

AUTOALCHEMY

VOL- 5

MAKING A DIFFERENCE

Holy Grace
Polytechnic College

Autolegion
AUTOMOBILE DEPARTMENT ASSOCIATION

DEPARTMENT OF AUTOMOBILE ENGINEERING

AUTOMOBILE TECHNICAL MAGAZINE

2025-2026

AUTO ALCHEMY

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Auto Alchemy is the technical magazine of the Department of Automobile Engineering, bringing classroom knowledge, emerging automotive technology, student creativity and professional curiosity together in one publication.

ENGINEERING THE NEXT GENERATION OF MOBILITY

From electrification and intelligent safety to connected vehicles, lightweight structures and smart manufacturing.

01
Electrification and energy management

02
Intelligent sensing and driver assistance

03
Vehicle connectivity and cybersecurity

04
Crash safety and lightweight engineering

05
Software-defined vehicles

06
Future-ready manufacturing

EDITOR'S NOTE

“Themodern automobileisanintegratedsystem of energy storage, electronics, software, communication, materials and

Automobile engineering is changing faster than ever. The transformation creates a wider learning space for students and demands curiosity across disciplines.

This fifth volume of Auto Alchemy brings together twelve student-written technical features. Each article focuses on a technology that connects engineering fundamentals with current vehicle development.

The intention is not simply to describe a technology, but to encourage students to ask how it works, why it is needed, what engineering trade-offs it creates and where it may lead next.

FROM THE EDITORIAL TEAM

We thank the student contributors, editorial team and faculty members who supported this edition. The magazine is intended as a learning platform where ideas can be shared, questioned and improved.

EDITORIAL TEAM

00
ALBERT JOSEPH T
Register No. 2301051572

01
RICHU V R
Register No. 2301050935

02
BHARATH KRISHNA K U
Register No. 2301051574

03
HRIJUKARAN M V
Register No. 2301051575

04
PRAVEEN P S
Register No. 2301051578

ARTICLE CONTRIBUTORS

01
ABHINAV BABU
Register No. 2301050915

02
ADHITH K VINOD
Register No. 2301050916

03
BHARATH K P
Register No. 2301050921

04
DELVIN DAVIS
Register No. 2301050922

05
JUDSON SAJI
Register No. 2301050928

06
MANAS KRISHNA M P
Register No. 2301050930

Student contributors bring the technical features of this volume from classroom concepts to contemporary automotive applications.

ARTICLE CONTRIBUTORS

07
ROSHAN SHAJU
Register No. 2301050936

08
SAYOOJ T S
Register No. 2301050940

09
SIJO SUNNY
Register No. 2301050941

10
YADHU KRISHNAN V S
Register No. 2301050943

11
ABHINAND C V
Register No. 2301051570

12
NIHAL P A
Register No. 2301051577

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DEPARTMENT OF AUTOMOBILE ENGINEERING

VISION

To generate value for students and other stakeholders in Automobile Engineering by consistently working towards the overall development of students, attaining an all-round in academic excellence, and promoting professional skills, social responsibilities and co-curricular activities.

M1

To ensure significant engagement in automobile engineering by imparting contemporary knowledge to students.

M2

To develop industry ready students by knowing the present needs of Automotive sector.

M3

Promote social responsibility and cultivate entrepreneurial skills within the automobile industry.

PROGRAMME EDUCATIONAL OBJECTIVES

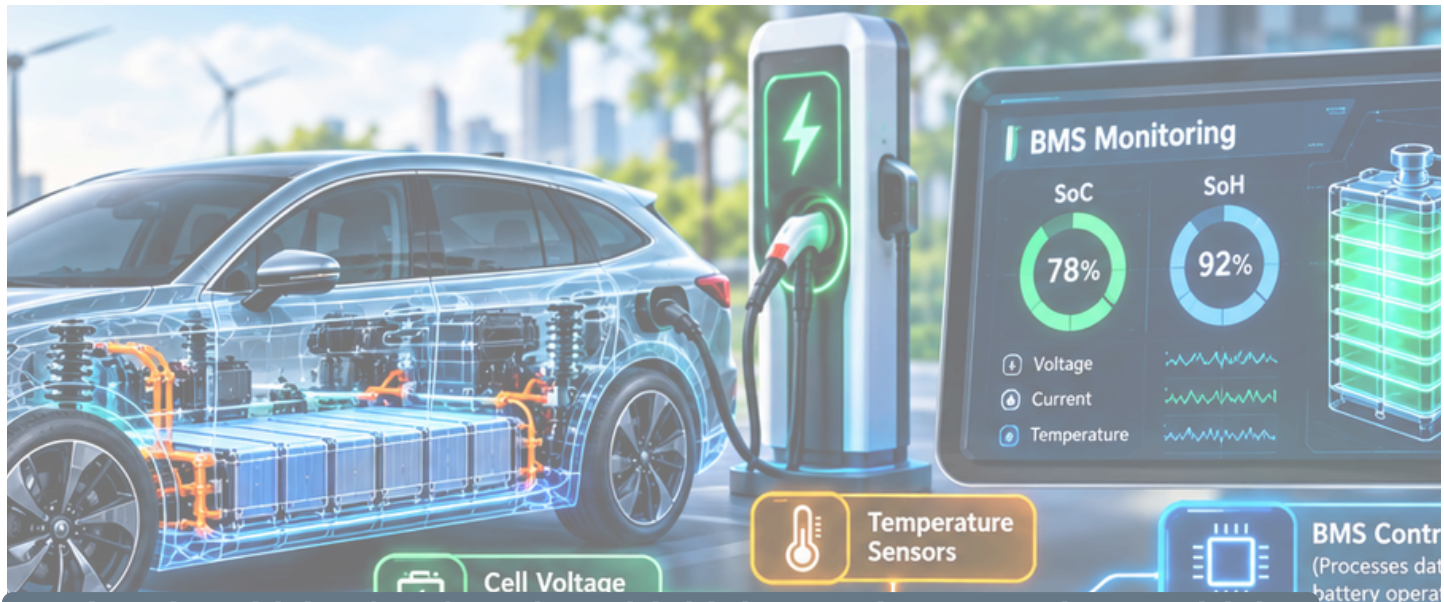
PEO 1 Excel in automobile engineering by applying advanced technical knowledge, practical skills, and innovative solutions for industry and societal impact.

PEO 2 Demonstrate professional ethics, technical competence, and a proactive mindset in personal and professional pursuits.

PEO 3 Pursue higher studies, entrepreneurial ventures, or successful careers in automobile engineering and allied industries.

Battery Management Systems for Next-Generation EVs

ABHINAVBABU•REGISTERNO. 2301050915



As electric vehicles (EVs) evolve with higher performance, longer driving ranges and faster charging, the Battery Management System (BMS) has become one of the most important electronic systems in a modern vehicle.

A BMS continuously monitors the battery pack and controls critical parameters such as cell voltage, current and temperature. It estimates the State of Charge (SoC) and State of Health (SoH) while protecting the battery from overcharging, deep discharge, overheating and excessive current.

Key functions of a BMS

Cell Monitoring: Monitors voltage, current and temperature of individual cells.

Battery Protection: Prevents unsafe charging, discharging and thermal conditions.

Cell Balancing: Maintains uniform charge levels between cells.

Thermal Management: Controls battery cooling and heating.

State Estimation: Calculates SoC, SoH and remaining driving range.

Communication: Exchanges information with the Vehicle Control Unit and charging system.

The next generation

Future BMS technology is moving toward AI-based diagnostics, cloud connectivity, predictive maintenance, adaptive cell balancing and advanced thermal management. These developments will help EVs achieve better safety, faster charging, longer battery life and improved energy efficiency.

BMS

EV BATTERY MANAGEMENT

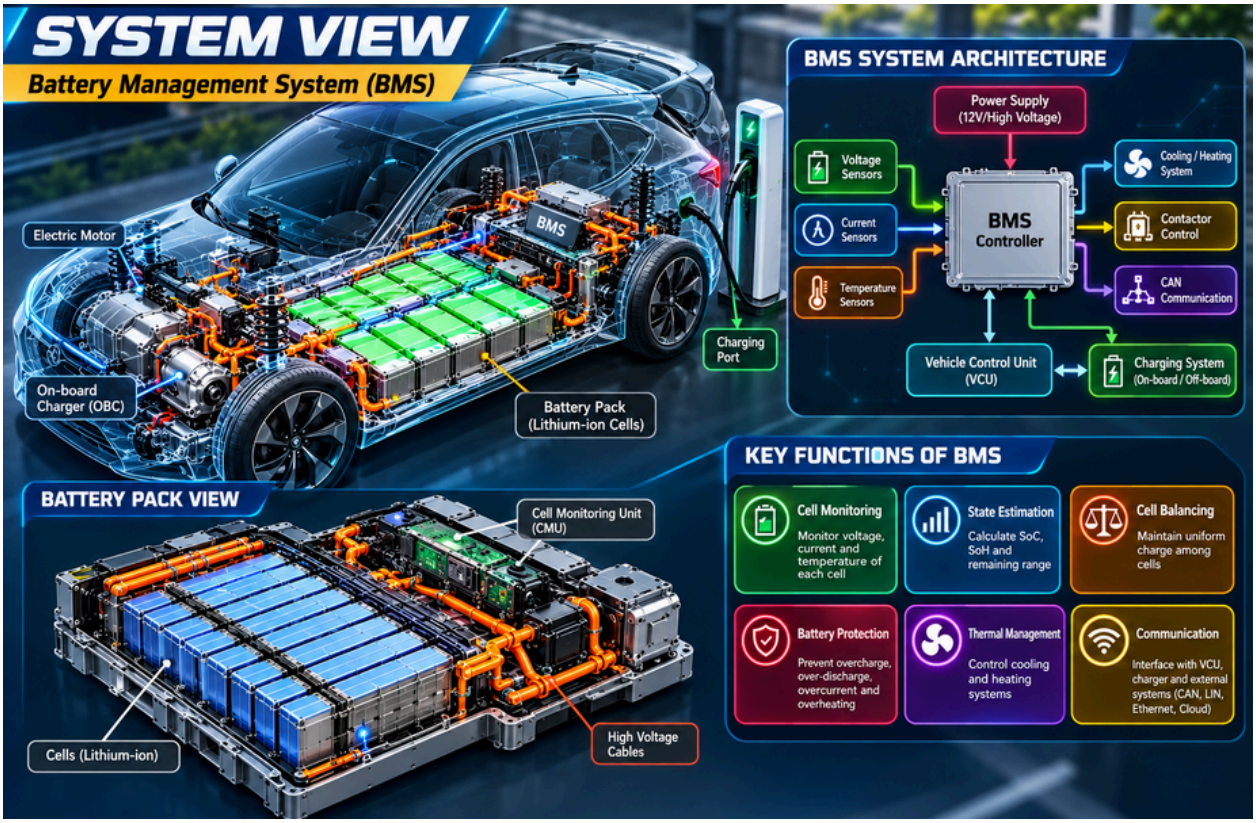
FUNDAMENTALS

THE BMS AS THE BATTERY'S NERVOUS SYSTEM A traction battery contains many series-connected cells and modules. Small differences in cell capacity, resistance and temperature can grow over time. The BMS observes these differences through voltage and temperature sensing, then coordinates contactors, charging limits, cooling requests and fault responses. Its basic objective is to keep every cell inside a safe operating window while allowing the vehicle to deliver the power requested by the driver.

CORE FUNCTIONS

Cell-voltage monitoring identifies over-voltage and under-voltage conditions. Temperature sensing identifies hot spots and cold conditions that can reduce power capability. Current measurement supports charge and discharge calculations. From these signals the controller estimates State of Charge (SOC), State of Health (SOH) and available power. Cell balancing reduces the usable-capacity loss caused by cell-to-cell variation.

SYSTEM VIEW



BMS

EV BATTERY MANAGEMENT

ENGINEERING CONSIDERATIONS

01 SOC ESTIMATION

SOC is estimated using current integration, open-circuit-voltage relationships and model-based correction. Accurate estimation matters during acceleration, charging and regenerative braking.

02 THERMAL MANAGEMENT

Lithium-ion cells operate within a limited temperature range. Cooling plates, coolant channels, heat pipes or air systems may be used depending on pack design.

03 BALANCING

Passive balancing dissipates excess energy through resistors. Active balancing transfers energy between cells. The choice affects cost, efficiency and complexity.

APPLICATIONS

EVs, electric buses, hybrid vehicles, stationary battery storage and high-voltage charging systems.

ENGINEER'S CHECKLIST

Define the operating range Identify failure modes and limits Validate with simulation and test Consider safety, cost and maintainability Document assumptions and interfaces

BMS

EV BATTERY MANAGEMENT

WHAT COMES NEXT?

Future BMS architectures are moving toward distributed sensing, wireless cell monitoring, cloud-supported health prediction and data-driven diagnostics.

KEY TAKEAWAYS

Understand the system boundary • know the main inputs and outputs • identify safety limits • connect theory with testing • consider the full vehicle lifecycle.

QUICK GLOSSARY

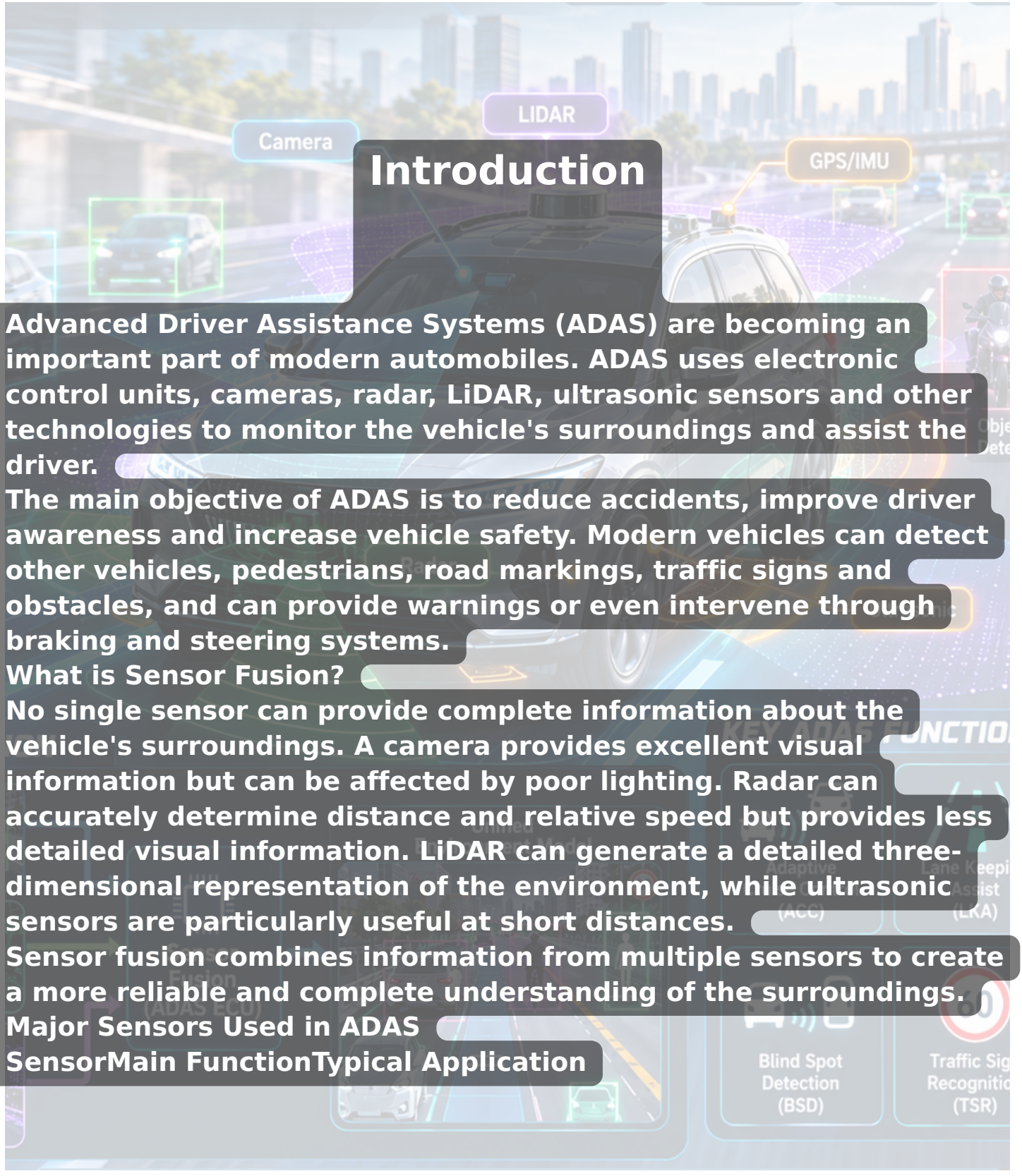
SOC — State of Charge. SOH — State of Health. Contactor — high-voltage switching device. Cell balancing — reducing differences between cells.

STUDENT REFLECTION

What part of this technology would you like to study in a workshop, project or final-year investigation? A strong engineering question begins with a measurable problem.

ADAS and Sensor Fusion in Modern Vehicles

•ADHITHKVINOD•REGISTER NO. 2301050916



Introduction

Advanced Driver Assistance Systems (ADAS) are becoming an important part of modern automobiles. ADAS uses electronic control units, cameras, radar, LiDAR, ultrasonic sensors and other technologies to monitor the vehicle's surroundings and assist the driver.

The main objective of ADAS is to reduce accidents, improve driver awareness and increase vehicle safety. Modern vehicles can detect other vehicles, pedestrians, road markings, traffic signs and obstacles, and can provide warnings or even intervene through braking and steering systems.

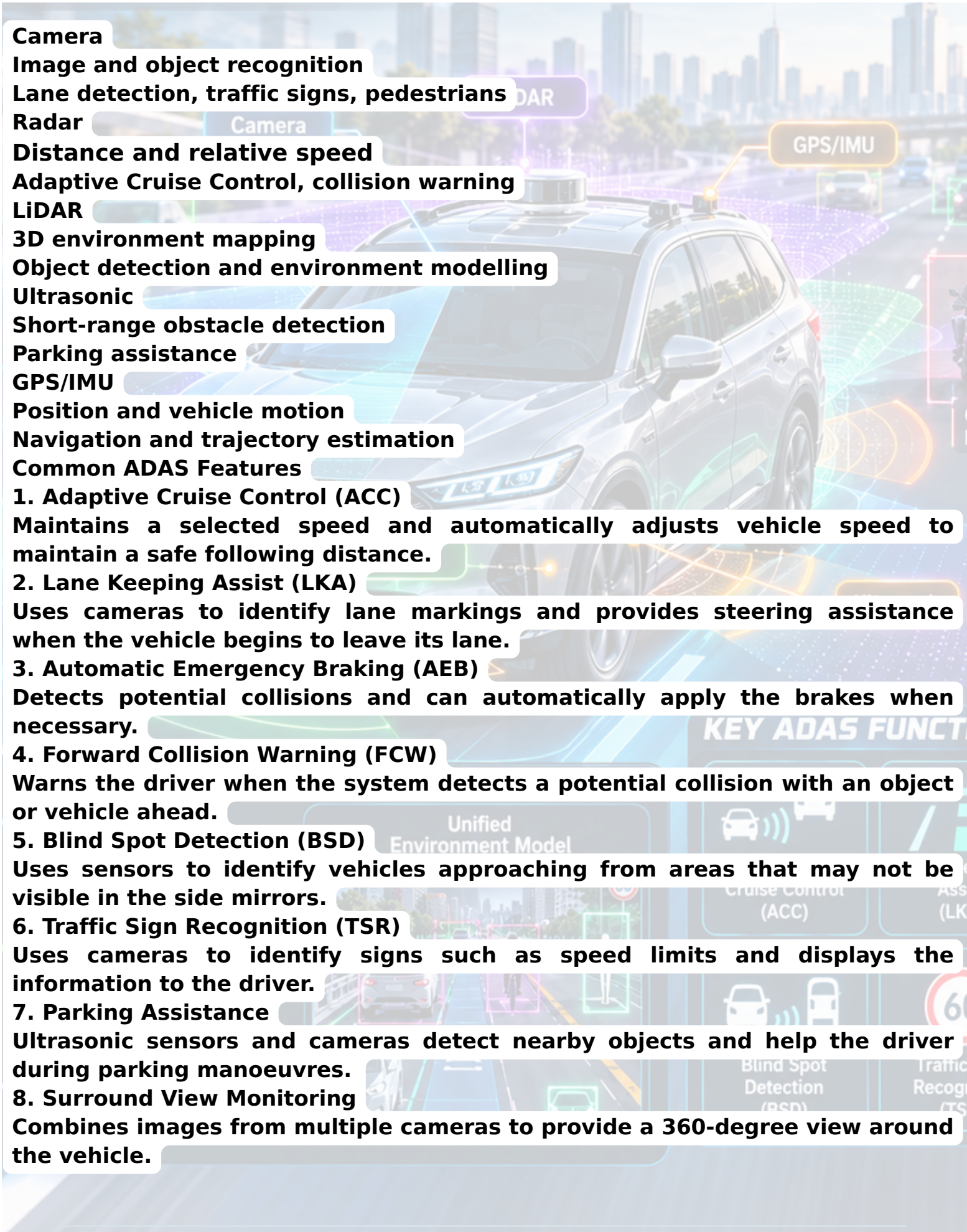
What is Sensor Fusion?

No single sensor can provide complete information about the vehicle's surroundings. A camera provides excellent visual information but can be affected by poor lighting. Radar can accurately determine distance and relative speed but provides less detailed visual information. LiDAR can generate a detailed three-dimensional representation of the environment, while ultrasonic sensors are particularly useful at short distances.

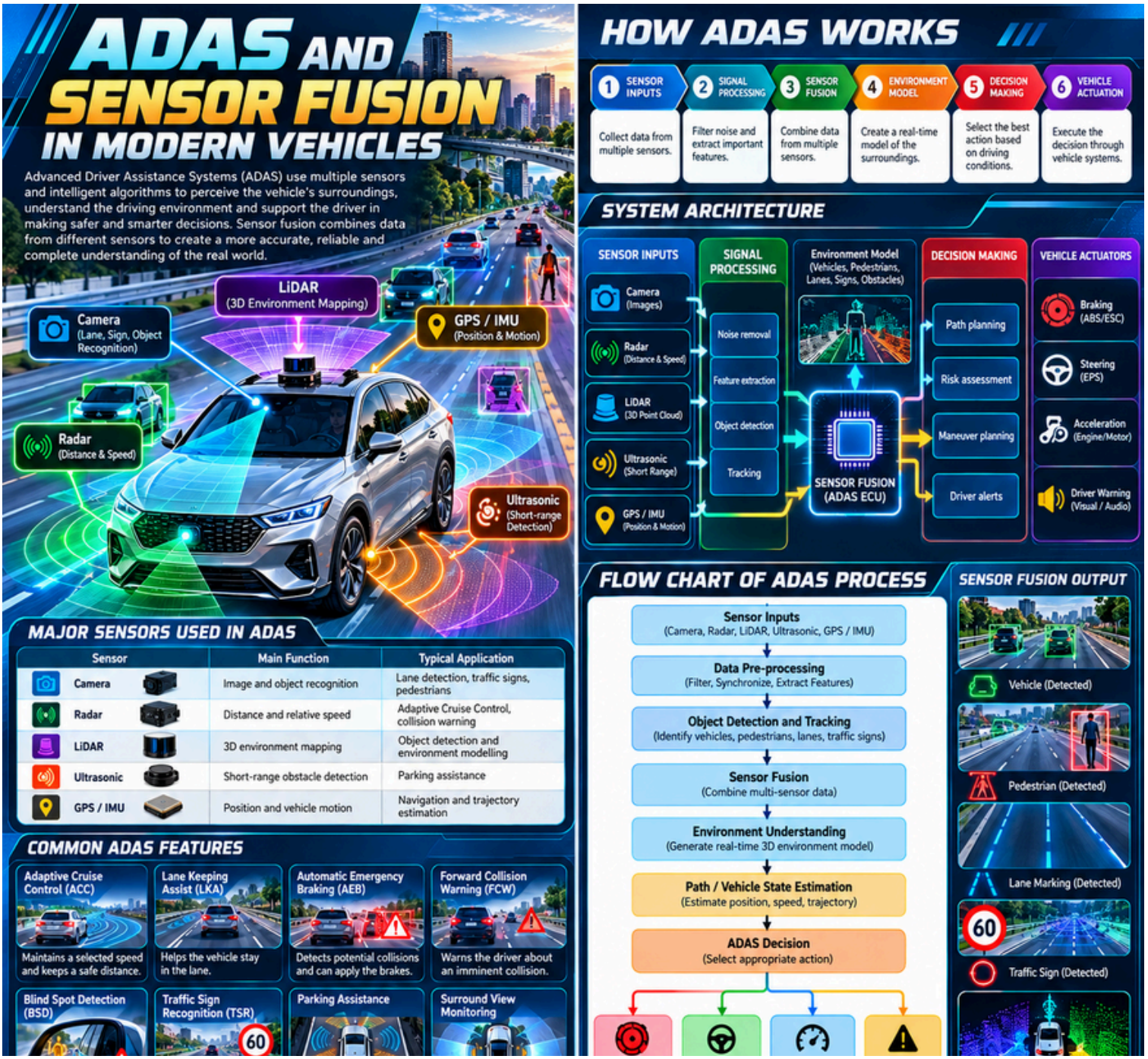
Sensor fusion combines information from multiple sensors to create a more reliable and complete understanding of the surroundings.

Major Sensors Used in ADAS

SensorMain FunctionTypical Application



Camera
Image and object recognition
Lane detection, traffic signs, pedestrians
Radar
Distance and relative speed
Adaptive Cruise Control, collision warning
LiDAR
3D environment mapping
Object detection and environment modelling
Ultrasonic
Short-range obstacle detection
Parking assistance
GPS/IMU
Position and vehicle motion
Navigation and trajectory estimation
Common ADAS Features
1. Adaptive Cruise Control (ACC)
Maintains a selected speed and automatically adjusts vehicle speed to maintain a safe following distance.
2. Lane Keeping Assist (LKA)
Uses cameras to identify lane markings and provides steering assistance when the vehicle begins to leave its lane.
3. Automatic Emergency Braking (AEB)
Detects potential collisions and can automatically apply the brakes when necessary.
4. Forward Collision Warning (FCW)
Warns the driver when the system detects a potential collision with an object or vehicle ahead.
5. Blind Spot Detection (BSD)
Uses sensors to identify vehicles approaching from areas that may not be visible in the side mirrors.
6. Traffic Sign Recognition (TSR)
Uses cameras to identify signs such as speed limits and displays the information to the driver.
7. Parking Assistance
Ultrasonic sensors and cameras detect nearby objects and help the driver during parking manoeuvres.
8. Surround View Monitoring
Combines images from multiple cameras to provide a 360-degree view around the vehicle.



Why Sensor Fusion is Important

Sensor fusion improves accuracy, reliability and robustness. For example, a camera can recognize a pedestrian while radar measures the pedestrian's distance and relative movement. Combining these observations allows the ADAS controller to make a better-informed decision.

The future of ADAS is moving toward AI-based perception, high-resolution radar, advanced LiDAR, vehicle-to-everything (V2X) communication and increasingly sophisticated sensor-fusion algorithms. These technologies will play an important role in the development of safer, smarter and increasingly automated vehicles.

ADAS

ADAS & SENSOR FUSION

ENGINEERING CONSIDERATIONS

01 PERCEPTION

The system identifies lanes, vehicles, pedestrians, cyclists and road boundaries. Machine-learning models may be used for object

detection.

02 TRACKING

A detected object is followed over time. Filters and motion models estimate position and velocity even when a sensor temporarily

loses a target.

03 DECISION AND CONTROL

The system converts perception into actions or warnings. Timing, fail-safe behaviour and driver override are essential.

APPLICATIONS

Adaptive cruise control, lane departure warning, lane keeping assist, automatic emergency braking and automated parking.

Alternative Fuels and Sustainable Transportation

•BHARATHKP•REGISTER NO. 2301050921

Biofuels

Biofuels are fuels produced from biological materials. The most widely known transportation biofuels include ethanol and biodiesel.

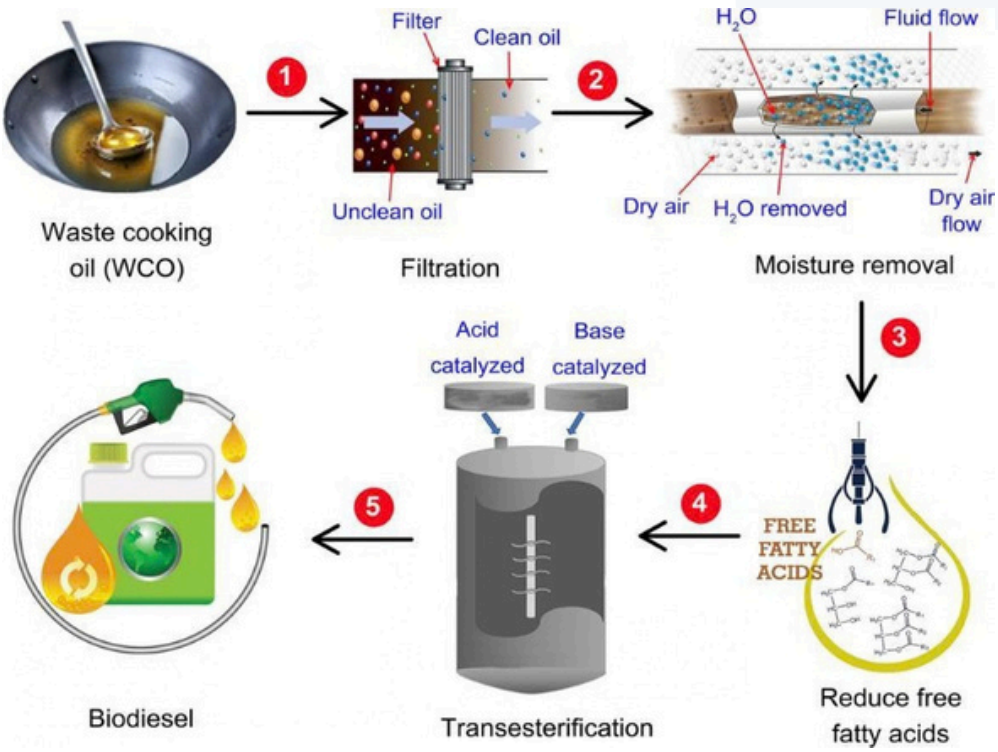
Ethanol

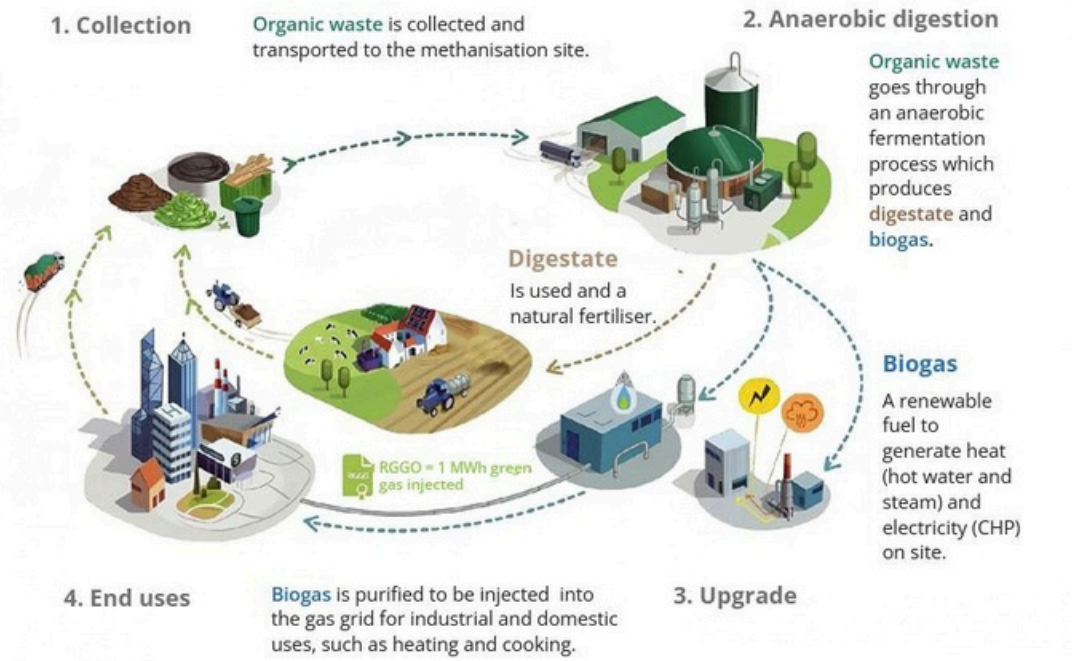
Ethanol can be blended with petrol and is commonly produced from crops or other biological feedstocks.

Biodiesel

Biodiesel can be produced from vegetable oils, animal fats and other suitable feedstocks. It can be blended with conventional diesel or used in appropriate diesel applications.

More advanced biofuel technologies can use waste materials, agricultural residues, cellulosic biomass and other non-food feedstocks. This is particularly important because sustainable transportation should avoid creating unnecessary competition with food production.





Biogas and Biomethane

Biogas is produced through the anaerobic digestion of organic material such as agricultural waste, food waste, sewage and animal manure.

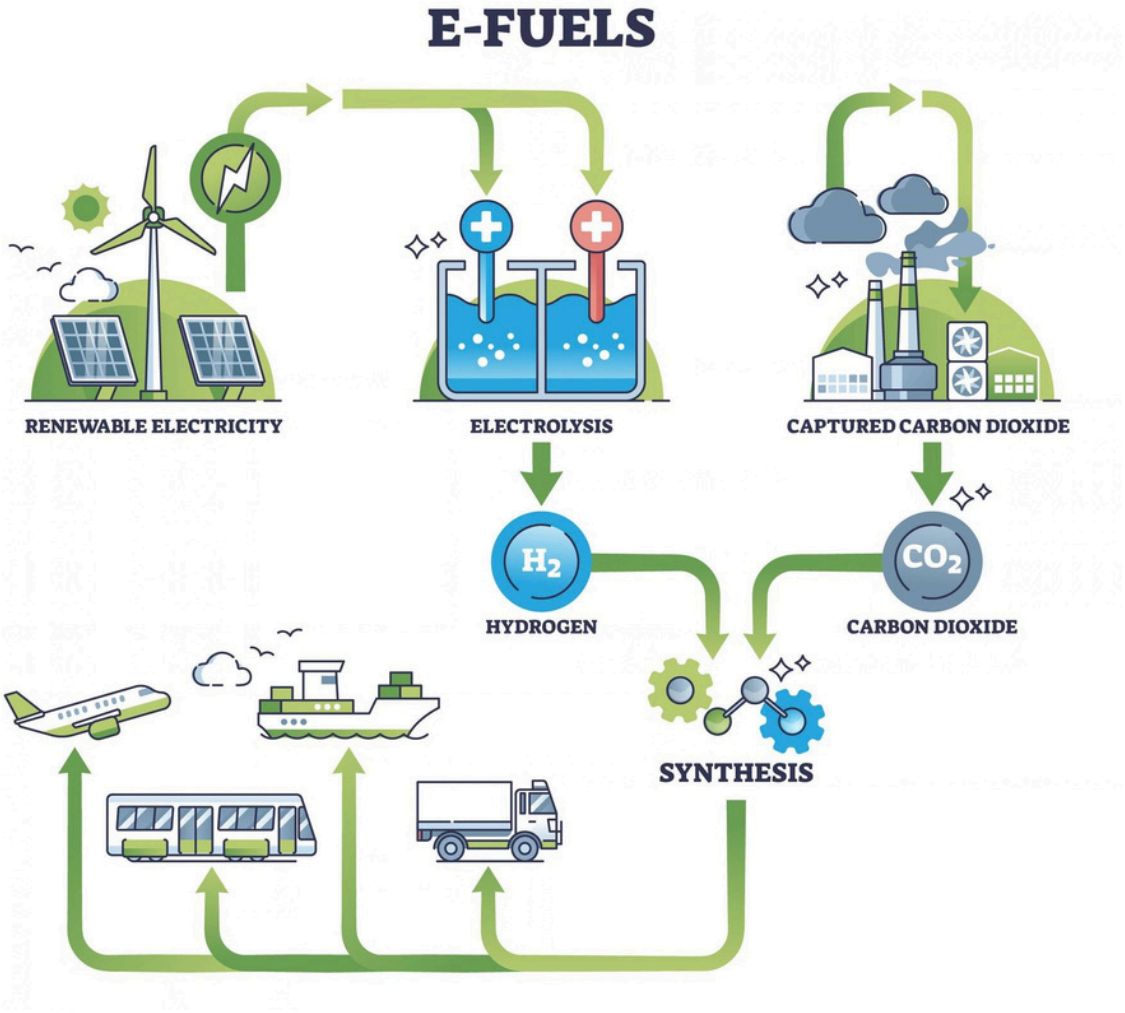
Raw biogas generally contains methane along with carbon dioxide and other components. After purification, it can be upgraded to biomethane, which can be used in suitable natural-gas vehicle systems.

Energy pathway

Organic Waste → Anaerobic Digestion → Biogas → Purification → Biomethane → Vehicle

This creates an interesting connection between waste management and transportation.

Biogas and biomethane are among the renewable-fuel pathways being developed alongside electrification and liquid biofuels.



E-Fuels and Synthetic Fuels

E-fuels, or electrofuels, are synthetic fuels produced using electricity-derived hydrogen and carbon-containing feedstocks.

A simplified pathway is:

Renewable Electricity → Electrolysis → Hydrogen → Fuel Synthesis → E-Fuel → Vehicle

Potential applications include aviation and shipping, where direct battery electrification can be more difficult because of energy-density requirements.

Sustainable Transportation Is More Than Alternative Fuels

Sustainable transportation does not simply mean replacing petrol with another fuel. It involves improving the entire transportation system.

Important approaches include:

Electrification

Using electric powertrains where they are technically and economically suitable.

Public Transportation

Encouraging buses, railways and other shared transportation systems can reduce the number of individual vehicles required.

Vehicle Efficiency

Lightweight materials, aerodynamic design, efficient motors and improved powertrain control can reduce energy consumption.

Intelligent Transportation Systems

Connected vehicles, intelligent traffic management and navigation systems can reduce congestion and unnecessary fuel consumption.

Shared Mobility

Car sharing, ride sharing and mobility-as-a-service can improve vehicle utilisation.

Renewable Energy

Using renewable electricity to charge EVs can further reduce the carbon intensity of transportation.





Driver Monitoring and Human-Centred Vehicle Safety

• DELVINDAVIS • REGISTERNO.2301050922

Keeping the Human at the Centre of Next-Generation Automotive Safety

Modern vehicles are becoming increasingly intelligent. Cameras, radar, artificial intelligence, electronic control units and advanced driver-assistance systems can now detect hazards and assist the driver. However, even the most advanced vehicle ultimately operates in a system that includes a human driver.

This has created an important area of automotive engineering: Driver Monitoring Systems (DMS) and Human-Centred Vehicle Safety.

A Driver Monitoring System continuously estimates whether the driver is attentive, distracted, drowsy or otherwise unable to respond appropriately. Modern systems can use cameras, infrared illumination, vehicle inputs and AI-based algorithms to assess driver state. Euro NCAP has developed dedicated protocols for driver engagement and occupant monitoring, while research organisations are studying how these systems can improve safety and driver acceptance

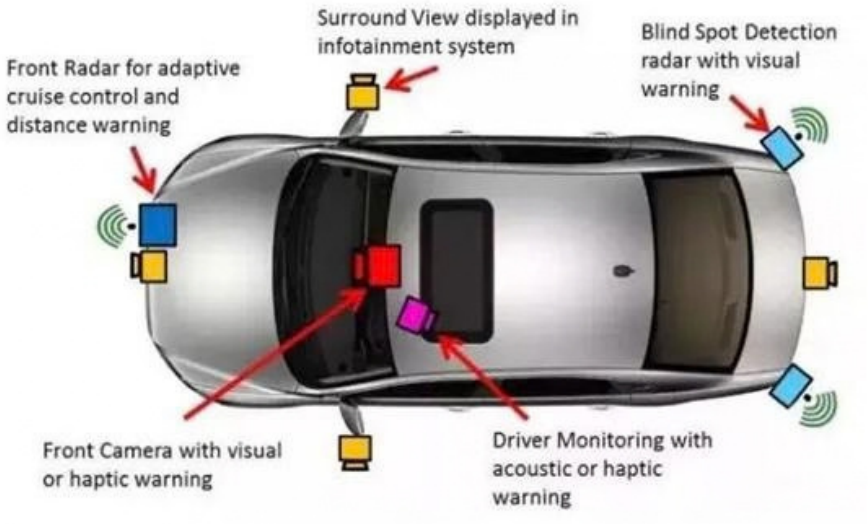
What is a Driver Monitoring System?

A Driver Monitoring System (DMS) is an electronic safety system designed to observe the driver's condition and determine whether the driver is sufficiently attentive to operate the vehicle safely.
A typical DMS uses an in-cabin camera, often supported by infrared illumination, to observe:

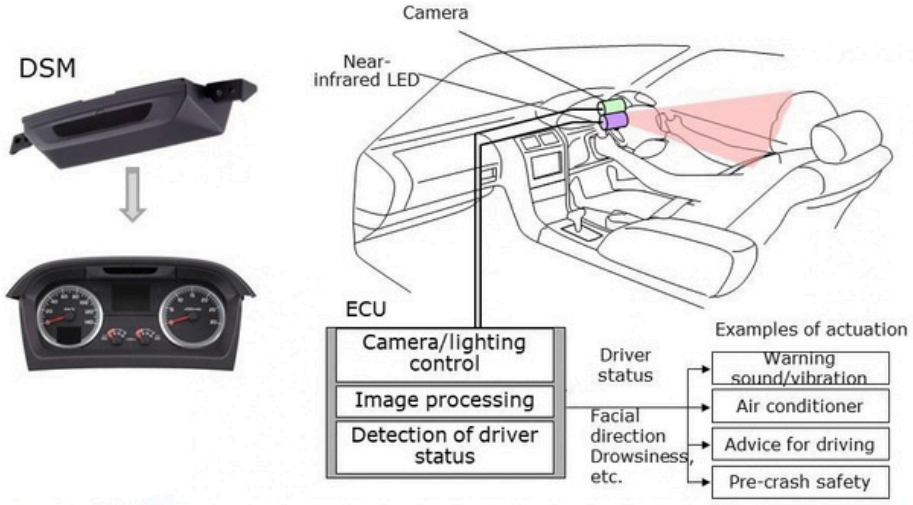


Eye opening and closing
Eye movement
Gaze direction
Head position
Facial orientation
Blinking frequency
Yawning
Signs of drowsiness
Driver distraction
Driver interaction with vehicle controls
Modern research also explores multimodal systems combining cameras with radar and vehicle information

Basic DMS concept
Driver → Camera/Sensors → Image Processing → AI Algorithm → Driver-State Estimation → Warning/Vehicle Response
The objective is not simply to "watch" the driver. The system uses the information to determine whether the driver's current state presents a safety risk.



- **Main Components of a Driver Monitoring System**
- **3.1 In-Cabin Camera**
- **The camera is generally positioned around the instrument panel, steering column or central dashboard area so that it has a clear view of the driver's face.**
- **3.2 Infrared Illumination**
- **Infrared LEDs can illuminate the driver's face without requiring bright visible lighting. This allows the system to operate during night-time driving and changing cabin-light conditions.**
- **3.3 Image Processor**
- **The camera captures images and sends them to an electronic processor. Computer-vision algorithms identify important facial features.**
- **3.4 Artificial Intelligence**
- **AI and machine-learning algorithms analyse patterns such as:**
- **Eye closure**
- **Gaze direction**
- **Head movement**
- **Facial orientation**
- **Repeated yawning**
- **Long periods of visual distraction**
- **3.5 Vehicle Interface**
- **The DMS can communicate with other vehicle systems through the vehicle's electronic architecture.**
- **Possible responses include:**
- **Audible warning**
- **Visual warning**
- **Steering-wheel vibration**
- **Seat vibration**
- **Infotainment interruption**
- **Increased ADAS alert level**
- **Escalation to emergency intervention in appropriately designed systems**





Key Advantages
Driver Monitoring Systems

Detect driver distraction
Detect signs of drowsiness
Improve driver awareness
Support ADAS
Improve safety during automated driving
Enable personalised safety responses
Human-Centred Safety
Reduces unnecessary driver workload
Improves human-machine interaction
Makes warnings more understandable
Helps maintain driver engagement
Improves acceptance of vehicle automation

Conclusion

Driver Monitoring and Human-Centred Vehicle Safety represent an important step in the evolution of modern automobiles. Traditional vehicle safety focused mainly on protecting occupants during a crash. Modern safety engineering increasingly aims to prevent the crash from happening in the first place.
DMS technology allows a vehicle to understand aspects of the driver's condition, while ADAS observes the surrounding environment. When these technologies work together, the vehicle can make better-informed safety decisions.

Vehicle Telematics and Connected Mobility

• JUDSONSAJI • REGISTERNO.2301050928



The automobile is rapidly evolving from a conventional mechanical machine into an intelligent, connected and data-driven mobility platform. Vehicle telematics and connected mobility are key technologies driving this transformation. Telematics combines telecommunications, information technology, vehicle electronics and data analytics to collect, transmit and process information about a vehicle.

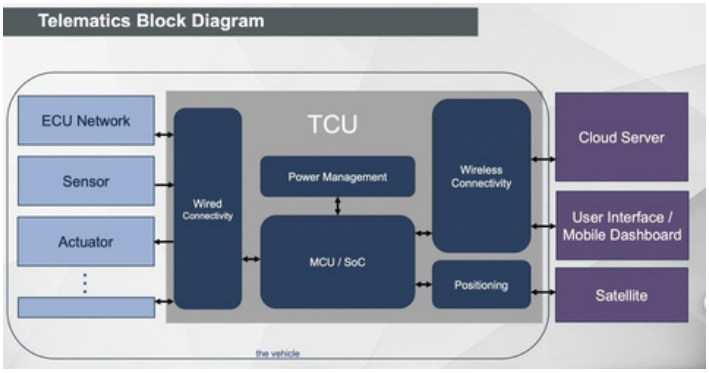
A modern connected vehicle can communicate with cloud platforms, smartphones, other vehicles, road infrastructure, service centres and emergency systems. This connectivity enables applications such as real-time vehicle tracking, remote diagnostics, predictive maintenance, driver monitoring, emergency assistance, fleet management, navigation, over-the-air software updates and intelligent traffic management.

What is Vehicle Telematics?

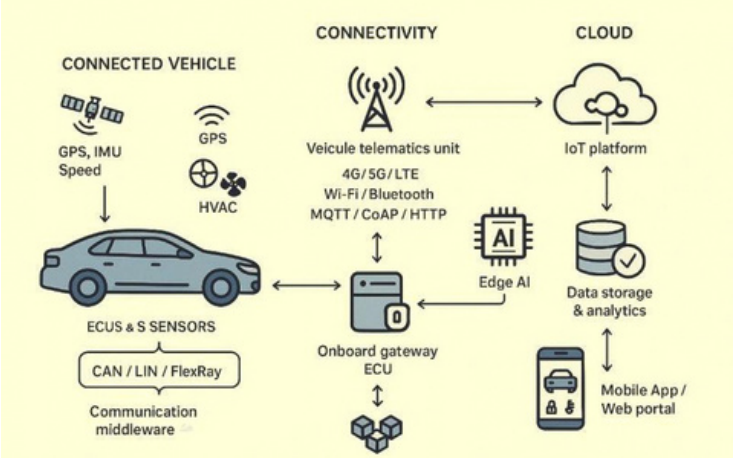
Vehicle telematics is the technology used to collect, transmit, analyse and exchange vehicle-related information over communication networks.

A typical telematics system collects information from:

Engine and powertrain ECUs
Vehicle speed sensors
GPS/GNSS receiver
Accelerometer and gyroscope
Battery Management System
CAN/CAN-FD network
OBD/diagnostic system
ADAS sensors
Door and safety systems
Fuel and energy systems



The information is processed by a Telematics Control Unit (TCU) or telematics gateway and transmitted through cellular, Wi-Fi, Bluetooth or V2X communication technologies to cloud-based platforms.



What is Connected Mobility?

Connected mobility refers to a transportation ecosystem in which vehicles, people, infrastructure, networks and digital services exchange information.

Instead of operating independently, vehicles become part of a connected transportation network.

Connected mobility ecosystem

Vehicle ↔ Vehicle ↔ Infrastructure ↔ Cloud ↔ Driver ↔ Pedestrian

This concept is closely associated with Vehicle-to-Everything (V2X) communication.

V2X can include:

V2V – Vehicle-to-Vehicle
V2I – Vehicle-to-Infrastructure
V2P – Vehicle-to-Pedestrian
V2N – Vehicle-to-Network
V2C – Vehicle-to-Cloud

V2X allows vehicles to obtain information beyond what their onboard sensors alone can detect.

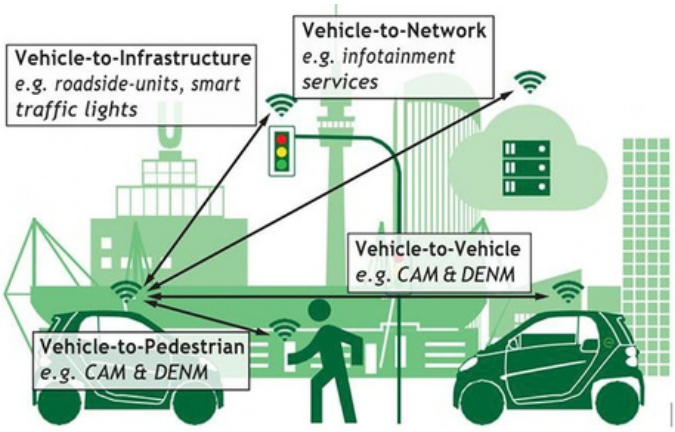
Working of Vehicle Telematics

The working process can be explained in six stages.

Step 1 – Data Generation

Sensors and ECUs continuously generate vehicle information.

Examples:



Engine RPM
Vehicle speed
Coolant temperature
Fuel consumption
Battery voltage
Battery state of charge
Brake status
GPS position
Acceleration
Diagnostic trouble codes

Step 2 – Data Collection

The TCU receives information from the vehicle's internal networks and sensors.

Step 3 – Data Processing

The TCU filters and processes the information before transmission.

For example, abnormal engine temperature can trigger an alert.

Step 4 – Wireless Transmission

Processed information is transmitted through cellular networks or other communication technologies.

Step 5 – Cloud Analysis

Cloud platforms store and analyse vehicle data.

AI and analytics can identify:

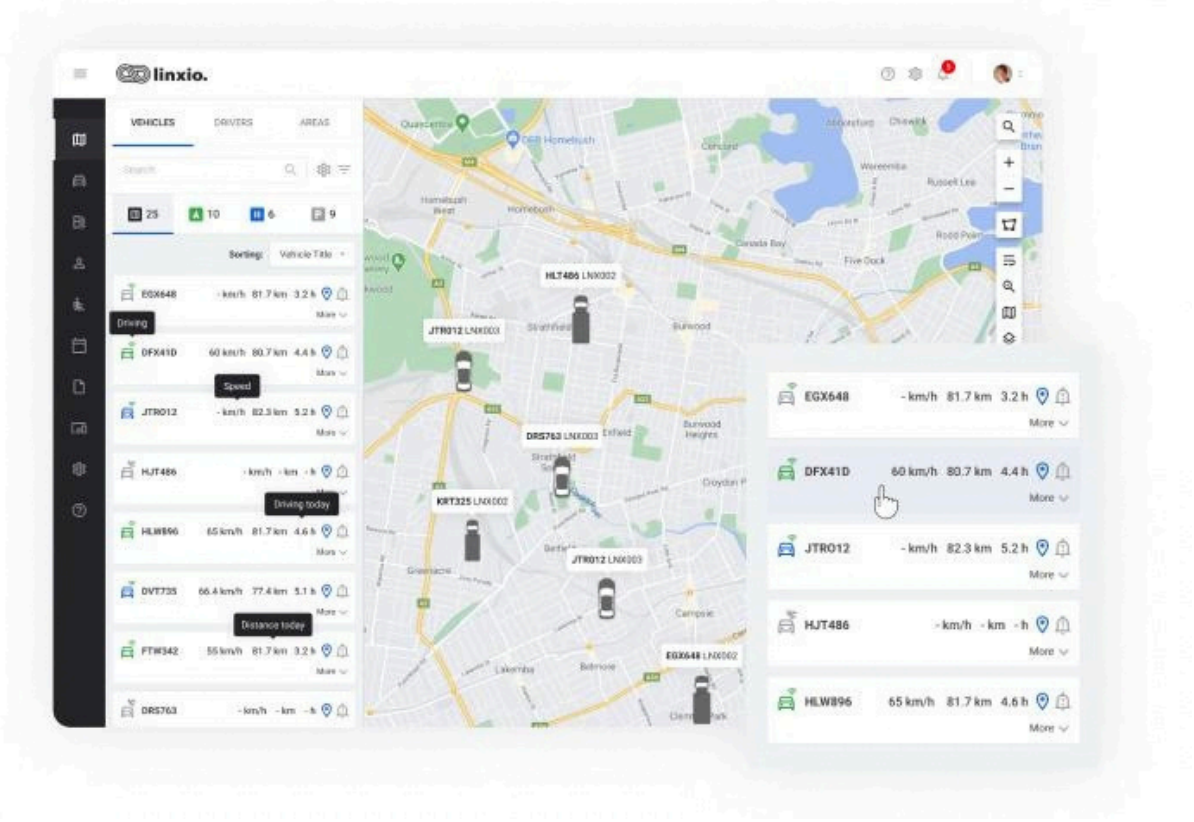
Abnormal vehicle behaviour
Maintenance requirements
Driver behaviour
Traffic conditions
Fuel/energy consumption
Battery performance

Step 6 – User/Application Response

The analysed information is presented through:

Mobile applications
Fleet management dashboards
Dealer/service portals
Vehicle infotainment systems
Traffic control centres

This general edge-to-cloud model is characteristic of modern telematics systems.



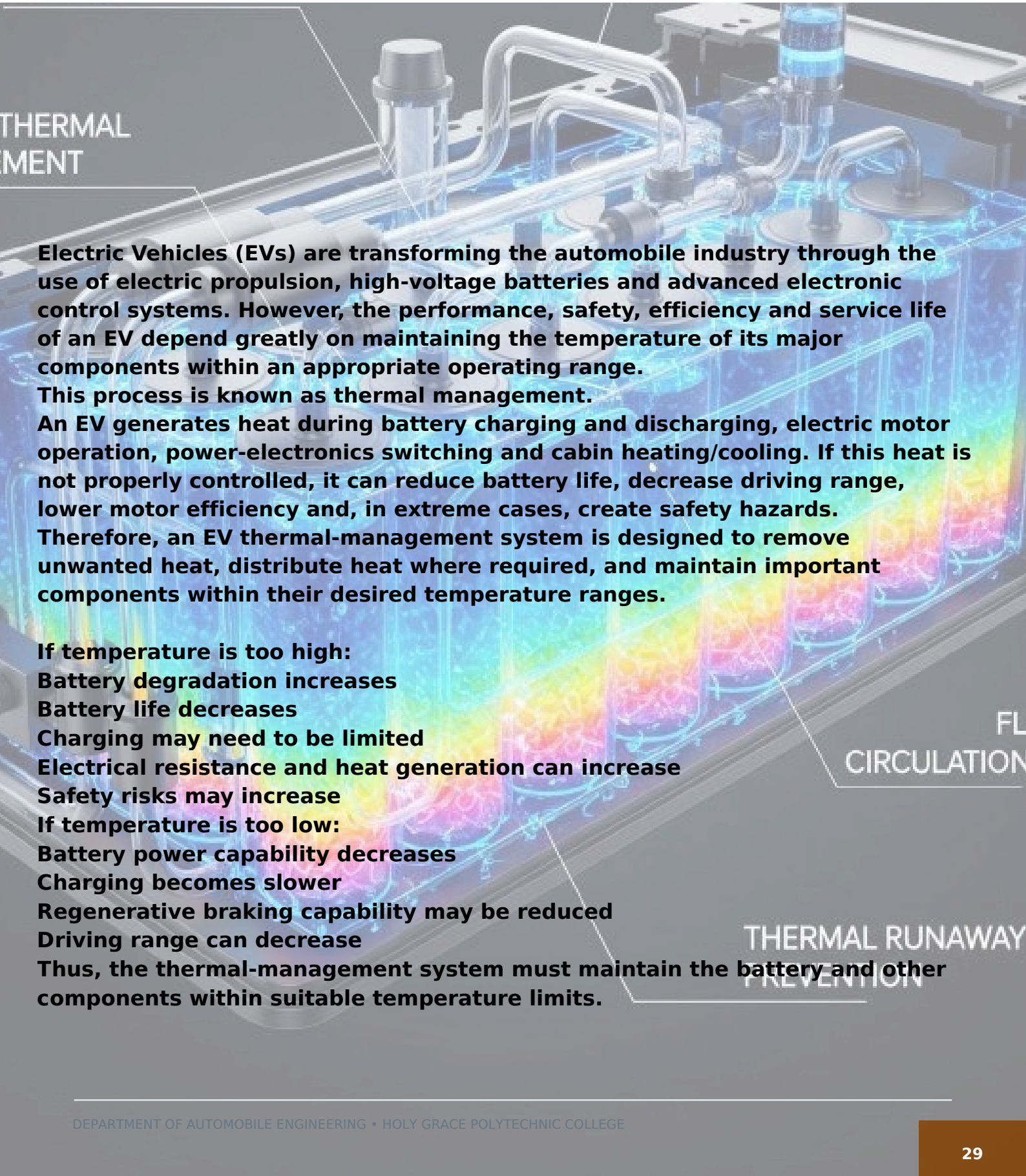
Vehicle Telematics and Connected Mobility represent a major transformation in automotive engineering. By connecting sensors, ECUs, telematics units, communication networks, cloud platforms and intelligent applications, vehicles can continuously exchange information with their surrounding environment.

Telematics is no longer limited to GPS tracking. It has evolved into an important technology platform supporting vehicle diagnostics, fleet management, predictive maintenance, electric mobility, V2X communication, safety, OTA updates and intelligent transportation systems.

The future automobile will therefore not operate as an isolated machine. It will function as an intelligent, connected node within a larger mobility ecosystem, communicating with other vehicles, infrastructure, pedestrians and cloud-based services.

Thermal Management of Electric Vehicles

•MANASKRISHNAMP•REGISTER NO. 2301050930



Electric Vehicles (EVs) are transforming the automobile industry through the use of electric propulsion, high-voltage batteries and advanced electronic control systems. However, the performance, safety, efficiency and service life of an EV depend greatly on maintaining the temperature of its major components within an appropriate operating range.
This process is known as thermal management.
An EV generates heat during battery charging and discharging, electric motor operation, power-electronics switching and cabin heating/cooling. If this heat is not properly controlled, it can reduce battery life, decrease driving range, lower motor efficiency and, in extreme cases, create safety hazards.
Therefore, an EV thermal-management system is designed to remove unwanted heat, distribute heat where required, and maintain important components within their desired temperature ranges.

If temperature is too high:
Battery degradation increases
Battery life decreases
Charging may need to be limited
Electrical resistance and heat generation can increase
Safety risks may increase
If temperature is too low:
Battery power capability decreases
Charging becomes slower
Regenerative braking capability may be reduced
Driving range can decrease
Thus, the thermal-management system must maintain the battery and other components within suitable temperature limits.

Methods of EV Thermal Management

Several techniques are used to control EV temperature.

Major methods

Air cooling

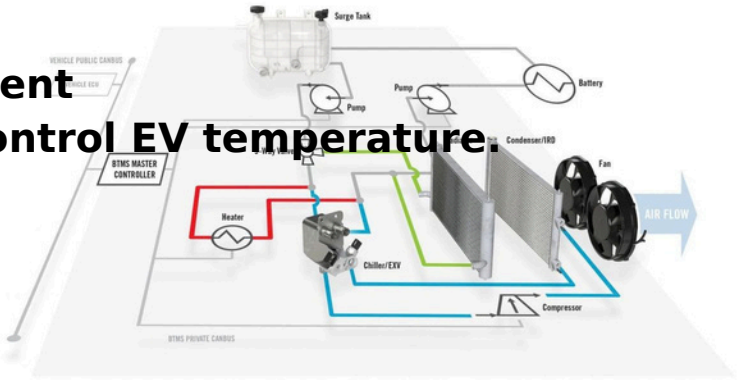
Liquid cooling

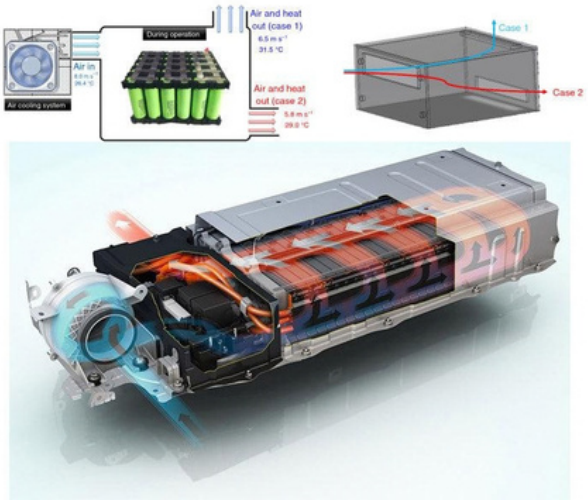
Refrigerant cooling

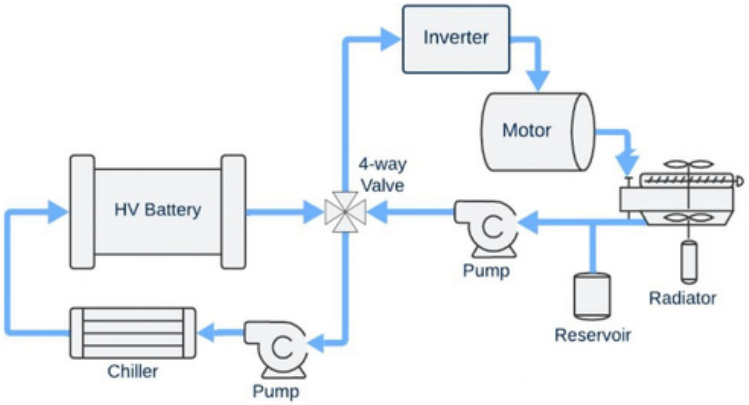
Phase-change material cooling

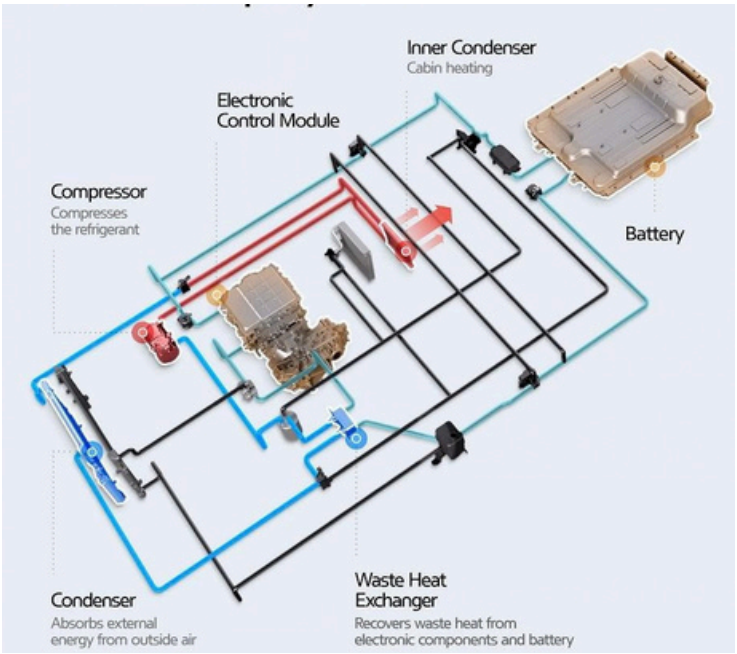
Heat pipes

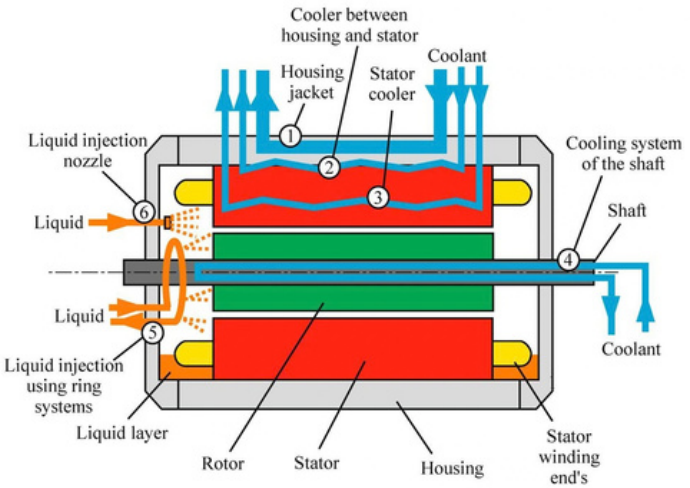
Combination/hybrid systems

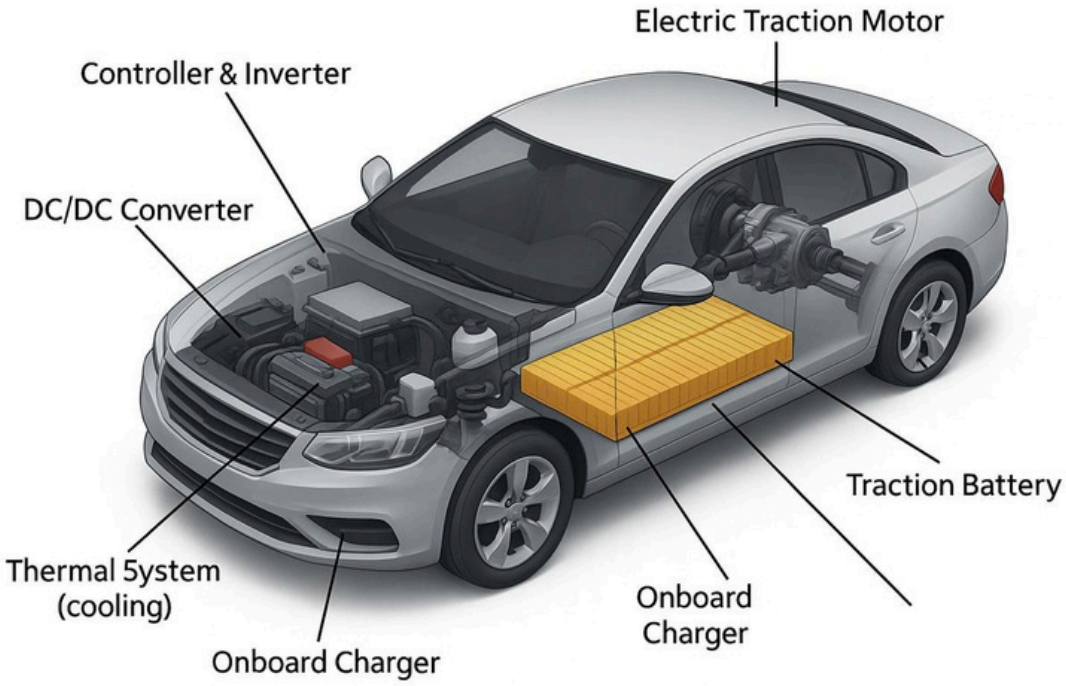












Benefits of Effective Thermal Management

A properly designed thermal-management system provides several advantages.

Battery

Longer battery life

Improved charging performance

Better power output

Improved safety

More consistent performance

Motor

Higher continuous power

Improved efficiency

Reduced thermal stress

Better reliability

Vehicle

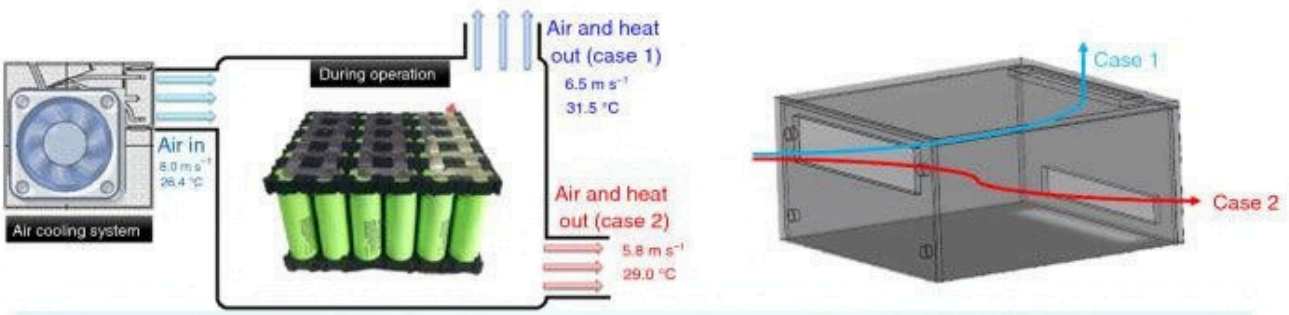
Improved driving range

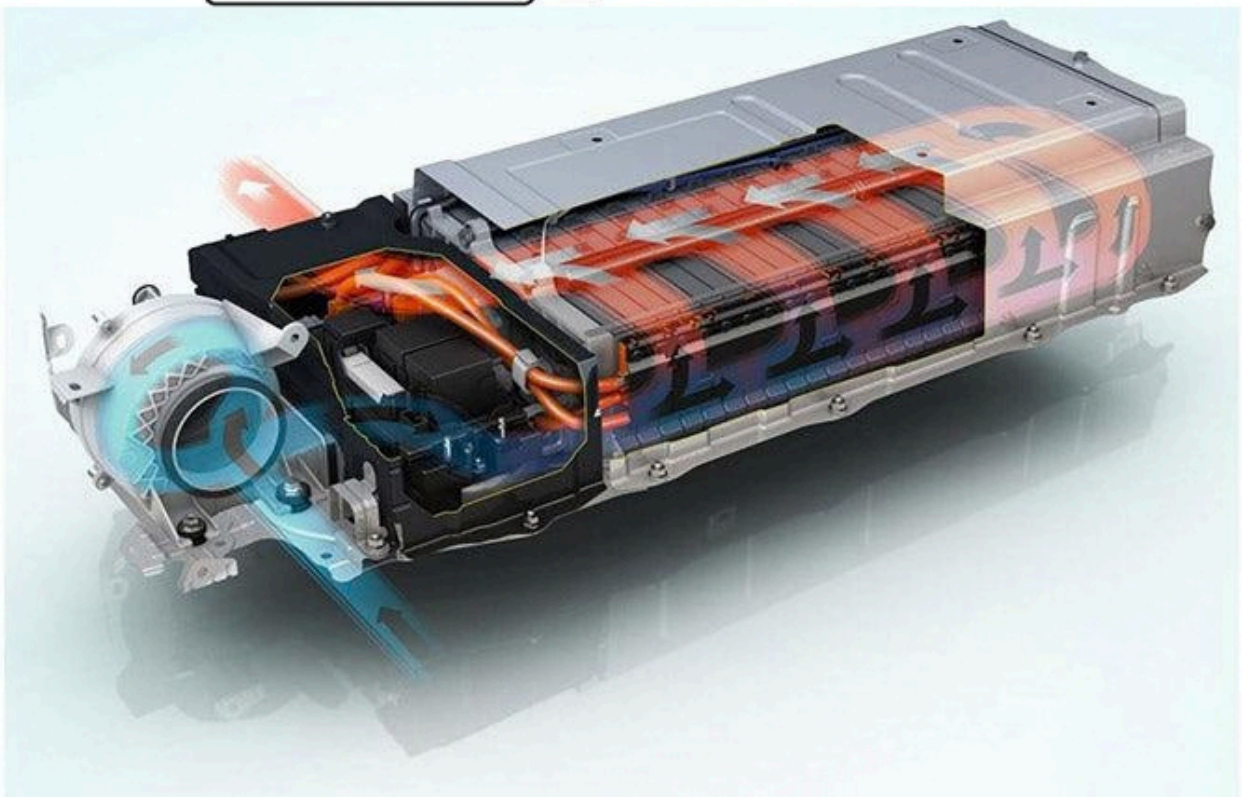
Faster charging capability

Better cabin comfort

Improved overall efficiency

Better component durability





Thermal management is a critical technology in electric vehicles. The performance of the battery, motor, inverter, charger and cabin systems depends strongly on controlling their operating temperatures.
An effective thermal-management system must perform two important functions:
Remove unwanted heat and provide heat when required.
Battery cooling is particularly important because temperature directly influences battery performance, charging speed, safety, degradation and service life. Liquid cooling, heat pumps, integrated coolant loops and advanced control systems are therefore becoming increasingly important in modern EVs.
As electric vehicles move towards higher battery capacity, ultra-fast charging, higher motor power and autonomous operation, thermal management will become even more sophisticated. Future EVs will use intelligent thermal systems that dynamically distribute heat and cooling energy across the vehicle.

Artificial Intelligence in Automobiles

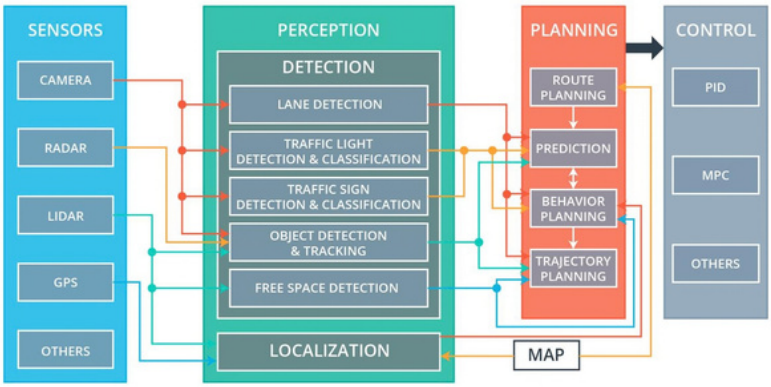
• ROSHANSHAJU • REGISTERNO.2301050936

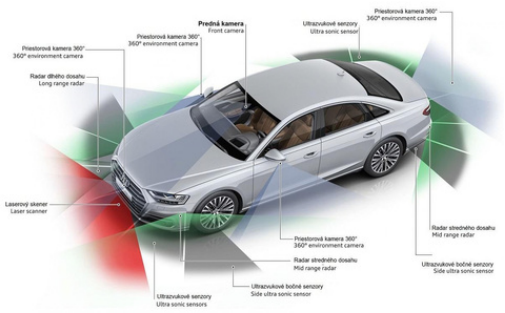
Artificial Intelligence (AI) is transforming modern automobiles from conventional machines into intelligent, connected and increasingly autonomous mobility systems. AI enables vehicles to understand their surroundings, learn from data, make decisions and assist drivers in real time. It combines cameras, radar, LiDAR, ultrasonic sensors, GPS, vehicle-control systems and machine-learning algorithms to improve safety, efficiency, comfort and driving performance.

Artificial Intelligence in automobiles refers to the use of machine learning, computer vision, neural networks, sensor fusion and intelligent decision-making algorithms to enable a vehicle to perform tasks that normally require human intelligence.

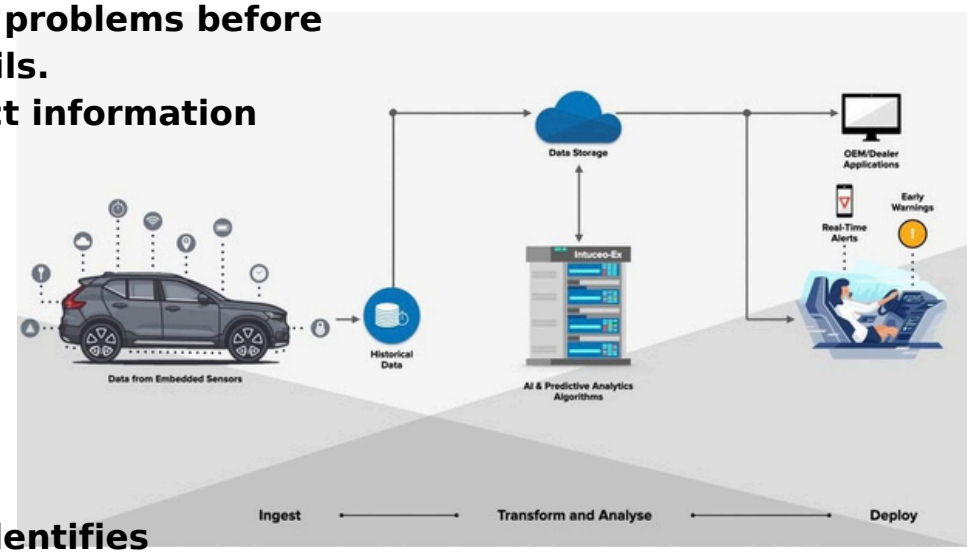


An AI-enabled vehicle can:
Detect vehicles, pedestrians and obstacles
Recognize traffic signs and road markings
Monitor the driver's attention
Predict possible collisions
Automatically apply the brakes
Maintain a safe distance from other vehicles
Keep the vehicle within its lane
Select appropriate driving actions
Assist with parking
Predict vehicle component failures
Optimize energy consumption in electric vehicles
The overall objective is to create vehicles that are safer, smarter, more efficient and easier to operate.

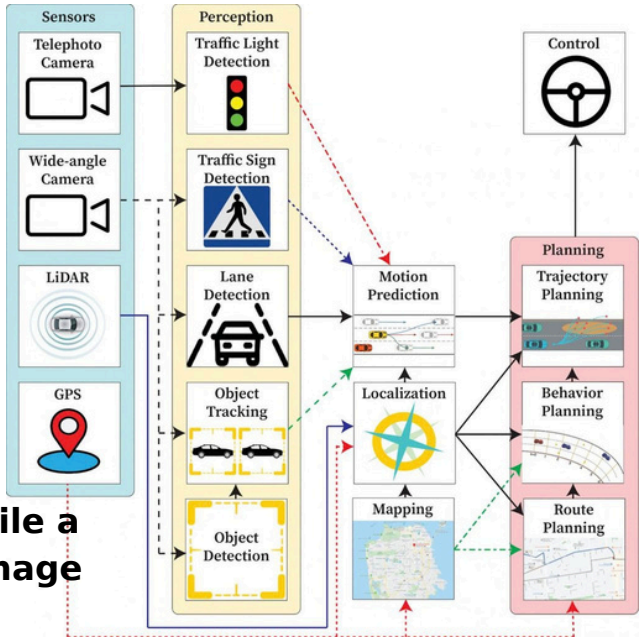


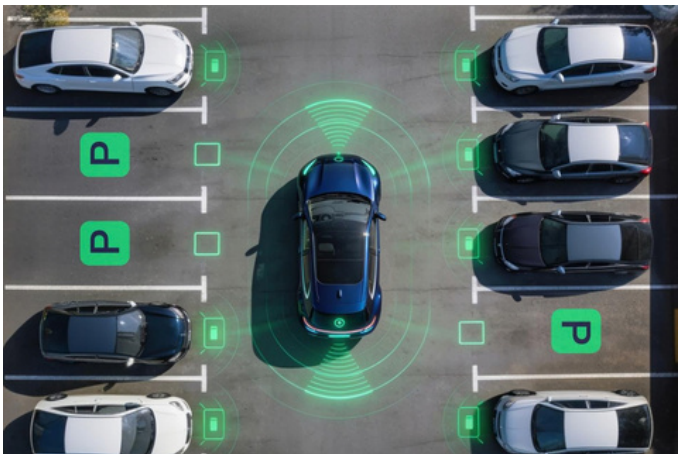


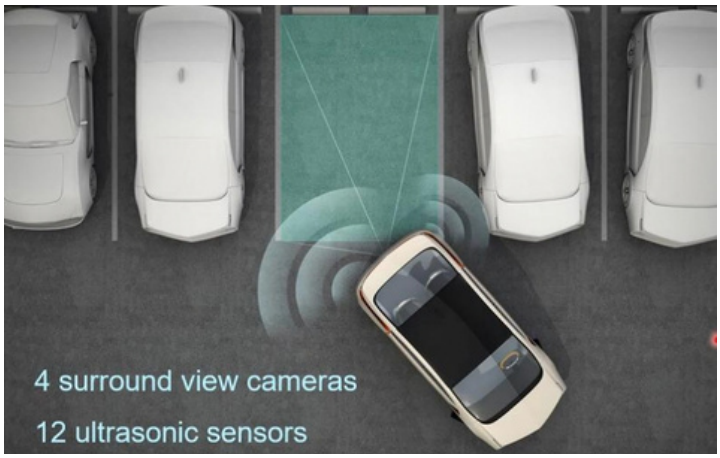
Predictive Maintenance
AI can help identify vehicle problems before a component completely fails.
Sensors continuously collect information about components such as:
Engine
Transmission
Battery
Braking system
Cooling system
Electric motor
Tyres
AI analyses this data and identifies abnormal patterns.



AI-Based Traffic Sign and Object Recognition
Computer vision allows vehicles to recognize road objects.
AI can identify:
Speed-limit signs
Stop signs
No-entry signs
Traffic lights
Pedestrians
Cyclists
Motorcycles
Other vehicles
Road markings
A camera captures the road image, while a trained neural network analyses the image and identifies relevant objects.

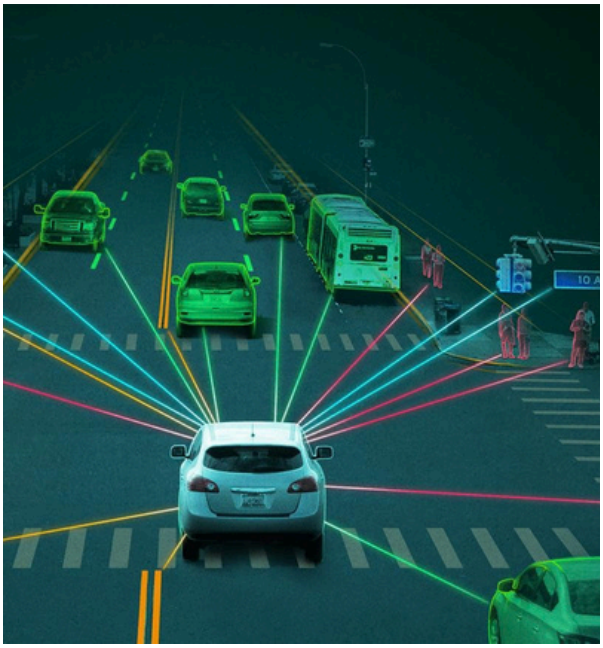






Intelligent Parking
AI is also used in automated parking systems.
The vehicle uses cameras and ultrasonic sensors to identify available parking spaces.
The AI system calculates:
Parking-space dimensions
Vehicle position
Distance from obstacles
Steering angle
Required trajectory
The vehicle can then automatically control steering and, in advanced systems, braking and acceleration.

Vehicle-to-Everything Communication
AI can also work with V2X (Vehicle-to-Everything) communication.
Vehicles can exchange information with:
Other vehicles — V2V
Infrastructure — V2I
Pedestrians — V2P
Networks — V2N



Benefits of AI in Automobiles

Improved Safety

AI can identify dangerous situations much faster than a human driver in certain circumstances and provide rapid warnings or interventions.

Reduced Accidents

Collision-warning and automatic-braking systems can help prevent or reduce the severity of crashes.

Better Fuel/Energy Efficiency

AI can optimize driving behaviour, powertrain operation and energy usage.

Predictive Maintenance

Potential failures can be identified before they become serious.

Improved Comfort

AI can automate parking, climate control, navigation and other functions.

Reduced Driver Workload

ADAS can assist drivers during long or demanding journeys.

Better Traffic Management

Connected and intelligent vehicles can contribute to more efficient traffic flow.

Challenges of AI in Automobiles

Despite its advantages, automotive AI has several challenges.

1. Sensor Limitations

Cameras, radar and LiDAR can be affected by weather, lighting and environmental conditions.

2. Cybersecurity

Connected vehicles can become targets for cyberattacks.

3. Data Privacy

Vehicles can collect large amounts of information about drivers and their activities.

4. High Development Cost

Advanced sensors, computing hardware and AI software can increase vehicle cost.

5. Ethical Decisions

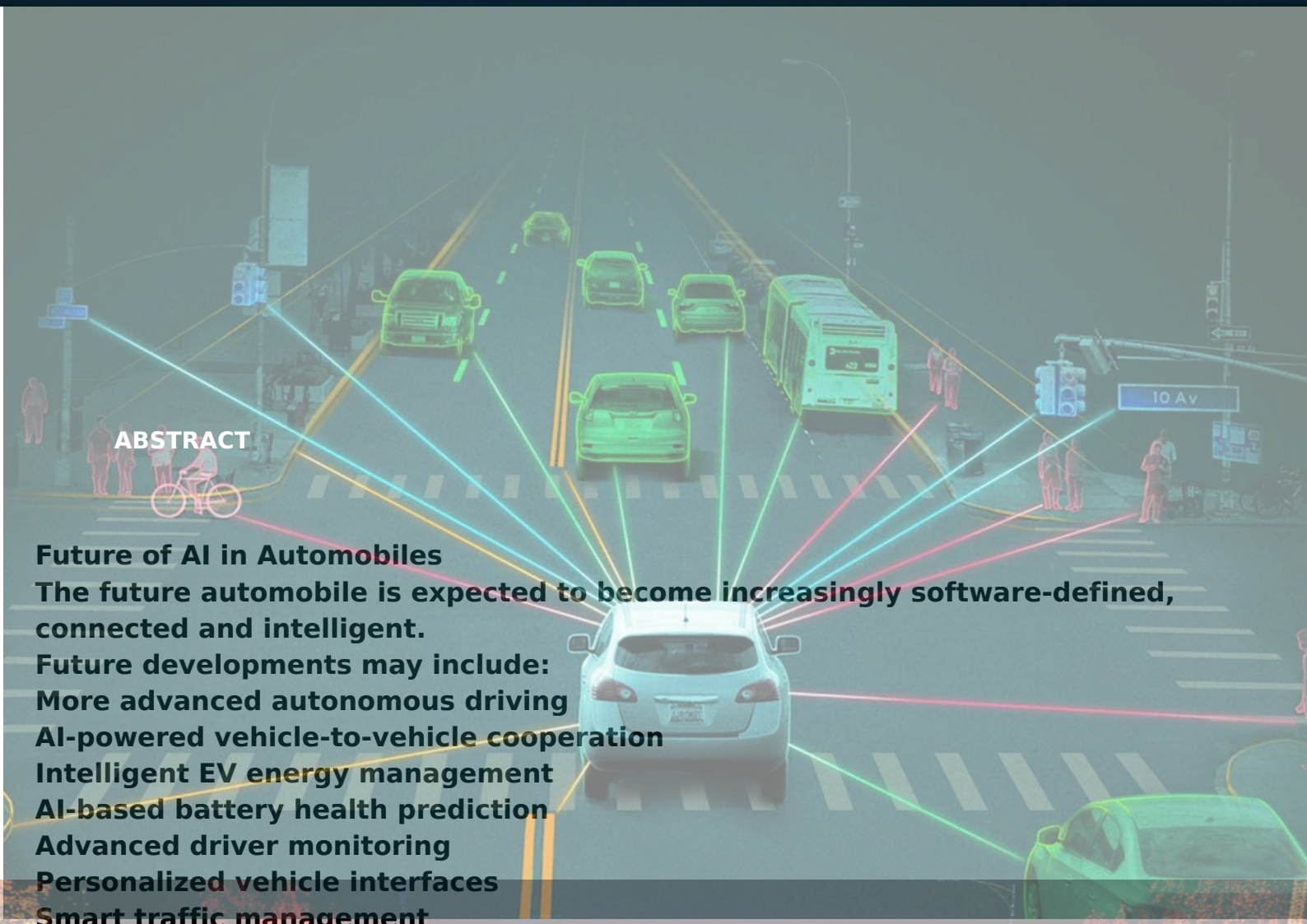
Autonomous systems must be designed to respond appropriately to complex and unexpected situations.

6. Reliability

AI-based systems must operate safely under a wide range of road and environmental conditions.

7. Human Dependence

Drivers must understand the limitations of driver-assistance systems and remain responsible for safe vehicle operation when required.



ABSTRACT

Future of AI in Automobiles
The future automobile is expected to become increasingly software-defined, connected and intelligent.
Future developments may include:
More advanced autonomous driving
AI-powered vehicle-to-vehicle cooperation
Intelligent EV energy management
AI-based battery health prediction
Advanced driver monitoring
Personalized vehicle interfaces
Smart traffic management
AI-assisted vehicle design and manufacturing
Digital twins for vehicle development
More sophisticated predictive maintenance
The combination of AI + sensors + connectivity + electrification + autonomous technology is expected to fundamentally change the automobile industry.

Artificial Intelligence is becoming a key technology in the development of next-generation automobiles. From ADAS and autonomous driving to predictive maintenance, intelligent parking, driver monitoring and EV battery management, AI enables vehicles to perceive their environment, analyse information and respond intelligently. As AI technology continues to improve, automobiles are moving from being simple transportation machines toward becoming intelligent mobility platforms.

Automotive Cybersecurity

•SAYOOJTS•REGISTER NO. 2301050940

Protecting the Connected Vehicle of the Future

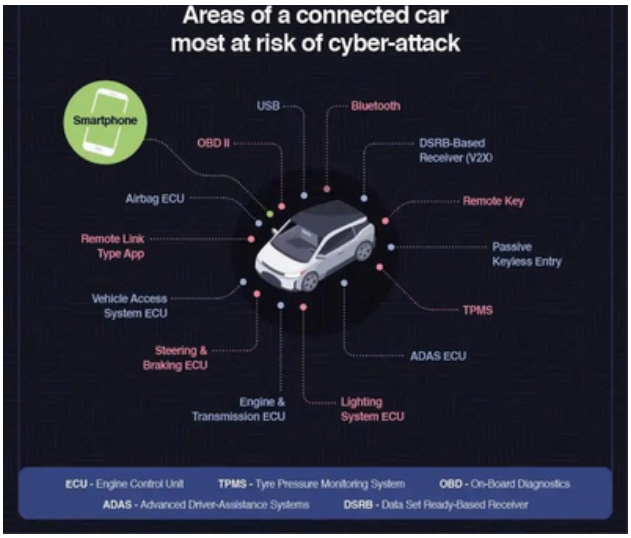
The modern automobile is no longer only a mechanical machine. Today's vehicles contain dozens of electronic control units (ECUs), cameras, radar sensors, wireless communication systems, mobile applications, cloud services and increasingly sophisticated software. As vehicles become connected and software-defined, cybersecurity has become an essential part of automobile engineering.

Automotive cybersecurity refers to the technologies, processes and practices used to protect a vehicle's electronic systems, software, communication networks, data and connected services from unauthorised access, manipulation or disruption.

Why Automotive Cybersecurity Is Important

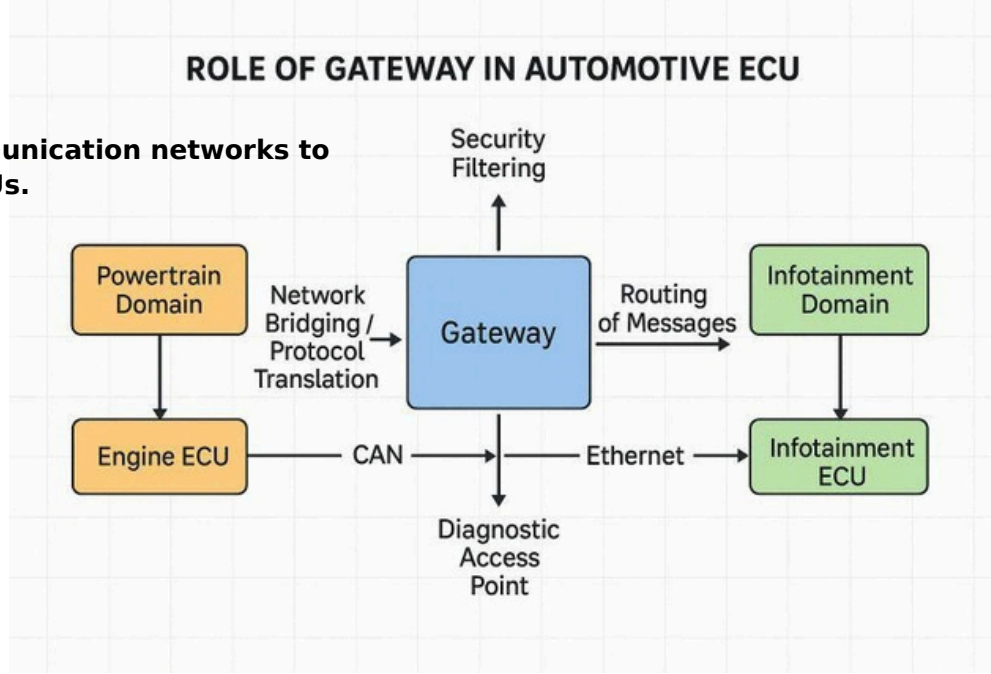
A modern vehicle may communicate with:

Smartphones
Mobile applications
Bluetooth devices
Wi-Fi networks
Cloud servers
Navigation services
Charging stations
Other vehicles
Road infrastructure
Diagnostic equipment

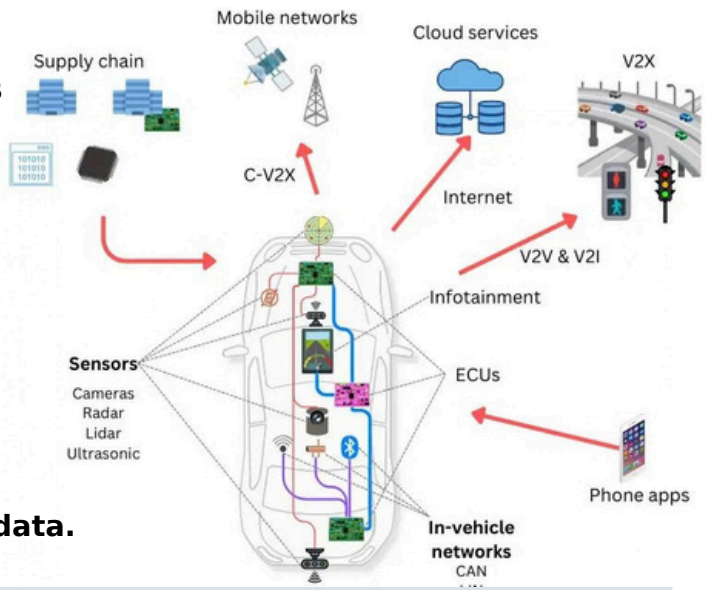


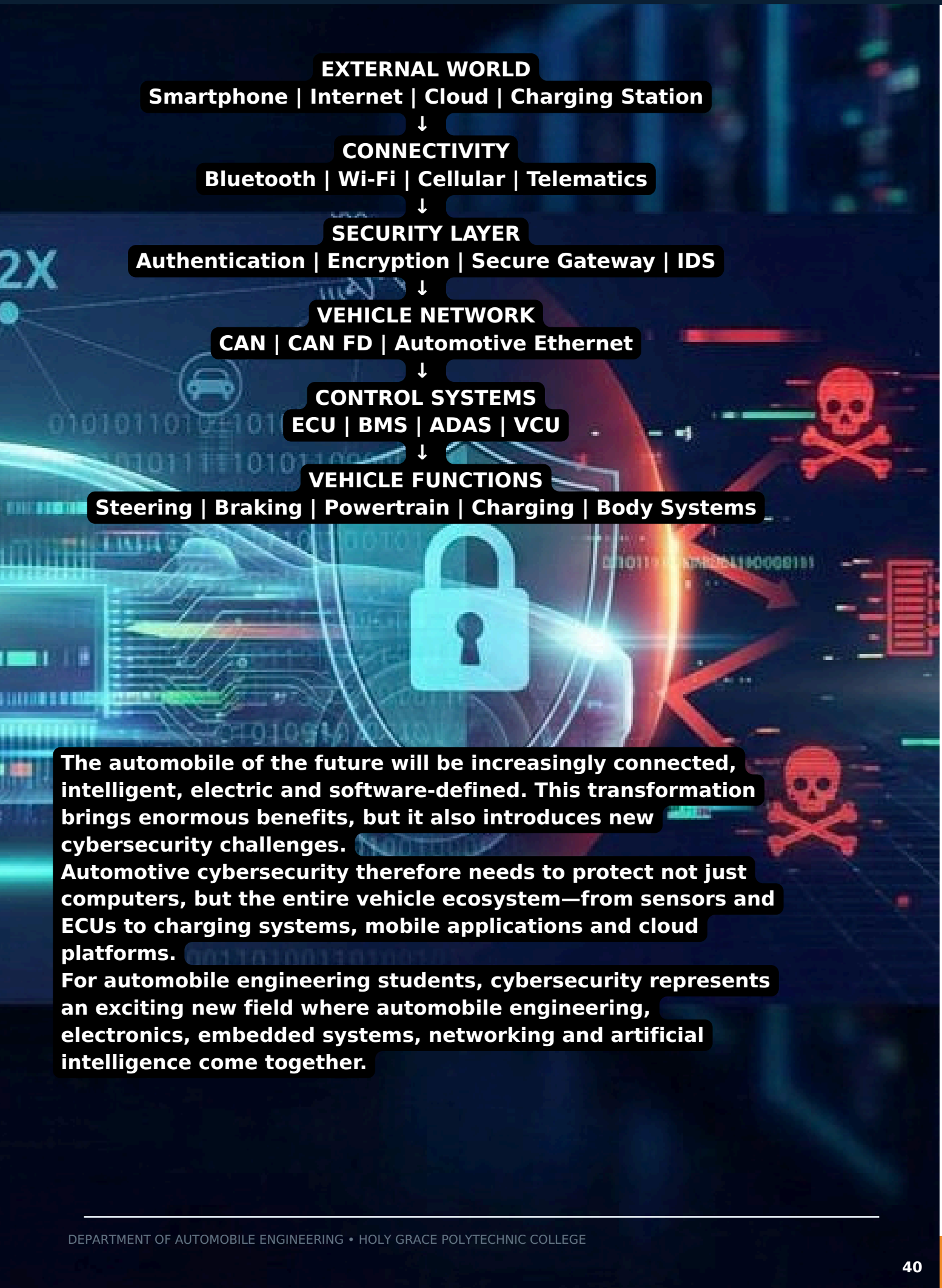
This connectivity provides many benefits, but it also creates additional potential entry points for cyberattacks.

What Can Be Attacked?
Automotive cybersecurity covers a wide range of vehicle systems.
Electronic Control Units
ECUs control systems such as:
Engine
Transmission
Braking
Steering
Airbags
Lighting
Body electronics
Battery management
ADAS
Communication Networks
Modern vehicles use internal communication networks to exchange information between ECUs.
Examples include:
CAN
CAN FD
LIN
Automotive Ethernet
Wireless Interfaces
Potential interfaces include:
Bluetooth
Wi-Fi
Cellular networks
GNSS/GPS
Keyless entry
Smartphone connectivity
Diagnostic Interfaces
Technicians use diagnostic systems to communicate with vehicle controllers. These interfaces must be protected against unauthorised access.
Cloud and Mobile Applications
Connected vehicles may exchange information with manufacturer cloud platforms and smartphone applications.



Cybersecurity in Autonomous Vehicles
Autonomous and highly automated vehicles depend heavily on software and sensors.
They may use:
Cameras
Radar
LiDAR
Ultrasonic sensors
GNSS
High-performance computers
AI algorithms
Digital maps
These systems exchange large amounts of data.





The automobile of the future will be increasingly connected, intelligent, electric and software-defined. This transformation brings enormous benefits, but it also introduces new cybersecurity challenges.

Automotive cybersecurity therefore needs to protect not just computers, but the entire vehicle ecosystem—from sensors and ECUs to charging systems, mobile applications and cloud platforms.

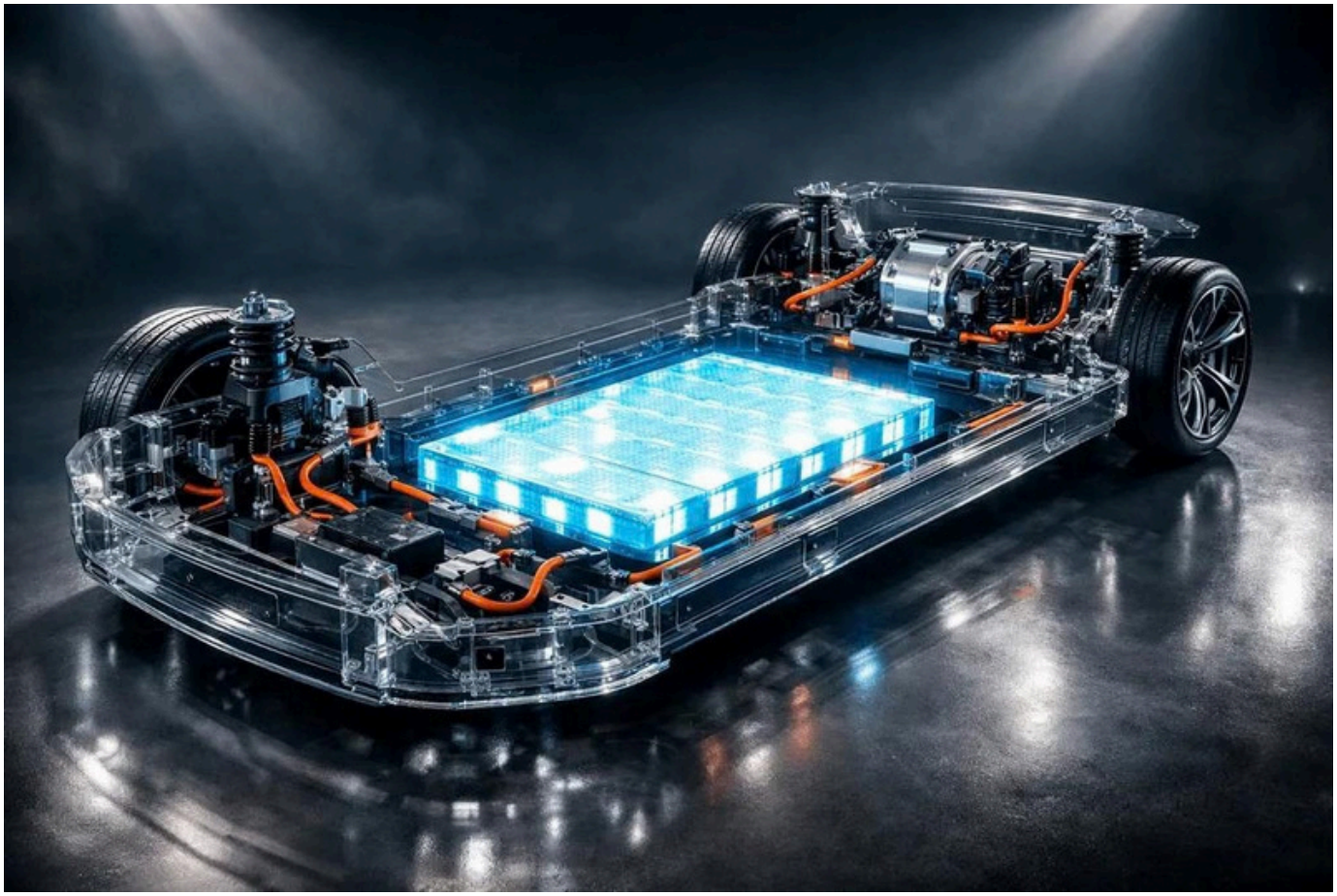
For automobile engineering students, cybersecurity represents an exciting new field where automobile engineering, electronics, embedded systems, networking and artificial intelligence come together.

Solid-State Batteries: The Next Generation of Electric Vehicles

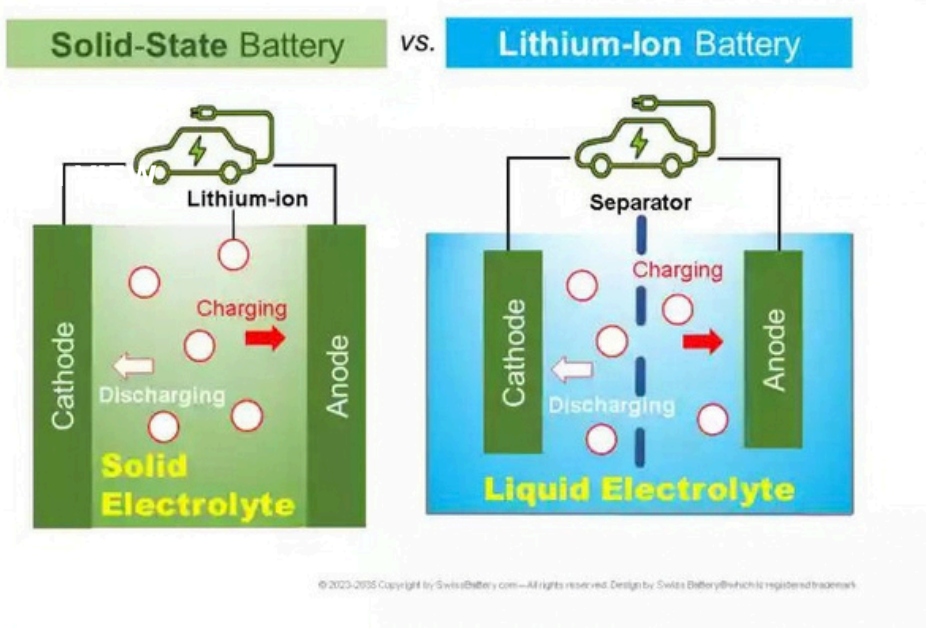
• SIJO SUNNY • REGISTERNO.2301050941

The rapid growth of electric vehicles (EVs) has increased the demand for batteries that can provide higher energy density, faster charging, longer life and improved safety. Although conventional lithium-ion batteries have made modern EVs practical, they still face limitations related to energy density, thermal management, charging time and the use of flammable liquid electrolytes.

Solid-state batteries (SSBs) are being developed as a next-generation battery technology that replaces the conventional liquid or gel electrolyte with a solid electrolyte. This fundamental change could enable EV batteries with greater energy density and improved safety while potentially reducing battery-pack size and weight.

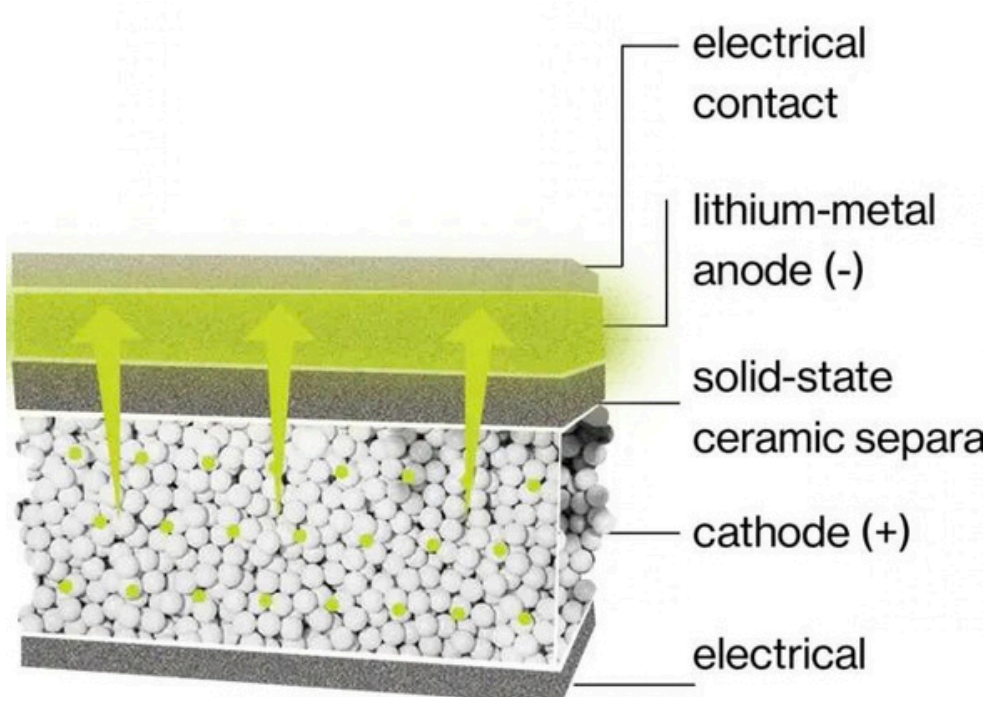


What is a Solid-State Battery?
A conventional lithium-ion battery generally consists of:
Cathode
Anode
Liquid electrolyte
Separator
Current collectors
In a solid-state battery, the liquid electrolyte is replaced by a solid electrolyte.



Lithium-ion technology has achieved excellent commercial success, but EV manufacturers continue to seek improvements in:
Energy Density
Higher energy density means more energy can be stored in the same battery mass or volume.
Safety
Conventional cells contain flammable organic electrolytes. Damage, manufacturing defects or severe overheating can contribute to thermal runaway.
Charging Speed
EV customers increasingly expect charging times closer to the refuelling time of conventional vehicles.
Weight
A lighter battery can improve vehicle efficiency and performance.
Packaging
Higher energy density could allow manufacturers to achieve the same driving range using a smaller battery pack.
Solid-state technology is therefore being investigated as one possible route toward higher-performance EV batteries.

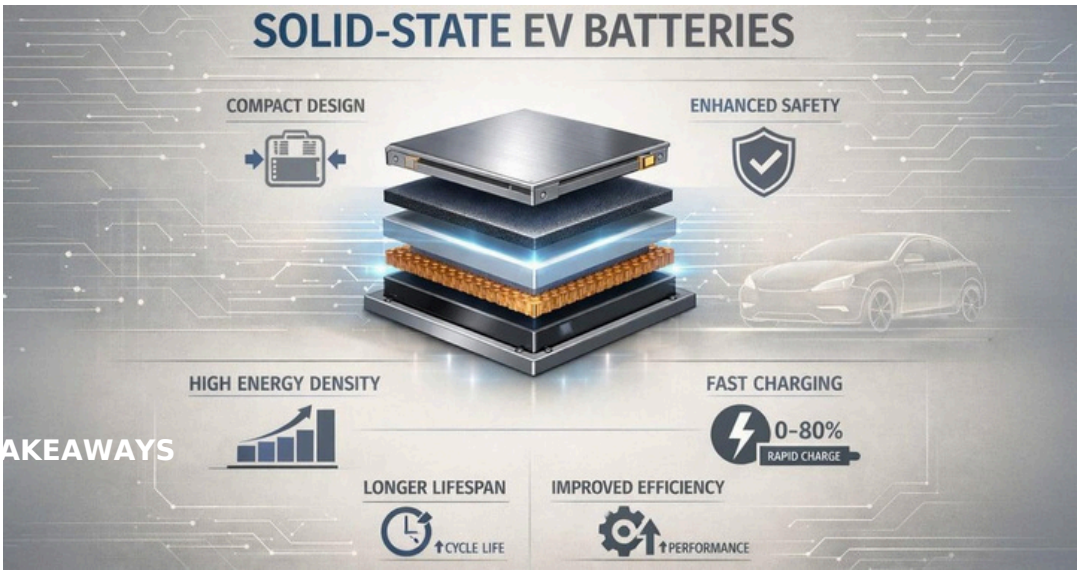
A simplified solid-state cell contains four major elements:
1. Cathode
The positive electrode stores and releases lithium ions during battery operation.
2. Solid Electrolyte
The solid electrolyte allows lithium ions to move between the cathode and anode.
Possible solid-electrolyte families include:
Ceramic/oxide electrolytes
Sulfide electrolytes
Polymer electrolytes
3. Anode
The anode receives lithium ions during charging.
Some solid-state designs use lithium-metal anodes, which can potentially provide significantly higher energy density than conventional graphite anodes.
4. Current Collectors
Metallic layers collect and transport electrons to and from the external circuit.

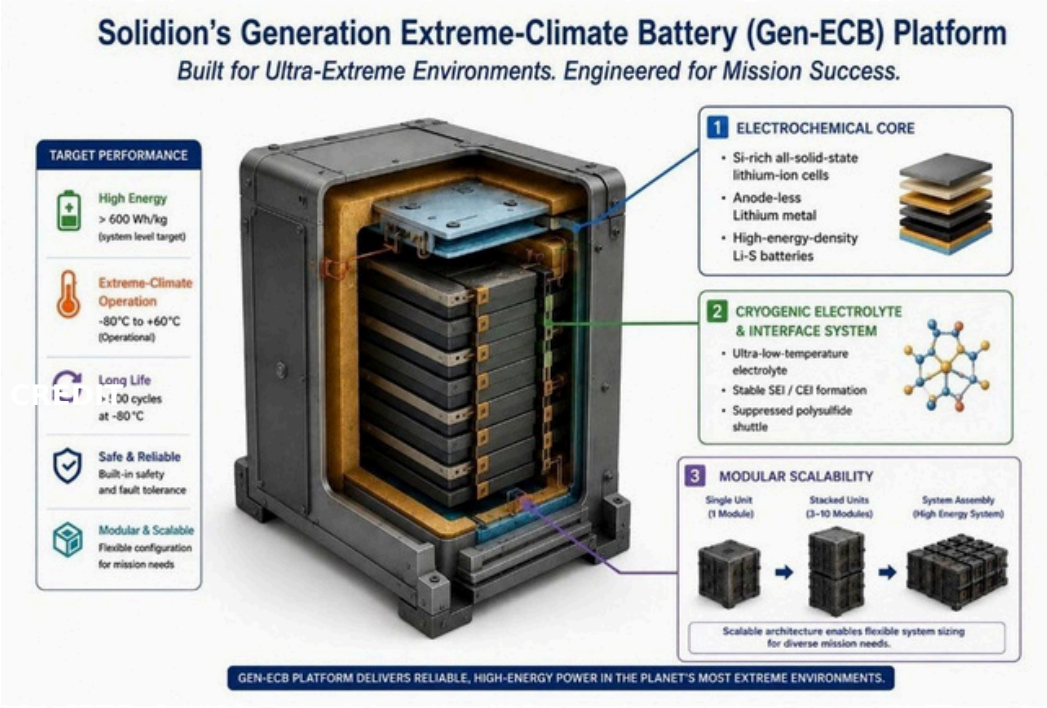


The basic electrochemical principle remains similar to a lithium-ion battery: lithium ions move through the electrolyte while electrons travel through the external circuit.

During Charging
When the battery is connected to a charger:Lithium ions migrate through the solid electrolyte toward the anode, while electrons travel through the external electrical circuit.

During Discharging
The process reverses.
Lithium ions move from the anode toward the cathode, while electrons flow through the external circuit and provide electrical power to the vehicle.





Solid-state batteries represent one of the most promising directions for next-generation electric mobility. By replacing the liquid electrolyte with a solid material and enabling new electrode designs, researchers aim to achieve batteries with higher energy density, improved safety, faster charging and potentially longer service life.

For automobile engineering, the importance of this technology extends beyond the battery itself. Future EV engineers will need knowledge of electrochemistry, battery materials, BMS, thermal management, power electronics, charging systems and vehicle integration.

FEATURE 10

Crash Safety Engineering and Occupant Protection

•YADHUKRISHNANVS•REGISTER NO. 2301050943



Engineering Vehicles to Prevent Crashes, Reduce Injuries and Save Lives
Automobile safety has evolved from simple seat belts and rigid vehicle structures into a sophisticated engineering discipline involving crash simulation, energy absorption, airbags, advanced restraint systems, electronic stability control, pedestrian protection and advanced driver-assistance systems.

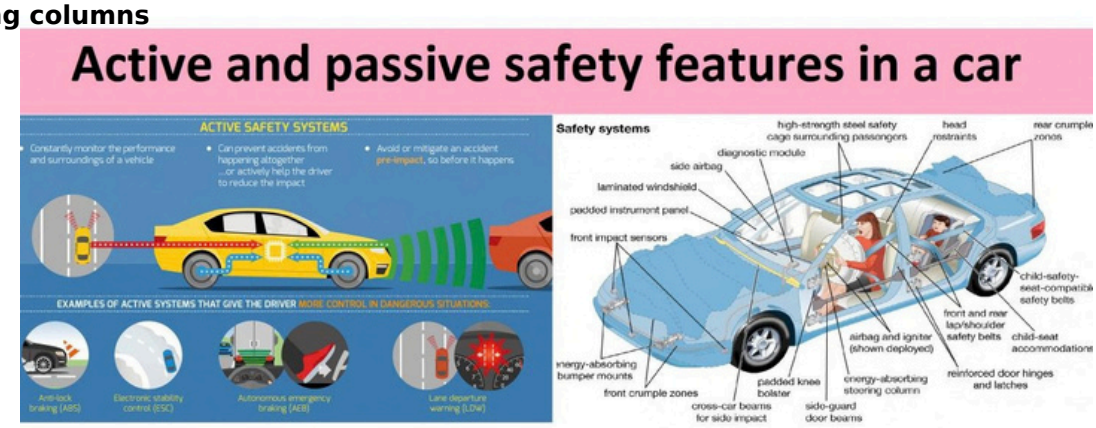
Crash safety engineering is the application of mechanics, materials science, computer simulation, electronics and human biomechanics to design vehicles that protect occupants during collisions.
Engineers study:
Vehicle deformation
Crash forces
Energy absorption
Occupant movement
Seat-belt performance
Airbag deployment
Head and chest injury
Leg and knee protection
Structural integrity
The vehicle is designed to absorb and redirect crash energy while maintaining a sufficiently safe occupant survival space.



Vehicle safety can broadly be divided into:
Active Safety
Active safety systems help prevent a crash.
Examples:
Anti-lock Braking System (ABS)
Electronic Stability Control (ESC)
Traction Control
Automatic Emergency Braking
Lane Keeping Assist
Blind Spot Detection
Adaptive Cruise Control
Driver Monitoring Systems

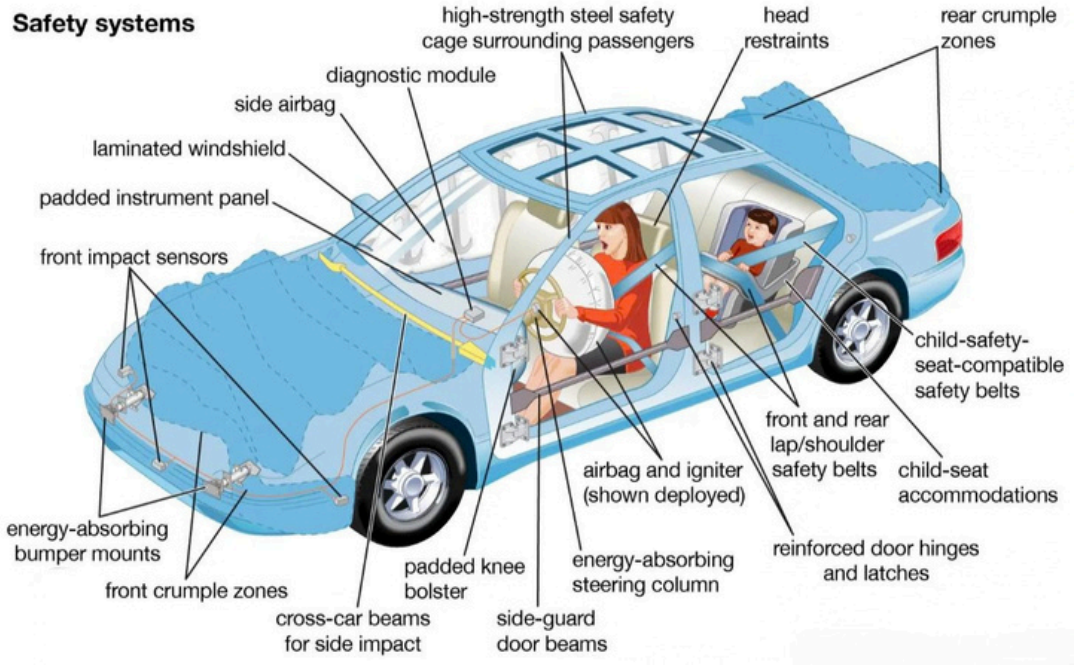


Passive Safety
Passive safety systems protect occupants when a crash occurs.
Examples:
Seat belts
Airbags
Crumple zones
Safety cage
Head restraints
Child restraint systems
Energy-absorbing steering columns
Side-impact protection



Crash Testing
Before a vehicle reaches the market, manufacturers perform extensive safety testing.

Common crash scenarios include:
Frontal Crash
Tests protection during a collision from the front.
Side Crash
Evaluates protection when another vehicle or object strikes the side.
Rear Crash
Evaluates occupant protection during rear impacts.
Rollover Testing
Examines structural and occupant protection during rollover-related scenarios.
Pedestrian Testing
Evaluates potential injury to pedestrians during vehicle impacts.



Computer Simulation in Crash Engineering

Modern crash safety engineering does not rely only on physical crash tests.

Engineers use Computer-Aided Engineering (CAE) and finite-element simulations to study vehicle deformation before building or testing physical prototypes.

Development process

Vehicle CAD Model

↓

Finite Element Model

↓

Virtual Crash Simulation

↓

Analyse Deformation

↓

Modify Structure

↓

Repeat Simulation

↓

Physical Crash Test

This can significantly improve development efficiency and allow engineers to evaluate many design concepts.

Future of Crash Safety Engineering

The next generation of occupant protection will increasingly combine AI, sensors, connected vehicles and adaptive restraints.

Future systems may include:

Predictive Pre-Crash Positioning

If a collision becomes highly likely, the vehicle could prepare occupants and restraints before impact where technically feasible.

Adaptive Airbags

Airbag deployment characteristics could be adjusted based on crash severity and occupant information.

Smart Seat Belts

Advanced belts could continuously adapt restraint characteristics to the driving and crash situation.

AI-Based Crash Prediction

Vehicle sensors could identify potential collision situations earlier.

External Airbags

Research continues into systems that can deploy outside the vehicle to reduce crash energy before it reaches the passenger compartment.



Crash Safety Engineering and Occupant Protection combine structural engineering, materials, electronics, biomechanics, computer simulation and intelligent vehicle systems.

A modern safe vehicle uses a carefully coordinated system:

Strong Passenger Cell + Controlled Crumple Zones + Seat Belts + Airbags + Sensors + ADAS + Intelligent Restraints

The most important lesson is that vehicle safety is not provided by one component. It is the result of many systems working together.

For automobile engineering students, crash safety offers an exciting field combining vehicle design, mechanics, electronics, materials science, simulation and human biomechanics.

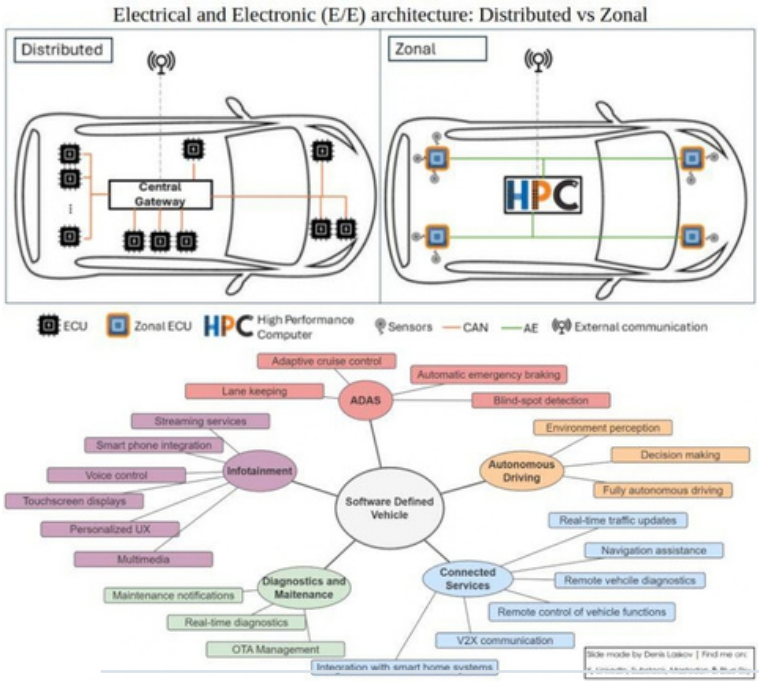
Software-Defined Vehicles

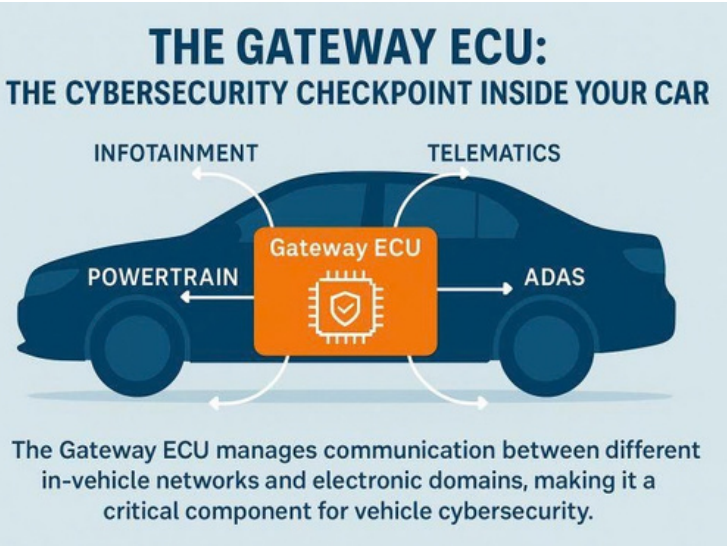
•ABHINANDCV•REGISTER NO. 2301051570

A Software-Defined Vehicle (SDV) is a modern vehicle in which a large portion of its functionality, performance, user experience, and connectivity is controlled and continuously improved through software rather than being permanently determined by hardware.

In a conventional automobile, many functions are controlled by individual Electronic Control Units (ECUs). In an SDV, these functions are increasingly consolidated into high-performance computers, domain controllers, and zonal control units, allowing software to control multiple vehicle systems. This architecture also enables manufacturers to introduce new functions and improvements through Over-the-Air (OTA) updates after the vehicle has been delivered to the customer. IEA

The concept is similar to a smartphone: the hardware provides the basic platform, while software can be updated, enhanced and customized throughout the product's life.





What is a Software-Defined Vehicle?

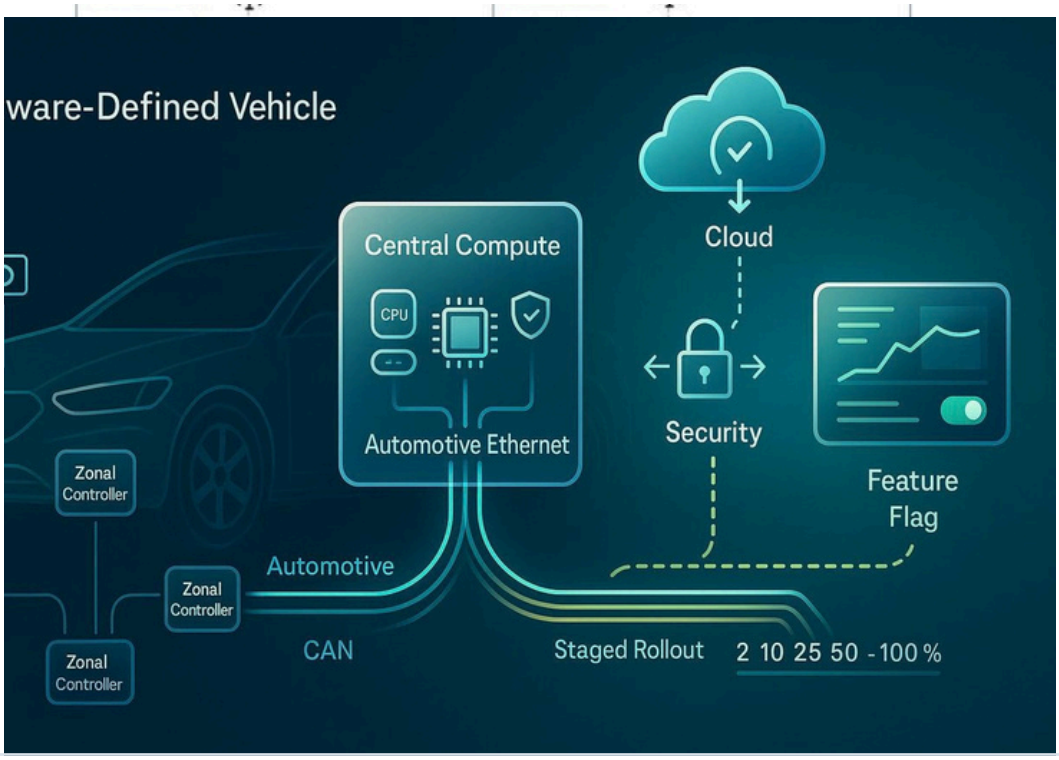
A Software-Defined Vehicle can be defined as:

A vehicle whose functions, features and user experience can be developed, controlled, updated and enhanced primarily through software.

Software can manage or influence:

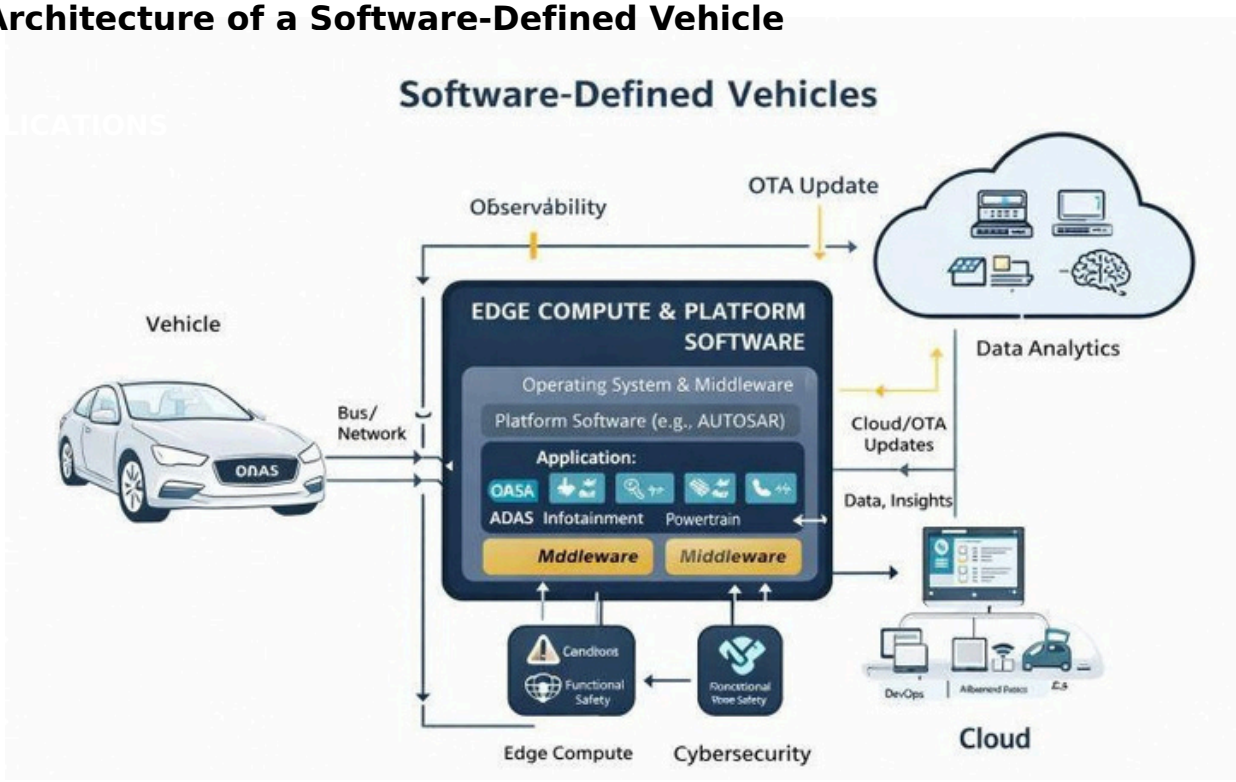
Engine and powertrain control
Electric vehicle battery management
Advanced Driver Assistance Systems (ADAS)
Autonomous driving functions
Infotainment
Instrument clusters
Vehicle connectivity
Climate control
Lighting
Vehicle diagnostics
Charging management
Driver personalization
Predictive maintenance
Cybersecurity

The International Energy Agency notes that vehicles are increasingly becoming software platforms, with continuously updateable functions and even software-based premium features.



Evolution from Conventional Vehicles to SDVs
Traditional Vehicle
Older vehicle architectures generally use many separate ECUs.
Sensors → Individual ECUs → Actuators
For example:
Engine ECU → Engine control
ABS ECU → Braking
Body Control Module → Lighting/body functions
Infotainment ECU → Entertainment
Airbag ECU → Safety
ADAS ECU → Driver assistance
This approach can result in a large number of controllers, wiring connections and communication networks.
Modern SDV
The architecture moves toward:
Sensors → Zonal Controllers → Central Computing → Software Applications
A smaller number of powerful computers can handle multiple functions. Modern zonal architectures organize electronics according to the physical location of components in the vehicle, rather than maintaining a separate controller for every function.

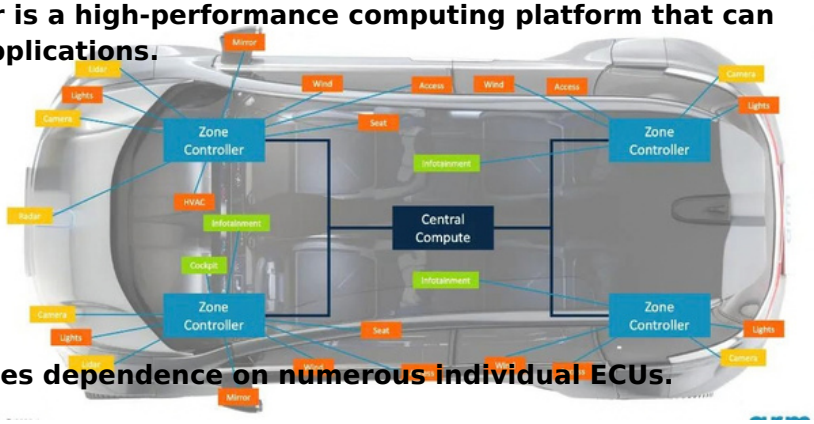
Basic Architecture of a Software-Defined Vehicle



Major Components of an SDV

A. Central Vehicle Computer

The central vehicle computer is a high-performance computing platform that can execute multiple software applications.



It may handle:

ADAS

Infotainment

Vehicle dynamics

Powertrain functions

Diagnostics

Connectivity

Data processing

Centralized computing reduces dependence on numerous individual ECUs.

B. Zonal Control Units

Zone Control Units (ZCUs) are located in different physical areas of the vehicle.

For example:

Front-left zone

Front-right zone

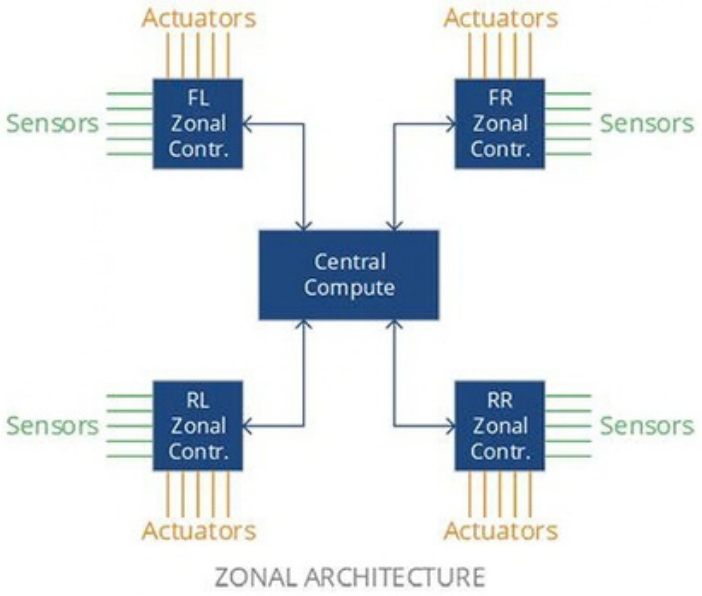
Cabin zone

Rear-left zone

Rear-right zone

Each zone connects nearby sensors and actuators to the vehicle's central computing system.

This arrangement can reduce wiring complexity, weight and the number of individual electronic modules.



Role of Software in SDVs

Software is the core element of an SDV.

It can control:

Vehicle Performance

Software can optimize:

Acceleration

Regenerative braking

Energy consumption

Torque delivery

Battery operation

Comfort

Software can control:

Automatic climate control

Seat adjustment

Ambient lighting

Personalized driver profiles

Infotainment

Safety

Software enables:

Automatic emergency braking

Lane keeping

Blind-spot detection

Adaptive cruise control

Driver monitoring

Connectivity

Software connects the vehicle with:

Smartphones

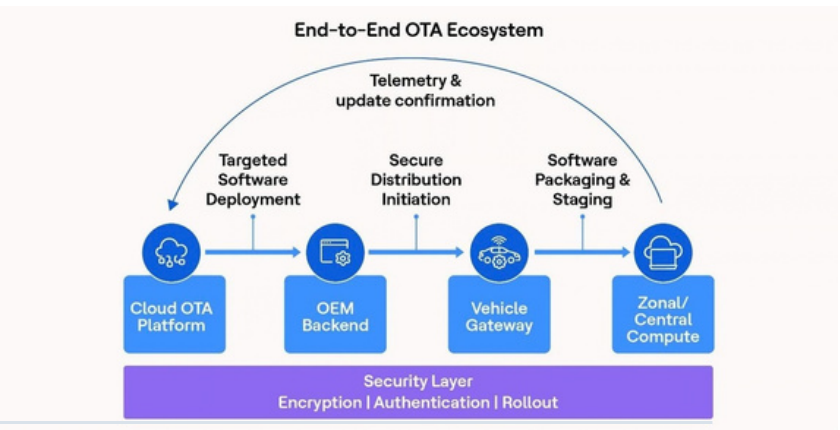
Cloud services

Navigation systems

Charging infrastructure

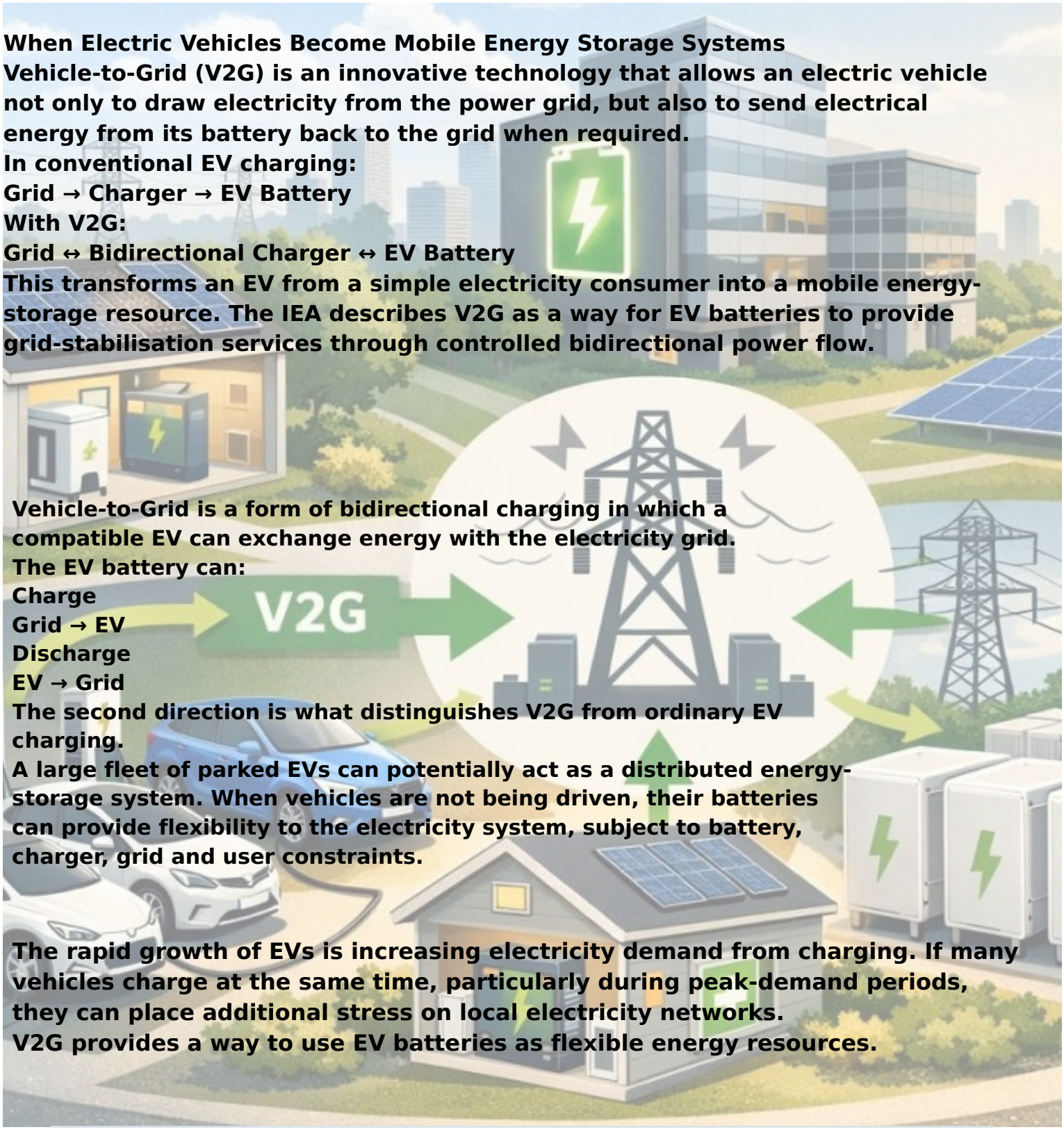
Other vehicles

Smart infrastructure



Vehicle-to-Grid (V2G) Technology

• NIHAL P A • REGISTER NO. 2301051577



When Electric Vehicles Become Mobile Energy Storage Systems

Vehicle-to-Grid (V2G) is an innovative technology that allows an electric vehicle not only to draw electricity from the power grid, but also to send electrical energy from its battery back to the grid when required.

In conventional EV charging:

Grid → Charger → EV Battery

With V2G:

Grid ↔ Bidirectional Charger ↔ EV Battery

This transforms an EV from a simple electricity consumer into a mobile energy-storage resource. The IEA describes V2G as a way for EV batteries to provide grid-stabilisation services through controlled bidirectional power flow.

Vehicle-to-Grid is a form of bidirectional charging in which a compatible EV can exchange energy with the electricity grid.

The EV battery can:

Charge

Grid → EV

Discharge

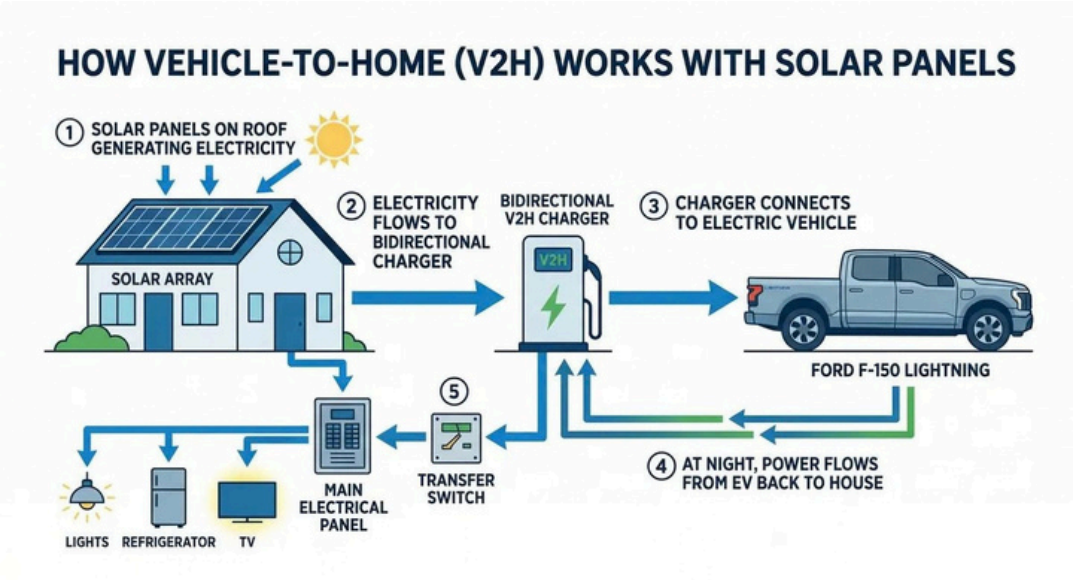
EV → Grid

The second direction is what distinguishes V2G from ordinary EV charging.

A large fleet of parked EVs can potentially act as a distributed energy-storage system. When vehicles are not being driven, their batteries can provide flexibility to the electricity system, subject to battery, charger, grid and user constraints.

The rapid growth of EVs is increasing electricity demand from charging. If many vehicles charge at the same time, particularly during peak-demand periods, they can place additional stress on local electricity networks.

V2G provides a way to use EV batteries as flexible energy resources.



V2G system contains several important components:

Electricity Grid

↕

Bidirectional EV Charger

↕

Vehicle Charging Interface

↕

Power Electronics

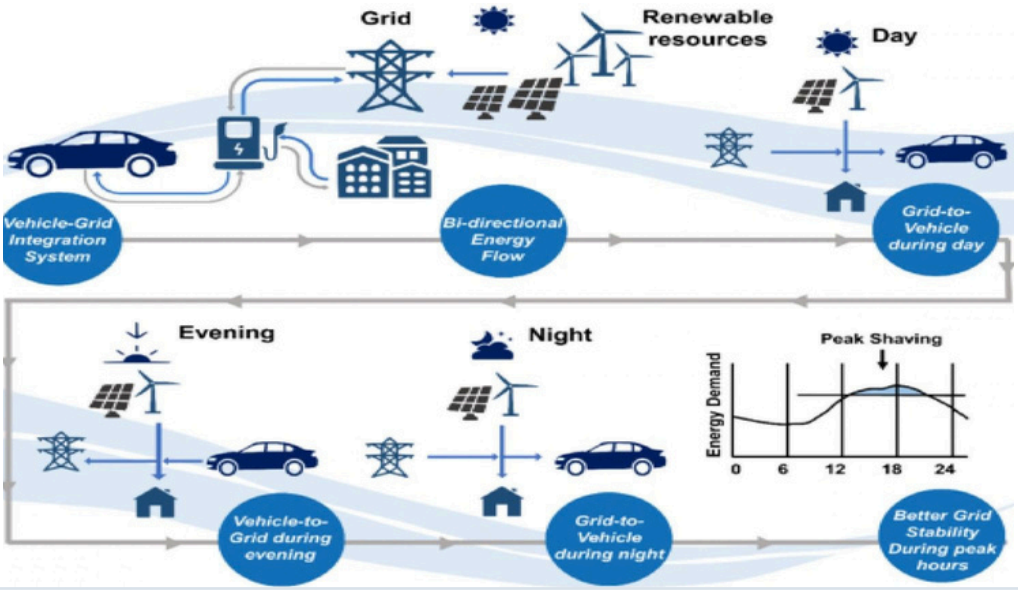
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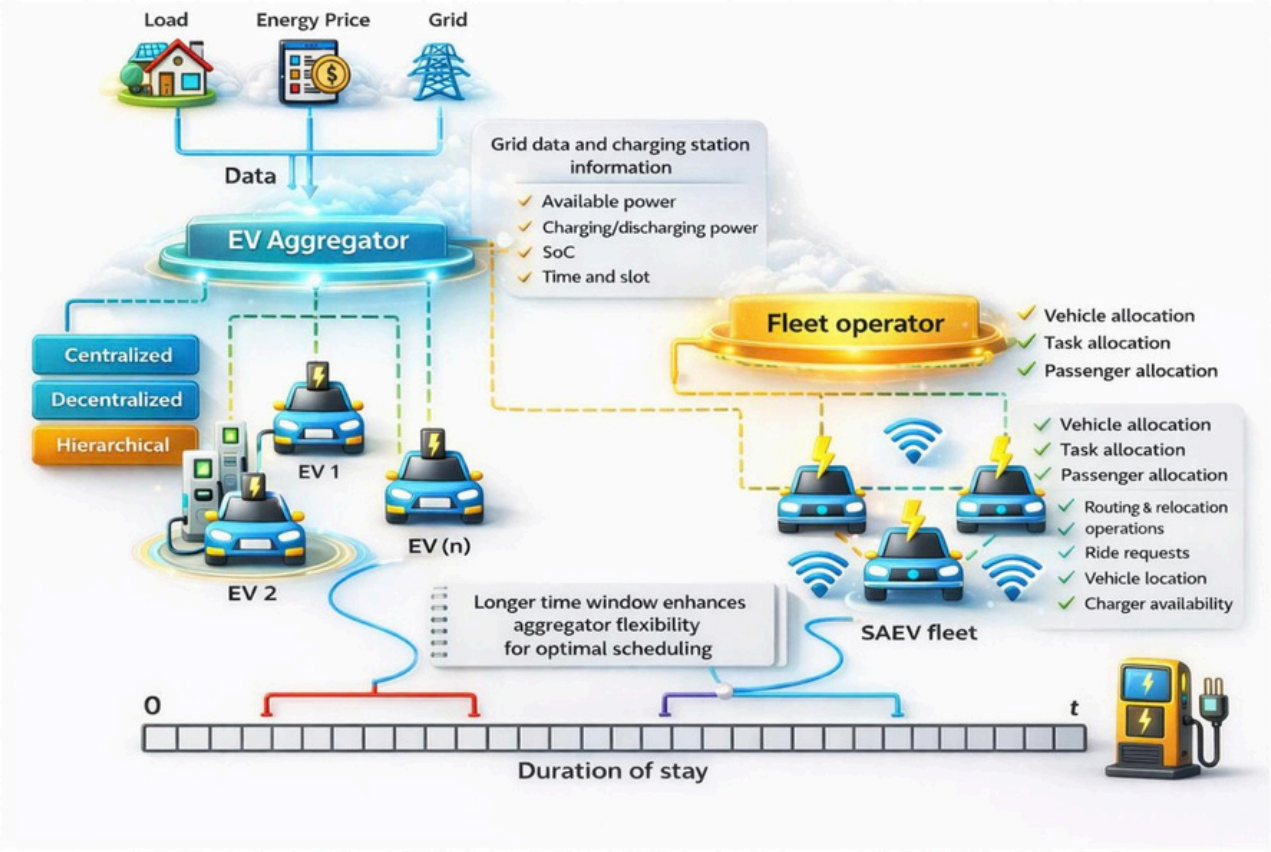
Battery Management System

↕

High-Voltage Battery

The system also requires communication and control between the EV, charger, energy-management system and grid.





V2G operation can be explained in several stages.
Step 1 – EV Connection
The EV is connected to a V2G-compatible charging station.
Step 2 – Communication
The vehicle and charging system exchange information about:
Battery condition
State of charge
Charging requirements
Available power
User preferences
Grid requirements
Step 3 – Energy Management
A control system determines whether the battery should:
Charge → Remain Idle → Discharge
Step 4 – Bidirectional Power Conversion
Power electronics control the direction and amount of electrical energy.
Step 5 – Battery Protection
The BMS ensures that charging and discharging remain within safe operating limits.
Step 6 – Grid Interaction
When authorised, electricity flows from the EV battery toward the grid.

Benefits of V2G

⚡ Grid Support

EV batteries can provide flexibility during periods of high demand.

🌱 Renewable Energy Integration

V2G can help absorb surplus renewable electricity.

💰 Potential Economic Benefits

Depending on local programmes and regulations, EV owners or fleet operators may be compensated for providing grid services. IEA

🔌 Backup Power

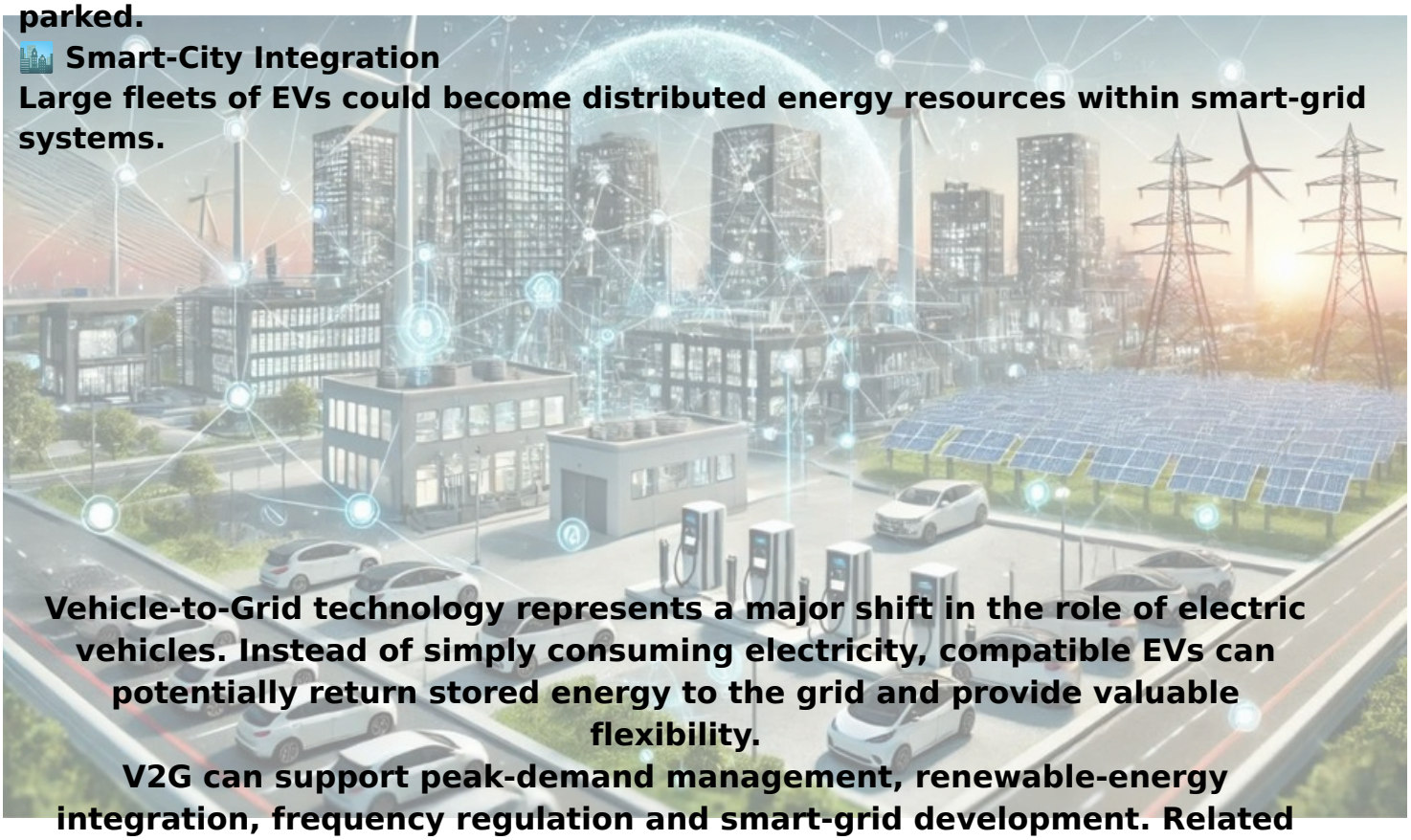
Related bidirectional technologies can provide power to homes and buildings.

🚗 Better Battery Utilisation

The EV battery can perform an additional energy-storage role when the vehicle is parked.

🏙️ Smart-City Integration

Large fleets of EVs could become distributed energy resources within smart-grid systems.



Vehicle-to-Grid technology represents a major shift in the role of electric vehicles. Instead of simply consuming electricity, compatible EVs can potentially return stored energy to the grid and provide valuable flexibility.

V2G can support peak-demand management, renewable-energy integration, frequency regulation and smart-grid development. Related technologies such as V2H and V2B can also provide backup power and energy-management benefits. IEA

However, widespread V2G adoption requires progress in bidirectional charging hardware, battery management, interoperability, cybersecurity, regulations, economics and battery-life management.

For automobile engineering students, V2G is an excellent example of how the automobile is evolving from a mechanical transportation machine into an intelligent, connected and energy-aware system.






AIR
COMPRESSOR









AUTOMOTIVE CAREER PATHWAYS

Automobile engineering skillscanlead to roles across mechanicalsystems,electrification, electronics, diagnostics, manufacturing, safety, testing and software-enabled mobility.

VEHICLE SERVICE & DIAGNOSTICS
Inspection • troubleshooting • scan tools • maintenance

EV & BATTERY TECHNOLOGY
Battery systems • charging • thermal management • power electronics

AUTOMOTIVE DESIGN
CAD • materials • vehicle systems • prototyping

SAFETY & TESTING
Crash analysis • validation • ADAS • testing

MANUFACTURING
Robotics • PLC • quality • production engineering

CONNECTED MOBILITY
Telematics • cybersecurity • software • data systems

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EDITORIAL TEAM

ALBERT JOSEPH T • 2301051572

BHARATH KRISHNA K U • 2301051574

PRAVEEN P S • 2301051578

RICHU V R • 2301050935

HRIJUKARAN M V • 2301051575

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