Automotive

Abstract The automotive industry is an extremely competitive market due to progressive technological advances and product development: all essential for long-term growth and brand recognition.

The automotive industry is an extremely competitive market due to progressive technological advances and product development: all essential for long-term growth and brand recognition.

Research and development are core elements in the industry's value-added chain, enabling it to remain competitive in the marketplace and continue to offer a diversified product range and allow it to create millions of employment opportunities globally.

The main criteria that differentiate car brands are quality, design, technology, andperformance. However, there are many barriers to competing in this field given that it is a capital-intensive industry and, as such, tends to have elevated levels of operating leverage, needing extremely high-tech machinery, equipment, and high liquidity to operate (Pratap 2018).

Currently, the automotive industry is facing several challenges forcing manufacturers to adjust business models to meet market demands. These include, but are not limited to, environmental trends where customers are becoming more aware of their carbon footprints and so favoring ecologically friendly, more energy-efficient models. This has made many businesses feel the pressure of having to produce and develop electric vehicles which produce 50% less carbon dioxide emissions than their gas-powered.

competitors. Electric cars must now be offered to capture market opportunities and satisfy market needs.

Electric cars have slight differences in their selling and distribution chains as they require complementary products and services to be offered, such as the temporary battery chargers needed to complete a specific range of kilometers. These cars also need different charging stations, which, unlike gas stations, are not readily available everywhere (Burns 2020).

Technology is one of the leading challenges for manufacturers as continuous modifications in production assembly are essential while remaining practically rewarding, as prices increase in direct proportion to any updates being offered, e.g., the fully automated and self-drive vehicles available in today's marketplace. Technology also heavily impacts production lines, with manufacturers moving toward more modern, smart factories where robots provide a more efficient assembly and better-quality assurance (Automotive Alliance).

The current COVID-19 pandemic has resulted in automotive companies realizing the weakness in having a globalized supply chain. Industries are now beginning to develop more regionalized supply chains to support them in adopting and recovering more rapidly from any potential future disasters (Piparsania 2020).

Value Chain

| Design & Development | Parts Procurement | Assembly | Product and Service Development | Distribution, Sales, and Marketing |

The automotive industry's value chain can be divided into five main phases: design and development, parts procurement, assembly, product and service development, and distribution, sales, and marketing.

The first phase of the value chain is comprised of researchers, automakers, and other players that are involved in research and development to design vehicles and modify their specifications.

The second phase of the value chain, parts procurement, includes activities that provide manufacturers with access to parts required for production. Relevant activities include the identification, selection, negotiation, and purchasing of the parts. These parts are then assembled by the manufacturers to produce functional products.

The product and service development phase is involved with increasing vehicle values by providing customer service, repairs, upgrade options, etc.

The last phase, distribution, sales, and marketing, then delivers the goods and services to their final consumer.

Case Studies

Case Study 1 **TOYOTA**

Self-Driving Vehicles

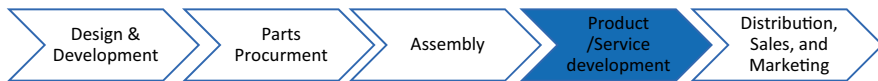- Country of implementation: Japan
- Company: Toyota Motor Corporation

Toyota is an automotive company, founded in 1937; it produces and designs vehicles and sells them to more than 170 counties. It manufactures diverse types of vehicles, such as sports vehicles, commercial vehicles, etc. It is the second-biggest automaker in the world.

Technology	Automation/fully autonomous vehicles
Description	Toyota's fully automated vehicles are called "e-Palettes" cars and are self-driving transparent boxes roaming around cities for delivering people, packages, and pizza. They are described as battery-electric vehicles that can be designed and customized to offer new features in mobile business services. The vehicle varies in size depending on its desired function (Hawkins 2018)
Stage	Testing
Beneficiaries	Businesses

Beneficiaries	Businesses	• Pop-up stores • Unique consumer experiences • Doorstep services, e.g., delivery
	Health care	• Extended neighborhood reach • Quarantine facilities

Case Study 2 ReachNow

Car Sharing

- Country of implementation: USA
- Company: Reach Now

Reach Now is a company that produces mobility services allowing people to easily reach their loved ones. It was founded in 2016 and was later acquired by BMW.

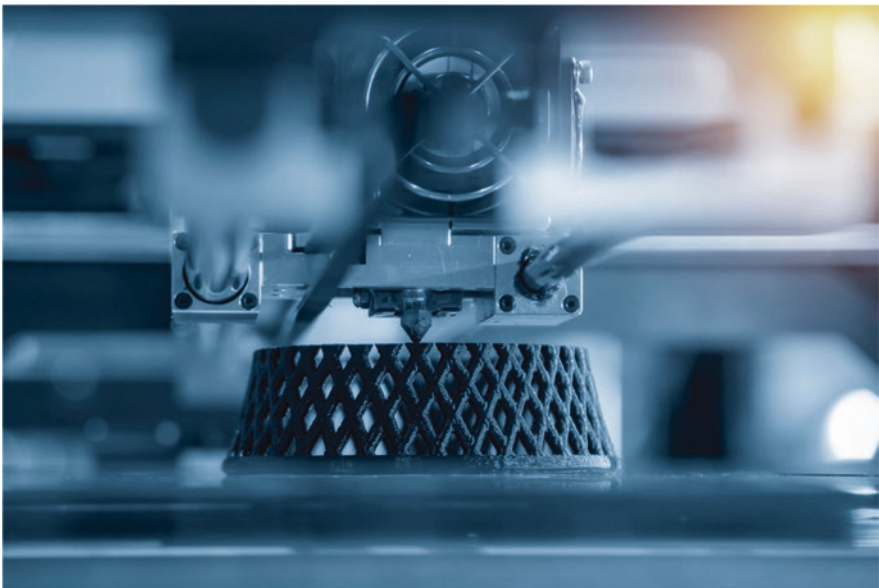| Technology	Platforms/mobility	
Description	It is a mobile app offering car sharing services allowing users to either drive or hail rides to required destinations, with many offering features that enrich the sharing experience. It allows users to rent cars, or to rent out their cars, to earn a return on their investment. Unlike other platforms, BMW offers a fleet of Mini Cooper and BMW cars with the possibility of renting it for several days (Automotive UX 2016)	
Stage	In market	
Beneficiaries	Customers	• Easy car rental • Multi-preference application • Convenient payment methods
	Car owners	• Additional income potential

Case Study 3 Betatype.

3D Printing for Automotive Applications

| Design & Development | Parts Procurment | Assembly | Product /Service development | Distribution, Sales, and Marketing |

- Countries of implementation: Europe
- Company: Beta type

Beta type is a 3D printing company that offers automakers functional, 3D-printed components through their data processing platform that enables 3D printing with control over material, shape, and structure (Beta type).

Technology	3D printing/car components, 3D scanning, laser powder bed fusion
Description	The beta type can reduce parts cost production, from $40 per part to only $4, and decrease lead times from 444 hours to only 34 Beta type uses additive manufacturing to produce greater design freedom with minimal material by using laser powder bed fusion to produce and stack multiple parts on top of each other while reducing thermal stress and manufacturing time
Stage	In market

Beneficiaries	Automakers	• Significantly reduces waste • Cost-effective • Reduced manufacturing time • Increased efficiency • Reduced inventory stocking • Environmentally friendly

Case Study 4

BMW Connected Drive Application

Design & Development → Parts Procurment → Assembly → Product /Service development → Distribution, Sales, and Marketing

- Country of implementation: Germany
- Company: BMW

BMW (Bayerische Motoren Werke) is one of the top car manufacturers in the world and was founded in 1916. It a is German manufacturer with more than 100 years' experience in producing automobiles and motorcycles. Among other competitors, BMW is well-known for investing heavily in car technology and they are leaders in automotive infotainment systems.

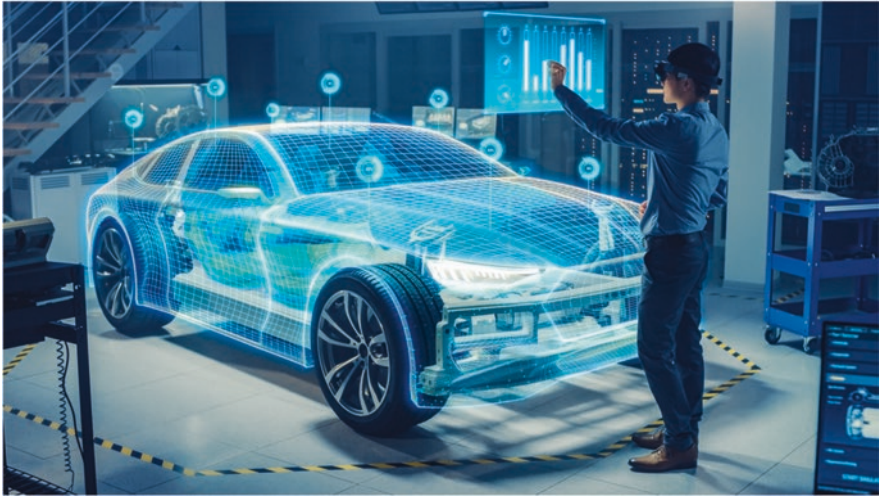| Technology	Internet of things (IoT)/remote car monitoring and controlling	
Description	The BMW ConnectedDrive application is a mobile app that connects drivers to BMW cars remotely, monitoring and controlling many functions including fuel and fluid levels, GPS location, mileage, battery voltage, and emergency and when breakdown assistance may be needed. Using this application, users can estimate real-time arrival times, have remote access to essential functions of their BMW, send arrival information to friends and family, and have access to door-to-door navigation, including guiding users from their parking spots to their final destination	
Stage	In market	
Beneficiaries	Customers	• Interactive and engaging digital applications • New, embedded technologies • Accessible channels for more convenience and connectivity

Case Study 5 Microsoft

Augmented Reality (AR) HoloLens
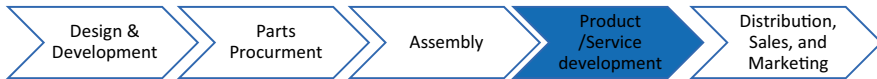
- Countries of implementation: Sweden and Japan
- Company: Microsoft Corporation

Microsoft Corporation is a software company that offers, designs, and develops software products and services. It was founded by Bill Gates and Paul Allen in 1975. The company also provides gaming hardware segments including Xbox gaming and other entertainment accessories.
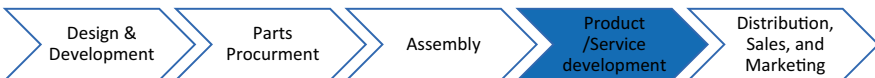
Technology	Augmented reality (AR)/AR glasses	
Description	Microsoft HoloLens, known as Project Baraboo, is a pair of mixed reality smart glasses developed and manufactured by Microsoft. HoloLens was the first head-mounted display running the Windows Mixed Reality platform under the Windows 10 computer operating system. HoloLens is integrated with many car assembly factories for more efficiency via visual digitalization. It enables production line workers to digitally view assembly instructions in real time. The HoloLens headset is used by manufacturers to support the design of cars, trucks, and SUVs without first having to build a prototype (Warren 2017)	
Stage	In market	
Beneficiaries	Manufacturers	• Increased efficiency • Increased consistency of production • High build quality • Increased detailing • Eliminated need for prebuilding

Case Study 6 ParkMobile

Self-Park and Pay

Design & Development	Parts Procurment	Assembly	Product /Service development	Distribution, Sales, and Marketing

- Country of implementation: USA
- Company: ParkMobile, LLC

ParkMobile is the leading company in creating innovative ways to enhance smart parking and provide mobility solutions; it was founded in 2008.
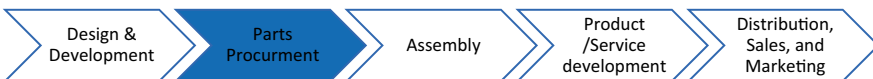

Technology	Big data/navigation and autonomous services
Description	ParkMobile is an app, connected to a platform, that helps navigate streets and finds parking slots with no interaction from drivers. Through ParkMobile, cars navigate and autonomously find parking slots and self-pay
Stage	In market
Beneficiaries	Customers

Beneficiaries	Customers	• Customer convenience • Mobile payment service • Virtual modification of set parking periods

Case Study 7

Transparency in Supply Chain

Design & Development	Parts Procurement	Assembly	Product /Service development	Distribution, Sales, and Marketing

- Country of implementation: Japan
- Company: Marelli Corporation

Marelli is an automotive company that supplies and designs different products, including thermal systems, electronic products, and exhaust systems. It was founded in 2019 by Calsonic Kansei and Magneti Marelli.

Technology	Blockchain/cloud technology	
Description	Automotive supply chains are overly complex with many different industries involved, depending on the needs of the parts and the availability of raw materials, making it exceedingly difficult to be able to track the component's origin route. PartChain is a combination of blockchain and cloud technology which creates transparency in the supply chain, enabling the traceability of all components. Blockchain technology creates a peer-to-peer network, connecting suppliers and carmakers around the world. Using blockchain technology, companies like BMW know the logistics of raw materials or parts (Marelli)	
Stage	Recent to market	
Beneficiaries	Manufacturing companies	• Efficient management • Tracing of supply chain processes • Purchasing transparency

Case Study 8 **automotive**Mastermind

Behavioral Analytics and Marketing Automation: Market EyeQ

| Design & Development | Parts Procurment | Assembly | Product /Service development | Distribution, Sales, and Marketing |

- Country of implementation: USA
- Company: Automotive Mastermind

Automotive Mastermind was founded in 2012 and is considered to be a leading provider of predictive analytics and marketing automation technology.
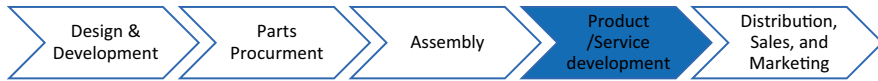
Technology	Big data and advanced analytics/platforms
Description	Automotive Mastermind® technology captures data gathered from car dealers and merges them with big data. Gathered data includes information about customers, products, sociodemographics, specific customer targeting, and personalized marketing campaigns. The company's cloud-based platform helps dealers make precise predictions on automobile buying trends and automates the creation of microtargeted consumer communications, leading to proven higher sales and more consistent customer retention. Automotive Mastermind® currently works with more than 800 dealer partners, providing access to their technology to more than 6000 dealerships nationwide (Hunt 2019)
Stage	In market

Beneficiaries	Automotive manufacturers	• Increased sales • Improved customer retention • Bespoke products • Full market profile available
	Consumers	• Increased satisfaction • Enhanced customer experience

Case Study 9 Google

Self-Driving Pod Waymo

- Country of implementation: USA
- Company: Google

Google is a multinational company that produces and designs internet-related services and products. It was founded in 1998 by Larry Page, Sergey Brin, and Wesley Chan. Google's product portfolio includes Google Search, Knowledge Graph, Google Now, Product Listing Ads, AdSense, Google Display, and DoubleClick Ad Exchange and YouTube.
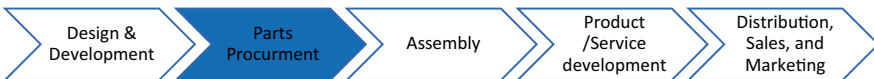
Technology	Automation/fully autonomous vehicles
Description	Google has been working on self-driving technology since 2009 and currently has over ten million miles of stored data. Waymo can recognize many road features through sensors and software embedded in the system which are constantly scanning for objects or obstacles around the vehicle. In October 2019, Waymo started to invite members of its early rider program to take driverless rides with no humanoid operator behind the wheels (Waymo)
Stage	Testing
Beneficiaries	Users

	• Reduced human risk error factors • Increased potential safety • A new era in mobility consumer reassurance

Case Study 10 COOPERTIRES

Guayule Plant-Based Rubber for Tire

Design & Development	→	**Parts Procurment**	→	Assembly	→	Product /Service development	→	Distribution, Sales, and Marketing

- Countries of implementation: USA and Mexico
- Company: Cooper Tire & Rubber Company

Cooper Tire & Rubber Company is considered one of the leading competitors in the tire industry around the globe. It was founded in 1914, and it aims to produce and design high-quality tires that enhance its performance and can endure for thousands of miles.
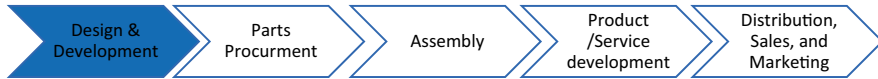

Technology	Green technology/biotechnology	
Description	Cooper Tire & Rubber Company has currently introduced a tire design made from a shrub plant called guayule, found in Mexico and the USA, to put an end to the production and use of synthetic rubber in automobiles. This eco-friendly product, which is made of bio-rubber replacing synthetic rubber, was tested on different roads and tracks and found to have no difference in performances in comparison to traditional tires (Hevea) and bio-rubber tires (Sustainable Brands 2015)	
Stage	Recent to market	
Beneficiaries	Automotive industry	• Environmentally friendly • Cost-effective • Innovative product line
	Environment	• Environmentally friendly

Case Study 11 TESLA

The Giga Factory

| Design & Development | Parts Procurment | Assembly | Product /Service development | Distribution, Sales, and Marketing |

- Country of implementation: USA
- Company: Tesla

Tesla is an automotive company founded in 2003. It aims to increase the use of sustainable energy by increasing the production of affordable electric vehicles and renewable energy production and storage. Tesla ensures reliability, performance, and safety in its vehicles.
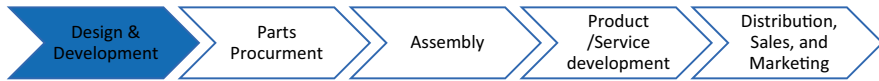
Technology	Green technology/solar energy
Description	Giga Factory is housed on 1.9 million square feet, with 5.3 million square feet of that given to operational space across several floors. It is being constructed in various stages to allow tesla to begin production at once while continuing the expansion of its premises. The factory is expected to be the biggest building in the world and designed to have net-zero energy, being powered primarily by renewable energy sources (tesla)
Stage	Recent to market (partially working and in development for further expansion)

Beneficiaries	Environment	• Cost-effective • Better public accessibility • Eco-friendly • Reduced waste

Case Study 12

Avatar Concept Car

Design & Development → Parts Procurment → Assembly → Product /Service development → Distribution, Sales, and Marketing

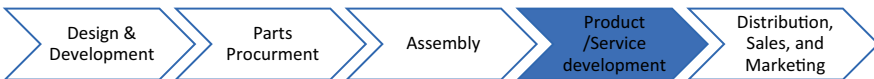- Country of implementation: Germany
- Company: Mercedes-Benz

Mercedes-Benz is one of the largest sellers of premium vehicles in the world. It was founded in 1926 by Karl Benz, Gottlieb Daimler, Wilhelm Maybach, and Emil Jellinek and aims to produce luxury vehicles that provide customers with comfort and safety.

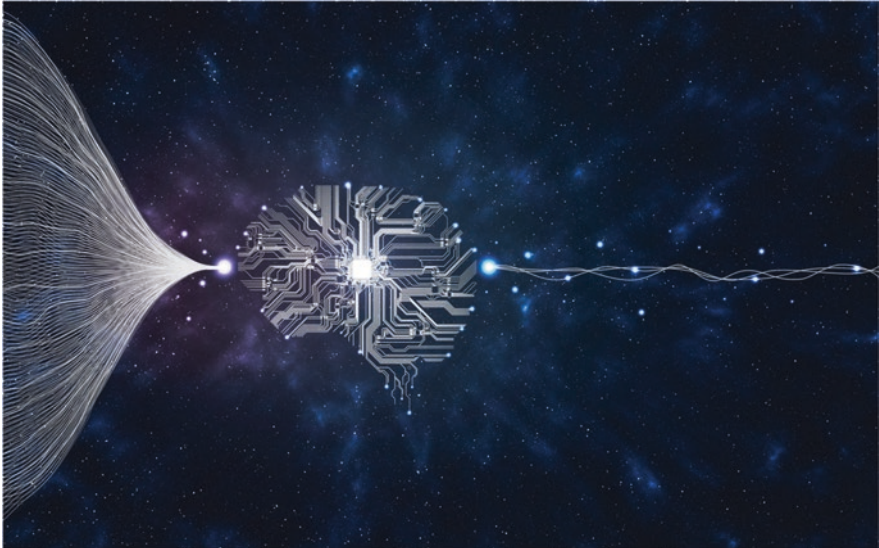| Technology	Biometrics/green technology	
Description	The vehicle forms a biometric connection with drivers. The conventional steering wheel is replaced with a control unit embedded in the central console which monitors drivers based on their heartbeat and breathing upon contact. The vehicle is also eco-friendly, aligned with avatar themes and the cars' battery is made with composite materials and fully recyclable, so aligns with global efforts to reduce reliance on fossil fuels (Mercedes Benz 2020)	
Stage	Idea stage	
Beneficiaries	Customers	• Improving and personalizing the customer experience through biometrics • Can identify the driver based on heartbeat and breathing, therefore, reduces chances of stealing • Environmentally friendly
	Environment	• Aligned with global efforts to reduce reliance on fossil fuels

Case Study 13 **SIEMENS**

MindSphere

Design & Development ▷ Parts Procurment ▷ Assembly ▷ **Product /Service development** ▷ Distribution, Sales, and Marketing

- Country of implementation: Germany
- Company: Siemens

Siemens is an electronics engineering company, founded by Johann Halske and Werner Siemens in 1847. It specializes in various sectors, including health care, energy, and industrial. Siemens provides innovative IT services and solutions, insurance solutions, financial products, and others.

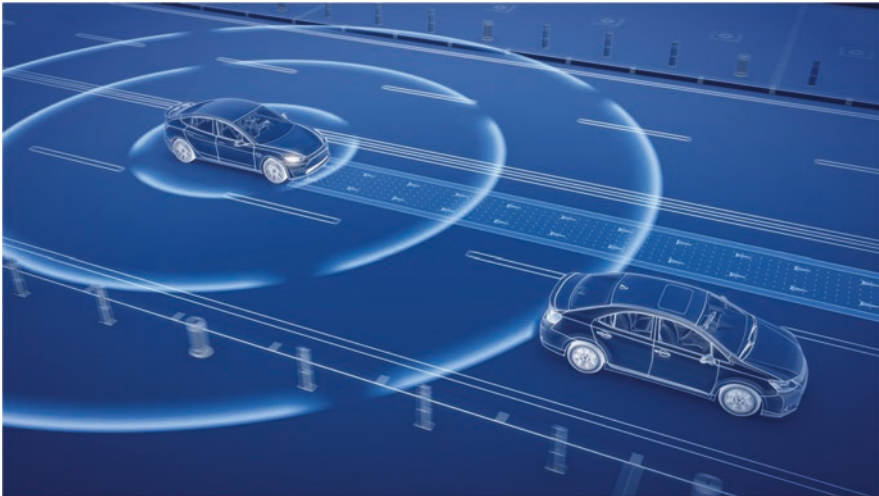| Technology	Internet of things (IoT)/artificial intelligence, data analytics, and sensors	
Description	MindSphere is a cloud-based operating system that allows other technologies or machines to collect data. This will help manufacturers observe the industrial assets using machine learning technology. MindSphere can connect all your machines, technologies, and systems which enables users to use the valuables of the data using advanced analytics. Sensors are also being used to collect information from different machines and then download them onto the industry's database in the cloud operating system. This collected information is then uploaded to the machine learning algorithm of the system to see these analytics and upload them onto a dashboard. Moreover, MindSphere can detect problems in the machines that are underperforming and define them. It then informs the maintenance operators about the type of problem exactly and recommends they either try to fix it or completely shut it down. MindSphere is also able to connect various applications (Jesus 2018)	
Stage	In market	
Beneficiaries	Industries	• Monitored data in real time • Prediction of performance challenges • Improves efficiency and profitability • Connected applications to increase data significance

Case Study 14 **MITSUBISHI ELECTRIC**

Robust Sensing for Autonomous Driving

Design & Development	Parts Procurment	Assembly	Product /Service development	Distribution, Sales, and Marketing

- Countries of implementation: Japan
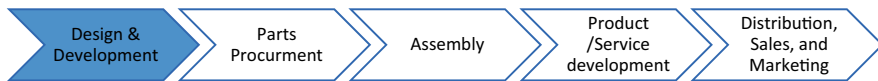- Company: Mitsubishi Electric Corporation

Mitsubishi Electric Corporation is a company that designs, develops, and sells electrical machines that can be used in different systems; it was founded in 1921. It designs equipment for different sectors including energy and electric systems, communication systems, industrial automation, and others (Crunchbase).

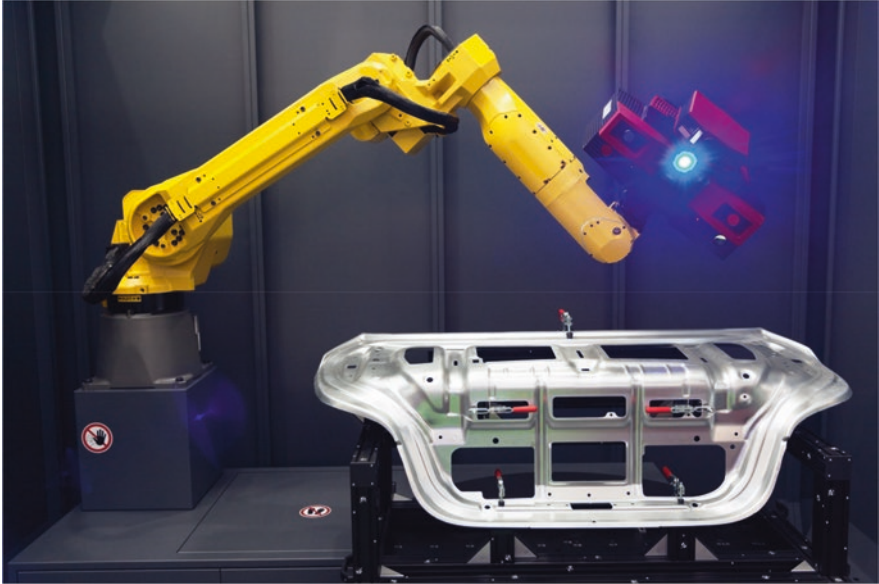| Technology	Automation/artificial intelligence	
Description	Mitsubishi Electric developed a sensing technology for the detection of the car's perimeters even in the presence of fog or rain, such as the positions, velocities, and sizes of any obstacles or vehicles surrounding it. This will enable the vehicle to be able to drive autonomously even in rough weather. This newly developed system can collect data from various sensors including time series data which collects information on the width, orientation, distance, velocity, etc. of the surrounding vehicles from sensors in real time. The technology is designed also using autonomous emergency braking (AEB) to test the performance of the vehicles in bad weather. Autonomous emergency braking (AEB) can safely perform emergency braking even if the sensors are not able to perform well. The LiDar embedded in this system can detect and monitor the surrounding environment using pulse laser signals. The millimeter-wave radar can detect velocities and distances of surrounding vehicles, and the camera can recognize the obstacles' sizes (Mitsubishi electric)	
Stage	Testing	
Beneficiaries	Customers	• High accurate detection is achieved in rough weather • Decrease the number of accidents in rain and fog conditions • High performance of autonomous braking system • The technology can detect the weather of the surrounding environment using LiDar • High accuracy detection of velocity, distance, sizes, etc.

Case Study 15

FreeMove

Design & Development → Parts Procurment → Assembly → Product /Service development → Distribution, Sales, and Marketing

- Country of implementation: USA
- Company: Veo Robotics

Veo Robotics is a company that develops innovative solutions to improve the performance of collaborative robotics. It was founded by Clara Vu, Patrick Sobalvarro, and Scott Denenberg in 2016. It designs products that use computer vision, artificial intelligence, and 3D sensing.

Technology	Artificial intelligence/3D sensing and computer vision	
Description	FreeMove is a technology-designed system that can combine the strengths and precision of industrial robots while at the same time using the creativeness of humans; it allows both humans and robots to work in the same environment or workplace while at the same time ensuring safety. Veo FreeMove consists of three systems: FreeMove sensors, FreeMove engine, and FreeMove studio. The FreeMove sensors consist of 3D sensors that are located on the work cell of the machine. The FreeMove engine is a high-performance computing system that processes and reads data collected from the sensors and ensures that there is a safe separation distance kept between the robot and humans. Hence the FreeMove engine monitors the distance that can be traveled by the robot to bring it to a safe stop. The FreeMove studio is a software system used for real-time visualization of the FreeMove sensors and FreeMove engine. The FreeMove systems can position all objects in their environment by calculating the separation distance then signaling the robots to either completely stop or slow down for the human's safety (Veo robotics)	
Stage	Testing	
Beneficiaries	Industries and factories	• Able to combine both worker and robots in the same place with no health or safety risks • Increases productivity • Enhancing workers' efficiency • Reducing capital and operating expenses • Reduced downtime • Greater manufacturing flexibility
	Workers	• Increases the safety of workers • Enhancing their skills

Case Study 16 NHTSA

Vehicle-to-Vehicle Communication

- Country of implementation: USA
- Company: National Highway Traffic Safety Administration (NHTSA)

NHTSA is founded by the Highway Safety Act in 1970; its goal is to try to find ways that can reduce crashes and accidents which in turn reduces the attendant costs. It tries to find ways to enhance safety and produce high standards in motor vehicles (Crunchbase).

Technology	Artificial intelligence/sensors
Description	Vehicle-to-vehicle communication allows vehicles to wireless communication with each other by exchanging data about their speed, direction, location, and movements. The technology slows vehicles to send and receive omnidirectional messages ten times per second which creates a 360-degree information about all surrounding vehicles. The vehicles can use this information to determine crash threats and hence this technology produces visual and audible alerts to warn drivers about any threats or obstacles. The information that is sent has a range of more than 300 m and can detect any danger, such as traffic or changes in the weather. This technology also has cameras and radars to monitor or detect any collision threats. This technology can be used by cars, trucks, buses, and motorcycles (NHTSA)
Stage	Testing

Beneficiaries	Users	• Increase the safety of drivers • Decrease crashes or any safety risks • Enhances the performance of vehicle's safety systems • Avoid traffic jams • Maintain a safe distance from other cars • Provides direction and route optimization • Assists by giving simple warnings

Case Study 17 Progress

Predictive Analytics Software: DataRPM

- Country of implementation: USA
- Company: Progress

Progress is a computer software company that was founded in 1981. It is the leading company in developing and designing strategic business applications. It aims to deliver high-quality digital experiences while minimizing the time and cost of partners and customers. It specializes in machine learning, application development, data connectivity, and others (LinkedIn).
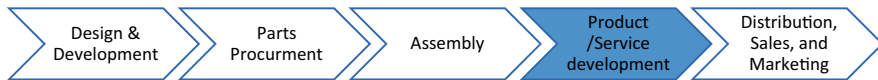
Technology	Artificial intelligence/machine learning	
Description	DataRPM is considered to be a cognitive intelligent software or in other words an anomaly detection and prediction software that can use the data coming from the industrial internet to enable industries to improve product output and quality. Industries can use this software to identify external factors that could affect the production of manufacturing engines. Moreover, using DataRPM manufacturers can spot engine failures weeks before it occurs due to machine learning vision. The software collects past data, current data, and any external factor's data so that it can establish a minimum starting point for comparison to measure the performance of the engines on an ongoing basis. Also, this technology helps automotive manufacturers in collecting and analyzing all data and generate possible recommendations to increase and enhance efficiency (Progress)	
Stage	In market	
Beneficiaries	Automotive industries	• Suggests possible recommendations in increasing efficiency and productivity • Predicts automated failures which reduce malfunctions, maintenance costs, and breakdowns • Optimize inventories • Improvement in delivery time • Optimizes resources

GM

Case Study 18

Robo-Glove

Design & Development	Parts Procurment	Assembly	Product /Service development	Distribution, Sales, and Marketing

- Country of implementation: USA
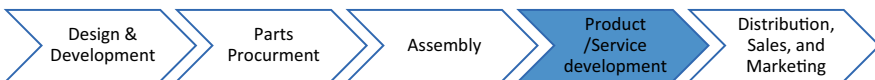- Company: General Motors

General Motors is an automotive company that has the goal of producing or designing technology to produce a safer and more sustainable environment. Moreover, its goal is to create a world with zero emissions (LinkedIn).

Technology	Artificial intelligence/robotics technology and sensors
Description	Robo-Glove allows humans to easily grasp heavy objects or any tools to reduce fatigue in hand muscles. It is designed using actuators that are embedded in the upper part of the glove to give support to the human fingers. It also has pressure sensors that are embedded in the fingertips of the Robo-Glove so that it can detect when the person is holding a tool. When the user is holding a tool, the synthetic tendons in the glove withdraw which pulls the fingers into a gripping position until the pressure sensor is released. The actuators and tendons embedded in the glove are used to mimic the muscles of the human hand. The Robo-Glove is powered by a lithium-ion power tool battery and a belt clip. This glove is a very lightweight technology that fits perfectly on the hand. It is also designed for multiple hands and arm sizes (Vincent 2016)
Stage	In market
Beneficiaries	Automotive repair workers

Beneficiaries (continued):
- Reduces muscle strain from doing repetitive tasks or carrying heavy objects
- Lightweight technology; therefore, the user barely feels it
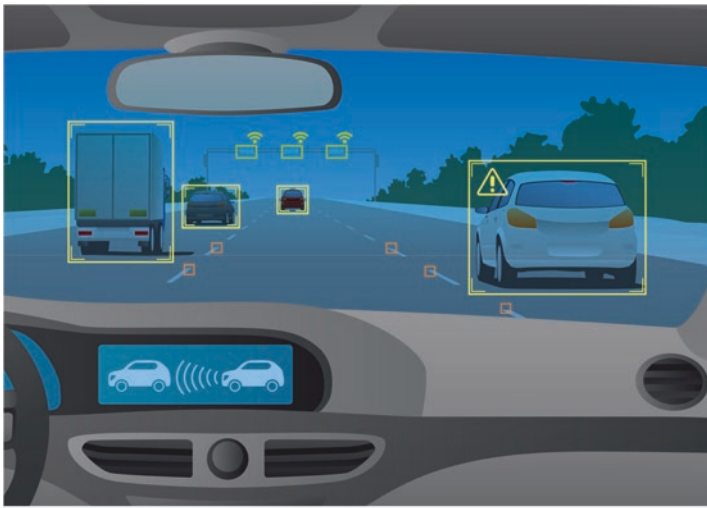- Increases productivity in demanding applications

Case Study 19 nauto

Predictive Collision Reacts

| Design & Development | Parts Procurment | Assembly | Product /Service development | Distribution, Sales, and Marketing |

- Country of implementation: USA
- Company: Nauto

Nauto is a computer software company that specializes in artificial intelligence to produce products or devices to predict and decrease high-risk events in the mobility ecosystem.

Technology	Artificial intelligence/biometrics and data analytics	
Description	Nauto developed a device that will be able to collect and analyze real-time data and alert the driver of any possible collisions. Predictive collision alerts reduce collision that can be caused by other vehicles, cyclists, changing lights, pedestrians, and others. It collects data about braking, speed, and movements of other vehicles from all angles. This technology is continuously scanning and analyzing the facial expressions and movements of the driver so that it can detect unsafe driver behavior. It gives alerts that are twice as loud to distracted drivers. There are three driver alerts: Mild, medium, and severe depending on how much the driver is distracted. If a vehicle is driving at 60 mph, the device gives alerts at 100 ft. This device keeps drivers attentive to reduce collisions and traffic violations (Nauto)	
Stage	In market	
Beneficiaries	Users	• Reduction in accidents and collisions • Increases the alerts depending on how much distracted the driver is • Reduce maintenance costs • Increase safety • Reduce traffic violations and their costs