



# Guide to robotic systems safety compliance

Overview of the robot certification process



OVERVIEW



*Because many robots, collaborative robots (cobots) and automated mobile platforms (AMPs) work in close proximity to people, certification and compliance with safety-hazard standards are essential.*

*UL is a trusted partner for robot manufacturers, system integrators and asset owners to help ensure that robotic systems are safe and reliable.*

*This guide provides a comprehensive understanding of the certification process.*

## Areas of expertise

We provide testing and certification services for the following robotic equipment and systems:

- **6-axis articulated robots**
- **Palletizers**
- **Delta/PKR robots**
- **Linear robots**
- **Cobots**
- **Personal care robots**
- **Automated guided vehicles (AGVs)**
- **Automated mobile platforms (AMPs)**
- **Storage and retrieval systems**
- **Controllers**
- **Grippers/end effectors**
- **Pendants, including wireless types**
- **Axis limiting and control devices**
- **Welding equipment**



## Overview of relevant standards for robotics

In areas as diverse as product safety, interoperability, performance, energy efficiency, functional safety and medical applications, UL helps customers meet regulatory requirements that include:

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### **ANSI/UL 1740**

Standard for Robots and Robotic Equipment

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### **ANSI/RIA R15.06**

Standard for Industrial Robots and Robot Systems – Safety requirements

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### **CAN/CSA Z434**

Standard for Industrial Robots and Robot Systems

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### **NFPA 79**

Electrical Standard for Industrial Machinery

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### **ISO 10218**

Robots and robotic devices – Safety requirements for industrial robots

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### **ISO 13482**

Robots and robotic devices – Safety requirements for personal care robots

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### **UL 3100**

Outline of Investigation for Automated Mobile Platforms (AMPs)

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### **ANSI/ISO 12100**

Safety of Machinery – General Principles for Design – Risk Assessment and Risk Reduction

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### **EN 61508**

Functional safety of electrical/electronic/programmable electronic safety-related systems

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### **ISO 13849**

Safety of machinery – Safety-related parts of control systems

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### **IEC 62061**

Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems

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### **HazLoc/Intrinsically Safe/ATEX**

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### **EU Machinery Directive**

(2006/42/EC)

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### **EU EMC Directive**

(2004/108/EC)

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# UL's global compliance full service offer

UL supports manufacturers, system integrators and operators of robotic systems with a variety of services to help ensure consistent compliance throughout the entire product life cycle.

## How can you benefit

Gain peace of mind for the entire value chain of robotic systems. Starting with the right choice of components, safe daily operations, effective market access and 'cybersecurity by-design' — UL is your partner of choice for robotic system compliance.

For answers to your questions or to start a project today, contact us at [UL.com/contact-us](https://www.ul.com/contact-us)

### Advisory

Advisory services related to electrical and functional safety during product development

### Training

Specific training regarding robotic functional safety requirements

### Testing/certification

Testing and certification of functional safety, including personnel qualification  
Testing for specific robotic applications and their corresponding standards

### Gap analysis

Gap analysis from the International Organization for Standardization (ISO) to UL to facilitate market diversification and access certifications (i.e., China, EU Machinery Directive, CE, etc.)

### Sourcing

UL Product IQ™ database to help source safety-compliant, pre-certified components

### HazLoc

Hazardous Locations (HazLoc) and Pressure Equipment Directive (PED) evaluations for safety compliance in explosive environments

### EMC and wireless

EMC and wireless testing to help ensure seamless communication

### Cybersecurity

Cybersecurity advisory, testing and assessment solutions to help avoid security breaches

### Relocation

Factory relocation services through a global team of field experts

### Remote services

Remote field evaluations and testing

### Risk assessment

Full-system risk assessment: engineered systems compliance

### HMI

Human-machine interface (HMI) safety services



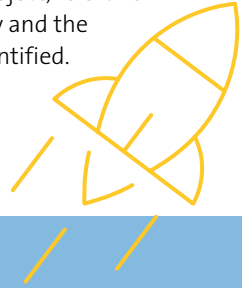
# Overview of a typical robot certification process

Click the fields to learn more



# Start up/kick off

In the start-up phase, UL will help you understand the evaluation, testing and certification processes, as well as the applicable technical and regional requirements within your target markets. Based on the scope of the project, relevant standards applicable for the specific industry and the corresponding certification needs will be identified.



## Key deliverables

- Establish certification requirements needed for product launch
- Identify the appropriate UL category as well as other global certification requirements
- Determine scope of work required
- Collaborate with UL's engineering team, where appropriate, e.g., to walk through the certification process and help determine the readiness to pursue certification
- Handle project start-up formalities, e.g., draft a formal quotation and address relevant service agreements

## Key benefits

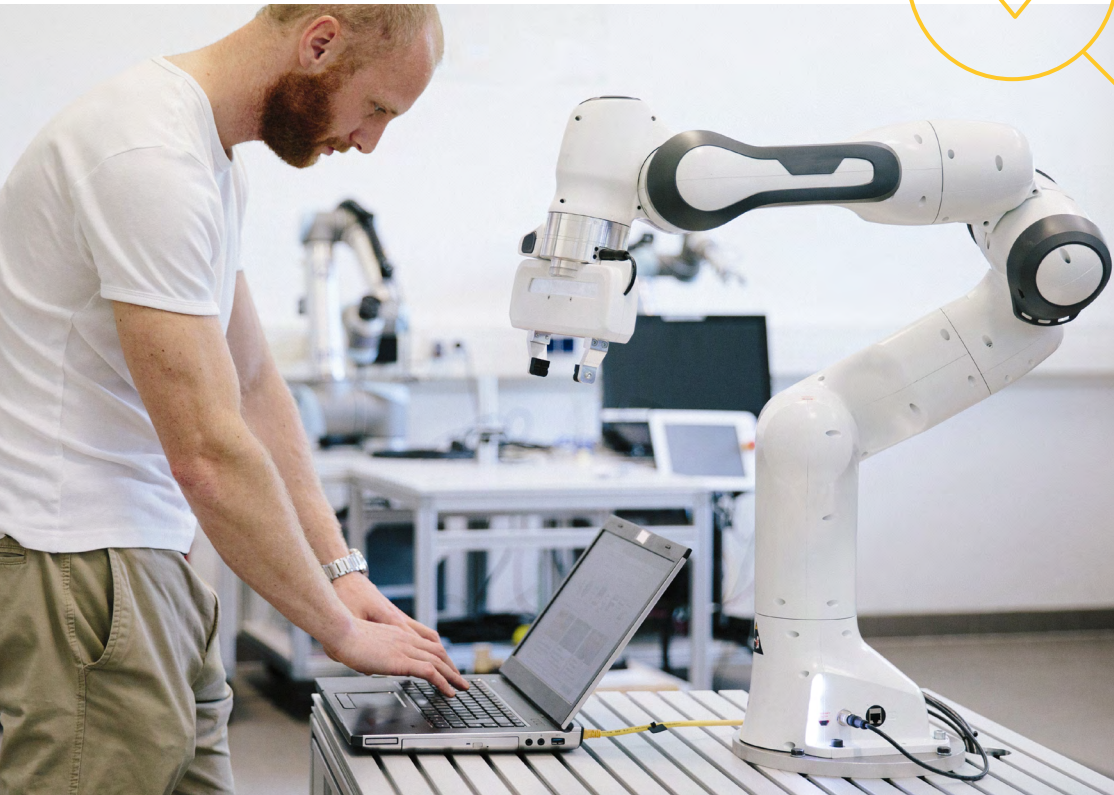
- Early on determination of certification readiness as result from the preliminary investigation
- Smooth project planning and realization
- Overview of project scope and costs
- Avoid any delays during the launch or commissioning of the robotic system



# Preliminary investigation/ pre-certification review (optional)\*

Ideally, UL experts are engaged as early as possible: during the product development and design cycle, even as early as the design drawing or prototype phases. This allows a design or preliminary investigation to the applicable construction requirements to help you identify areas that may need to be revised or reworked before the manufacturing processes are established.

\* While this is not a substitute for the complete product evaluation and does not lead into the certification mark immediately, it will provide significant time and cost savings later on.



## Key deliverables

- An engineering evaluation that includes a review of the documentation and several factors without testing, such as the ratings, protection methods and construction to the appropriate standard(s)
- The development of the test program to determine the setup and sample requirements for the robot or robotic system that is submitted for certification
- Review of the documentation and identification of what is needed to prepare reports for all applicable target market certifications
- A final letter detailing the compliance/non-compliance findings and documentation requirements

## Key benefits

- Help avoid rework and changes in the manufacturing process
- Early identification of potential risks and effective management
- Time and cost savings



# Certification project definition and confirmation of the scope of certification

Once the formal order has been received, UL initiates a project, which includes the verification of the applicable requirements and the customer preference for the delivery of the project. Additionally, a project number is generated, and the details of the scope of certification is agreed upon. The project will then be transferred to UL's robotic engineering team to begin the next steps of the certification. The assigned UL engineer becomes the primary contact throughout the entire project.



## Key deliverables

- Establish a project plan and delivery stages, e.g., discuss a modular approach
- Determine a preferred project completion date
- Define mutually agreed date to submit additional documentation: schematics, bill of material, samples, etc.

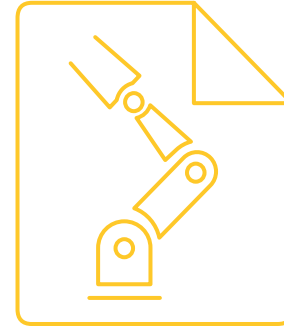
## Key benefits

- One single point of contact throughout the entire project
- Transparency on project milestones and completion date





# Functional Safety Evaluation



Did you know?

**July 21, 1984**

accident in Michigan, USA,  
where the first human  
was killed by an  
industrial robot\*

The Functional Safety assessment will be carried out in accordance with applicable standards depending on the market and the type of robotic system, e.g., UL 1740, EN ISO 10218-1/ISO TS 15066 or UL 3100, ISO 13849, IEC 62061.

UL experts can work with your teams to evaluate artifacts, conduct interviews, examine source codes and look at all the functional safety related processes.

## Key deliverables

- Concept evaluation and initial gap analysis (letter report)
- Preliminary functional safety report

## Key benefits

- Help avoid rework and changes in your development process
- Early identification of potential schedule risks and effective project management
- Time and cost savings

\*Source: <https://de.wikipedia.org/wiki/Robotik>

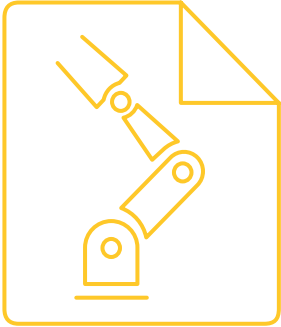


# Functional Safety Evaluation

## Required documentation for evaluation phases

### Concept verification and system design

- Concept/risk assessment, functional safety management and concept, change and configuration management
- Verification and validation planning



### Engineering review of documentation, audit and failure insertion testing

#### ISO 13849/IEC 62061:

- Functional safety management plan including tool qualification, commercial of the shelf units (COTS) qualification plan, configuration and change management plan
- Risk analysis (including Safety Integrity Level (SIL)/ Performance Level (PL) assignment)
- Quality manual/development procedures, ISO 9001 certificate
- System (safety) requirements specification including functional and safety integrity requirements
- System architecture description, software architecture description
- Verification and validation plan
- Environmental and electromagnetic compatibility (EMC) requirements specification
- System design specification
- Fault Tree Analysis/Failure Mode Effects Design Analysis (FMEDA)/ Probability of Dangerous Failures (PFD) calculation
- Software and hardware requirements specifications/design documentation
- Hardware related documents (schematics, bill of materials (BOM), block diagram)
- Verification and validation test results, including agreed fault insertion tests
- Safety assessment report, e.g., prove of quantifiable aspects, systematic aspects, architecture requirements
- Installation, operation and maintenance manuals

#### ISO 10218-1/ISO TS 15066, in addition to those of ISO 13849/IEC 62061:

- Stopping time and distance metrics
- Marking
- Information for use
- Verification and validation report related to Annex F of ISO 10218-1



# Risk of Fire, Electrical Shock and Injury



During technical evaluation and testing, the robotic system will be primarily tested to assess the risk of fire and electrical shock depending on the applicable standards and previously defined in the project setup. UL's designated engineer will contact you directly to confirm the project scope and the assumptions.

Typically, during this phase of the project, the samples are sent, the product construction is evaluated, the documentation is reviewed, the test plan is developed and the samples are prepared for testing. The testing may be conducted either in a UL laboratory or remotely at the customer's laboratory witnessed by the UL engineer.

## Associated working steps

- **Review of the documentation and the development of the test plan**
  - Evaluation of the construction
  - Determination of the final test plan plus creation of data sheets
  - Determination of samples need for testing
- **If the tests are witnessed:** information about the customer equipment specifics and calibration is required
  - Witnessing of tests

## Key deliverables

- Completed datasheet
- Draft descriptive UL report

## Key benefits

- Clear overview of work that has been completed, remaining gaps and missing information



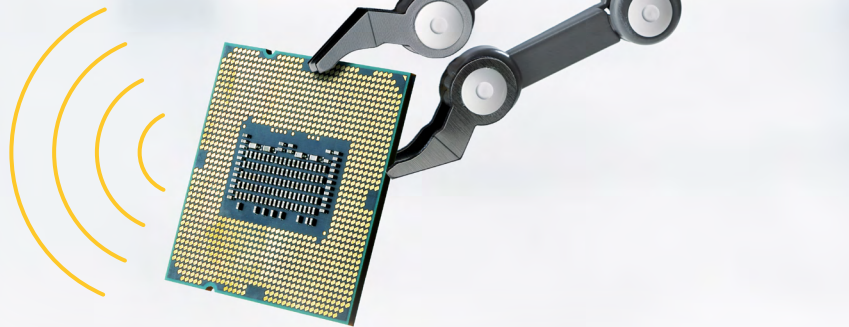
## Additional assessments

# EMC/wireless

Electromagnetic compatibility (EMC), radio performance, radio frequency (RF) exposure and safety requirements are mandatory in most markets; however, there is no universal standard and regulations vary from country to country.

### Associated services

- Wireless regulatory testing and certification to FCC/ISED/CE
- EMC testing and certification
- Radio type approvals for 180+ countries
- Compatibility and performance testing
- Comprehensive support and guidance from design concept to product completion



### Key deliverables

- IECCE CB Scheme – CB Test Reports and Certificate
- Informative test reports
- Notified Body certificate for EMC Directive and for RE-Directive
- UL is specifically experienced/knowledgeable (> 20 years' experience) in wireless technologies and its regulatory testing certification and mmWave radio frequency testing (> 5GHz frequency)
- FCC and ISED Canada testing and certification
- CoC (Certificate of Conformity), SDoC (Supplier Declaration of Conformity), radio type approval for specific countries, e.g., South Korea, Japan, India, to country specific regulations.
- Additional in-country specific test reports
- Customized regulations research capabilities (optional)

### Key benefits

- UL internally manages different service deliverables, including knowledge sharing/documentation, re-using samples when possible, even providing different testing services in the same location
- UL has a network of global testing laboratories and provides the flexibility to adapt to customer testing location needs (based on capabilities and accreditations)
- Bundling EMC/W and GMA/W provides a strong internal collaboration and reuse of data between the two services
- Local-to-local support in local language (in both the engineering and sales teams)
- Digital solution to support easier regulations knowledge: UL Go platform
- UL may offer remote witnessing of tests during which customers can talk in real-time with UL engineers testing the products without spending time and resources traveling to a test laboratory

## Additional assessments

# Cybersecurity

Robotic systems are always an integral component of a larger industrial automation system and therefore it is best to assure the risk of cyber breaches is managed effectively by a certification in accordance to the international standard IEC 62443. Ideally, the robotic system will also be subjected to a thorough cybersecurity assessment during the early stage of development with the focus on:

- Product and manufacturing development procedures (following IEC 62443-4-1)
- Security functionalities and robustness of the individual product components (following IEC 62443-4-2)



## Key steps/solutions

- Training on the IEC 62443 family of standards (interactive or tailored workshop)
- Gap analysis: constructive review of the differences between current and desired state for meeting IEC 62443 sub-standards. Report can be customized to include testing if necessary or requested.
- Penetration testing: provide clear insights into the security level of the product, system and infrastructure. Report contains results of the test including demonstrated vulnerabilities within the product, system and infrastructure.
- Certification: assesses the conformity of your product or system to various IEC 62443 sub-standards, developing a certification strategy.
- Surveillance and inspection: verification if sufficient security measures have been taken to maintain certification status. Report can be used to determine the actions that will help ensure the security level meets the set goals.

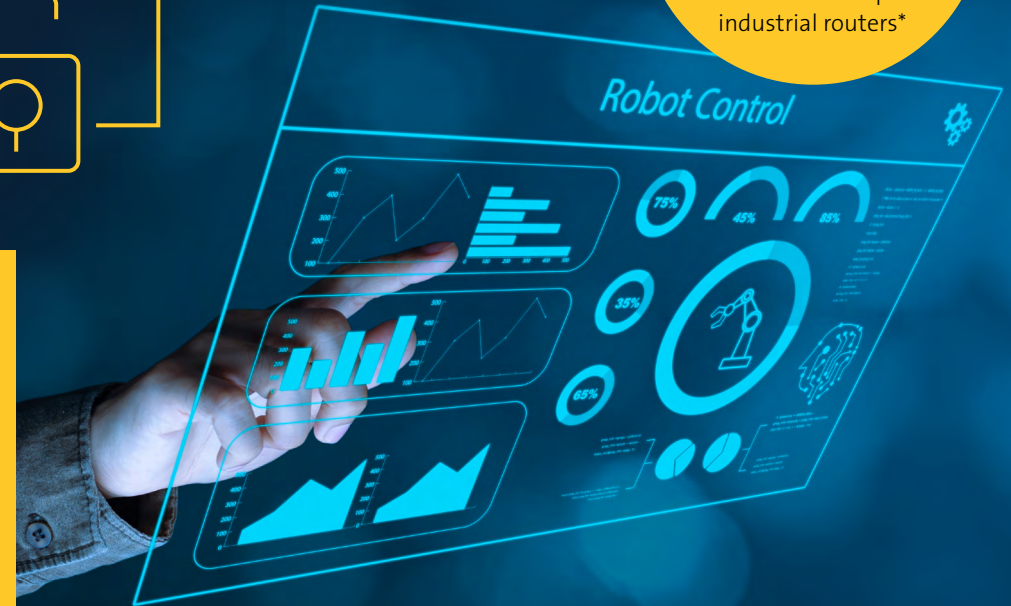
Did you know?

Approximately

**84,000**

**industrial robots**

were exposed via their FTP servers and exposed industrial routers\*



\*Source: Tab. 1, Rogue Robots: Testing the Limits of an Industrial Robot's Security, Trend Micro (2017)



OVERVIEW



# Cybersecurity

## Key deliverables

- Guidance on how to structure the robot controlling devices development process
- Determination of the difference between processes in place and those needed to assure security-by-design
- Test reports on robots controlling devices' security or certification
- Assessment or certification of security capabilities of system integrators
- Assessment or certification of security capabilities of maintenance services providers
- Guidance for asset owners on how to structure security in their environment
- Assessment or certification of systems ready to start operations or during operations
- Risk assessment for robots controlling devices in development as well as systems in operation

## Key benefits

- Transparency of the development process allows to help prevent vulnerabilities, ultimately preventing costs for remediation and potential liabilities
- A certification of system integrators will help to make the asset owners trust the system integrator and will be more inclined to use him as preferred partner
- Product certifications allow the robot product vendor to distinguish what their security quality products offer compared to low-cost products without such features
- For all parties involved with the IEC 62443 framework in conjunction with an IEC 62443 expert partner like UL, cybersecurity challenges are handled in the most effective and efficient way, saving resources

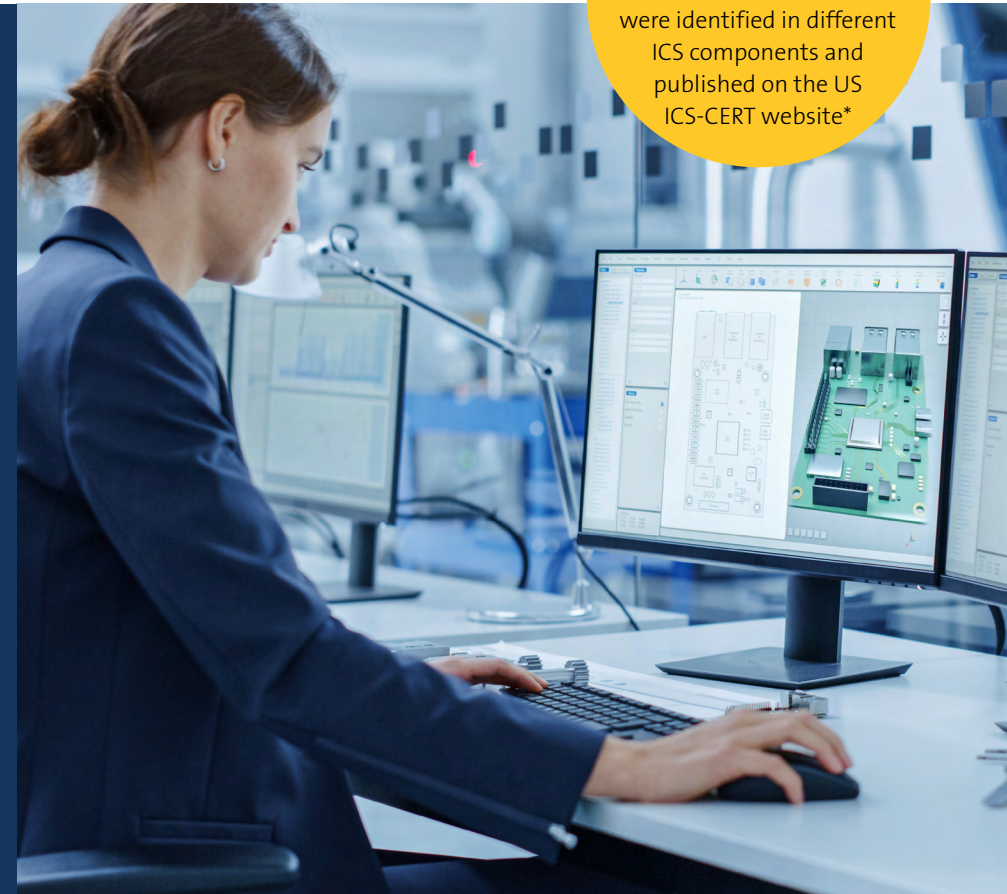
\*Source: Threat landscape for industrial automation systems. H2 2018; [https://ics-cert.kaspersky.com/media/kl\\_ICS\\_CERT\\_H2\\_2018\\_REPORT\\_EN.pdf](https://ics-cert.kaspersky.com/media/kl_ICS_CERT_H2_2018_REPORT_EN.pdf)

Did you know?

**415**

**vulnerabilities**

were identified in different ICS components and published on the US ICS-CERT website\*



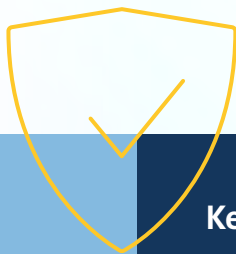
# Final report for certification

## followed by review attestation and certification decision



Once all the assessments, evaluations and tests have been completed and the robotic system complies with the respective standards, the certification process starts.

This results in a final review of all evaluation data, resulting in the applicable certification documentation being issued to the customer, such as notice of authorization to apply the UL Mark and final certification documents, or notification of an initial product inspection prior to notice of authorization (see next page).



### Key deliverables

- European Commission (EC) type certificate
- Final functional safety report
- The UL certification or letter report (as applicable)

### Key benefits

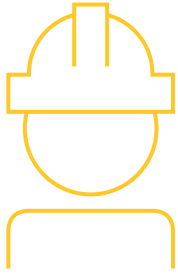
- Report to demonstrate product compliance
- Authorization to apply the UL Mark, one of the most widely recognized safety symbols in the world (as applicable)



Examples of UL Marks



# Inspections (Follow-Up Services)



Throughout the lifetime of the UL certification, products undergo regular inspections at the manufacturing facility to verify the continuous compliance with the respective certification documents. Generally, the inspection includes:

- An Initial Production Inspection (IPI) scheduled with UL's field engineer representative
- Regular follow up helps prevent disruption in application of the UL Mark.

The frequency of these inspections is based upon several factors, including (but not limited to) the type of product and quantity of Marks to be applied. Similarly, manufacturing visits may also be required for other certification schemes that allow the customer to use a certification mark.



## Key benefits

- Quality assurance
- Continued compliance with certification documents
- Technical onsite support





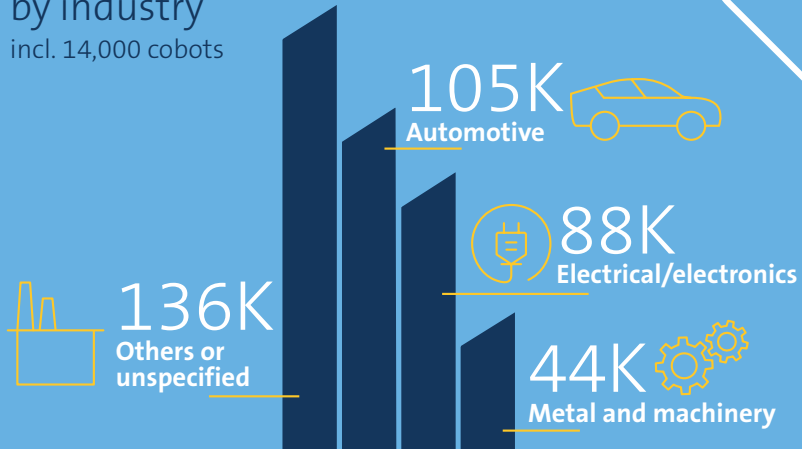
# The global robotics market today



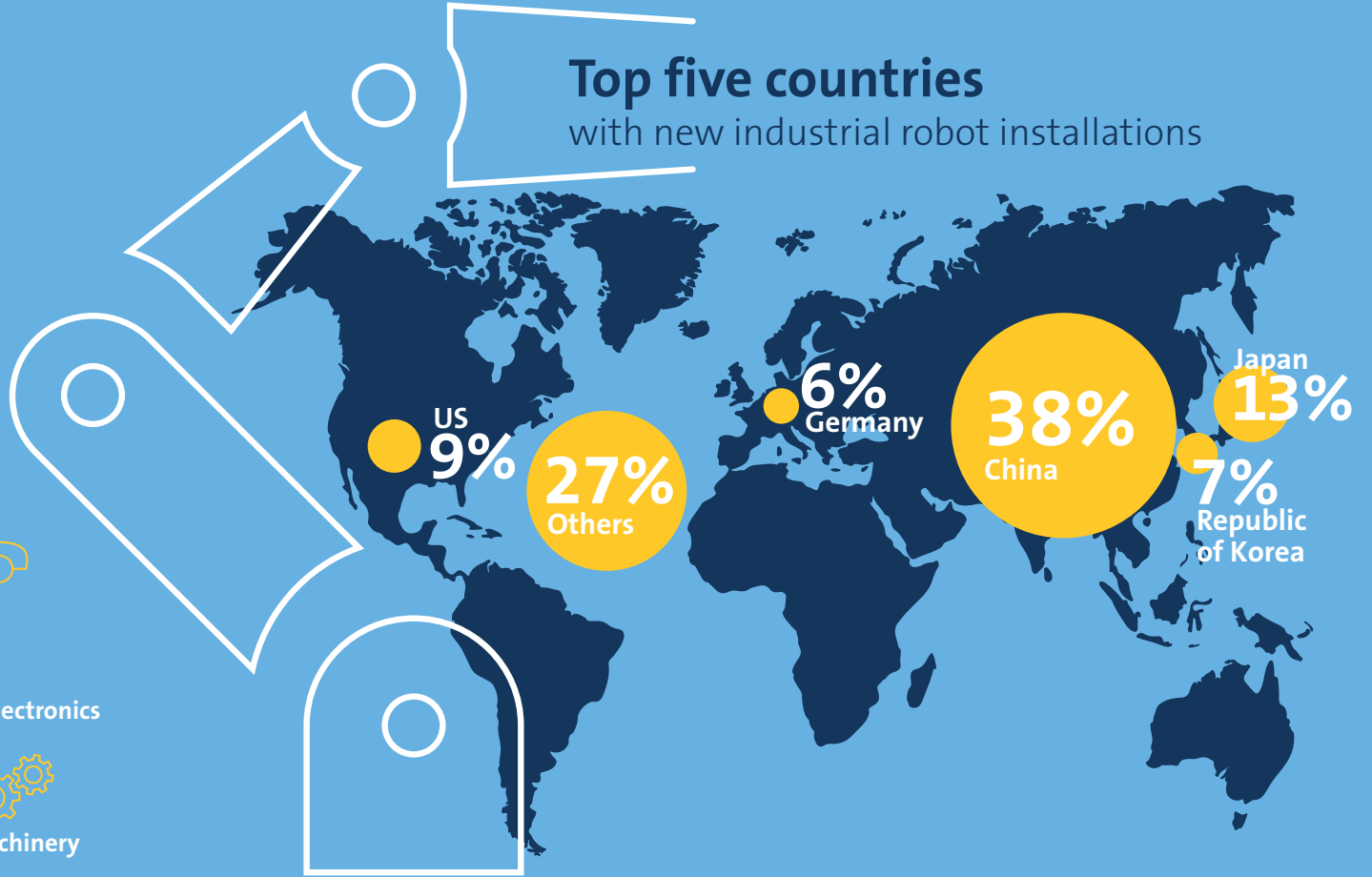
Operational stock of industrial robots **2,722,000**

**373,240** New installations worth USD 13.8 billion  
*(calculated, without software and peripherals)*

## Worldwide installations by industry incl. 14,000 cobots



## Top five countries with new industrial robot installations



Data is for the year 2019. Source: International Federation of Robotics (IFR), World Robotics 2020



OVERVIEW





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