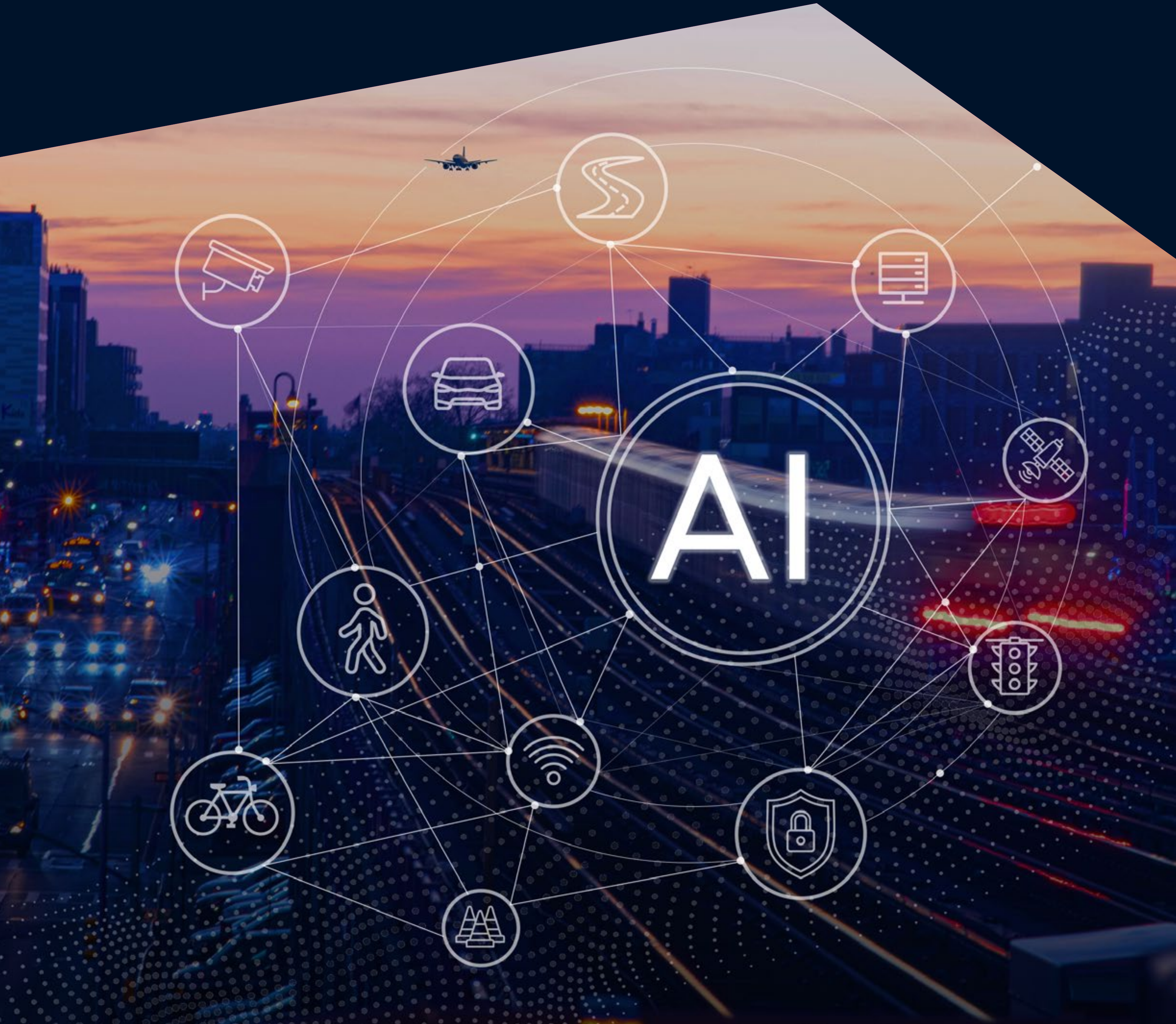
The Impact of AI on Transportation and Mobility



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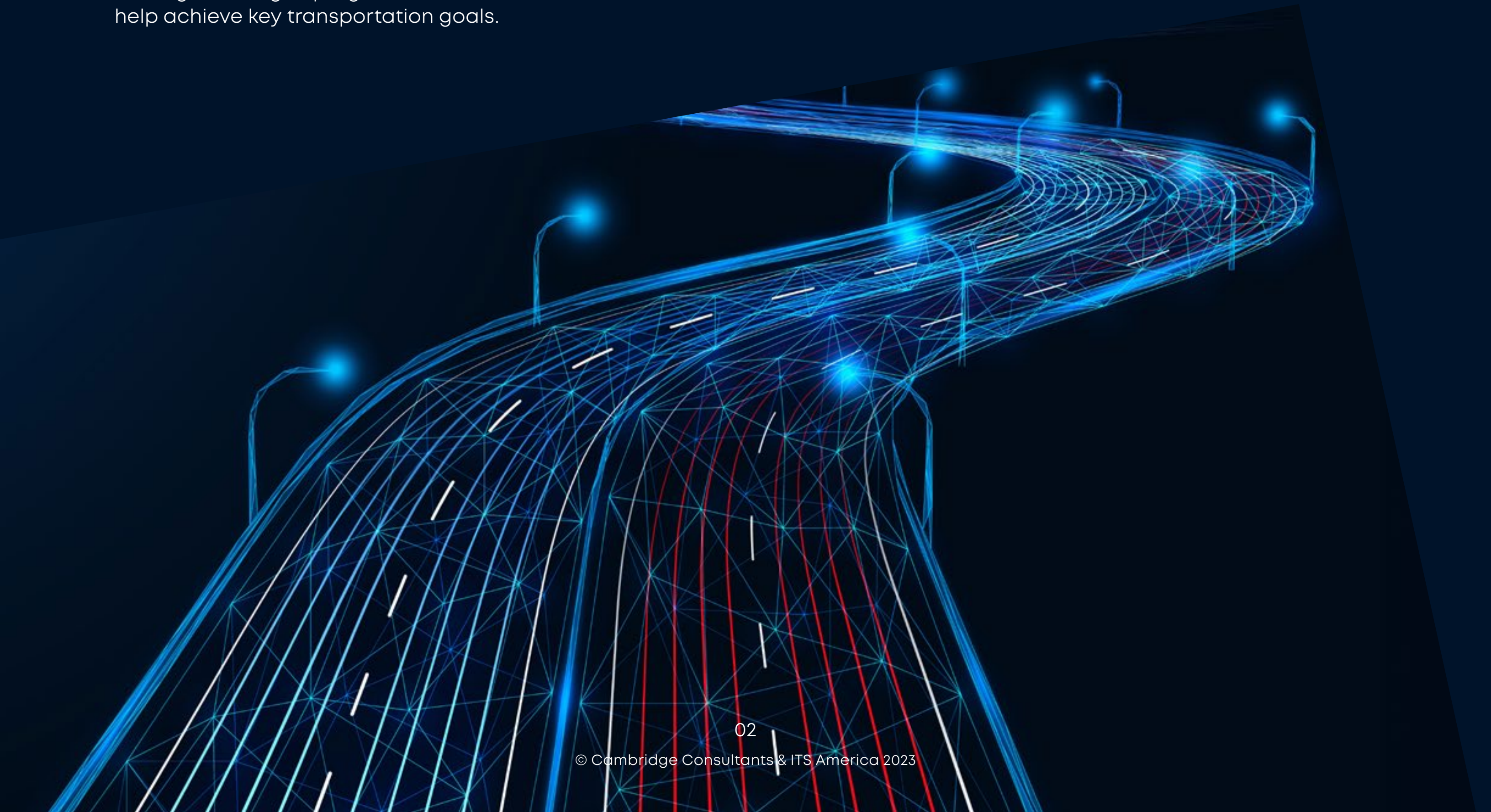
Executive summary

This report is a collaboration between the Intelligent Transportation Society of America (ITS America) and Cambridge Consultants. It explores how artificial intelligence (AI) can fundamentally change the capabilities of the American transportation sector, while outlining key challenges and solutions associated with the deployment of transportation AI technology. This report proposes key principles of responsible AI utilization, identifies key stakeholders involved with AI implementation, and summarizes the recent regulatory environment for AI within the United States and among key global partners. Ultimately, it is expected to serve as a roadmap for transportation and technology stakeholders considering deploying AI.

This report also highlights numerous transportation-specific opportunities associated with AI utilization, including ways that AI can bolster shared transportation goals like safety, efficiency, sustainability, and equity. It contains significant discussion on how AI interacts with transportation data, both in terms of the possibilities associated with AI's real-time analysis of transportation trends as well as challenges associated with dataset limitations. It outlines key considerations for cybersecurity vulnerabilities associated with AI deployment, as well as ways that AI can help bolster longstanding security methods for current transportation infrastructure. It details how the various categories of AI stakeholders interact, including those we classify as "thinkers," "planners," "deployers," and "users." The report also discusses how those stakeholders can navigate an incomplete regulatory AI environment, accessing new market opportunities and positively impacting society while making meaningful progress towards innovations that will help achieve key transportation goals.

At its core, it is meant to articulate a bold, optimistic vision for a transportation sector empowered by human-centered AI implementation. We believe that technology cannot be deployed for technology's sake, and that transportation innovations must be designed to make meaningful improvements towards real challenges faced by all transportation users, including those with the fewest mobility options. We believe that this report offers actionable proposals as to how AI implementation can embrace that philosophy, and thereby represent a foundational building block on which the next generation of transportation progress will be delivered for all.



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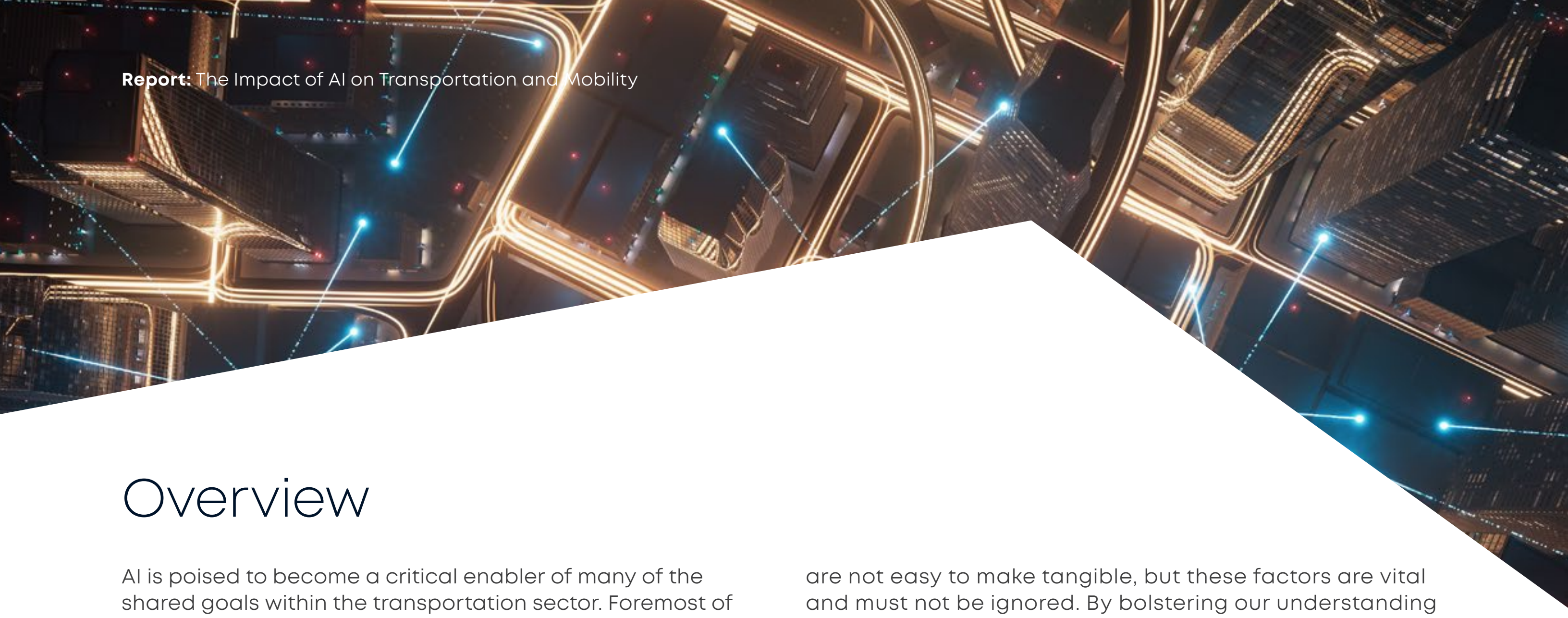

Overview

AI is poised to become a critical enabler of many of the shared goals within the transportation sector. Foremost of these goals is improving transportation safety, reducing or eliminating the 43,000 fatalities that occur on American roads on an annual basis. Additionally, AI can provide benefits related to efficiency, equity, and sustainability. Stakeholders have a unique opportunity to help shape the growth of AI transportation applications to achieve these goals – while creating new markets and business models within the sector and boosting economic growth.

Going forward, there are three fundamental considerations to assure the success of AI within transportation:

First, it is vital to recognize the complex, interdependent moving parts of transportation systems in both the public and private sectors. These networks are multifaceted – incorporating road, rail, air and maritime travel – and are increasingly interdependent with energy, communication and industrial networks. The improvement and development of these networks must bear this complexity and mutuality in mind, especially in the context of AI.

The connections are everywhere. Improving traffic management efficiency will impact not just road but also rail transit; efforts to reduce emissions will have far reaching implications across the country. An assured, bird's-eye view of the entire ecosystem is essential if we are to achieve substantial network-wide improvements.

Second, the future of AI-enabled transportation must be viewed through a holistic, human lens. It is imperative that AI development prioritizes the human user. This is an opportunity to enhance the safety, efficiency, equity and sustainability of our transportation system – and a responsible approach to AI will do just that.

Development that reflects this approach will create services that respond to the full breadth of human needs. Rather than retrofitting accessibility into established transportation, these services should be carefully conceived by paying attention to a diversity of voices. This report will showcase how we can develop AI tools that reflect a variety of interests.

Third, processes and outputs must be transparent so that humans can understand them and be able to correct errors and malfunctions. The transparency and 'explainability' of AI are not easy to make tangible, but these factors are vital and must not be ignored. By bolstering our understanding of AI decision making, we can iterate and improve on how these decisions are made. With transparency, we can eliminate harmful biases and incorrect answers as we forge an AI-enabled transportation system that provides better services for all.

Further to these considerations, a key element for the realization of AI transportation solutions is the vast proliferation of data generated by people and machines. Fifteen billion devices are connected to the internet in 2023, a number projected to almost double by 2030. Fully utilizing the data provided by connected smart infrastructure devices demands increasingly advanced connectivity, data management and processing, as well as a shift in thinking for human operators. AI can process and analyze that data at a scale and speed that would be impossible without this technology, and as such it becomes an essential tool with which human operators work and interact.

Another key capability of AI is how it can transform unstructured data into relevant, useful insights. While transportation data from an ever-increasing range of sources is becoming more readily available, many transportation agencies lack the ability to process meaningful conclusions from raw data. AI is poised to serve as that medium between raw data and insights, weaving together a narrative from various datasets by rapidly categorizing and collating data trends at the granular level. AI can drive new opportunities for both technological development and business innovation while accelerating digital transformation across the transportation ecosystem.

As for challenges, the transportation industry must grapple with how to link technologies and insights within a complex ecosystem. Solving this entails an assessment of the interoperability of data and technologies, as well as privacy, cybersecurity, network capacity, storage capacity and information latency. We must also consider AI risks and mitigation tactics.

If the AI transformation is to benefit all travelers, a horizontal view across public and private sectors is crucial. Holistic thinking will give an overarching perspective of opportunities and challenges, while flexibility and cooperation will be needed to achieve a multimodal, integrated and intelligent transportation system.

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1 The convergence of AI and digital infrastructure

The digital infrastructure transformation is being enabled by significant advances in sensing, computing and wireless communication technology. To maximize digital infrastructure's potential, we must recognize the complex, interdependent moving parts of transportation systems in the public and private sectors. Innovation in one area, such as autonomous vehicles, must be accompanied by timely advances elsewhere, such as in communication systems, compute power and data processing. Systems level coordination will accelerate a scaled digital transformation founded on AI solutions.

AI's development has been accelerated by the confluence and availability of both data and more complex algorithms enabled by greater computational power. The complex nature of AI algorithms requires significant computational resources to train and execute tasks effectively. More powerful hardware and infrastructure enable AI systems to handle larger and more complex datasets, leading to improved performance and scalability. Accessibility of high-quality data combined with ample computational resources allows AI systems to learn, adapt and perform at a higher level. Here we describe these enablers and pinpoint important key challenges that need to be incorporated into AI solutions.

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1.1 Data generation as an enabler for AI

The new technologies that harmonize intelligent transportation and digital infrastructure implementation generate data at an unprecedented scale. These data sources are a crucial enabler for the further innovation necessary to achieve the US Department of Transportation's safety, equity and sustainability goals, as well as commercial and efficiency benefits for end users. Data will provide insight into virtually all stages of the transportation value chains and will remain a fundamental building block of the future landscape.

AI algorithms are data hungry, but at the same time these data need to be clearly structured, managed and processed to be used effectively.

01 **Structuring**

Data needs to be structured, organized and stored in a manner that enables efficient access and modification. This in turn enables the establishment of interrelationships and the application of different operations and functions to these data. The principle of 'build once, use many' is pivotal for maximizing the value of data.

02 **Processing**

Data processing techniques also have evolution requirements. This evolution is already advancing at the edge and in the cloud, but taking full advantage of opportunities requires coordination between different sectors for capture, processing, storage and data exchanges. Going forward there will be a steady increase in the embedded systems that comprise sensor data, storage, compute and advanced AI capabilities in edge devices.

03 **Skills**

New skills will be necessary to address these challenges and holistically incorporate the data driven insights delivered by digital infrastructure. These skills requirements will include cloud infrastructure expertise, data analytics, data architecture, software engineering, DevOps engineers and AI/ML engineers, designers and product managers among others.

04 **Management**

Advances in cloud optimization and orchestration are needed so that data storage and management can be expanded at less cost, while being more sustainable and enabling faster decision making.

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Challenges

AI algorithms need large amounts of data for training and testing. The availability of data created by new sensors and communication devices has provided a huge number of datasets that, when properly structured, managed and processed, can be used to train and test new algorithms and create AI solutions.

There are, however, key challenges that need to be addressed so these data can really facilitate AI solutions at scale.

Efforts to ensure that enough high-quality data is being utilized by AI algorithms should remain a top priority, as this variable has a direct impact on the effectiveness of AI solutions. Also, contractual agreements should take note of the requirement to keep AI systems up to date by retraining over their lifetime – or at least include a supplier requirement to monitor and declare when datasets are becoming obsolete so they can be safely retired. Through this coordination, intelligent transportation systems (ITS) can effectively take advantage of scalable solutions.

01 Data updates

A serious limitation of extensively trained AI systems is 'dataset shift' – the fact that real-world conditions change over time, gradually taking an AI system outside its training data distribution. In practice this means the decisions of a deployed AI system are guaranteed to become gradually worse (less performant, or potentially less safe), until it is retrained with up-to-date data. This known issue presents a particular risk in public/private sector procurement, where, without attention, a system might be procured as a 'once only' deliverable with no capacity to provide ongoing monitoring of dataset shift and AI retraining when necessary.

02 Data availability and sharing

Advances in cloud optimization and orchestration are needed so that data storage and management can be expanded at less cost, while being more sustainable and enabling faster decision making.

03 Data representativeness

It is still prohibitively expensive to collect sufficient real-world data to train a transportation AI system across all the possible inputs that might be encountered. Technologies are emerging to meet this challenge and cover all possible situations (different weather conditions, traffic conditions and emergency situations, for example). Either synthetic data is required, or extremely good monitoring of whether an AI system is going 'out of training distribution' so that alternative mitigations can be deployed. While synthetic data may suffer from its own limitations in modeling the real world, emerging 'equivalence' techniques provide a solution to measure error, monitor risk, and iteratively improve synthetic data quality until acceptable.

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1.2 Computer power as an enabler for AI

Another critical enabler for AI solutions has been the evolution of communications networks, computer power, and cloud computing. The largest models in the early years of deep learning were devoted to image classification. Here, researchers quickly realized that increasing computing power reliably led to better performance. After image recognition systems began to surpass human performance, cloud services were developed to offer economies of scale by sharing maintenance personnel, building space, cooling and other operational necessities for data storage solutions across many projects and sectors.

Here are some of the key computational elements of AI.

01 Compute requirements

Deep learning is computationally expensive by design. Recent trends have meant that increasing scale of data and processing needs is key to accuracy and performance in training deep learning models. This has driven an exponentially growing demand for computing power.

02 Capacity

Usually, large AI models are trained using a cluster of many chips known as an AI supercomputer. Supercomputers are hosted in data centers, which provide the infrastructure to keep the hardware running. Data centers as a whole – including the connected chips within them – represent the infrastructure layer of AI compute.

03 Concentration

Large data centers enable cloud computing, a market that is well known to exhibit a high degree of concentration. More than 30% of the world's data centers are located in the United States. These U.S. data centers are located in areas with abundant electricity demands, large amounts of water for cooling, affordable real estate, tax incentives and away from regions that are prone to natural disasters. They are also concentrated in the hands of very few companies.

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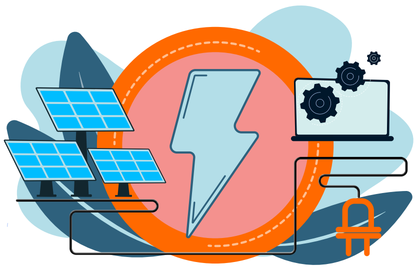
Challenges



01 Sustainability

An interesting development in compute power is projects that are starting to measure and calculate compute expenditure in terms of time and energy necessary to run AI algorithms and incorporating them into carbon emission calculations. This will likely become best practice. It will be invaluable to have a clear picture of the impact that AI training and system use will have on the planet.

02 Energy

AI systems perform transactions between memory and processors, and each of these transactions requires energy. As AI becomes more elaborate and data-intensive, there is a need for more memory storage and more energy. The power required to run supercomputers in data centers already accounts for about two percent of the nation's electricity use and huge water quantities are required for cooling.

03 Reducing compute

The result of this growth in computation, along with the availability of massive data sets and better algorithms, has yielded much AI progress in very little time. It is difficult to say if the same pace of computation growth will be maintained. Large-scale models require increasingly more compute power to train, and if computation does not continue to ramp up, it could slow progress. For some applications, AI at the edge can reduce the network traffic, latency and bandwidth consumption necessary to run algorithms and accelerate speed of response which can be extremely powerful in real time transport applications. AI at the edge has the benefits of lower computing and data security by keeping data processing locally. However, the AI model still needs to be trained with a supercomputer and considerations of raw data loss or model monitoring need to be considered. Hybrid models of cloud and edge will be the key.

Key points

1. We are witnessing a unique moment in the convergence of the technologies that will realize the potential benefits of AI solutions for transportation systems.
2. Data availably – provided by digital transportation infrastructure – compute power and investment in algorithm development have made the rapid evolution of new AI solutions possible.
3. Data needs to be abundant, of high quality, and able to help develop scalable AI solutions.
4. The continuous training of AI for transportation applications needs to exploit new techniques such as synthetic data that can capture all situations of real-world operations.
5. AI development and use must be sustainable to create future-proof opportunities.

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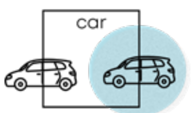
2 Technology with human focus

The development of AI algorithms over the past decade has predominantly had a technological focus. In general terms, AI encompasses different ways of ingesting data and producing outcomes depending on how it is trained.



Supervised learning

The data used for training the algorithm are labelled so it learns these to then classify or predict outcomes on unseen data.

(i.e., an algorithmm gets trained in thousands of pictures of cars to learn the patterns that classify an image as a car)

Unsupervised learning

The algorithm is trained with unlabelled data. The algorithm groups the data in groups or clusters based on common features

(i.e., the detection of traffic data trends)

Reinforcement learning

The algorithm is trained on “trial and error” cycles based on rewards and penalties to learn how to perform a task

(i.e., a self-parking car)

Symbolic learning

The learning is based on learning representation and reasoning, with associations and rules and an understanding of cause and effect

(i.e., collision avoidance)

Although the technological advances of AI algorithms are immense, difficulty arises in applying them to operational environments when humans try to understand and work with them. This is mainly because most have been developed from a technological point of view that doesn’t take human context and practical useability into account.

A new era of research is starting to question whether algorithms can, from the moment of conception, augment, team with, and assist humans to perform tasks. We believe that it is vital for such human-focused AI to be at the core of future intelligent transportation systems. It will ensure that the needs of individuals, groups and society as whole are prioritized to create safety, efficiency, equity and sustainability.

In the next section, we explore how we might utilize current and future trends to ensure human augmentation, along with human cognition and agency. We include current approaches within transportation as well as developments to consider as AI continues to evolve.

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2.1 Current approaches

AI transportation applications are being implemented in a variety of ways and are driven by advances in particular algorithms and supervised learning techniques. They include deep neural networks for prediction tasks and reinforcement learning techniques for training autonomous vehicles.

Implementation has focused on very particular areas, such as forecasting and planning capabilities, transit and autonomous vehicles. The reason for this is a mixture of specific, ready-to-use algorithms at scale, integration with location and communication systems and investment.

01 **Transportation management systems**

AI can improve planning, forecasting and managing across the transportation ecosystem. These applications are important to mitigate the continuously rising demand with limited infrastructure supply. This includes the better use of accurate prediction and detection models aiming to forecast traffic volume, traffic conditions, and incidents. For example, data driven AI in the current form has the ability to solve problems in real time transportation such as managing design, operation, time schedule and administration of logistical systems and freight transportation.

02 **Applications of AI**

AI can be applied to improve public transportation with smart transit solutions. These benefits can be derived through vehicle operation information transmitted to end users and control centres. This real time application is facilitated by communications networks, vehicle to infrastructure communication and data-driven algorithms for route and operations by using telematic data for further optimization of transit performance.

03 **Other data-driven applications**

Other data driven applications include the identification of polluting particles and carbon emission hot spots (sustainability), driver behavior monitoring (with a focus on user safety), control systems (traffic lights for traffic fluidity and emergency services prioritization) and the predictive maintenance of infrastructure and vehicles.

04 **Connected and autonomous vehicles**

Connected vehicles and infrastructure can enhance efficiency by, for example, routing and rerouting vehicles. This can reduce the number of traffic jams, facilitated by vehicle location and route data capture. Additionally, the capabilities of autonomous vehicles are consistently advanced by manufacturers employing detect and avoid improvements using reinforcement learning techniques.

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There are, however, many innovations in AI algorithms research and concept development that surpass many of the above applications. But the current gap between AI research and implementation is still vast, including for the following reasons:

Black box algorithms

Many of the AI algorithms are created within a research and development technological vacuum, either within academia or within industry, without considering how a human is going to be able to understand and use them. They are considered a 'black box' that is difficult to understand and explain even by the developers themselves. The more complex the algorithms and the more safety critical the application, the more necessary it is to have transparency and explanations for the outcomes.

Lack of a system level view

It is not clear how these AI solutions fit into an intelligent transportation system and what interactions, consequences and trade-offs the implementation will entail if all these crucial elements are not properly addressed when the technology is developed. It is only with a system-wide approach that sustainability goals can be addressed, and only with understanding of interactions and cooperation between the different parts of a system that we can take full advantage of AI.

Limited solutions yield limited value

Many applications only deal with some of the users (drivers, for example), only focusing on certain aspects of situational awareness and not providing solutions for all. Trying to implement only part of the solution means that it is more difficult to realize value and might create further disparities and inequalities (i.e., some users are provided with lots of technological advances while others are not).

Development to implementation gap

Transparency and explainability are a must within the implementation context, especially in safety critical sectors such as transportation. However, research and development of AI does not tend to focus on the actual interpretation of the AI, risks of implementation, robustness, resilience, safety, security, and what monitoring needs to be in place. Potential users are left to assess these themselves – which makes the transition from development to implementation more challenging.

Key points

1. Bridging the gap between advanced research and implementation is not easy and explains the slow adoption of certain advances in real-life operations.

2. To bridge this gap, emphasis needs to be put on developing AI solutions with a human-focused approach that includes AI trustworthiness and assurance, in order to take full advantage of new developments.

3. This is essential to move intelligent transportation forward. AI can help strategically and with targeted improvements to enhance the evolution of intelligent and complex transportation systems so that humans benefit in a safe, secure and sustainable way.

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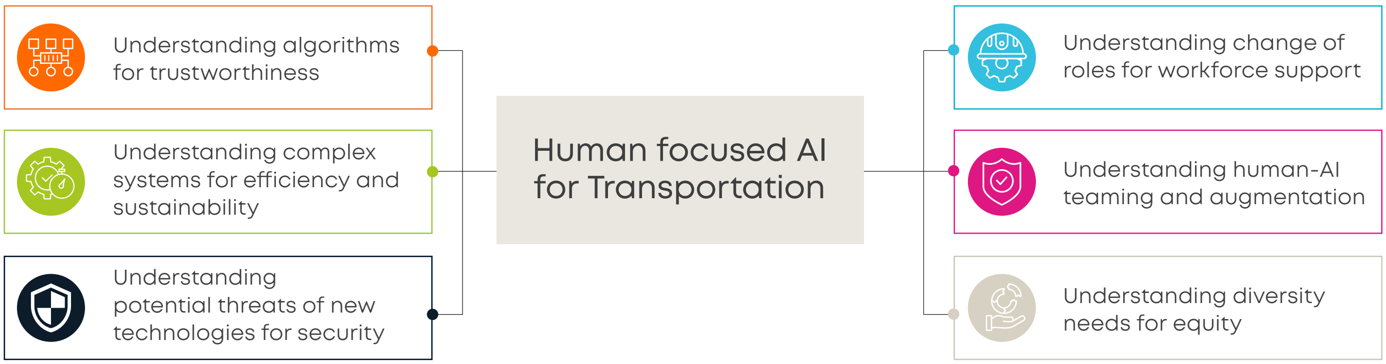
2.2 Future approaches

Having learned from the current implementation challenges we've outlined, future AI evolution for transportation systems must address human priorities. Here are some of the potential areas of attention.



Understanding algorithms for trustworthiness

While data-driven-based solutions are very effective in many applications, there are still some open research issues that limit their deployment in real-world scenarios. One such challenge relates to the methods with which AI learns from existing data sources. AI applications are typically trained on existing datasets through a process known as supervised learning. In supervised learning, AI algorithms are fed large amounts of labeled data, and they learn to make predictions or decisions based on that data. This training process helps AI models recognize patterns, make predictions, and improve performance over time. However, there are some limitations to this approach. The quality of existing datasets can heavily influence the performance and accuracy of AI models. Biased or incomplete datasets can result in biased or inaccurate AI predictions, which can have real-world consequences. Additionally, there are concerns about the transparency of what AI is learning from existing datasets. It is often difficult to interpret how AI models make decisions or what features they are using to make predictions, which can make it challenging to identify and rectify any biases or errors in the training data. This is particularly relevant when considering transportation data, which, given too narrow of a dataset, might lead AI analysis to conclude that transportation solutions specific to one community can be universally applied, neglecting to consider the diversity of transportation challenges between communities.

To address these limitations, researchers are exploring ways to improve the quality and diversity of training datasets, as well as developing methods for ensuring the transparency and interpretability of AI models. This includes techniques such as data augmentation, algorithmic fairness, and explainable AI, which aim to create more reliable, unbiased, and transparent AI systems. By addressing these limitations, we can work towards building AI systems that are more accurate, reliable, and ethical.

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Understanding complex systems interactions for safety efficiency and sustainability

Intelligent transportation systems are complex in nature, formed by different elements (such as digital infrastructure, physical infrastructure, modes of transportation, transportation users) that interact with and that impact each other. Cooperation between these systems can be facilitated by AI models that discover and deliver insights about the interaction between the different components, as well as identify trends and gaps that in turn can be used to achieve safety and sustainability goals. As transportation elements continue to become more deeply connected and interdependent, AI is poised to serve as a vital real-time mediator and coordinator between disparate transportation assets, modes, and operations.

For example, AI can a) make use of the data capture and exchanges to understand trends hot spots, b) enable scenario planning through simulations and real and synthetic data to understand interactions and trade-offs and c) orchestrate optimal collaboration and exchanges between the different components of the complex system to meet defined goals on safety, sustainability and equity.

As the transportationt sector increasingly utilizes AI technology, the cybersecurity risks that they face tend to amplify as well, due to the interconnected and constantly evolving nature of AI-enabled vehicles and infrastructure.

Understanding future cybersecurity threats when using AI

AI-related transportation assets rely on various interconnected systems, such as sensors, communications methods, and data processing systems. This greater degree of connectivity can create additional opportunities for hostile actors to access critical transportation infrastructure, threatening to cause significant disruption to the traveling public.

To begin to address these cybersecurity concerns, it is crucial to work to further identify potential vulnerabilities in AI-equipped transportation infrastructure, as well as to develop additional comprehensive techniques capable of detecting unauthorized incursions. Additionally, we recommend that policymakers dedicate additional support for building further professional cybersecurity capacity within the transportation sector, in order that transportation agencies have a sufficient workforce capable of preventing and responding to cybersecurity incidents. Further, cybersecurity considerations should remain a top priority during the design, development, and deployment of AI tools. To accomplish this, robust cybersecurity measures should be incentivized through the procurement process by transportation practitioners in the market for AI solutions.

Finally, while AI can be the source of some cybersecurity concerns, it is simultaneously poised for use as a tool to detect and mitigate cyber threats through predictive analytics of potential vulnerabilities, continuous monitoring of transportation assets, and through the enabling of automated responses to ongoing hostile activity. Ultimately, while AI introduces additional security variables into the transportation sector, proper management of the technology can simultaneously manage the risks associated with AI deployment while maximizing its security benefits.

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Understanding diversity needs for equity

In order for AI to reach its potential as a transformational force multiplier in the transportation sector, it must be developed in a way that is representative of the diverse perspectives and experiences of the people who will be impacted by these technologies. While AI derived from insufficiently diverse datasets can threated to reinforce existing inequalities within the transportation system, diverse datasets can provide additional insight into innovative ways to solve specific transportation challenges, broadening the scope of what the AI-based solutions can accomplish. The gulf among transportation characteristics for urban, suburban, or rural communities, as well as wealthy or underserved communities, should be reflected in the development of any AI system that will be contributing to these communities' transportation planning. Instead of designing for AI-based solutions to focus on outcomes for the average user, AI systems should be built specifically to accommodate successful transportation outcomes in a variety of situations and to a variety of users – from vulnerable road users to the disabled community, to communities with limited transportation options.

Understanding Human-AI teaming and augmentation

As we consider the potential trajectory of AI operations within the transportation sector, it is clear that the greater adoption of AI will improve the capabilities of transportation operators to garner insights from various sources of transportation data, but coordinated effort will be required to ensure that the workforce is positioned to fully utilize these tools. Specifically, there is a clear need for a strategy to upskill the workforce that uses these algorithms. Organizations cannot rely solely on recruiting, instead they must close the talent gap by embracing a culture of lifelong learning and continuous investment in upskilling. Human-machine teaming and human augmentation will not happen by default.

From the outset, AI design must consider the aim of tasks and the type of human interaction involved. It needs to incorporate team structure and team elements that include AI and human interactions and roles, thereby creating hybrid intelligent systems.

Key points

1. Any look into the future of transportation and AI solutions needs to be through a holistic human-focused lens.
2. Humans must understand the logic behind the outcomes and functioning of algorithms in order to use and trust them.
3. Humans need to understand the complexity of ITS and Cooperative ITS to make better decisions – and AI can help them do this.
4. New cyber risks must be understood and prepared for to protect transportation systems from attacks.
5. Only with inclusive design will equity be achieved.
6. The skills gap needs to be addressed now so that there is a reskilled and trained workforce to work with AI systems in the future.

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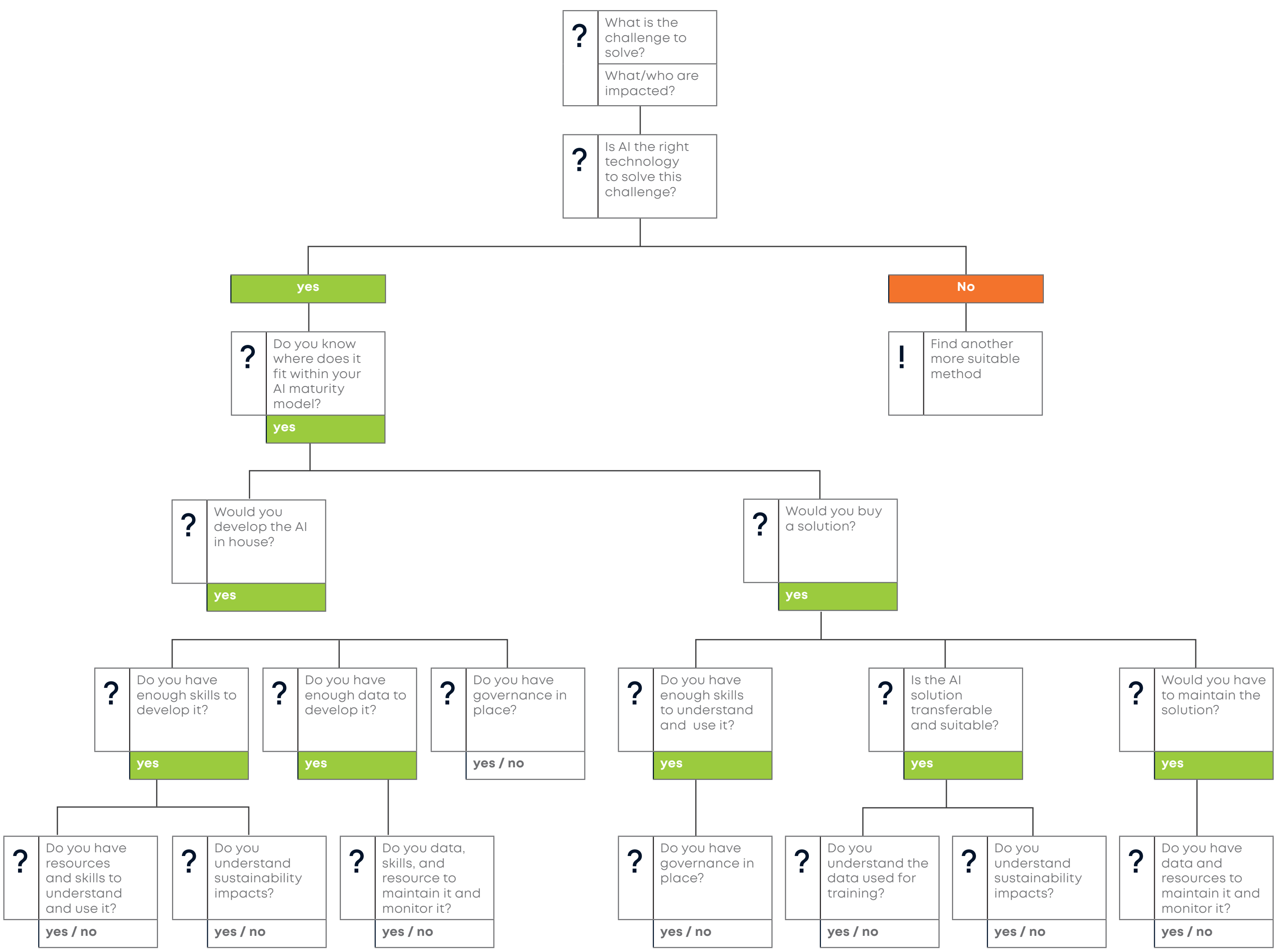
2.3 Navigating complexity and evolving current practices

As detailed in the "main players" section of this paper, significant progress remains to be completed before a firm, overarching set of standards and regulations will be finalized for AI developers, deployers, and operators to adhere to. This regulatory vacuum represents a challenge for AI stakeholders, as the uncertainty inherent in the future regulatory conditions that AI will be operating under increases the relative complexity associated with AI deployment in the short-term. To help reduce and navigate this complexity, we recommend that a maturity roadmap should be developed to help bridge the gap between AI technology and AI standards – one that can help prospective AI deployers gauge the readiness of both the market, the regulatory environment, and their own particular solution in order to chart an appropriate path to deployment. This would ideally couple short-term steps and determinations with a long-term vision for the particular AI application in question. This maturity roadmap could be based on a methodology developed by Carnegie Mellon University[1] for maturity models, and it would definitely aid the thinking process behind the deployment of new solutions. The questions below do not aim to be exhaustive, but just serve as an example. They would have to be expanded and developed to reflect the progression and capabilities within a maturity roadmap.



1 **Reference:** Paulk, M. C., Curtis, B., Chrissis, M. B., and Weber, C. V. 1993. "The Capability Maturity Model for Software," Software engineering project management (10), pp. 1-26

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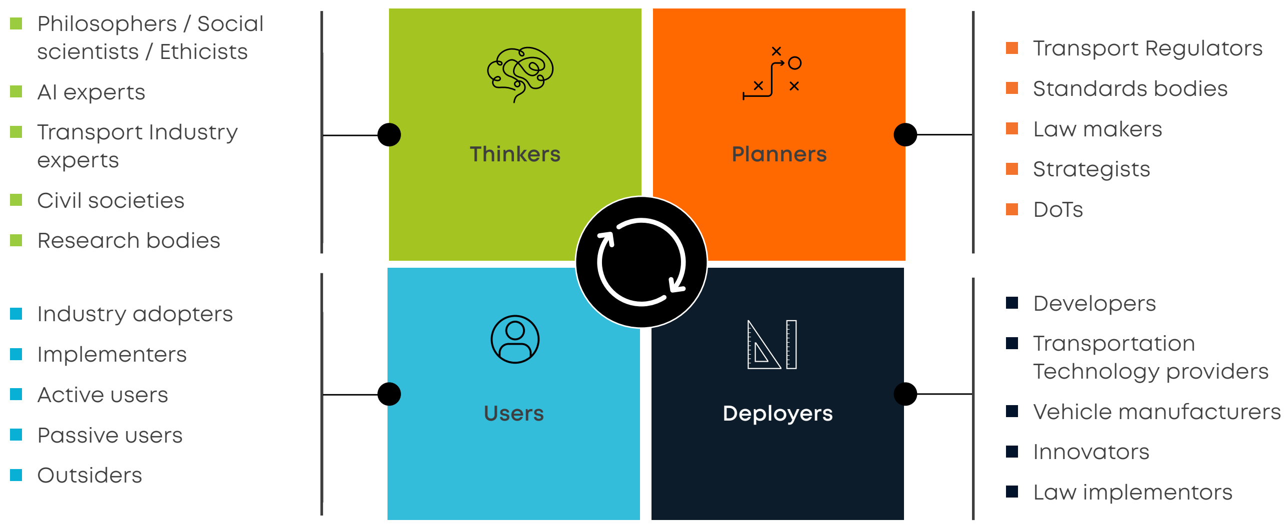
3 The main players

If we understand the universe of stakeholders involved in AI-enabled transportation systems, we can accommodate the needs of the most important groups and ensure successful system deployment that meets USDOT transportation goals.

In our previous Digital Strategy Infrastructure Report (published September 2023) we outlined a user-centric stakeholder map (Fig. 4, page 24) detailing the groups most deeply involved or impacted by transportation digital infrastructure. This mapping (outlining the relationships between end users, digital infrastructure interfaces, state and local public entities and enabling organizations) is worth referencing as a similar high-level baseline for understanding the main players in the AI transportation space.

Another useful, and simpler, perspective is to consider the needs of groups as categorized here.



3.1 Thinkers

Traditionally, AI integration for public services such as transportation infrastructure is considered, discussed, and tested within research bodies (particularly in academia) and industry think tanks. AI thought leaders also provide an anticipatory perspective. The role of these key players is crucial to ensure that AI integration is considered and prepared for before it happens at scale, driven by a well-informed understanding of the direction, and likely potential magnitude of AI capabilities.

Thinkers provide the necessary deep discussion and different points of view about the vision for the future of transportation. They consider the challenges people might face with the introduction of AI, the possible socio-technical scenarios for the development of a future vision, and the possible solutions and mitigations to unintended harms. They are the ones who dissect the possibilities and the research to provide the evidence of current challenges and impacts that can be used to inform planners.

3.2 Planners

Planners provide strategic framing and prioritization. Their main aim is to ensure fair and non-discriminatory access to transportation for all. Planners include DoTs and MPOs, as well as regulators, administrations in charge of policy, and standards bodies. They create the framework that includes various interactions that underpin the transportation sector, such as the legal relationships between the transportation operators and passengers, and relationships between operators and public administration bodies.

Within AI, planners need to comply with technical and safety regulations, as well as social and environmental protection. Planners must be independent from any other body, but must still consider the views of all the other main stakeholders to form an impartial viewpoint.

Transportation policy makers at different levels need to use a broad variety of strategies and policy instruments to tackle challenges and promote opportunities for AI development. This can generally be a complex task when it comes to new and disruptive technologies such as AI, therefore, much of thestrategic development tends to fall behind the speed of technology development by the deployers – leaving a gap between the plans being adopted and the technology being deployed.

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3.3 Users

Users are the key to the way the thinkers envision the future of transportation. Users need to be the focus of planners, and will be the ones who benefit from the delivery of the deployers' solutions. Users, such as goods distributors, emergency responders, communities, individuals and businesses, should clearly represent the primary audience of transportation advancements, and transportation advancements powered by AI are no exception.

Given the inherent complexity in AI operations, it is particularly important that the interfaces of AI systems be designed to be accessible to the intended user of that application, whether that is an active user intending to utilize an AI system for a specific job function , or a passive user interacting with AI as a function of their daily life. For many AI applications, operators cannot assume that the users of their AI application will have any great technical literacy related to the intracacies of AI functionality, and therefore must ensure that their solutions are accessible to all types of users. This is particularly important when AI systems are being incorporated into public transportation elements, such as transit, for example, as the AI solution cannot represent an additional barrier to travelers being able to use transit options. Ultimately, a successful transportation AI system will be able to deliver on the complexities of their intended mission while embracing a human-focused design which establishes an accessible and approachable solution to the larger traveling public.

3.4 Deployers

When it comes to AI in transportation, deployers are currently operating in a rapidly-evolving regulatory environment – one that affords them a great deal of responsibility for the outcomes of the solutions they are bringing to market. Thinkers, planners and users have yet to establish uniform regulations and standards that deployers need to apply to AI solutions. In the absense of such guidance, deployers are responsible for creating services that are sufficiently safe, efficient, equitable and sustainable.

The result is that deployers, such as AI technology innovators, AI technology developers and OEMs, are currently creating their own best practices. They are following guidelines and frameworks for the responsible development of AI solutions, taking into account the input of thinkers and industry experts. They are keeping updated on regulations, executive orders, legislation and ways these polict aspects might be translated into transportation AI policy, while considering the diverse needs of users. They must also anticipate how the standards regulating AI will ultimately be structured in order to avoid finding their already-deployed AI solutions out of compliance with new Federal policy.

Deployers are advancing technological development and exploring the possibilities that AI can offer within the transportation sector. They are developing vehicle automation, solutions for intelligent traffic light management, applications of mobility as a service (MaaS), carbon emissions measurement and much more. Ultimately, given the diverse opportunities within the transportation sector for AI enhancement, public and private stakeholders across the larger transportation industry will have to work in close coordination for AI to achieve advances at system and human levels.

Key points

1. The new ecosystem around AI and transportation is still being formed and developed. Influences, interactions and cooperations between the main players are in a currently nascent form.

2. Four main groups with clear characteristics and role to play in this ecosystem have been identified to encompass the new ways in which the AI within transportation needs to work.

3. These main players will need to work together towards common goals that guarantee the safety, efficiency, equity and sustainability of AI solutions.

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4 Building blocks for responsible AI development

How AI technology is implemented will determine whether it improves American transportation or creates new challenges that will need to be solved. There are specific areas of focus for AI stakeholders to consider, ranging from issues arising from macro-level assessments to technical-level considerations around AI implementation. Macro-level risk assessments include aspects related to ethics and sustainability, regulations and standards, privacy, and trust, while technical-level considerations could include robustness and resilience, transparency, safety, and security factors. While specific solutions for each of these considerations will continue to be developed in coming years, we will attempt to frame some of the considerations for each of those variables in the following sections.

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4.1 Macro level risk assessments

A macro-level risk assessment deals with those areas of ethics and regulations that are overarching and applicable to any technology and aim to protect the user from any harm. While this risk assessment needs to be conducted for all technologies, it is especially important for AI, which presents greater potential to cause significant challenges due to its scalability and its capability of amplifying negative impacts throughout the transportation system. These assessments include:

Ethics and Sustainability	Regulations and Standards	Privacy	Trust
▪ Agree on a moral compass and the protection of people's and planet's rights ▪ Asses potential impacts on individuals, groups, societies, planet of AI within transport, including job losses/ job skills evolution ▪ Identify potential harms that AI could incorporate (impacts on equity, sustainability, environment) ▪ Uncover intended and potential unintended consequences of an AI within a transport application ▪ Agree on potential mitigations and inclusive human focused and sustainable solution designs that are beneficial for humans and the planet	▪ Assess existing regulations and standards that might apply when incorporating AI within the Transport industry ▪ Understand upcoming regulations and standards more general to AI ▪ Understand Guidance, principles, regulatory ecosystems being formed and how this affects the incorporation of AI within Transport ▪ Understand related regulations that an AI application might have to consider (privacy) ▪ Apply best practice/ assurance frameworks that include expert knowledge of AI and transport	▪ Asses the potential to erode privacy rights through third party data sharing ▪ Assess the potential to create new/hidden discriminatory practices based on protected characteristics ▪ Understand the commonalities and differences between privacy laws in different states and what that means of AI solutions within transport. ▪ Explore the potential of AI as tool to actually protect privacy and apply privacy laws	▪ Create foundational trust by taking the user needs and concerns into account from the start of the design ▪ Create appropriate tools for user interpretation and understanding of new techonology ▪ Promote a balanced trust on AI so it is used as intended (avoiding over trust and under trust). User understanding of limitations and advantages in different transport contexts ▪ Governance processes are in place to assure the traceability and transparency of any AI from design to implementation to monitoring

Key points

1. AI solutions for the transportation industry need to look very carefully at all aspects of ethics, upcoming regulations and standards that apply to AI. Particular focus should be put on new impacts and harms that AI could bring through unintended consequences.

2. Privacy laws still apply to any AI development within transportation. The deployment of any solution must be clear on privacy rights, sharing of data and evaluate any bias that might arise.

3. Trust is one of the biggest barriers to the adoption of AI within high safety industries. Trust needs to be built with transparency, understanding, interpretation and usability of these tools. Otherwise, users will put the wrong level of trust in them with the consequence of misuse and safety implications.

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4.2 Technical level risk assessments

In addition to those macro-level assessments related to impacts, there are more specific quantitative risk assessments of the technology itself. These are also considered in the White House AI Executive order and EU AI Act, and are mentioned in the UK AI White Paper. The NIST AI Risk management framework covers many of these risks in detail, the primary of which include:

Robustness and Resilience	Transparency	Safety	Security
▪ AI based on historical data flows should be able to accomodate unforeseen operational circumstances, such as data distribution shifts or unprecedented levels of information uncertainty ▪ An AI trained with data coming from current traffic conditions may not be easily transferable to other road networks, especially when different patterns and changes occur ▪ Failure of data inputs or model performance needs to be monitored and fail-safe modes and redundancy systems in place until they are restored	▪ Transparency answers the question "what happened" in a system (NIST) ▪ Explainability answers the question of "how a decision was made" (NIST) ▪ Interpretability answers "why a decision was made" (NIST) ▪ Oversseing and misunderstanding these characteristics can be grave: a system making mistakes cannot be improved if the process by which it generates output is not understood or explained ▪ Black-box solutions need to be accompanied by tools that help answer the above questions, especially in high safety transport solutions where understanding the systems are key for safety, equity, security and sustainability	▪ AI system should "not under defined conditions, lead to a state in which human life, health, property, or the environment is endangered", (NIST) which is even more important in transport applications ▪ Risks assessments on safety implications of AI solutions within transport operations need to be done by design by developers, product and solution providers and by any agency that incorporate them into their system ▪ Managing AI safety risk is a continuous process of improvement, and simulation, testing and monitoring to the assure continuous safety of such systems	▪ Security concerns include targeted attacks on AI vulnerabilities such as those targeting the data that is used for training, data poisoning ▪ Models can also be targeted and manipulated with attacks. These, such as an Oracle Attack, can manage the exfiltration of models and the manipulation of outputs ▪ There can be breahces of other intellectual property through AI system endpoints ▪ Unauthorized access to AI systems can cause substantial disruption across any ecosystem, and for transportation systems any attack can be catastrophic. New cybersecurity defense methods are crucial

Key points

1. AI is a very different type of family of algorithms to the ones that has so far been employed in transportation solutions. As such it must be created and tested so that robustness and resilience are assured and validated.

2. Ongoing monitoring of systems needs to be in place because the systems can drift from original performance resulting in the need to be re-trained.

3. Transparency of processes and outputs is essential for human understanding and correction of possible malfunctions and errors.

4. AI introduces new risks that can have serious implications for safety and security. These are two key areas that need to be embedded into the design, development and implementation of solutions.

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5 Outcome-driven tech

Ultimately, while the technological capabilities of AI are impressive, the goal of transportation-based AI deployment is not to continue to push the needle on what is technologically possible; rather, it is to provide meaningful, positive change for transportation users across the board. Below, we identify examples of use cases across four pillars that represent some of the main areas of focus for the future of transportation: safety, efficiency/sustainability, equity and multimodal applications. These have been identified from use cases illustrated in the Summary of Potential Application of AI in Transportation by the US Department of Transportation Publication Number: FHWA-JPO-20-787.

These use cases represent how AI can be an enabling technology to achieve improvements in transportation and be combined with other measures to achieve transportation industry goals. Some of these are already being trialed and implemented, while others are more conceptual. These use cases are valuable examples of how AI will impact transportation. These use cases can be coupled with the recommended approaches outlined earlier in this report to better achieve more integrated, holistic and human-focused AI solutions.

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5.1 Safety

Improving safety across the transportation network is crucial. With more than 43,000 fatalities on U.S. roadways each year, there is significant potential for AI to fundamentally improve safety outcomes, making meaningful progress towards a world without transportation fatalities. For the sake of this paper, we have decided to focus on use cases that can significantly reduce road fatalities, consistent with the common goals of Vision Zero, which envisions a road network with zero deaths due to improvements in vehicle and transportation infrastructure safety. Below are some examples of how AI could help achieve that vision, including through applications capable of reducing vulnerable road user fatalities and improving driver performance. These examples include:

Use case	Description
Creating safe intersection crossings	AI can detect a pedestrian's intention to cross before they enter the intersection, automatically switching the crossing signal on and staying on until the pedestrian is safe. This will assist those with sight and mobility related disabilities, improving safety and equity across the country and making less abled citizens safer.
Recognizing dangerous driving	AI in vehicles can detect dangerous driving, such as when a driver is distracted or drowsy, and can predict and analyze information about road incidents before the driver must react to them. The implementation of drowsiness detection in vehicles exists already, with many carmakers already using some form of alert, based on driving patterns. This is radically improving, where AI is increasingly able to spot distracted or drowsy driving earlier with more reliability.
Smart headlights	Predict the location and intensity of precipitation and road objects, enabling headlights to respond dynamically to changing low visibility conditions with a quicker reaction time than the driver. Also detecting vehicles in the opposite direction and change lights accordingly and on time so that they do not impede the other driver's visibility.

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5.2 Equity

Improving equity is a central pillar of the U.S. Department of Transportation strategic plan. There are critical ways in which AI can play a role in enhancing equity, namely through improving accessibility and providing better, more efficient and more cost-effective transportation links to marginalized and unconnected communities. AI can be leveraged for both indoor and outdoor wayfinding, as well as to help sight-, hearing-, and mobility-impaired passengers across the network be able to locate where they need to go and the safest way to do so. AI can help passengers with language barriers and disabilities communicate with transit staff or receive personalized travel alerts on a real time basis. Additionally, AI can be used by transportation planners to better ensure coverage of areas that historically have had limited transportation options. While this is not an exhaustive list, these are a few areas in which AI is poised to provide significant equity benefits to the traveling public. Further elaboration on some of these themes is included below.

Use case	Description
Automated buses and shuttles	Low speed automated shuttles are usually between 4 - 15 passengers, 10-25 MPH, and SAE Level 4. There are many demonstrations and pilots, and the technology already exists in prototype form now. These shuttles can provide routes to underserved neighborhoods, while also providing more options for less affluent citizens.
Personalized information exchanges	In transportation, AI enables chat-based interfaces for customers to interact with: a customer can receive details about problems on the roads, road closures, emergency alerts and alternative routes. This can be progressively personalized to respond to the user particular needs, using text, audio or images as aid to inform the user according to personal preferences.
Accessibility and information about optimal routes	Digital infrastructure and AI solutions can enhance equitable access in all areas of transportation according to different user needs. From identifying user needs, patterns, gaps, forecasting and planning, to integrating accessibility across the transportation network, including wheelchair access, audio and visual aids and using AI for optimal routing and available assistance, that uses all that key information, so transportation is integrated and easy to use by all.

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5.3 Efficiency and sustainability

Another key area of focus for AI in the transportation sector is achieving greater fuel efficiency and other sustainability goals. Through the utilization of AI's unique abilities to process and interpret large amounts of data, transportation systems can be optimized to reduce traffic congestion, decrease fuel consumption, and minimize environmental impacts. This can be accomplished through a variety of ways, including AI-powered route optimizations, traffic signal management, and maintenance monitoring of transportation infrastructure assets to minimize asset downtime and associated congestion challenges.

These elements are critical in the ongoing net zero strategy, and the improvement in energy efficiency in USDOT's 2022 Sustainability Plan.

Further, as new transportation projects move forward, there is a need to project how land use will change over time, and how those changes will impact emissions and the climate. With AI, land use changes can be predicted, documented and analyzed over time, enabling a better understanding of what measures to take to prevent undue pollution and climate risk.

Use case	Description
Preparing environmental impact assessments for transportation construction works via remote Sensing	AI can be used to detect land use change from satellite imagery, LiDAR and predicting environmental impacts from parking lots and roads. This is achieved through remote sensing and predicting environmental impacts, e.g. through deforestation, hydrology, heat and smog.
Predictive maintenance and fuel efficiency for transportation systems	AI can increase the efficiency of tracking and monitoring infrastructure, repair and maintenance. It can reduce unplanned downtime by monitoring sensor data and alerting management to abnormal metrics, which can help technicians by providing insights that are hard to see or track over time. AI can also be used to ease data overload by fusing and highlighting the most critical areas. Furthermore, intelligent fuel efficiency algorithms can help reduce emissions and pollution by making small changes in how a vehicle operates, through the use of engine control and engine diagnosis.
Traffic signal control systems	AI can be used for Traffic Signal Control (TSC) systems, where counting the number of vehicles, the vehicle distances and the queue lengths are all important for regulating traffic flow, improving energy management for vehicles, adaptive energy management for different road conditions, freeway control and using these data for traffic simulations to measure carbon zero emissions and create further solutions.

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5.4 Multimodal applications

The transportation ecosystem is incredibly varied, including freight and passenger travel across numerous modalities that share many of the same routes and intersect at different points and in different ways. It is therefore very difficult to manually model how a change in one area may impact changes in others given the system of systems.

AI provides considerable value to coordinating multimodal transportation. Intelligent systems can delineate varying traffic flows and transportation modes at different times, using network analysis to increase accessibility and manage numerous infrastructure components at once. AI can assist with multimodal transportation planning and routing, calculating changes and predicting reroutes more easily, all with the goal of improving access and equity to all transportation end-users.

Use case	Description
Multimodal intelligent traffic signaling system	AI can optimize traffic signaling to service all modes of transportation by predicting vehicle and pedestrian arrivals, queues and delays. This could be used for emergency vehicles, freight, pedestrians or cyclists, and can even be expanded to have individual intersections control their own traffic.
Multimodal mobility on demand	AI can improve multimodal mobility on demand for individual users and the transportation network by analyzing group behaviors and prioritizing efficient transit for groups of travelers with similar goals and destinations. Further, individual experiences can be dynamically optimized, creating the best outcomes for the most people – mobility impaired travelers can be guided to transit with more seating, or travelers with time constraints can have speed prioritized.

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5.5 Use cases of applications targeting multiple outcomes

Not all applications are focusing only on one particular outcome. More often, in fact, they are targeting several of the key outcomes described above. Examples include:

Key outcome	Use case	Description
Sustainability/ efficiency/ safety	Predictive maintenance	Predictive maintenance can be carried out by different approaches with the aim of sustainability, efficiency and safety as a minimum. For example, digital twins combine data and models and create links between the physical world and the digital one. They can be used as training beds for AI in order to build predictive models and testing beds where AI can be fed historical data about – for example – maintenance problems and create predictive maintenance algorithms that can then be applied in real operations. Consistently maintained road safety furniture can considerably improve safety. Instead of barriers that may already be weakened or damaged to create hazards, transportation administrators will have a clear view of which elements of the network need attention.
Sustainability/ efficiency/ safety	EV charging	AI can assist planning for sustainability and efficiency of EV charging point availability, management impacts of electric vehicle uptake and measuring and predicting impacts on the grid and grid's service needs. Equity is also improved, as more communities across the country have access to charging points that work, which means that they are able to travel to work or leisure more easily with more uptake of EVs and electrification of transportation that contribute towards carbon zero targets. Different vehicles can use these charging points for longer, allowing for the same infrastructure to better serve a variety of uses.
Sustainability/ efficiency/ safety	Traffic light optimization at intersections	Intersections are a substantial source of emissions as well as accidents, with pollution much worse at these points than at other points in a transportation network. The predominant reason why these emissions are so much worse at intersections is due to the starting and stopping of vehicles. Early results of the project claim a 30% reduction in stops and 10% reduction in emissions at intersections. With a variety of data collected at intersections and traffic light optimization, an AI model can provide recommendations to civil and traffic engineers who can optimize the system with a clearer understanding of where hot spots for accidents can be found and prevented by responsive traffic light optimization.

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6 The main enabler: implications of regulatory approaches

There are currently many guidance documents, frameworks, pieces of legislation and regulations seeking to regulate AI in different industries and parts of the world. Given continued public and private sector interest in AI, policymakers are increasingly considering potential regulatory approaches to govern AI research, development, deployment, and use. Here is an overview of three of the main approaches from the United States, European Union, and United Kingdom

6.1 US approach

Achieving an appropriate regulatory framework for development and utilization of AI has been a key priority of the Biden Administration and Federal lawmakers. In comparison with some of the United States' global partners, policymakers in the U.S. have historically adopted a more hands-off approach to AI regulation, often allowing industry self-regulation while prioritizing innovation and competition. This section will describe some of the specific ways in which the United States has approached AI regulation, including aspects specific to transportation.

This approach was reflected in the National AI Initiative Act (NAIIA) of 2020, which established the National AI Initiative Office (NAIIO) to coordinate key AI activities across the federal government. The National Institute of Standards and Technology (NIST), a non-regulatory agency, was made responsible for developing standards, guidelines, and other resources to guide AI use through establishing best practices, technical guidelines, and tools to help organizations manage the risks and benefits associated with the development and deployment of AI systems. The NAIIA specifically directed NIST to develop an AI risk management framework, a voluntary tool that organizations can use to evaluate, assess, and manage risks that may result from the use of AI. NIST released the first iteration of this framework in early 2023 and made clear that the document was intended to be "voluntary, rights-preserving, non-sector-specific, and use-case agnostic, providing flexibility to organizations of all sizes and in all sectors and throughout society to implement the approaches in the Framework."

In October of 2023, the White House released an Executive Order on Artificial Intelligence which required that companies which are developing large AI models related to national security, safety, public health, or the economy will be required to share "test results" and models with the Federal government prior to making the models public. The order further directed NIST to to set rigorous AI standards for extensive testing to ensure that AI-powered systems are safe, secure, and trustworthy before release, as well as additional provisions related to privacy concerns and workforce considerations. In the absence of successful legislation establishing a more prescriptive Federal legislative framework, NIST's leadership over standards and best practices remain the primary way in which AI development is guided within the United States.

Specific to transportation, the October 2023 Executive Order directs the Secretary of Transportation to utilize the Nontraditional and Emerging Transportation Technology (NETT) Council to "assess the need for information, technical assistance, and guidance regarding the use of AI in transportation," as well as to "support existing and future initiatives to pilot transportation-related applications of AI, as they align with policy priorities articulated in the Department of Transportation's (DOT) Innovation Principles, including, as appropriate, through technical assistance and connecting stakeholders." The Order directs the Secretary of Transportation to direct appropriate Federal Advisory Committees of the DOT to provide advice on the safe and responsible use of AI in transportation, and to direct the Advanced Research Projects Agency-Infrastructure (ARPA-I) to explore the transportation-related opportunities and challenges of AI — including regarding software-defined AI enhancements impacting autonomous mobility ecosystems. The Order also specifically encourages the Architectural and Transportation Barriers Compliance Board to leverage AI solutions to increase access to transportation options for people with disabilities.

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Legislatively, the NAIIA was the largest major step that Congressional leaders have taken to regulate AI, and the impacts that legislation has had on Federal AI policy are briefly described above. More recently, various policymakers have released proposals in the Senate that aim to outline key policy objectives for an AI framework. Most notably, in June 2023, Senate Majority Leader Chuck Schumer (D-NY) released a "SAFE Innovation Framework," which outlined five policy objectives for AI governance. Those objectives included safety, accountability, foundations (aligning AI with societal goals), explain (information sharing), and innovation. Additionally, in September 2023, Senators Richard Blumenthal (D-CT) and Josh Hawley (R-MO), Chair and Ranking Member of the Senate Judiciary Subcommittee on Privacy, Technology, and the Law announced a bipartisan legislative framework to establish guardrails for artificial intelligence. The framework lays out specific principles for upcoming legislative efforts, including the establishment of an independent oversight body, ensuring legal accountability for harms, defending national security, promoting transparency, and protecting consumers and children. While neither of these proposals were specific to transportation, they demonstrate the manner in which legislators are approaching AI regulation as of late 2023.

While some states have created working groups to consider AI regulations or have limited to use of AI in certain hiring practices, states are primarily following the lead of NIST and other Federal partners in terms of adopting AI best practices on issues including data collection and use, privacy regulations, and workforce regulations. These key issues represent main focuses of NIST's efforts in this space, particularly in their efforts to establish performance-based standards which attempt to ensure safety and reliability without stifling innovation and economic competitiveness. NIST is well-positioned to share resources with states to help avoid a patchwork approach to AI regulation, but a key challenge will be continuing to update standards at a pace that tracks with AI development, as well as effectively communicating new AI standards to the public and private sectors quickly enough to respond to emerging AI opportunities and risks.

In the absence of additional legislative support for a wider Federal framework governing AI (which would ideally address security, accessibility, and privacy), Congress could help NIST address these challenges by appropriating additional funding for Federally sponsored AI research, which can help NIST and Federal regulators keep pace with emerging AI developments. There is palpable excitement within the transportation and technology sectors about the possibilities for AI, and industry continues to push forward with developing AI applications. It is critical that Federal leaders move quickly to create a robust Federal AI framework in order to channel that momentum towards solutions that benefit the public, such as encouraging the deployment of AI use cases that promote transportation safety, efficiency, and sustainability for all travellers.

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6.2 EU approach

The EU's approach to AI risk management and regulation is multifaceted. The new EU AI Act (still in progress) will be bridging into already implemented legislation, such as the General Data Protection Regulation (GDPR), and linking to newly enacted legislation, the Digital Services Act and Digital Markets Act.

The EU AI Act, as it stands, represents a prescriptive legislative framework. It is based on the classification of AI applications into prohibited, high-risk and low risk. Prohibited applications are very clear. For the rest, depending on whether the application is considered high-risk or low risk, it imposes legislative obligations at all stages of the lifecycle of an AI system, from training, testing and validation to conformity assessments, risk management systems and post-market monitoring.

The EU AI Act has a horizontal approach across industries, the purpose of which is to improve the functioning of the internal market with a uniform legal framework for the development, marketing and use of AI. On the other hand, industry verticals such as transportation is governed by Article 4(2)(g) and Title VI (Articles 90–100) of the Treaty on the Functioning of the European Union, making transportation one of the EU's most strategic common policies.

The intersection between the vertical and horizontal approaches is going to need a very complex exercise of harmonization of current and proposed policies that affect safety, security and impact on equity and sustainability. Representatives of the transportation sector (Committee on Transport and Tourism for the Committee on the Internal Market and Consumer Protection and the Committee on Civil Liberties, Justice and Home Affairs) who are reviewing the Act say that it:

- Needs to not overlap with sectoral legislation by imposing double/conflicting obligations on transportation actors.
- Needs to promote the development of, and upholding, international standards, that are particularly important for the transportation sector.
- Needs to foster research and innovation to ensure the EU's transportation sector develops its know-how in the implementation of AI, while upholding the highest ethical standards.

There is a strong emphasis from transportation sectors that with the integration of AI systems in the sector, new challenges could emerge in risk management. But the opinion is that this new AI regulation should only apply to high-risk applications in the transportation sector in so far as that they are not already covered by sectoral legislation and where they could have a harmful impact on the environment or health, safety and fundamental rights of persons.

In this sense, there are still question marks about how the regulation coming from the AI Act might work since transportation and mobility are already highly regulated. Some EU agencies have already begun to consider how AI affects their regulatory processes. One leading example is the EU's Aviation Safety Agency (EASA), which first set up an AI taskforce in 2018, published an AI roadmap oriented towards aviation safety in 2020, and released comprehensive guidance for AI that assists humans in aviation systems in 2021.

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6.3 UK approach

The UK is opting for no further legislation at this stage. Instead, the UK White Paper titled 'UK regulation: a pro-innovation approach', released in August 2023 outlines five principles that UK regulators should consider to best facilitate the safe and innovative use of AI in the industries they monitor: **(1) safety, security and robustness; (2) transparency and explainability; (3) fairness; (4) accountability and governance; and (5) contestability and redress.**

The UK government has issued these principles on a non-statutory basis, but it may introduce a statutory duty on regulators at a later date. Strengthening the UK approach, especially around AI safety, 28 countries gathered in November 2023 at an event convened by the UK. Here, the U.S., China, EU, and others agreed to the Bletchley Declaration on opportunities, risks and the need for international action on frontier AI (systems where we face the most urgent and dangerous risks).

The UK principles will be implemented by existing regulators, such as the Medicines and Healthcare products Regulatory Agency (MHRA), the Equality and Human Rights Commission, the Information Commissioner's Office (ICO), the Competition and Markets Authority and transportation regulators (industry control and regulation is exercised principally through the Department for Transport (DfT), its executive agencies and the Traffic Commissioners).

This approach makes use of regulators' domain-specific expertise to tailor the implementation of the principles to the specific context in which AI is used. The UK Government is aware that regulatory co-ordination will be essential. The risk is that in the absence of a centralized regulator, UK regulators will diverge in approach. The white paper discusses measures that the UK government will take to mitigate this risk, including issuing guidance for regulators in implementing the principles, central monitoring and evaluation of the framework and principles, and a multi-regulator AI sandbox.

The DfT is already in consultation with industry experts to gather insights into the main issues they need to focus on when it comes to issuing extra regulation for AI in transportation. The DfT recognizes that it has a critical role to play in supporting the responsible growth and adoption of the AI industry. It is already a frontrunner in creating world-first regulatory frameworks in areas such as self-driving vehicles, as well as supporting research and development initiatives. To scale its use of AI, DfT is interested in developing a governance framework for responsible AI trials and an AI Strategy for Transport that is already in preparation.

Key points

1. We are experiencing an evolving and complex time in history where regulations on AI are being defined and developed in different geographies, with the USA, UK and EU being at the forefront of these developments.
2. All three regulatory approaches recognize the delicate balance in order to achieve and promote innovation while assuring safety and responsible AI development.
3. These AI horizontal and overarching regulations will need to be harmonized with the transportation industry regulations already in place, with an emphasis from transportation authorities on avoiding duplication and complexity.
4. How regulations are developed (risk-based approach, guidance-based approach or more prescriptive-based approach), will shape the development of AI in transportation in different countries.
5. Going forward, evolution of regulations and harmonization at global level will be key. Best practices and knowledge exchange between industries and geographical areas will be necessary to advance and update regulations when needed and in order to anticipate and answer the needs of the exceptional fast-paced growth of AI.

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7 Conclusion

The US transportation system is poised for a dramatic transformation based on the deployment and application of AI technologies. In the coming decades, AI innovation can help propel far-reaching improvements in transportation safety, efficiency, equity and sustainability. We believe that AI can be a critical contributor to significant public benefit within the transportation sector, helping transportation stakeholders successfully achieve ambitious improvements to the way that transportation planning, operation and user experience are managed within the U.S.

However, utilizing AI to achieve these outcomes will require robust coordination among Federal leaders, transportation planners, technology developers, and other related stakeholders. This paper has outlined what we believe are some of the key considerations for navigating the next phase of AI in transportation development and deployment, including what we see as opportunities as well as challenges related to successful transportation AI implementation. Ultimately, a U.S. transportation future powered by AI is within our reach. It is our hope that the recommendations within this paper will help shape that future to be one in which AI is positioned to make meaningful strides towards a safer, smarter and greener transportation system for all road users.

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The Intelligent Transportation Society of America was founded by Congress to advise the federal government on digital transformation in transportation and is the only organization that brings together private industry, government, researchers, non-profits, and communities to advance the deployment of intelligent transportation technologies to save lives, promote sustainability, and increase access and opportunity for all communities. Our vision is a better future transformed by transportation technology and innovation that is Safer, Greener, and Smarter for All. For more information, please visit www.itsa.org.

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