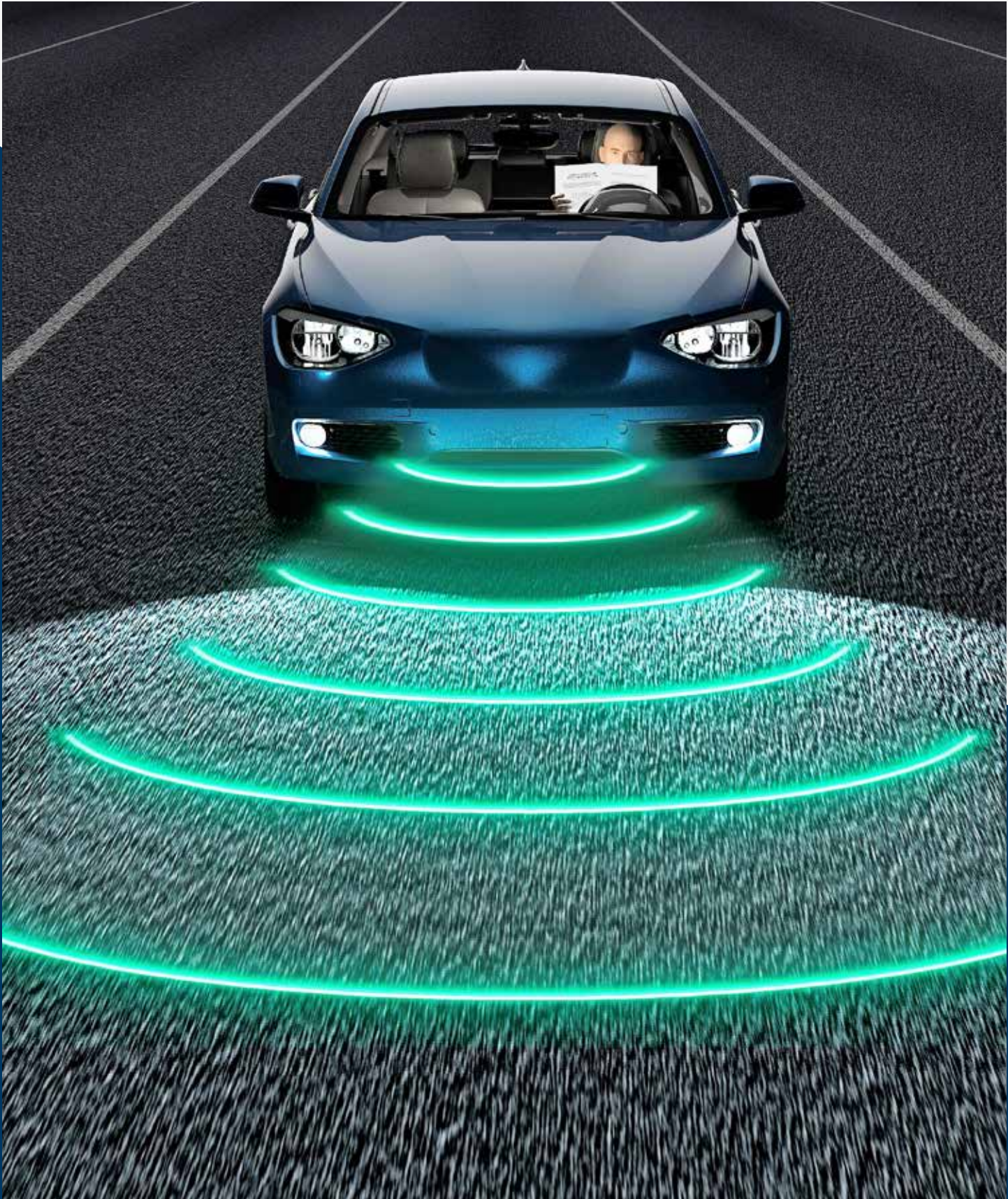




The new age of mobility







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Preparing the transition

Not so long ago, owning a car was experienced as a way of increasing one's personal freedom. It was even seen as a rite of passage into adulthood, helping the young on their way to gaining full independence. But those perceptions are gradually changing, especially in large cities. CO₂ pollution as well as endless traffic jams and difficulties to park are perceived as limiting one's personal freedom rather than facilitating it.

We are moving into a different era: while the 20th century was the age of the fuel-powered car, the 21st will most probably be characterized by new and less polluting forms of transport. Various types of electric vehicles (EVs), from electric cars and buses to e-scooters or e-bikes are becoming ubiquitous in our cities. Hybrid solutions involving batteries and combustion engines have already been widely adopted. Self-driving technology is also making headway as car manufacturers rival one another to produce the most appealing robot vehicles. Many underground systems worldwide already run autonomously and other forms of public transport – pods or buses – could soon become driverless. Car ownership is predicted to decrease as various types of rental systems are offered by cities. Even flying taxis are one of the options envisaged by some city planners.

As we prepare for this new age of mobility, IEC International Standards and Conformity Assessment Systems are helping the various industries, regulators and experts involved to move forward and pave the way for these transport systems to be safe and performance-driven while being as green and as energy efficient as possible.

IEC recently established a new technical committee, IEC TC 125, to prepare standards for personal e-transporters intended for use on the road or in public spaces. IEC TC 125 has built liaisons with several other IEC TCs, including IEC TC 69: Electrical power/energy transfer systems for electrically propelled road vehicles and industrial trucks. It also collaborates with some ISO TCs, including ISO TC 22: Road vehicles, and ISO TC 149: Cycles. IEC TC 125 is currently working on the first edition of a safety standard for personal e-transporters, IEC 63281.

IEC TC 69 prepares standards for a wide variety of EVs and is leading the way on the development of many technologies used for these new mobility systems. Its scope of standardization includes, but is not limited to, passenger cars and buses, two- and three-wheel as well as light four-wheel vehicles, goods vehicles, trailers and trucks, including special and industrial trucks.

IEC TC 21 produces standards for secondary cells and batteries and works closely with IEC TC 69.

Smart cities and smart transport

New mobility systems are an integral part of smart city planning. IEC has developed many standards which deal with crucial elements for the efficient functioning of cities. Rather than focus on each of these standards in isolation, IEC has adopted a systems approach to city standards. IEC SyC Smart cities, the IEC systems committee for electrotechnical aspects of smart cities, aims to foster the development of standards in the field of electrotechnology to help with the integration, interoperability and effectiveness of city systems, including smart mobility systems.



IEC has also formed with the International Standardization Organization (ISO) the joint technical committee ISO/IEC JTC 1 to prepare standards in the field of information technology (IT). Many of the standards issued by its various subcommittees pave the way for the future of smart cities. One of the JTC 1 working groups, ISO/IEC JTC 1/WG 11, is tasked with preparing functional standards for the use of information and communication technology (ICT) in smart cities. It recently published the key standard ISO/IEC 30146, which provides assessment indicators and evaluation methods with which to measure the functionality of different ICT systems within an urban area. Indicators have been developed to evaluate a city's transportation, public safety and city management services. They can be used to measure a smart city holistically or be tailored to measure individual components such as transport systems.

Many other ISO/IEC JTC 1 Standards play a part in defining advanced mobility systems, especially for autonomous vehicles.

IEC Standards and CA Systems for safe mobility systems

In transportation, safety has always been a key concern. EVs and new forms of autonomous mobility require standards to perform adequately and safely. For instance, lithium-ion batteries, which are increasingly used for EVs,

may suffer thermal runaway and cell rupture if overheated or overcharged, a situation which in extreme cases can lead to fires.

While the IEC publishes safety standards for lithium-ion batteries (see page 7), it has also established the conformity assessment (CA) system IECEE (IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components), which applies to batteries and charging systems. These can be tested for safety, performance, component interoperability, energy efficiency, electromagnetic compatibility (EMC), hazardous substances, chemicals and explosion safety. Another CA system, IECQ (IEC Quality Assessment System for Electronic Components) offers the IECQ automotive qualification programme, which certifies the electronic components used in vehicles.

Together IEC International Standards and CA Systems are laying the groundwork for new, smart and greener mobility systems, which will enable a more sustainable use of planetary resources. IEC work contributes to meeting all United Nations Sustainable Development Goals (UN SDGs), including SDG 7, which aims to ensure access to affordable, reliable, sustainable and modern energy for all; SDG 11, which seeks to make cities and human settlements inclusive, safe, resilient and sustainable; and SDG 13, which vows to combat climate change and its impacts.



Electric vehicles are becoming mainstream



According to a report on electric vehicles published by the International Energy Agency (IEA), the global stock of EVs is increasing rapidly year on year. The number of electric charging station points has also skyrocketed.

In one of its less ambitious scenarios, based on the impact of announced policies, the IEA estimates that in 2030, global EV sales will reach 23 million and the overall stock will exceed 130 million vehicles (excluding two/three-wheelers). Projected EV stock in the policies scenario would cut demand for oil products by 127 million tonnes of oil equivalent (about 2,5 million barrels per day). Electricity demand to serve EVs is projected to reach almost 640 terawatt-hours. The IEA also points out that resulting CO₂ emissions savings are significantly higher for electric cars used in countries where the power generation mix is dominated by low-carbon sources. Even when the power mix relies partly or extensively on fossil fuels, the use of EVs significantly reduces global carbon emissions.

These projections indicate how the increasing use of EVs will have a direct impact on the environment and climate change, especially if the electricity used to power them is not generated by coal or other fossil fuels. These IEA estimations do not include e-bikes, e-mopeds, e-scooters or electric pods and buses, which are also transforming our cities. Neither do they include EVs used throughout industry and agriculture, from forklift trucks to electric tractors. For example, most forklift trucks are now propelled by batteries or hybrid systems combining batteries and diesel or petrol as well as fuel cell technology.

E-scooter rental systems, especially, have proliferated in numerous cities recently, as they are easy to use, are not hindered by traffic bottlenecks and are easy to park.

In China, a massive number of buses are now electrical. Another important means of transport in China is e-bikes, which look more like mopeds than the electric bikes with



pedals used in Europe and the US. IEC TC 21 is preparing IEC 63193, a performance standard for the batteries used in these types of EVs as well as electric rickshaw-type three wheelers. The latter are also widespread in China and many other Asian countries.

EVs and the electrical grid

EVs use the power provided by the electricity network to recharge their batteries. This means that electrical grids will have to be able to accommodate this increased demand for electrical power.

IEC TC 57 prepares some of the core standards relevant to smart grid technology and the integration of renewable energy sources, as well as distributed energy resources (DERs), in the existing grid. The IEC 61850 series includes multiple ground-breaking standards in that area. One of

the TC 57 working groups, WG 17, was set up to prepare IEC 61850 Standards for distribution automation, storage and microgrids and DERs, including the smart charging of EVs. It publishes the technical report IEC TR 61850-90-8, which shows how one of the IEC 61850 Standards, IEC 61850-7-420, can be used to model the essential parts of the e-mobility standards related to EVs and EV supply equipment.

Renewable sources of energy are increasingly complementing other energy sources, in a bid to reduce CO₂ emission levels. They are integrated into the electricity networks which are becoming smarter and capable of dealing more easily with fluctuating sources of energy such as sun and wind. At least six IEC TCs prepare specifications for renewable energy systems:

- IEC TC 4: Hydraulic turbines
- IEC TC 5: Steam turbines
- IEC TC 82: Solar photovoltaic energy systems
- IEC TC 88: Wind energy generation systems
- IEC TC 114: Marine energy – Wave, tidal and other water current converters
- IEC TC 117: Solar thermal electric plants

Energy storage and batteries

An interesting feature of EVs plugged into the electric mains is that they could be used instead of, or in conjunction with, other electrical energy storage systems in emergencies or during extreme supply shortages, to deliver power to the grid. Leveraging a two-way flow of electricity from EV battery storage to balance power supply and demand could also help global efforts to integrate more renewables into the power mix. In that function, EVs become DERs just like wind turbines or solar modules. The vehicle-to-grid communication interface which is necessary for this two-way flow of energy can be derived partly from the specifications in IEC 61850-7-420, published by IEC TC 57.

IEC is laying the groundwork for new forms of energy storage systems. Several technical committees are involved in preparing standards for forward-thinking storage technologies. One of these involves hydrogen, an attractive option for large-scale and long-term energy storage as well as for powering EVs.

In Japan, car manufacturers have taken the lead in championing fuel cell EVs. Unlike conventional vehicles which run on gasoline or diesel, fuel cell cars and trucks

combine fuel – usually hydrogen – and oxygen inside a cell to produce electricity, which powers a motor. The cars emit water vapour instead of CO₂.

IEC TC 105 develops standards dealing with many aspects of fuel cell technology. IEC 62282-4-102, for instance, covers performance test methods of fuel cell power systems intended to be used for electrically powered industrial trucks.

Most EVs, however, function thanks to the energy stored in conventional batteries. IEC TC 21 publishes several important standards, including the IEC 62660 series on secondary lithium-ion cells for the propulsion of EVs, which includes three different publications: the first deals with performance testing, the second with reliability tests and the third with safety requirements. While lithium-ion batteries are increasingly used for EVs, other types of batteries are also employed, whether nickel-metal hydride or lead-acid. IEC TC 21 publishes safety and performance standards for lead-acid and nickel-metal hydride batteries. One example is IEC 61982-4, which specifies test procedures and criteria for the safety performance of nickel-metal hydride secondary cells used for the propulsion of EVs.

Ultracapacitors store energy using electrodes and electrolytes. These can accept and deliver charge much faster than batteries can and tolerate many more charge and discharge cycles than rechargeable batteries. IEC TC 40 publishes IEC 62391-1, which establishes the generic specifications for fixed supercapacitors used in electric and electronic equipment, also known as electric double-layer capacitors. IEC TC 69 issues IEC 62576 which specifies test methods for electric double-layer capacitors for use in hybrid EVs.

Dealing with e-waste and recycling

Batteries used for EVs have limited lifespans. While lead-acid batteries are 98% recyclable, using easily accessible processes, they nevertheless contain lead which is being phased out in many countries. Lithium-ion batteries can also be recycled, but this process remains expensive and, for the time being, the rates of material recovery rarely top 20%. In addition to lithium, the raw materials used in these batteries include nickel, cobalt and manganese which are both expensive and difficult to procure. Research is progressing quickly, however, and some labs have managed to reach 80% recovery levels.

Another option which is gaining ground is the reuse of these batteries for second life applications. Lithium-ion batteries that have been used in one application could be assessed for their ability to be used in other, less demanding applications. Batteries from EVs could be reused in everything from back-up power for data centres to energy storage systems. In Europe several vehicle manufacturers, who are pioneers in the electric car market, have installed used batteries in different kind of energy storage systems, ranging from small residential devices to larger containerized grid-scale solutions.

IEC TC 21 and IEC TC 120, which develop standards for large electrical energy storage systems, have several ongoing projects to formalize issues relating to second-life battery usage. The EU is preparing legislation on the topic and is examining existing standards.



Circular economy models reassess how resources are managed and how waste is dealt with throughout the entire lifecycle of a product from its initial design to its use, repair, reuse, remanufacture and, ultimately, its transformation into parts for new products.

IEC is preparing the ground for these new models. It has set up the IEC Advisory Committee on environmental aspects (ACEA), which provides guidance on standardization related to the environment, including the circular economy. IEC TC 111 develops horizontal standards related to environmental issues, covering material declaration, environmentally conscious design or toxic substance measurement. One of its most recent publications is IEC 62474, a material declaration standard, which helps organizations to determine whether they comply with restricted substance lists, as specified by regulators across

the world. Companies can also use the information to shape environmentally conscious design and for other uses – for example end-of-life and recycling methods.

IEC TC 21 publishes IEC 62902, which defines how to use the markings indicating the chemistry of secondary batteries. Many recycling processes are chemistry specific and incidents can occur when a battery which is not of the appropriate chemistry enters a given recycling process. The marking of batteries ensures safe handling during sorting and recycling. A new machine-readable edition which will involve a different marking system is under consideration.



Wireless charging and energy harvesting

The concept of medium-range wireless power transfer (WPT), achieved using near-field electromagnetic coupling, has existed since the pioneering work of Nikola Tesla more than a century ago. In a wireless power transmission system, a transmitter device, driven by electricity from a power source, generates a time-varying electromagnetic field, that transmits power across space to a receiver device, which extracts power from the field and supplies it to an electrical load.

For medium-range applications, such as EV charging, inductive WPT systems have generally been preferred. They use magnetic field coupling between conducting coils embedded in the roadway and the vehicle.

IEC TC 69 publishes several standards on WPT systems, and its WG 7 deals specifically with EV WPT systems. IEC TC 69 publishes IEC 61980-1, which specifies the general requirements for EV WPT systems.

Dynamic or in-motion WPT is a promising technology for EVs but is still in its infancy. A future is at hand in which power generated by nearby wind and solar resources is delivered wirelessly from the road to the vehicle while it is in motion. IEC TC 69 set up a project team to deal with interoperability and safety issues relating to dynamic WPT systems.

IEC TC 47 develops standards for semiconductor devices including where energy harvesting (EH) is concerned. Thermoelectric generators (TEGs) can be used to harvest energy from roads. TEGs convert geothermal energy – produced from the heat differential between the road surface and the layers beneath – into electrical energy. As the temperature differential increases, more electrical energy is produced. The IEC 62830 series of standards is laying the foundation for various types of EH, whether thermoelectric or piezoelectric.

Piezoelectric crystals can be embedded beneath a layer of asphalt. As vehicles drive over the road, the wheels exert a force that causes these crystals to deform and generate electrical energy. This energy can then be stored in batteries for later use. IEC TC 49 develops standards which address piezoelectric, dielectric and electrostatic devices.





Plugging in the mains

While the IEC is preparing the future for EH and WPT, most EVs still plug into the electric mains to recharge their batteries. IEC TC 23/SC 23 H develops standards for plugs and couplers intended for the connection of EVs to the supply network and/or to dedicated supply equipment. The IEC 62196 series of standards deals with these aspects and anything connected to the conductive charging of EVs.

IEC TC 69 publishes the IEC 61851 series of standards pertaining to EV requirements for conductive connection to an alternate current (AC) or direct current (DC) supply.

DC charging systems are an exciting breakthrough for EVs. Unlike AC chargers, a DC device includes a converter inside. That means it can feed power directly to the vehicle's battery and does not need an onboard charger to convert from AC to DC. This renders the process much faster, as the available charging power is considerably higher. It is also more energy efficient.

IEC TC 8 publishes IEC 60038, which specifies standard voltage values intended to serve as preferential values for electrical supply systems and as reference values for equipment and systems design. The standard applies to both AC and DC traction systems.

Autonomous and smart mobility

The advent of self-driving vehicles is envisaged by city planners as well as by manufacturers in the transport industries. Most cars, as well as trucks and buses, already have semi-autonomous features, such as assisted parking or even some form of obstacle detection.

While the technology involved is progressing quickly, many regulatory and safety hurdles need to be overcome before fully autonomous vehicles can hit the roads. IEC publishes international standards to address those issues.

Autonomous vehicles require sensors, cameras, radar system and in some cases light detection and ranging (LIDAR), which is a remote sensing method that uses light in the form of a pulsed laser to measure variable distances between objects. IEC Standards help to specify the safety and performance benchmarks for many of these devices.

IEC TC 47, which produces some of the key standards relating to sensors, publishes IEC 62969, which deals with the general requirements of power interfaces for automotive vehicle sensors. IEC TC 100 publishes standards for audio, video and multimedia systems and has established Technical Area 17 focused on multimedia systems and equipment for vehicles. IEC TC 100/TA 17 issues IEC TS 63033-1, covering a technology which enables drivers to see all around their vehicles, from different perspectives. The drive monitoring system uses “free eye point” technology to create a composite 360° image from external cameras. It ensures the correct positioning of a vehicle in relation to its surroundings by creating an optimal display based on input image from a rear-view monitor for parking assistance, a blind corner monitor and a bird’s-eye view monitor.

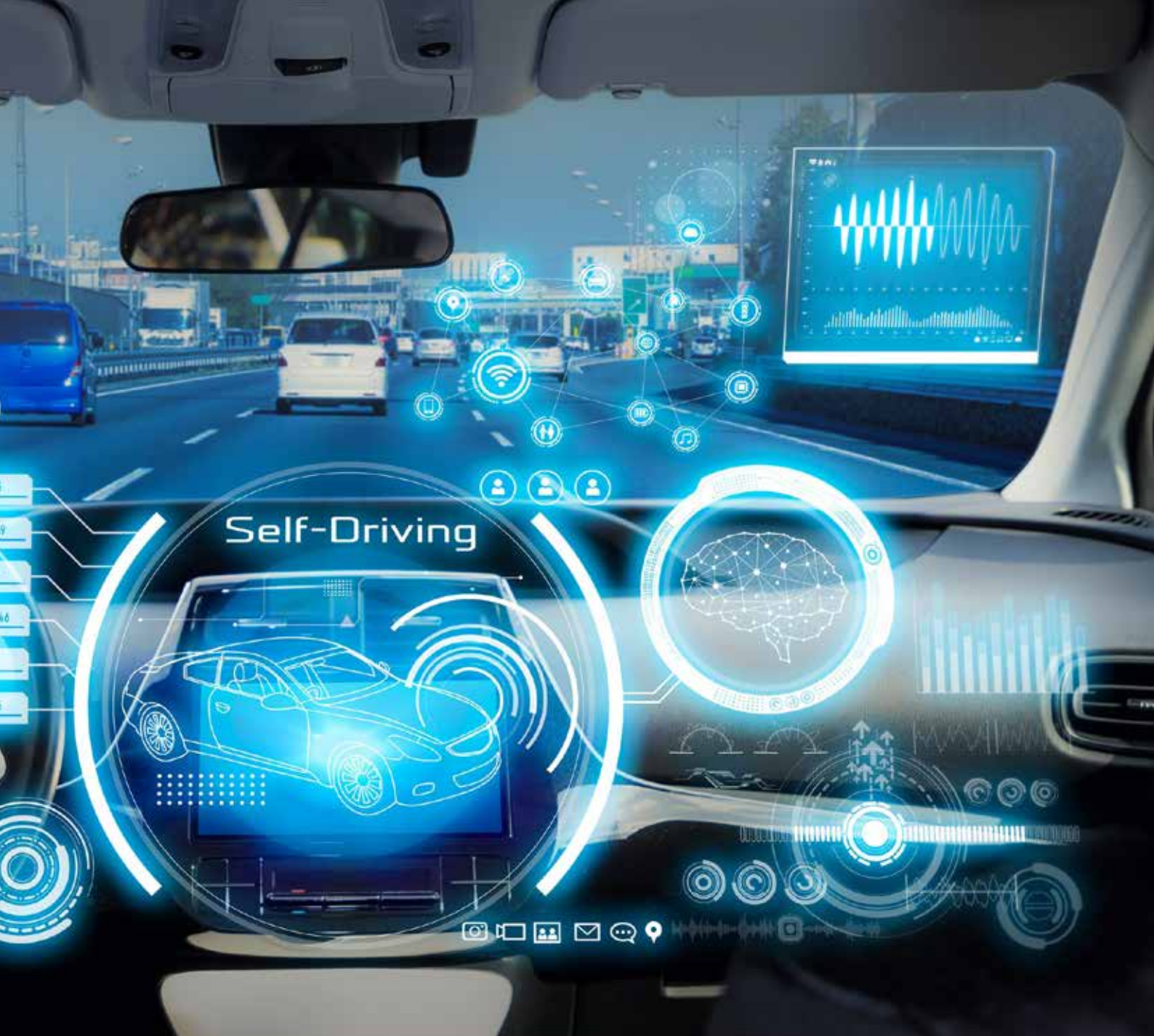
The Internet of Vehicles

Automotive manufacturers and telecom operators are making plans for connected cars, based on 5G communication networks, which are in the early phases of roll-out in some countries. The connection speed of this latest generation mobile communication system is much higher and delivers signals more reliably than in previous networks.



IEC TC 106 prepares standards for measuring human exposure to electromagnetic fields, and publishes IEC 62232, which provides methods for determining radio-frequency field strength near the radio base station and includes frequencies used for 5G.

Most experts refer to the systems employed to connect autonomous vehicles with other devices as the Internet of Vehicles (IoV). ISO/IEC JTC 1 is already paving the way for the IoV. Its subcommittee SC 41 prepares standards for the IoV. It publishes generic standards which help IoT systems to interoperate, for instance ISO/IEC 30141. It is also planning to issue standards relevant to specific applications areas such as the IoV. An advisory



group has been established to prepare the ground for autonomous and data rich vehicles standardization.

Sensors for autonomous vehicles capture data which is stored in a central cloud or edge-computing system. ISO/IEC JTC1/SC 38 produces standards for cloud computing and distributed platforms. The data collected and stored from connected vehicles is shared and analyzed using different types of analytics software and algorithms whether descriptive, predictive or prescriptive. The data can be put to multiple uses, for instance to predict breakdowns, thereby considerably increasing safety. Lane changing algorithms have been devised by researchers from the MIT Computer Science and Artificial Intelligence Laboratory, allowing automated cars to behave like humans and make split-

second decisions on whether to stay in a lane or not. The researchers tested their algorithm in a simulation involving up to 16 autonomous cars driving in an environment with several hundred other vehicles, without collision.

ISO/IEC JTC 1/SC 42 prepares standards in the area of artificial intelligence (AI) including ISO/IEC 20547-3, which establishes a reference architecture for big data. IEC is also a founding member of the Open Community for Ethics in Autonomous and Intelligent Systems (OCEANIS). This global forum brings together organizations interested in the development and use of standards as means to address ethical matters arising in autonomous and intelligent systems, including road-based transport.

Entertainment on board

5G networks will also help new in-vehicle entertainment features to become fully effective. Virtual reality (VR) and augmented reality (AR) immersive experiences are under development to entertain travellers while on the road. ISO/IEC JTC 1/SC 24 is preparing standards in the area of AR and VR. ISO/IEC JTC 1/SC 29 covers coding of audio, picture, multimedia and hypermedia information. IEC TC 110 covers electronic display devices and certain components, such as dashboard touchscreens in cars.

Image recognition systems will be used to anticipate drivers' moods. A Korean manufacturer's concept car features facial recognition technology that uses AI to assess the emotional state of the driver. The software can change the vehicle's interior lighting, for instance, or warn the driver when it detects that s/he is tired. ISO/IEC JTC 1/SC 37 prepares standards in the area of biometrics. It publishes ISO/IEC 19794, a standard which includes several parts dealing with the various aspects of biometric data.

Voice recognition technology is also being integrated into these smart vehicles, with voice-activated virtual assistants automatically warning of potential dangers on the road or responding to voice requests from the driver or passengers. ISO/IEC JTC 1/SC 35: User interfaces, publishes ISO/IEC 30122-1, which specifies the framework and gives general guidance for voice command user interfaces. It has recently set up a new working group on affective computing. The technology allows for the use of chatbots and virtual assistants that have enhanced empathy and the ability to transform emotions into data.

Energy efficient technology for lights

Light emitting diodes (LEDs), organic light emitting diodes (OLEDs) and laser diodes can be used in the manufacturing of lights for road transport vehicles. LEDs have already been employed for some time now to save energy as these lights last longer and are more energy efficient than conventional ones.

OLED taillights are also produced by several car manufacturers. Due to their extremely thin and flat shape, they allow for new form factors and design options. Moreover, automotive companies are looking to produce prototypes of flexible, three-dimensional OLED taillights. IEC TC 34 produces key safety and performance standards for LEDs as well as OLEDs.

Laser technology is the new kid on the block: it enables cars to use a much narrower and precise beam of light. The brightness is almost four times that of an LED. This means that headlights can be made much smaller in the future, without compromising on light intensity. The improved visibility makes road traffic safer. IEC TC 76 develops safety and performances standards for laser equipment, including laser lights.

Global safety and cyber security

Whether electric, semi or fully autonomous, rented or owned, public or private, the smart mobility systems we are starting to use, and will continue to employ increasingly in the future, need to ensure they will be as safe and as secure as previous means of transport, in order for people to feel comfortable enough to fully adopt them. IEC International Standards and CA Systems are essential in helping these new means of commuting to reach the appropriate levels of safety, meeting and often anticipating regulatory requirements.

EVs differ greatly from vehicles with combustion engines. Unlike the latter, they do not operate on fuel but require a relatively complex system of battery charging, involving either plugs, chargers and couplers or wireless transfer electrical systems. Each separate device of these systems needs to run safely, with no possibility of short circuit, electric shock or electric fire.

The IEC has established an advisory committee on safety (ACOS) whose task is to guide and coordinate IEC work on safety matters and to ensure consistency between the various IEC safety standards. IEC ACOS has requested for a joint working group be set up between IEC TC 23 subcommittees 23E and 23H, IEC TC 64, IEC TC 69, ISO TC 22 subcommittees 37 and 38 on the safety of electric vehicle charging systems.

IEC TC 64 publishes several horizontal standards which deal with electrical installations and protection against electric shock, notably IEC 60364-7-722 which specifies requirements for the supply of EVs. The standard applies to circuits intended to supply energy to EVs but is also for circuits to feed electricity from EVs back into the grid. Requirements for electrical installations incorporating WPT systems are included in the standard.

Water, fire and explosion proof

Ensuring that chargers and plugs are waterproof is essential for avoiding the risk of electric shock. People want to be sure they will stay safe when charging their EVs in the rain, for instance. IEC TC 70: Degrees of protection against



enclosures, publishes the key standard IEC 60529, which rates water resistance using the ingress protection (IP) rating code. While the first IP digit refers to dust, the second is specific to water ingress (see table on page 16).

Manufacturers the world over use this IP classification to specify the water resistance of the electronic devices they produce, including plugs, sockets and chargers. The ingress levels begin with simple resistance to water drops, which is the lowest level of protection, and extend to continuous immersion in water and resistance to high pressure jets.

While plug-in hybrid vehicles are now being manufactured, a majority of hybrids rely on the internal combustion engine to turn an electrical generator, which either recharges the vehicle's batteries or directly powers its electric drive motors. Some more recent models use energy efficient technologies such as regenerative braking that convert the vehicle's kinetic energy to electrical energy, which is stored in the battery.

As a result, a significant number of hybrids still refuel and fuel stations are subjected to specific safety standards. IEC TC 31 develops standards concerning explosive


Ingress protection (IP) ratings guide

IP ratings are represented by combining the first and second digits of the below columns

1st numeral - solid foreign objects

0	No protection	
1	Protected against solid foreign objects of 50 mm Ø and greater	
2	Protected against solid foreign objects of 12,5 mm Ø and greater	
3	Protected against solid foreign objects of 2,5 mm Ø and greater	
4	Protected against solid foreign objects of 1,0 mm Ø and greater	
5	Dust-protected	
6	Dust-tight	











Example:



IP 65

- Protected against water jets
- Dust-tight

2nd numeral - water

0	No protection	
1	Protected against vertically falling water drops	
2	Protected against vertically falling water drops when enclosure tilted up to 15°	
3	Protected against spraying water	
4	Protected against splashing water	
5	Protected against water jets	
6	Protected against powerful water jets	
7	Protected against the effects of temporary immersion in water	
8	Protected against the effects of continuous immersion in water	
9	Protected against high pressure and temperature water jets	

atmospheres and is preparing the first edition of IEC 60079-45 which specifies requirements for electrical ignition systems for internal combustion engines.

EVs are not immune to fire risks. Overcharge, mechanical damage and high temperatures can lead to fire and explosion in lithium-ion batteries. Plugs and chargers can sometimes provoke short circuits which can also lead to fire.

IEC TC 89: Fire hazard testing, publishes standards which specify the use of electrical and electrotechnical products in a way that reduces the risk of fire hazard to a tolerable level. IEC 60695-1-10 is a horizontal standard which provides general guidance with respect to fire hazard testing and the

potential effects of fires involving all types of electrotechnical products.

IEC TC 21 publishes the key safety standard for lithium-ion batteries IEC 62660 (see page 8).

Certification is key

IECEx (IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres) offers several solutions for manufacturers of equipment used in refuelling operations. The system has put in place several schemes providing assurance that equipment and systems are manufactured and operated according to the highest international standards of safety.

When testing and certifying EV batteries, IECEE focuses on multiple aspects. Electrical energy storage is an important element as it impacts EV range and battery-charging frequency. Endurance and lifespan are also under scrutiny. To avoid risks such as overheating and short circuits, which can result in electric fires or explosions, parameters such as voltage, current, power and temperature also need to be measured and tested.

IECEE has also launched a specific programme for EVs through its registered certification body testing laboratories (CBTLs) and national certification bodies (NCBs). They can test and certify charging systems and stations and plugs against the IEC 61851 and IEC 62196 Standards.

Electromagnetic compatibility

In EVs, passengers sit very close to an electric system of significant power, usually for a certain amount of time. Passengers could be exposed to electromagnetic (EM) fields which is why it is indispensable to evaluate the EM environment in the interior of these vehicles before releasing them into the market. IEC TC 106 specifies measurement methods for EM fields in relation to people's safety. EMC addresses two concerns; firstly, the ability of a device to limit its radio-frequency emissions so that it does not interfere with other nearby devices (in particular radio receivers); and secondly, its ability to operate as required in the presence of electrical and EM interference.

By meeting the requirements in EMC standards, EVs can avoid being subjected to, as well as avoid emitting interference, during charging, for instance. WPT systems for charging are known to emit EM radiation.

IEC TC 69 publishes a couple of standards relevant to EMC. IEC 61851-21-1 specifies EMC requirements for on-board electric chargers. IEC set up an advisory committee on EMC (ACEC), which publishes IEC Guide 107, providing both normative requirements and informative material on drafting EMC publications. This guide is also used as a tool to coordinate the EMC work of different IEC TCs.

IEC TC 77 publishes core horizontal standards relevant to EMC. They include the IEC 61000 series, which describes EM phenomena and the EM environment. The International Special Committee on Radio Interference (CISPR) is made up of the participating IEC National Committees as well as the International Telecommunication Union

(ITU), the European Broadcasting Union (EBU) and other organizations.

CISPR covers a very broad scope of standardization in the field of EMC, aspects of which are addressed by its various subcommittees. CISPR/B deals with interference relating to industrial, scientific and medical radio-frequency apparatus, overhead power lines, high voltage equipment and electric traction.

Cyber security is a pressing issue

As vehicles become increasingly connected and smart, they are more and more likely to fall prey to various forms of cyber attacks. For several years now, hackers have used systems that spoof the signal from a wireless car key to open a vehicle's doors, and even drive it away. With mobile phones increasingly used to access vehicles, it has become possible to obtain the GPS coordinates of a car, open its doors, start its engine, and turn on its auxiliary devices simply by hacking the phone itself.

Autonomous transport systems are data-rich vehicles that use an enormous amount of software and computing power and they are therefore increasingly vulnerable to cyber criminals. The control systems can be hacked into and taken over and some scenarios envisage cyber attacks leading to car crashes and pile ups.

One of the ways to make connected cars more cyber secure is through the use of edge computing and blockchain technologies. Instead of storing data in a single central cloud using one or two large data servers, distributed storage systems, situated in the vehicles themselves, enable devices to continue functioning even if the main storage system is broken into. ISO/IEC JTC 1/SC 41 is preparing documents to standardize these areas.

ISO/IEC JTC 1/SC 27 publishes the ISO/IEC 27000 family of standards. These standards are specifically relevant to IT systems and address both privacy and security aspects. They provide a horizontal framework to protect information and can be used by any IT system, anywhere. They cover cryptographic and other security mechanisms, as well as security aspects of identity management, biometrics and privacy, among other relevant issues. These aspects are becoming important for protecting autonomous vehicles.



The ISO/IEC 27000 Standards have been integrated into the IECQ approved process scheme. This scheme meets the growing need of organizations to provide independent proof of compliance with ISO/IEC 27001, which specifies the requirements for information security management systems. Among other things, the standard makes recommendations regarding actions to address risks.

Accessing the grid

Perhaps even more worrying is that EVs could enable sophisticated cyber criminals to gain access to the electrical grid when they are plugged in to recharge. This could potentially lead to brownouts and even blackouts, bringing entire cities to a halt.



One of the answers to this threat could be an increased reliance on microgrids. Japan is often cited as an example. Before the Fukushima disaster, the country had invested in microgrid technology which helped it deal more successfully with the huge challenges posed in the wake of the earthquake and resulting tsunami. The Sendai microgrid, for instance, enabled the continued supply of

services immediately after the earthquake, using energy from solar cells and storage batteries. Since the gas supply network in the city of Sendai was intact, the gas engine generators were soon able to restart after the power failure at the utility grid and to function as the main power supply of the microgrid. This ensured that patients in the hospital and in the medical and welfare buildings of the city survived. IEC TC 57 is planning to extend the IEC 61850 Standards to include and support microgrids (IEC TR 61850-90-23).

Electrical installations and power plants form part of the critical infrastructure of countries. Supervisory control and data acquisition (SCADA) technology and human-machine interfaces (HMI) are now widespread in electric power plants as the latter automatize an increasing number of tasks. SCADA systems are based on large communication networks that reach directly or indirectly into thousands of facilities. They are used to oversee electric grids as well as plant and machinery in industrial installations. The challenge for many SCADA systems is how to distinguish between normal and potentially intrusive data that could cause harm. IEC publishes different cyber security standards, which help facilities to stay on top of such threats. One of these standards, IEC 62443 series published by IEC TC 65, can be applied to any critical infrastructure facility, such as power utilities or healthcare units. These transversal standards establish efficient security processes and procedures that cover the whole value chain, from the manufacturers of automation technology to installers as well as operators. They address and mitigate current security vulnerabilities as well as pre-empt future ones.

The industrial cyber security programme of IECCE tests and certifies cyber security in the industrial automation sector. IECCE System includes a programme that provides certification to standards within the IEC 62443 series.

IEC TC 57 publishes IEC 62351 which provides guidance on designing security into systems and operations before building them, rather than applying security measures after the systems have been implemented. The different security objectives include authentication of data transfer through digital signatures, ensuring only authenticated access, prevention of eavesdropping, prevention of playback and spoofing, and intrusion detection.

Making our planet a safer and more sustainable place

EVs and autonomous forms of transport are fundamentally changing our cities and ways of commuting. These new mobility systems are not only less polluting, they also improve everyone's quality of life. They involve the integration of new technologies which require testing before they can be safely used on our roads. All sorts of electrical and electronic devices and systems around the world need to function together safely and securely for this new mobility age to take hold. IEC International Standards are paving the way for this to happen, thus contributing to a more sustainable and safer world.





About the IEC

Key figures

173

members and affiliates

>200

technical committees

20 000

experts from industry, test and research labs, government, academia and consumer groups

>10 000

international standards published

4

global conformity assessment systems

>1 million

conformity assessment certificates issued

>100

years of expertise

The IEC, headquartered in Geneva, Switzerland, is the world's leading publisher of international standards for electrical and electronic technologies. It is a global, independent, not-for-profit, membership organization (funded by membership fees and sales). The IEC includes 173 countries that represent 99% of world population and energy generation.

The IEC provides a worldwide, neutral and independent platform where 20 000 experts from the private and public sectors cooperate to develop state-of-the-art, globally relevant IEC International Standards. These form the basis for testing and certification, and support economic development, protecting people and the environment.

IEC work impacts around 20% of global trade (in value) and looks at aspects such as safety, interoperability, performance and other essential requirements for a vast range of technology areas, including energy, manufacturing, transportation, healthcare, homes, buildings or cities.

The IEC administers four conformity assessment systems and provides a standardized approach to the testing and certification of components, products, systems, as well as the competence of persons.

IEC work is essential for safety, quality and risk management. It helps make cities smarter, supports universal energy access and improves energy efficiency of devices and systems. It allows industry to consistently build better products, helps governments ensure long-term viability of infrastructure investments and reassures investors and insurers.



A global network of 173 countries that covers 99% of world population and electricity generation



Offers an affiliate country programme to encourage developing countries to get involved in the IEC free of charge



Develops international standards and runs four conformity assessment systems to verify that electronic and electrical products work safely and as they are intended to



IEC International Standards represent a global consensus of state-of-the-art know-how and expertise



A not-for-profit organization enabling global trade and universal electricity access

Further information

For further information, please visit the IEC website at www.iec.ch. In the “Who we are” section, you can contact your local IEC National Committee directly. Alternatively, please contact the IEC Central Office in Geneva, Switzerland or the nearest IEC Regional Centre.

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