Maritime transport
Modernizing maritime transport

Since time immemorial, vessels have been used for coastal fishing and travel. Even before ancient Egyptians and Phoenicians navigated the seas, early tribes are thought to have discovered far-flung territories by using some form of water transport.

Nowadays, maritime transport sustains worldwide trade and fosters economic development. According to the Review of Maritime Transport, published by the United Nations Conference on Trade and Development (UNCTAD), ships and ports worldwide transport and handle 70% of global trade in value. Global maritime trade continues to grow annually and the number of seaborne passengers increases commensurately, as giant cruise ships become ever more popular. This continued growth poses a number of challenges which the shipping industry must address in order to continue competing with other forms of transport. New technologies are being investigated or used to help shipping meet these challenges. Most of them are dependent on electricity which is a green and particularly versatile form of energy.

Cutting harmful emissions

The International Maritime Organization (IMO) is a specialized agency of the United Nations and the global standard-setting authority for the safety, security and environmental performance of international shipping. According to estimates it publishes, greenhouse gases (GHG) emitted by international shipping have accounted for 2.2% of carbon dioxide emissions in recent years. In 2018, the organization announced a strategy to halve GHG emissions from the shipping industry by 2050. A number of advances in the field of electrical and electronic devices and systems are making this target achievable. The increased use of electricity on board and when in port is helping the industry to clean up its act. New technologies are also being developed to reduce or eliminate other forms of maritime pollution such as oil spills or the discharge of sewage.

The complexity of electrical and electronic requirements of power systems on board ships is increasing. Making sure all these electrical and electronic systems work together safely in standard and emergency situations is more important than ever. While fully autonomous ships are yet to materialize, modern systems on board ships are increasingly computer-managed. These new processes save time and cost for shipping companies but they augment the risk of cyber attacks occurring. IMO has given ship owners and managers until 2021 to incorporate cyber risk management into ship safety.

IEC Standards for the shipping industry

Two IEC technical committees (TCs) are dedicated to preparing international standards for the maritime industry. In agreement with IMO, IEC TC 80: Maritime navigation
and radiocommunication equipment and systems, has taken on the role of developing international standards for the Global Maritime Distress and Safety System (GMDSS), an internationally agreed set of safety procedures and communication protocols used to increase safety and make it easier to rescue ships in distress. The TC prepares the IEC 61097 GMDSS series of standards relating to the various components of ship safety systems.

IEC TC 18: Electrical installations of ships and of mobile and fixed offshore units, also cooperates with IMO where electrical systems on board ships are concerned. It publishes international standards in line with the International Convention on Safety of Life at Sea (SOLAS), an international maritime treaty which sets minimum safety standards in the construction, equipment and operation of merchant ships. The IEC 60092 series, applicable to all electrical installations on board ships, are employed worldwide by naval architects, marine engineering design and consulting companies, ship and offshore unit builders, cable and electrical equipment manufacturers, installers, classification bodies, test houses, ship owners, operators and national and international authorities.

Many other IEC TCs develop international standards which are relevant to the maritime industry and help it plan a greener, safer, more secure and cost-efficient future. IEC also administers four conformity assessment (CA) systems that certify that components, equipment, installations and systems used in the maritime industry conform to the specifications outlined in its international standards.

From artificial intelligence (AI) to the Internet of Things (IoT) and from energy efficient technologies to increased digitization and cyber security, IEC work is essential in laying the groundwork for the shipping industry to continue to prosper alongside the demands of our time.
Boosting energy efficiency and reducing pollution

From the loading of goods and their transport on board right down to their unloading upon arrival, cargo ships rely increasingly on electrically-powered devices. Containerization revolutionized the loading, unloading and transport of goods for cargo ships when it was first introduced in the 1950s, widely boosting international trade. Before containers appeared on the scene, the loading and unloading of individual goods in barrels, sacks and wooden crates was slow and cumbersome.

The emergence of containers streamlined the process by facilitating the transfer from rail to ship and other forms of transport. Alongside containers, new more efficient means of loading and unloading goods started to be used. Grab cranes and conveyor belts, forklift trucks and stackers replaced manual labour in ports worldwide. Most of the electric motors powering cranes and conveyor belts are standardized by IEC TC 2: Rotating machinery. The TC publishes the IEC 60034 series of international standards which ranks electric motors according to their energy efficiency. Regulators, the world over, have taken this classification system on board and made it an intrinsic part of their policies.

Electricity: a green way of moving freight

Most forklift trucks are now propelled by batteries or hybrid systems combining batteries and diesel, gas or petrol as well as fuel cell technology. A fuel cell combines hydrogen and oxygen to produce electricity. IEC TC 105 publishes standards relating to fuel cell technologies. IEC 62282-4-101 applies, among other things, to materials handling equipment such as forklift trucks.

IEC TC 21: Secondary cells and batteries, issues the IEC 61982 series of standards. They establish the specifications for batteries which propel electric road vehicles (EVs). IEC TC 69 publishes international standards related to the charging of these batteries. They include the IEC 61851 standards on conductive charging systems.

IECEE (IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components), has a scheme which applies to batteries, chargers and charging stations. They can be tested for safety, performance component interoperability, energy efficiency, electromagnetic compatibility (EMC), hazardous substances, chemicals and safety in the case of explosion.

Hybrid and electric systems for propulsion

One of the ways of reducing the CO₂ emitted by the shipping industry is to use more electricity for ship propulsion. Hybrid systems combining fuel engines, electrical batteries or even fuel cells are now widely employed by ships for traction.

Fully electrically-propelled commercial ships are on the horizon. A number of barges and ferries already use battery power for traction. Some cargo ships have also been using electricity as a means of propulsion over short distances. IEC TC 21, IEC TC 69, and IEC TC 105 are keeping abreast of these new developments. IEC TC 18 is preparing a revised standard for electric batteries for ships, IEC 60092-305, Electrical installations in ships – Part 305: Equipment – Batteries.

Research continues into electrochemistry and new battery technologies, such as advanced lithium-ion, lithium-sulphur and lithium-air. The demand for higher energy density (driven by the road vehicle industry) is spurring on development.

Researchers are also looking at ultra-high density supercapacitors as a way to transform the storage of energy on ships. Supercapacitors store energy using electrodes and electrolytes. They can accept and deliver charge much faster than batteries, 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.

Limiting CO₂ emissions

Cold ironing is the process of providing shore side electrical power to a ship at berth while its main and auxiliary engines are turned off. It helps to reduce harmful emissions from the diesel engines which would normally have to be left running. Cold ironing enables refrigeration, cooling, heating, lighting, emergency and other equipment to receive continuous
electrical power while the ship loads or unloads its freight. IEC TC 18 issued a publicly available specification (PAS) for high-voltage shore connection in 2009, containing requirements for such systems. IEC in collaboration with ISO and the Institute of Electrical and Electronics Engineers (IEEE) then developed the PAS into an international standard, IEC/ISO/IEEE 80005-1. IEC TC 23: Electrical accessories, publishes IEC 62613 on plugs, socket-outlets and ship couplers for high-voltage shore connection systems. It also publishes IEC 60309-5 on connectors for ships (low-voltage shore connection systems).

Renewable energy systems, such as solar photovoltaic (PV) modules, are beginning to be used to power electrical and electronic devices on board. IEC TC 82: Solar photovoltaic energy systems, publishes the IEC 62788 series of standards which establishes the measurement and test procedures for the materials used in PV modules.

To save energy, many large cruise vessels are already using LEDs. These lights can significantly reduce the total energy consumption not devoted to propulsion. IEC TC 34: Lamps and related equipment, publishes IEC 62031 which specifies the safety requirements for LEDs.

IECQ (IEC Quality Assessment System for Electronic Components) has created a scheme for certifying LED lighting. It can ensure that manufacturers and suppliers of the electronic components, modules and assemblies used in the production of LED packages, engines, lamps, luminaires and LED ballast/drivers, meet appropriate standards in terms of reliability, safety and cost-efficiency.

**Dealing with e-waste**

Electrical and electronic devices and systems used on board ships must also be recycled or disposed of safely. IEC TC 111: Environmental standardization for electrical and electronic products and systems, develops the IEC 62321 series of international standards. They define standardized methods for determining the levels of potentially toxic substances in electrical and electronic products. Another crucial international standard, IEC 62430, establishes guidelines for minimizing the adverse environmental impact of devices throughout their lifecycle.

Advanced materials such as graphene, a carbon derivative, will be used to build lighter vessels. Graphene-based coatings are expected to protect ship hulls against corrosion and fouling. An improved bottom-coating paint for ships could reduce drag and enable ships to go faster while using less fuel. Graphene-based paint is also more eco-friendly than the traditional petrochemical-based alternative. Nano-treated aluminium could also be an extremely efficient substitute for making hulls and various other ship structures where light weight and high strength are highly desirable. Carbon nanotubes are another alternative, for in addition to being much stronger and lighter than steel, they also provide excellent thermal and electrical conductivity. IEC TC 113: Nanotechnology for electrotechnical products and systems, is preparing publications in this area.

IMO announced a strategy to halve CO₂ emissions from the shipping industry by 2050.
Digitizing key processes

The berthing – meaning the arrival and “parking” in the port – of ships is being digitized. Sensors are being installed along the quay walls of ports and mooring posts to provide information and data streams on water, tide, currents and temperature in real time. This information is processed through centralized dashboard applications. These technologies can reduce berthing time and are potentially more cost-efficient than conventional radio and radar communications between captains, pilots and terminal operators. The joint technical committee formed between ISO and IEC, ISO/IEC JTC 1, has several subcommittees (SCs) dealing with these technologies. SC 38 publishes ISO/IEC 17789 on the reference architecture for cloud computing. SC 41 issues ISO/IEC 30141 on the reference architecture for IoT.

Port gates are a key checkpoint for identifying and recording every entity entering or leaving the port. Ships must go through a number of security checks and verifications. These are crucial tasks, necessary to protect the integrity of the port. But they also consume a lot of time. Automating basic processes, such as entry/exit logs, verification, and docking payments can be done with the help of the relevant IT systems. They can make the entire process flow smoother and faster. SC 32 publishes standards for data management and interchange. Additionally, cranes, stackers and forklift trucks can be automated or self-driving. IEC publishes many standards relevant to self-driving vehicles. IEC TC 47 prepares standards relating to semiconductor devices, which facilitate the design, manufacture, use and reuse of sensors. IEC 62969 deals with the general requirements of power interfaces for automotive vehicle sensors, for instance.

Improving safety levels

The use of sensors is also increasing on board ships, especially in relation to safety aspects. Modern machinery control systems incorporate an enormous volume of measurement instrumentation. All of these devices provide information to operators and are essential for triggering alarms and equipment safety features, such as automatic shutdowns. IEC 60747-14-1 establishes the generic specifications for sensors. The installation of alarms follows requirements established by IEC TC 79. Video surveillance cameras are ubiquitous on cruise ships to deter crime and detect any suspicious activity. TC 79 also publishes IEC 62676-1-1, on the general requirements of video surveillance systems (CCTV).
Artificial intelligence (AI) is increasingly helping captains and crews make critical decisions. The aim is to improve maritime safety and reduce the risk of human error. Algorithms have been developed to detect human error in the command chain and raise the alarm before any incident occurs. ISO/IEC JTC 1/SC 42 is preparing the ground for AI standardization. IEC is also a co-founder of the newly created Open Community for Ethics in Autonomous and Intelligent Systems (OCEANIS), which will deal with the key ethical issues relating to AI. OCEANIS provides a high level global forum where organizations interested in the development and use of standards for the advancement of autonomous and intelligent systems can discuss, debate and collaborate.

Robots to the rescue
Robots have been devised to inspect the hull of ships below water. Very small and cheap detection robots or underwater drones have been produced using 3D printing technology. Powered by lithium-ion or wirelessly rechargeable batteries, equipped with a wide variety of sensors, these robots can detect illegal cargo or identify damage under the waterline. Motion sensors such as accelerometers, gyroscopes and compasses are used to navigate and accurately track their position as well as keep them balanced. Many other sensors are used for obstacle detection and collision avoidance from ultrasonic (sonar) to infrared devices. Underwater cameras can be used to capture and store images and even stream video in real time.

Robots are also employed to detect and clean up oil spills. Oil-eating bots, controlled from a distance by satellite, are becoming an essential tool to help emergency teams during clean-up. Dropped by aircraft above the spill, the robots suck up oily water, spin the liquids, and send clean water back into the sea. Oil collected during the process can be stored and recycled. Some robots clean up to 2,000 gallons of oil per minute, eliminating the spill in just a few days.

ISO/IEC JTC 1/SC 28 covers standards relating to office equipment, including 3D printers. SC 41 develops standards related to underwater acoustic sensor networks (UWASNs). It publishes ISO/IEC 30140-4 which specifies interoperability between the selected physical entities of UWASNs.

Other IEC TCs involved in standardization work for specific areas affecting rescue and disaster relief robots include IEC TC 44 which deals with the electrotechnical aspects of machinery safety and IEC TC 22 which prepares standards for power electronic systems and equipment.

Paving the way for autonomous ships
Maritime transport is expected to become autonomous in the future. Self-piloting vessels would use up less space (no need for crew quarters, etc.) and therefore consume less power. They are seen as more energy-efficient and less costly to use than manned ships. Routine tasks on board would be automated and only the more demanding navigational and technical jobs transferred to a remote operation centre.

Manufacturers are looking at different types of radars, high definition visual cameras, thermal imaging and laser-range finding systems known as LIDAR. They are also investigating various sensor technologies, including ones already used in other forms of autonomous transport (buses, trucks, cars…). Marine sensors have to be sufficiently robust to withstand harsh weather conditions. A new era of connectivity on board vessels is opening up, thanks to greatly improved satellite services. 5G, the new generation of mobile technology, will cater for integrated satellite and terrestrial-based services for the shipping industry. The information and data gathered by these various technologies will replace human eyes and help operators control the vessels from afar. The work of IEC TC 100: Audio, video and multimedia systems and equipment, covers some of those areas. IEC TC 80 publishes IEC 61097-15, which specifies the minimum operational and performance requirements for Inmarsat Fleet Broadband 500, which provides high speed data communications from ship to earth. It is included in the international GMDSS standards developed for IMO.
Port authorities use a variety of methods to detect illegal trafficking or dangerous contents. Some authorities have opted to scan all of the cargo containers using X-ray machines. IEC SC 45B: Radiation protection instrumentation, publishes IEC 62523 which applies to radiographic inspection systems of cargo, vehicles and cargo containers, used essentially for the detection of contraband.

Alongside these measures, tracking technologies are used to locate containers and prevent them from being tampered with. Radio frequency identification (RFID) active tags, equipped with sensors, can detect whether a container door has been opened, for instance. ISO/IEC JTC 1/SC 31 covers automatic identification and data capture techniques. It publishes standards on bar code symbols and RFID. One such standard is ISO/IEC 18305 for the testing and evaluation of localization and tracking systems. Cruise organizers and port authorities are testing novel ways of checking the identity of passengers. New facial recognition tools are being used to make sure the same people who board disembark. These tools enhance security but are also expected to speed up boarding procedures. In the future, facial recognition could replace manual passport
checking. As giant cruise vessels transport thousands of people, the time gains will be substantial. ISO/IEC 19794, published by ISO/IEC JTC 1/SC 37, has 14 parts that deal with the various aspects of biometric data, including facial recognition. As with containers, RFID tags are used to track luggage and match it with the correct owner. RFID wristbands enable passengers to unlock their room and make purchases on board.

**Increased immersion**

Virtual reality (VR) tools are used in a variety of ways, whether for training purposes or to enhance the cruise experience for passengers. IMO recommends the use of simulation for crew training in Resolution A.960.

Marine simulators have improved greatly since the early days when only a basic computer screen was available. They can be used to train for navigation tasks as well as for almost every aspect of ship operation including crane handling and towing. A high degree of realism is provided by the use of headsets on board virtual navigation stations, giving users a sense of total immersion.

Some travel agencies enable customers to check out the features of their cruise in advance, using a VR headset. Some passengers on board may opt for a virtual tour of a location to check out its attractiveness before disembarking.

VR simulators employ a wide variety of sensors, most of which follow the specifications outlined in IEC 60747-14-1. IEC TC 110 standardizes the use of electronic display devices. It publishes the IEC 61988 series on plasma display panels. ISO/IEC JTC 1/SC 24 is working on standards relating to virtual and augmented reality.
As the control systems of ships are digitized, cyber security threats are expected to become more frequent. IMO has established guidelines on maritime cyber risk management, referring to ISO/IEC 27001 which specifies requirements for implementing and maintaining a security management system. The standard is part of the ISO/IEC 27000 family, a critical set of publications dealing with cyber security, published by ISO/IEC JTC 1/SC 27.

**Emergency systems**

Power on ships is supplied by generators driven by the main engines. If these fail, electricity is provided by batteries or emergency back-up units. They ensure that essential systems continue to function (navigational gear, fire fighting systems, navigational and emergency lights, etc.). The increasing power demands of ships have led to the construction of separate engine rooms so as to offer full redundancy. They are expected to provide enough electricity for emergency services but also for basic passenger comforts, such as lighting and functional toilets.

IEC TC 18 issues IEC 60092-305 on accumulator batteries, which are essential for emergency power systems.

Major advances in electronic equipment over the years have made navigation more accurate and safer. They include:

- bridge navigational watch alarm systems (BNWAS).
  
  They can be described as monitoring systems which notify other navigational officers if the member of crew on watch does not respond. IEC TC 80 issues the required specifications in IEC 62616
- electronic chart display and information systems (ECDIS) which are defined by TC 80 in IEC 61174
- automatic identification systems (AIS), which are part of GMDSS and are published by TC 80. Operational requirements for shipborne equipment of the AIS are defined in IEC 61993-2

**Supplying electricity safely**

Giant cruise ships are like floating cities and have huge electricity requirements. A wide number of everyday electrical and electronic appliances are used during each journey. A large ship requires lighting, air-conditioning, cooking, washing and cleaning appliances, television sets, cinemas, lifts, etc. IEC TC 61: Safety of household and similar electrical appliances, publishes international standards on safety requirements for a wide number of devices, from fridges to washing machines. IEC 60335-2-90 specifies safety requirements for commercial microwave ovens, which must meet specific safety conditions on board ships.

Cruise ships welcome a large number of elderly passengers and people with disabilities. Vessels have implemented a number of measures to make sure their facilities are disability-friendly, from lifts adapted to wheelchairs, to automatically opening doors. IEC has established the Systems Committee Active assisted living (SyC AAL) which aims to encourage standardization of AAL products, services and systems to help disabled and elderly people live as independently as possible.

Enclosures protect electrical and electronic equipment from contact with the elements, especially water. IEC TC 70 prepares standards on the degrees of protection provided by enclosures, such as IEC 60529. The document specifies the degrees of protection for enclosures against mechanical impacts, corrosion, solar radiation, fungus, moisture, etc.

Different safety devices are used and installed on the main switchboard and electrical distribution panels, from fuses to circuit breakers, to ensure no short circuit can happen and that staff and passengers are protected from electric shock. IEC TC 64 develops and maintains standards relating to electric installations and protection against electric shock.

IEC 61140 is a basic safety publication which establishes the common aspects for installations and equipment against electric shock. IEC TC 89: Fire hazard testing, publishes IEC 60695-1-10, which specifies the use of electrotechnical products in a way that reduces the risk of fire hazard to a tolerable level.

The advances in power electronics are steering the development of ships towards hybrid alternative current (AC) and direct current (DC) or even full DC power systems. IEC TC 8: Systems aspects of electrical energy supply, is a horizontal TC which prepares standards relating to the overall system aspects of electricity supply systems, including generators and microgrids. The TC is responsible
for maintaining horizontal standards on voltages, in particular IEC 60038 on standard voltages for AC and DC systems. The publication 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 AC and DC traction systems, among other things.

The electromagnetic environment
Electromagnetic compatibility (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 electromagnetic (EM) interference. The EM environment for ships includes high power communication radios and navigation radars. The reliability of these devices is critical to the safety of ships and to nearby passing vessels: radios are used to communicate and receive distress signals from other ships and they need to be able to function at all times without interference caused by other electrical and electronic systems. IEC TC 18 publishes one of the main international standards relating to EMC for ships: IEC 60533. The standard specifies the minimum requirements and criteria for EMC of electrical and electronic equipment for ships with a metallic hull. The TC has published a new standard, IEC 62742, which sets requirements for ships with a non metallic hull. Non metallic hulls made of composite materials are becoming more widespread as shipowners opt for lighter vessels. EMC requirements for non metallic hulls are far more stringent as metal stops EM interference.

IEC TC 77 issues basic and generic EMC standards, such as the IEC 61000 series which includes terminology, descriptions of EM phenomena and the EM environment. It also specifies measurement and testing techniques and guidelines on installation and mitigation.
The international special committee on radio interference (CISPR) is made up of the participating IEC national committees and several international organizations including the International Telecommunication Union (ITU) and the European Broadcasting Union (EBU). CISPR has a very broad scope for standardization in the field of EMC, aspects of which are addressed by its various SCs.

CISPR publications 12 and 25 list the specifications for radio disturbance and the methods to protect on board receivers. A CISPR radio disturbance limit is a ceiling that is recommended to international organizations as well as national authorities for incorporation in national standards, relevant legal regulations and official specifications.

**Explosive atmospheres**

The transport of flammable goods by oil or gas tankers must receive extra care. IEC TC 18 issues IEC 60092-502, which specifies the particular features required for electrical installations on board tankers carrying liquids that are flammable. IEC TC 31 publishes the IEC 60079 series of standards which specify the general requirements for equipment used in explosive (Ex) atmospheres.

IECEx (IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres), has established mechanisms to help industry, authorities and regulators ensure that equipment (electrical and non-electrical) used in Ex environments as well as people working in Ex locations remain safe. IECEx operates the following industry-specific schemes:

- **IECEx certified equipment scheme**
- **IECEx certified service facilities scheme**
- **IECEx scheme for certification of personnel competence**
- **IECEx conformity mark licensing system**
IEC is a crucial partner for the shipping industry

IEC plays a key role in ensuring that the increasingly complex electrical and electronic devices used for shipping work together safely, efficiently and have a limited impact on the environment. IEC Standards also pave the way for new technologies to be used by the shipping industry in a way that will prepare it to meet future challenges head on.
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 172 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.

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.

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

A global network of 172 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.

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

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**Key figures**

- **172 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**
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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