs, with efforts underway to address technical, legal, and societal challenges.

Legislative action is critical to the successful integration of autonomous vehicles in India. A proactive and well-thought-out legislative framework can help navigate the technological, infrastructural, and societal challenges, ensuring that autonomous vehicles contribute positively to India's transportation landscape. By addressing these areas through targeted policies and regulations, India can position itself as a leader in the future of mobility. India has to develop a comprehensive policy framework specifically for autonomous vehicles, incorporating international best practices and tailoring them to India's unique context and Establish a dedicated regulatory authority to oversee AV testing, certification, and deployment. Public-Private Partnerships may encourage the collaboration between government, industry, and academia to foster innovation and address infrastructure and technological challenges.

Acknowledgments

I thank our Research Guide and Supervisor Associate Prof. Dr.Mohd. Saleem from School of Law, Presidency University, Bangaore who provided insight and expertise that greatly assisted the research, although they may not agree with all of the interpretations/conclusions of this paper. I thank Prof. Jagdish Godihal, Engineering Department for assistance with Research Methodology, that greatly improved the manuscript.

Author contributions

Ravikumar Vellingiri: Conceptualization, Methodology, Software, Field study, Writing-Original draft preparation, Software, Validation., Field study

Conflicts of interest

The authors declare no conflicts of interest.

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