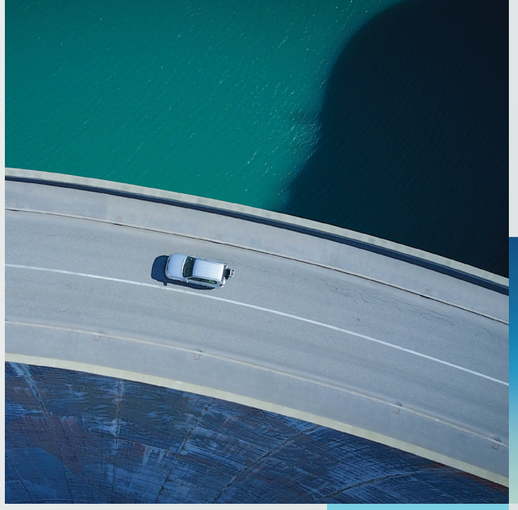
E-BOOK

AI in Automotive



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EXECUTIVE SUMMARY

Reinventing the Automotive Industry

Organizations across the automotive industry are rapidly adopting artificial intelligence (AI) to expand into new markets, optimize workflows, and move ever closer to fully autonomous driving. Across every use case—from connected and autonomous vehicles to mobility services and smart manufacturing—success in AI depends on one thing: your data. This e-book will help you understand the top use cases for AI in the automotive industry and how to build an effective data pipeline to address key challenges for every use case.

Read on to learn about:

- Top use cases for AI in the automotive industry
- AI data challenges for each use case
- Architectural considerations for building a multistage data pipeline
- Accelerating your journey to AI with smart, powerful, and trusted AI solutions

New Dynamics Mean Big Changes

Since its earliest days, the automotive industry has been characterized by the constant drive for improvement and the pursuit of a competitive edge. Today, two sweeping new dynamics are generating profound change for automotive companies.

First is a vast expansion beyond the basic car-as-transportation model. Customers now expect their car to function as an extension of their home through internet-connected services. And they want smart cars that can actively keep them safe on the road and make critical decisions—even drive—for them.

Second is an explosion of new services that focus on mobility instead of traditional car ownership. Consumers, particularly those in urban environments, have new expectations for mobility on demand. Instead of owning a car, they want pay-per-use services through ride sharing applications as well as short-term rentals of vehicles of every kind, including cars, bikes, and scooters.

To remain competitive, automotive companies must transform the way they do business so that they can offer the new products and services customers want while maximizing operational efficiency and shareholder value. To meet these needs, today's automotive leaders are investing heavily in data-driven software applications to advance the most important innovations in autonomous and connected vehicles, mobility, and manufacturing.

Artificial intelligence (AI) is revolutionizing the automotive industry as large datasets are making it possible to gain critical insights into roadways, people, and processes. Most automotive leaders are already on the AI spectrum, with workloads ranging from high-performance computing (HPC) and analytics to machine learning (ML) and deep learning (DL). But such workloads tend to be siloed and well insulated within the organization, each with its own infrastructure and its own budget.

That approach can take a company only so far. Today's autonomous and AI workflows traverse the organization, linking large volumes of data from multiple sources and extending out into the cloud. Taking AI from concept to implementation requires a data pipeline to seamlessly capture and move data from devices at the edge to the core and to the cloud.

This e-book discusses some of the top use cases for AI in the automotive industry, including connected and autonomous vehicles, mobility services, and smart manufacturing. You'll learn the importance of building an AI-ready data pipeline. And you'll learn about key architectural considerations for designing a multistage data pipeline to fuel your AI implementation.

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Types of Artificial Intelligence

Artificial Intelligence

AI is a category of computer science engaged in the effort to engineer computers capable of performing tasks that were traditionally considered impossible without human thought. AI spans multiple disciplines, including ML, DL, predictive analytics, and prescriptive analytics.

Using AI, automotive companies can design new vehicles that are equipped to meet the growing demand for mobility and delivery services and personal cars with advanced safety and comfort features.

Machine Learning

Machine learning is the scientific study of algorithms that help software improve methodically over time, in response to collected data.

In-car personal assistants powered by AI can do more than turn on the radio with a voice command; they can "learn" drivers' preferences over time. So they can do things like turn on the news automatically during commute hours and music on the weekends. AI safety systems can also "remember" drivers' bad habits and offer constructive feedback to improve safety on the road.

Deep Learning

Deep learning is a branch of ML that is based on the concept of artificial neural networks. Neural networks efficiently digest vast amounts of data, learn from it, and offer researchers new insights.

DL algorithms on the factory floor can point to correlations between common driver behavior and equipment failures—connections that even highly trained engineers and designers might miss. Collecting massive quantities of data gives DL programs the ability to make new connections and empower engineers to make better decisions.

Predictive and Prescriptive Analytics

Predictive analytics uses machine learning and deep learning to predict future events. It becomes prescriptive when it proactively initiates decisions without human intervention.

In the future, autonomous cars will be able to use prescriptive analytics to suggest destinations based on information pulled from social media channels or other applications. Some virtual assistants can already pull appointment information from your calendar and combine it with map data to suggest departure times for upcoming appointments.

Autonomous Vehicles

When you think about AI applications in the automotive industry, autonomous driving is probably the first thing to come to mind. However, even the most advanced vehicles on the market today are not fully autonomous. The National Highway Traffic Safety Administration (NHTSA) rates levels of autonomy on a scale of 0 to 5, as shown in figure 1.

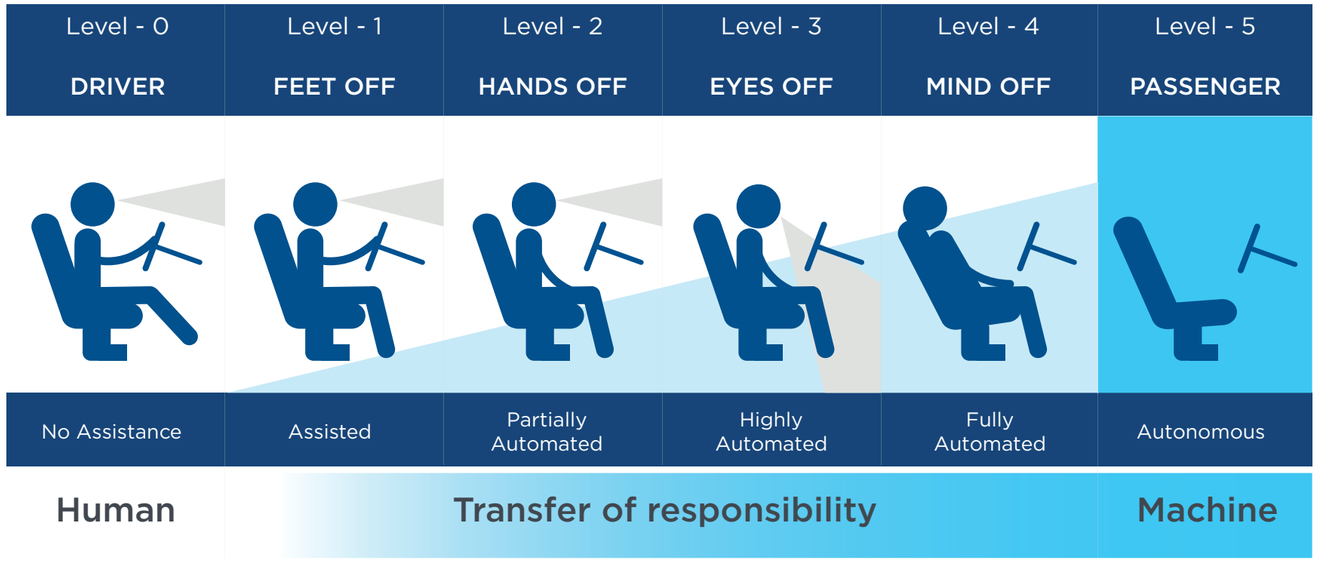


Figure 1) The five stages of autonomy.
Source: SAE International

Autonomous Vehicles

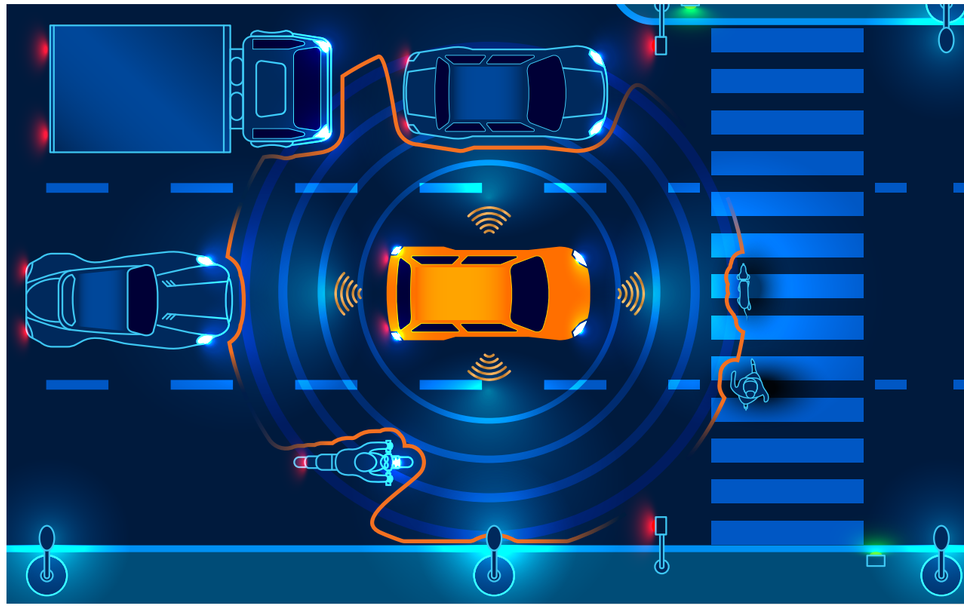
Advanced Driver-Assist Systems

Advanced driver-assist systems (ADAS), which reduce the likelihood of catastrophic human error, are the first step toward fully autonomous vehicles. Today, most ADAS-enabled vehicles range from Level 1 to Level 3 on the NHTSA scale. Trained AI software and sensors tell ADAS-equipped vehicles to keep a safe distance from surrounding vehicles. As a result, distracted commuters have a safer drive to work. Cars can park themselves. And sideswipes are less likely.

Additional layers of AI enable some ADAS-equipped vehicles to scan drivers' faces to detect whether they may be drunk or drowsy. Voice recognition applications, powered by machine learning, allow drivers to speak to their car to make a hands-free stereo adjustment or to place a phone call while keeping their eyes on the road.

AI-powered ADAS applications can also collect and analyze driver data and give personalized feedback that can help drivers be safer on the road. They might even detect the driver's emotions or level of alertness, perhaps adjusting the temperature to rouse a drowsy driver or playing gentle music to calm someone who is getting agitated and starting to drive aggressively.

In the future, smart windshield technologies will turn the entire windshield into a transparent projection screen so drivers can see points of interest, maps, or climate information while still having an unobstructed view of the road. When this system is partnered with voice-recognition applications, the driver can be offered a truly hands-free experience.



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Autonomous Vehicles

Autonomous Vehicles

Autonomous vehicles are poised to revolutionize transportation. Leaders in this space are testing the limits of Level 4 automation and are well on the road to full automation. However, no manufacturer has yet succeeded in achieving Level 5 automation. For obvious safety reasons, this is a highly regulated environment.

Today, the AI software that "drives" these cars has been trained to recognize vehicles, pedestrians, traffic signals, and more. It can also predict external traffic behavior and hazards. Autonomous vehicles are now being developed not only for personal use, but also for product delivery and mass transit solutions.

Tesla, for example, uses AI to process algorithms for its Autopilot software, which enables the self-driving capabilities in its cars. Eight surround cameras, 12 ultrasonic sensors, and forward-facing radar feed data into an onboard computer.[2] Fed by data from cars on the road, cloud-based machine learning drives continual improvements in the speed and accuracy of the software's decision making.[3] Currently, Tesla Autopilot requires active driver supervision and is not rated as a fully self-driving system.

allegro.ai: Powering the Deep Learning Platform

In the automotive industry, computer vision is a crucial component of the AI that enables autonomous vehicles to interpret and react to their surroundings.

Allegro.ai's deep learning computer vision platform provisions a complete lifecycle management solution for AI, from data labeling to training and deployment. Hyundai automotive group has invested in allegro.ai, as part of the company's strategy for developing AI and DL applications relevant to their automobile production, including self-driving cars.[4]

Learn how allegro.ai and NetApp partner to accelerate training and improve GPU utilization.

allegro.ai

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Autonomous Vehicles

AI Challenges

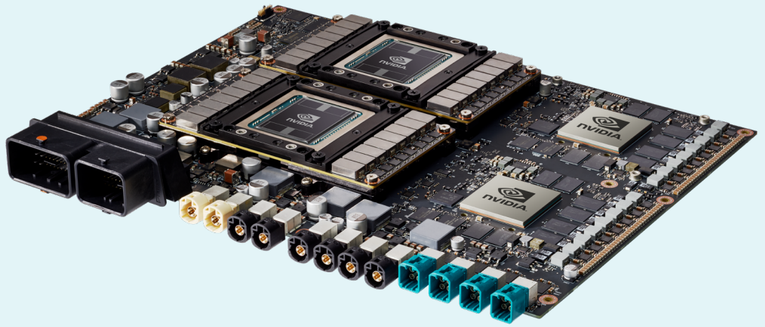
The challenges to achieving full self-driving are significant. Each car deployed for R&D generates a constantly increasing mountain of data. NetApp's automotive customers are preparing their infrastructures to handle up to 200TB per day per test car, or up to 10PB per test car per year. Autonomous driving teams can soon expect to accumulate hundreds of petabytes to exabytes of data as autonomous driving projects progress.

Questions to Ask

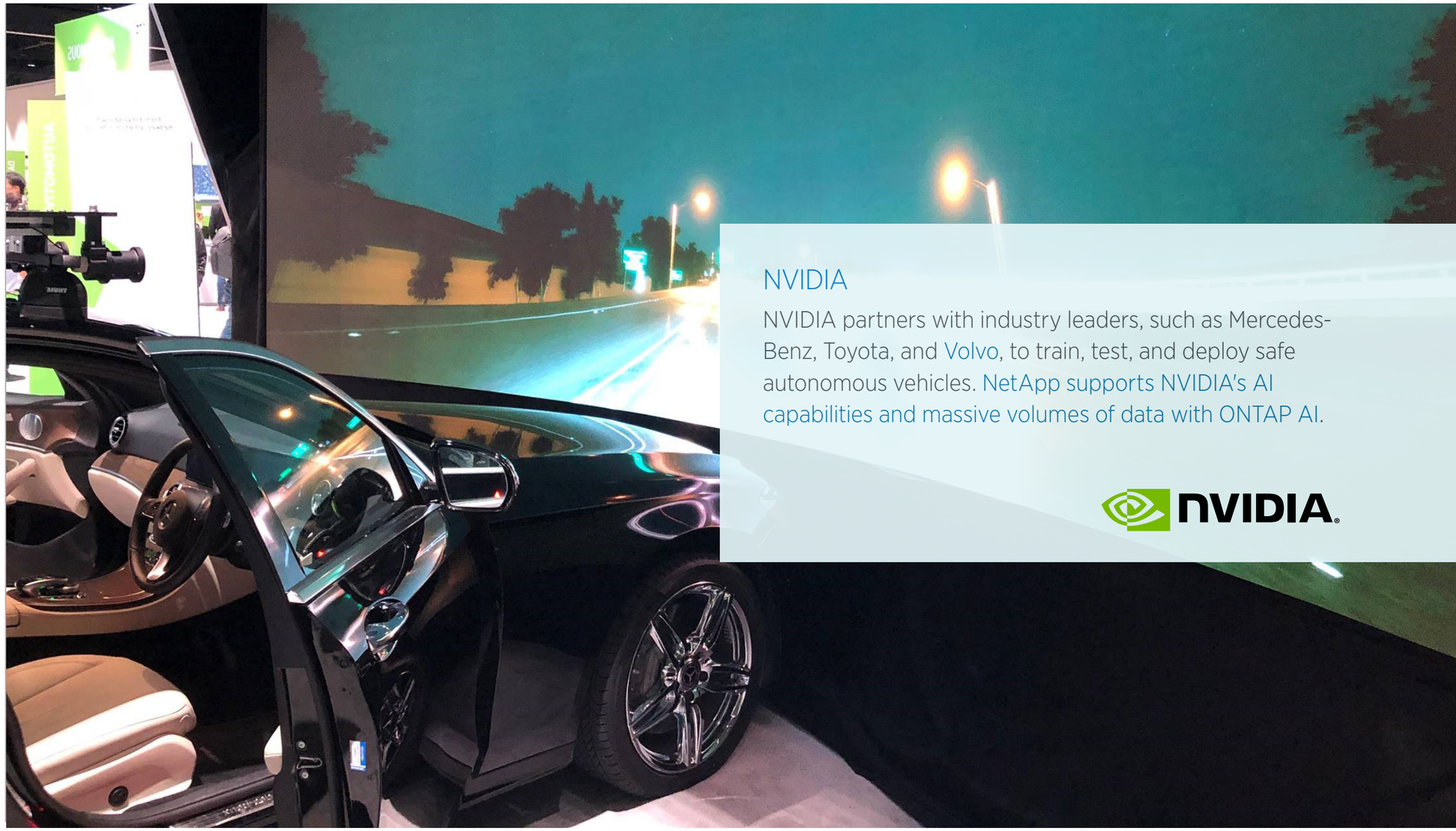
- How do you create a pipeline to move data efficiently from vehicles to train your neural network?
- How do you efficiently prepare image and other sensor data and label (annotate) data for dynamic neural network training?
- How much storage and compute will you need to train your neural network? Should your training cluster be on the premises or in the cloud?
- How do you correctly size infrastructure for your data pipelines and training clusters, including storage needs, network bandwidth, and compute capacity?
- What other data flows do you need to take into account?

NVIDIA DRIVE Autonomous Driving Platform

NVIDIA first announced the open and scalable NVIDIA DRIVE® autonomous driving platform in 2015. It offers end-to-end solutions for data collection, model training, simulation, and driving, scaling from driver assistance systems to robotaxis.



Autonomous Vehicles



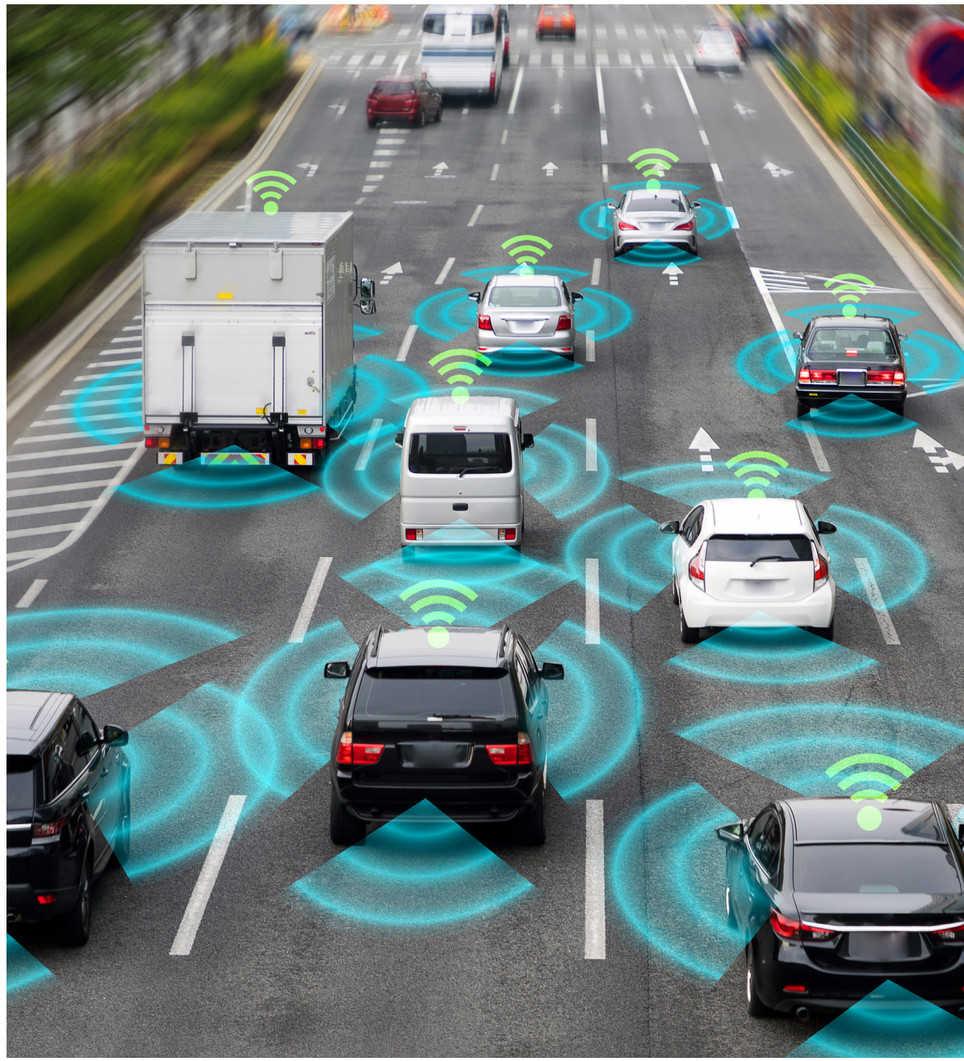
NVIDIA

NVIDIA partners with industry leaders, such as Mercedes-Benz, Toyota, and Volvo, to train, test, and deploy safe autonomous vehicles. NetApp supports NVIDIA's AI capabilities and massive volumes of data with ONTAP AI.

Connected Vehicles

Fully autonomous, Level 5 vehicles may be the technology of the future, but AI is already used on a massive scale in connected cars. These cars are moving IoT platforms, connecting to the internet for seamless integration of entertainment and navigation features, such as HD maps, as well as things like service reminders, maintenance diagnostics, and cruise control. With widespread access to low-latency 5G networks, connected cars can help smart cities get smarter while benefiting from rich data services.

In the future, connected cars will do much more than alert drivers to low fuel or battery levels—they will interact with one another as they work to alleviate rush hour congestion, much like traffic meters at on-ramps do today. Connected cars will interact with one another to maintain safe distances. Delivery trucks will be able to drive in tight convoys at speed—which human drivers could not do safely—to minimize wind resistance and conserve fuel. A further evolution will be the connection between cars and smart cities, creating a seamless transportation and mobility grid in urban environments.



Connected Vehicles

In-Car Personal Assistants

Some vehicle companies embed third-party in-car personal assistants, such as Apple CarPlay or Android Auto, into their vehicles. Others have chosen to create their own applications or to partner with AI startups. Ford Motor Company, for example, is working with Clinc, whose voice-recognition software relies on natural language processing to offer an AI-powered in-car assistant. The assistant can adjust the temperature, respond to follow-up questions about how much gas is left in the tank, and learn individual drivers' speech patterns over time.[5]

Mercedes-Benz partner SoundHound uses AI to connect driver to vehicle through voice. In addition to performing basic vehicle functions with voice activation, the car can provide location-specific information based on where it is and where it's headed. As the application learns the driver's habits and preferences, the user experience becomes more and more personalized over time.[6]

Predictive Maintenance

Artificial intelligence can take the guesswork out of routine maintenance and act as a constant set of eyes monitoring your car for larger problems before they get out of control. Low tire pressure warnings or sensors that tell you when you're due for an oil change are convenient, but predictive maintenance applications actually scan your car for indications of big problems before they result in loss of safety or function. You'll know that you need to schedule a repair or take your car to the shop before you're stranded.

Connected Vehicles

AI Challenges

Connected car development is often based on a continuous integration, continuous development (CICD) model. It relies on instant, always-on access to data from vehicles all over the world to make improvements and enhancements. A company in Germany may receive data from a car in Los Angeles that needs to be accessed and manipulated at headquarters before sending actionable intelligence back to the car that same day.

Sharing data from vehicles to data centers globally and back again is a challenge for connected car manufacturers. With data moving into and out of cars, security is paramount. Security vulnerabilities could expose the car's software to unwanted access and compromise the safety of passengers. Regulatory compliance for personally identifiable information must also be considered.

Speed of innovation is a competitive advantage for connected car development, but edge computing also remains a challenge. Spotty connectivity necessitates the use of regional solutions and "fog" computing at the edge. When data is trapped in applications and silos, it slows progress and stunts development.

Questions to Ask

- How do you create a pipeline to move data efficiently from vehicles to train your neural network?
- How do you create labeled training data
- How much storage and compute will you need to train your neural network? Should your training cluster be on the premises or in the cloud?
- How will you ingest and prepare large amounts of data at the edge?

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Mobility as a Service (MaaS)

By challenging the need for personal vehicle ownership and disrupting the delivery industry, MaaS represents a huge change and a huge opportunity for business growth. Creative companies are inventing new ways to move consumers and the things they need by using ML applications and trained computer algorithms. Mobile apps make it easy for consumers to hang up their keys in favor of bike, scooter, or car-sharing services.

Robo-Taxi Services

If innovative companies like Waymo and Zoox have their way, people in California are months away from being able to hail a robo-taxi—a taxi that drives itself and is hailed by an app. Licensed by the California Public Utilities Commission, Zoox service can launch a pilot program in 2020. At its core is a proprietary AI application that allows the company's vehicles to navigate the demanding environment of dense cities like San Francisco.[7]

Delivery Services

Other companies envision MaaS as a new way to move things—not just people—around efficiently and quickly. Ford Motor Company, for instance, sees MaaS as a way to help small-scale businesses deliver their products and expand their customer reach.[8] Ford has also recently announced a partnership with Amazon's in-car delivery service.[9] Prime members with compatible Ford vehicles can have packages delivered to their locked car to avoid the problem of porch theft. A mobile app lets customers check delivery times and see that their car has been relocked after delivery.

Daimler's Vision Van, too, brings many of these concepts together in a seamless package. The connected vehicle is loaded with packages according to an algorithm that plans the delivery route. The driver is assisted by safety features that signal the presence of pedestrians that a human might miss. Drones mounted on the vehicle can deliver small packages, while the driver handles packages that require the human touch.[10]

NVIDIA Carter Robotic Delivery Platform

Robotic delivery systems are another way in which AI is moving mobility forward. "Carter," an indoor robot from NVIDIA, is learning the halls of the NVIDIA campus by delivering popcorn orders to employees. Once the algorithm is trained, this little robot will be able to tackle more complex deliveries and help people with tasks like finding parking spaces.[11]

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MaaS

AI Challenges

Mobility services rely on analyzing customer behavior and optimizing routes so that transportation can be efficient and easy. Mobility teams understand that the market is an online auction and that consumers have choices. These organizations are competing for business based on how customers want to be moved. Understanding customers and the attributes they look for when moving from place to place is essential. To make these decisions and deliver actionable intelligence to mobility services providers, companies rely on AI to process data in real time.

Vehicles in mobility fleets need to be connected to data centers where the processing takes place so that they have the most complete information about customers and their desired routes. Mobility teams must leverage AI and become brokers of information, enabling microsecond decisions that can have a dramatic impact on the experiences of their customers and give them a competitive edge.

Questions to Ask

- How do you predict customer demand?
- How do you optimize ride sharing for fleet efficiency and to minimize customer wait times?
- How do you dynamically set prices in response to demand?
- How do you protect customer data and balance privacy versus convenience?
- How do you plan the optimal route for a delivery vehicle?

Smart Manufacturing

Even the most forward-thinking mobility services require vehicles to power them. Thus, the factory remains a crucial part of the automotive and mobility industries.

The arrival of Industry 4.0 means that using AI as part of a smart manufacturing design is a prerequisite for staying competitive. Small add-ons aren't enough. Staying relevant—and profitable—in the automotive industry today means either building a new manufacturing model from the ground up or retooling traditional factory floors.

Smart manufacturing incorporates IoT and business data with the analytical and predictive power of AI in real time. Trained algorithms can speed production, perfect product lifestyle management, and offer actionable insights for management teams looking to maximize profit without sacrificing quality and customer satisfaction. AI systems can support people working on factory floors as well, creating a safer and more efficient work environment with real-time analytics and smart machinery.

Robots on the Factory Floor

Although some robots in manufacturing replace human beings, many are designed to work alongside them. Robots can improve workplace safety by performing dangerous tasks, such as welding. Then a trained employee with an experienced eye inspects the weld for problems the machine may have missed.[12]

Robovision

Belgian-based company Robovision offers a complete pipeline for AI and DL projects. Robovision guides DL customers in every industry from ingest to crowd labeling, building initial predictive models, and offering curated and labeled datasets with access through the cloud.

Robovision worked with Audi to create the Walt Cobot. Walt is a "collaborative robot" that works on the factory floor alongside workers assembling the bodies of Audi vehicles. Robovision supplied crucial support in training the DL model that allows Walt to recognize specific factory workers and greet them by name. Robovision's technology also enables Walt to recognize both speech commands and sign language.[13]

Smart Manufacturing

Wearable Robots

Wearable robots deployed in factory environments support automotive workers where they need it. Hyundai developed the H-CEX, an adjustable "knee-joint protective device" that helps support workers' body weight as they sit or crouch.[14] Another Hyundai prototype focuses on protecting workers' necks and backs when they are working with their arms in a prolonged overhead position.[15]

Anomaly Detection and Predictive Maintenance

Industrial equipment that produces automobiles at scale is expensive. Equipment failures disrupt the flow of production with a damaging ripple effect throughout the business and ultimately affect the bottom line. AI models can monitor manufacturing equipment and be calibrated to sense the precursors to failure, signaling factory managers to address a problem before it shuts down the entire production line. With a heads-up from a predictive maintenance algorithm, maintenance can be scheduled during off hours, and potentially troublesome parts can be swapped out or adjusted without disruption.

Trained algorithms on the factory floor can also be used to detect anomalies in production and performance. Catching defects in air bag technology before it's installed in millions of vehicles prevents injury and death to drivers, helps avoid costly recalls, and mitigates potential litigation. AI programs can also flag connections between certain driving behaviors and patterns of failure in preproduction—connections that might take years of driving on the road to detect. Identifying and correcting these problems in development can create safer vehicles, greater reliability, and positive brand differentiation.

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Smart Manufacturing

AI Challenges

Smart manufacturing depends on AI to process data from across the stack and maximize production while minimizing loss of profits. As robotics and smart devices become more commonplace, AI is tasked with taking in data from hundreds of individual endpoints and analyzing a variety of characteristics to make sure that equipment is running optimally and the workforce is operating efficiently.

Analytics and machine learning performed on site can improve manufacturing effectiveness and cut down on human error by autonomously implementing adjustments of human input. And with a more complete, detailed picture of how a plant or facility is running over time, managers can make better-informed decisions about how to improve productivity or expand margins.

Questions to Ask

- How do you ensure that data rules meet corporate governance and security standards to protect against the risk of IP theft?
- How do you analyze data in real time to react faster to business opportunities, production changes, and incidents?
- How do you use containers to speed development cycles while integrating into existing business systems and processes?
- How do you quickly integrate data from different sources?
- How do you bring together data from distributed plant locations to optimize output?

Smart Manufacturing

Fraunhofer and Industry 4.0

Industry 4.0 is the continuous digitization of production processes through which the shop floor connects to the office floor.

The Fraunhofer Institute for Experimental Software Engineering (IESE), in partnership with more than a dozen industry leaders in manufacturing, research, and IT, has developed BaSys 4.0, an open-source reference architecture for Industry 4.0.

BaSys 4.0 enables organizations of any size to participate in digitalization by using automation to improve production, processes, and negotiations.
BaSys 4.0 enables a seamless, continuous pipeline across the shop floor and the IT world, enabling real-time visibility into order status, quality control, and delivery.

Learn more.

Fraunhofer IIS

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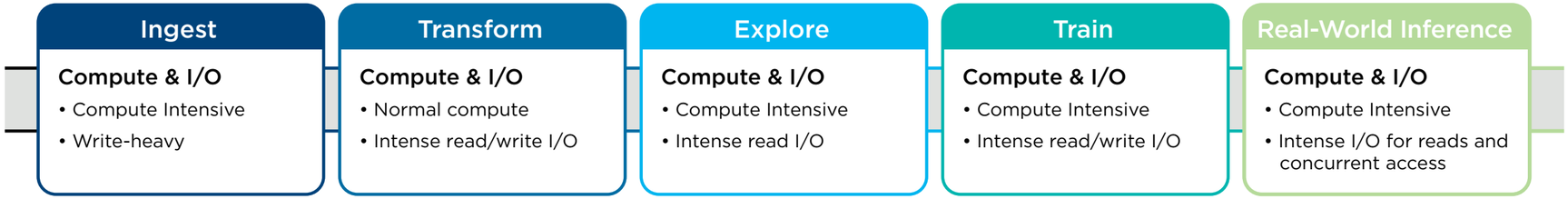
Becoming AI Ready

Successful deployments of AI in the automotive industry create new workflows that link together business units that were traditionally isolated—from HPC, analytics, and core IT to workflows at the edge and in the cloud. These business units often have their own specialized platforms, protocols, and architectures that now must participate together to train, validate, and operationalize an AI algorithm.

To become AI ready, you can no longer afford to invest in solutions that keep data locked in insolation. Your data must be able to move seamlessly and securely across a hybrid cloud environment. As you progress in your journey to AI, you need future-proof solutions that can carry you from analytics and HPC through to ML, DL, and prescriptive analytics.



- Data creation often occurs at the edge of your network; intelligent point-of-sale devices are one example. IoT-connected devices and sensors are becoming increasingly important across all industries.
- Preprocessing is necessary to normalize your data before training can occur. Preprocessing takes place in a data lake, possibly an Amazon S3 object store in the cloud or a file store on premises.
- During the explore stage, you figure out which deep learning models are most promising based on your datasets and the outcome that you want.
- Data must be moved into the training cluster periodically to train inference models. Training is an iterative process that typically takes place at regular intervals throughout the life of a model.
- After an inference model has been trained and tested, it is deployed in the real world. Models are often stored in a DevOps-style repository where they benefit from ultralow-latency read access.

Figure 1) A well-designed data pipeline enables data to flow freely through multiple AI stages, meeting the unique I/O requirements of each stage and preventing bottlenecks.

Accelerate Your Journey to AI

NetApp offers a future-proof platform for your AI journey from analytics and HPC to autonomous decisions. That means you can optimize your IT investments, pay only for what you need when you need it, and enable a single, unified experience across hybrid, multicloud environments.

Unlock the potential of data science wherever you are on your journey to AI with solutions that are:

- Smart. Get up and running fast with simplified integration, automation, and orchestration of data in clouds and on the premises. Leverage smart features such as intelligent data movers, auto data tiering and provisioning, and predictive analytics.
- Powerful. Confidently tap into growing data sources with virtually unlimited, nondisruptive scalability and performance to feed, train, and operate data-hungry ML and DL applications.
- Trusted. Enable trusted data protection, compliance, and secure access. Integrate, protect, and secure your data pipeline from edge to core to cloud.

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Accelerate Your Journey to AI

The following table summarizes the key components of a data fabric.

Edge Solutions	Core Data Center Solutions	Cloud Solutions
NetApp ONTAP® Select gives you the power of ONTAP software on your choice of commodity servers, hypervisors, and media. Available in ruggedized configurations, it can support the harshest environments.	NetApp AFF A800 all-flash storage systems deliver ultralow latency of less than 200 microseconds and massive throughput of up to 300GBps. The NetApp ONTAP AI proven architecture, powered by NVIDIA DGX supercomputers and NetApp cloud-connected storage, meets the most demanding AI training needs. FlexPod® AI is based on an industry-leading converged infrastructure, powered by NetApp AFF cloud-connected storage, Cisco Nexus switches and Cisco UCS ML M5 purpose-built, AI/ML servers. FlexPod AI provides a versatile, UCS-based platform for AI/ML innovation that is trusted worldwide.	NetApp's cloud data services deliver instant productivity. Bring NetApp's superior data management and NFS capabilities to Azure with Azure NetAppFiles, to Amazon Web Services with Cloud Volumes Service for AWS and to Google Cloud with Cloud Volumes Service for Google. The NetApp AI Control Plane provides full-stack data and experiment management across the hybrid cloud.

Table 1) Key solution examples for the data pipeline.

NetApp and NVIDIA

NetApp's deep partnership with NVIDIA, the leader in AI compute, is designed to help you accelerate your journey to AI. NetApp® ONTAP® AI brings together NVIDIA DGX® supercomputers, NetApp cloud-connected all-flash storage, and Cisco Nexus switches.

At the heart of ONTAP AI is the NVIDIA DGX-1™, the world's first integrated AI system purpose-built for enterprise. The DGX-1 delivers over 1 petaFLOPS of AI performance, powered by the DGX software stack with optimized deep learning, machine learning, and HPC software from NGC. The system delivers revolutionary performance and a plug-in, power-up deployment experience for the fastest path to AI-powered insights and effortless productivity for data science teams.

NetApp AFF systems keep data flowing to DL processes with the industry's fastest and most flexible all-flash storage. The AFF A800 is capable of feeding data to NVIDIA DGX-1 systems up to 9 times faster than competing solutions.

The ONTAP AI proven architecture simplifies, integrates, and accelerates your data pipeline for ML and DL, so you can reduce overall costs while accelerating AI innovation and productivity.

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Find Out More

To learn more about the entire NetApp AI solutions portfolio, including ONTAP AI, visit NetApp.com/AI.

Endnotes

[1] https://blog.netapp.com/artificial-intelligence-in-the-automotive-industry/

[2] https://www.tesla.com/autopilot

[3] https://www.forbes.com/sites/bernardmarr/2018/01/08/the-amazing-ways-tesla-is-using-artificial-intelligence-and-big-data/#cfd8dc342704

[4] https://www.digitaltrends.com/cars/alllegro-ai-helps-hyundai-leverage-the-power-of-artificial-intelligence/

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[14] https://www.webwire.com/ViewPressRel.asp?aId=230472

[15] https://www.webwire.com/ViewPressRel.asp?aId=230472

Refer to the Interoperability Matrix Tool (IMT) on the NetApp Support site to validate that the exact product and feature versions described in this document are supported for your specific environment. The NetApp IMT defines the product components and versions that can be used to construct configurations that are supported by NetApp. Specific results depend on each customer's installation in accordance with published specifications.