STRATEGIC BUSINESS PLAN
ISO/TC 299 Robotics

EXECUTIVE SUMMARY

ISO/TC 299 Robotics works to meet the growing needs for standardization in the robotics domain in different environments, including industrial, public, and domestic, as well as the growing number of applications throughout the entire society.

The domains in which robotics is applied are continuously expanding with steady growth in new markets and applications. At the same time there are rapid technical developments in areas such as artificial intelligence, perception, localization & mapping, autonomy, 5G, and human-machine interaction. Consequently robots, the applications where robots are utilized, and the environments around robots are constantly evolving.

With the growth of robotics, the need for standards only intensifies. The focus of ISO/TC 299 is to identify and address the needs of the robotics market for simplification and transparency to reduce technical barriers to trade. Areas include interoperability, approaches to risk assessment, risk reduction and functional safety, vocabularies, and criteria for performance characterization.

The scope of ISO/TC 299 reads: “Standardization in the field of robotics, excluding toys and military applications.”

The robotics standardization is currently performed in nine working groups, with additional administrative and study groups:

- CAG, Chair’s advisory group
- AG 1, Communications group
- SG 1, Study group on ”Common robotics safety standard”
- WG 1, Vocabulary and characteristics
- WG 2, Service robot safety
- WG 3, Industrial safety
- WG 4, Service robot performance
- JWG 5, Medical robot safety (joint with IEC/TC 62 SC 62A and SC 62D)
- WG 6, Modularity for service robots
- WG 7, Management systems for service robots
- WG 8, Validation methods for collaborative applications
- WG 9, Electrical interfaces for industrial robot end-effectors

Due to the rapid evolvement of the robotics area, issues of gaps, overlaps, and conflicts must be identified. These are being explored both within ISO/TC 299 and with relevant stakeholders outside. With several other committees within ISO and IEC looking into areas related to robotics, attention to this topic is needed to avoid market confusion.

Recommendation for a common robot safety standard for industrial and service robotics has been made by SG1 and approved. This work will be completed jointly by members of WG 2 and WG 3, commence when new revisions of the current safety standards (ISO 10218-1, ISO 10218-2, and ISO 13482) have been released.

To address the standardization needs in the growing market of mobile robotics and mobile manipulators, a joint ad-hoc study group has been working together with ISO/TC 110/ SC 2, "Safety of powered industrial trucks." The result is a proposal to establish a joint working group, under the lead of TC 299, hopefully during 2023, to address the identified needs for standardization in this area. There are additionally two more NWIP proposals in this area to be discussed and decided within the near future.

1. INTRODUCTION

1.1 ISO technical committees and business planning

The extension of formal business planning to ISO Technical Committees (ISO/TCs) is an important measure which forms part of a major review of business. The aim is to align the ISO work programme with expressed business environment needs and trends and to allow ISO/TCs to prioritize among different projects, to identify the benefits expected from the availability of International Standards, and to ensure adequate resources for projects throughout their development.

1.2 International standardization and the role of ISO

The foremost aim of international standardization is to facilitate the exchange of goods and services through the elimination of technical barriers to trade.

Three bodies are responsible for the planning, development and adoption of International Standards: ISO (International Organization for Standardization) is responsible for all sectors excluding Electrotechnical, which is the responsibility of IEC (International Electrotechnical Committee), and most of the Telecommunications Technologies, which are largely the responsibility of ITU (International Telecommunication Union).

ISO is a legal association, the members of which are the National Standards Bodies (NSBs) of some 164 countries (organizations representing social and economic interests at the international level), supported by a Central Secretariat based in Geneva, Switzerland.

The principal deliverable of ISO is the International Standard.

An International Standard embodies the essential principles of global openness and transparency, consensus, and technical coherence. These are safeguarded through their development in an ISO Technical Committee (ISO/TC), representative of all interested parties, supported by a public comment phase (the ISO Technical Enquiry). ISO and its Technical Committees are also able to offer the ISO Technical Specification (ISO/TS), the ISO Publicly Available Specification (ISO/PAS) and the ISO Technical Report (ISO/TR) as solutions to market needs. These ISO products represent lower levels of consensus and therefore do not have the same status as an International Standard.

ISO also offers the International Workshop Agreement (IWA) as a deliverable which aims to bridge the gap between the activities of consortia and the formal process of standardization represented by ISO and its national members. An important distinction is that the IWA is developed by ISO workshops and fora, comprising only participants with direct interest, and so it is not accorded the status of an International Standard.

2. BUSINESS ENVIRONMENT OF THE ISO/TC

2.1 Description of the business environment

2.1.1 General introduction

Robotics has been a core pillar in the manufacturing industry for several decades and is today a multi-billion-dollar industry with applications that go far beyond manufacturing. Commercial growth in the robotics industry is projected to increase significantly over the next five years. Since the installation of the first industrial robot more than 60 years ago, the sector has continuously expanded into new markets and new applications.

Today robotics is no longer a technology only for manufacturing and use within industrial workplaces but has evolved to also address a much wider range of applications and domains in which a variety of services are provided to different end users beyond working adults. The robotics area is today split into three main categories: industrial robotics, service robotics, and medical robotics.

Main drivers for the development and adoption of robotics vary depending on the environment and use, but typically involve:

- achieve improved and reproducible quality
- address the ever-increasing shortage of skilled and unskilled labor
- improve health & safety of workers by having robots doing the dangerous and non-ergonomic activities
- provide improved work environments where humans perform higher value work while robots do the dangerous, dirty, and dull work activities
- increase production output / performance rates
- reduce operating costs
- reduce material waste and increase yield
- increase production and logistics flexibility
- enable greater resilience in sourcing and manufacturing through automation and thus keep production and jobs in high-cost countries
- improve quality of life for service robot users
- improve patient rehabilitation outcomes in medical sectors
- meet the increasing demands of service and consumer sectors

2.1.2 History

The ISO robotics committee was first created as ISO/TC 184/SC 2 with the title “Robots for manufacturing environments” in 1983. The initial efforts were primarily related to industrial safety with some activity in vocabulary and performance. In 2003, this title was updated to “Robots for industrial environments” to accommodate broader industrial applications other than only within manufacturing. The title was again, in 2006, updated to “Robots and robotic devices” to include not only industrial and medical robotics but also non-industrial robotics, which then were called “personal care robots”. With increased importance and activity within robotics, greater visibility was needed for better focus and coordination. This resulted in ISO/TC 184/SC 2 being upgraded to be ISO/TC 299, with the title of “Robotics” in 2016.

In 2019, personal care robots were re-named service robots as these provide services in a wide range of sectors. Industrial environments are defined as workplaces in the

manufacturing industry, warehouses etc. with working adults, where public access is restricted or excluded. Service robot environments include close human-robot collaborations as well as direct human-robot contact. Some medical robot applications even permit invasive operations into the human body for intended tasks. These changes over the years have been reflected in the increasing and broadening standardization activities in the field of robotics.

2.1.3 Business environment, industrial robotics

Industrial robots have traditionally been strong in the automotive industry with welding applications being dominant. The electronics industry has now become the largest market for industrial robotics, measured in number of installed robots per year, with automotive as the second largest.

Recent global growth has to a large part been driven by the strong market development in China, with the large demand for robotic solutions in segments such as consumer electronics. China is now the biggest market for industrial robots with more than 45% of all robots installed in 2020 being in China.

The concept of industrial robotics is today finding uses in many applications beyond manufacturing, e.g. material handling, logistics, small parts assembly, laboratory workplaces, and construction. These are all workplaces that restrict public access.

Future growth in industrial robotics will be driven by closer human-robot interaction, including planned human-robot contact while the robot application is operational (often referred to as collaborative applications), and mobile robotics (e.g. mobile robot systems with manipulators). Another important driver is the deglobalization trend, strengthened by the pandemic, which will drive resilience and local production decisions thereby increasing the needs for automation with robotics. In addition, the fast growth of digital technologies such as artificial intelligence, perception, localization & mapping, autonomy, human machine interaction, 5G, and Industry 4.0 (including industrial internet of things) is expected to have a big impact on future robotics. The evolution of all these areas will open a whole new frontier of industrial robot applications and drive continued growth.

2.1.4 Business environment, service robotics

Service robotics is divided into professional and personal sectors, with the primary distinction being the targeted user and buyer. Intended tasks are to provide a variety of services outside the industrial environment. The services are primarily for humans but can also be to other equipment. Tasks in personal sector include handling or serving of items, transportation, physical support, providing guidance or information, grooming, cooking and food handling, and cleaning. Tasks in professional sector include inspection, surveillance, handling of items, person transportation, providing guidance or information, cooking and food handling, and cleaning.

Continued growth of the service robotics sector is foreseen motivated by the increasing demand to meet the growing needs of the society in domestic and public sectors due to factors such as the ageing population, growing middle-class, and increasing lack of labor. The advancements in and reduced cost of technology further lowers the threshold for when and where service robotics might be applied.

The service robotics areas cover solutions able to provide that are not limited to working adults – whether in homes, schools, stores, indoors, or outdoors. They are all intended for

non-industrial environments which means that users of any age can get directly interact with and use the service robot. In most of the applications, close human-robot interaction is foreseen, and often physical human-robot contact is essential for providing the intended service.

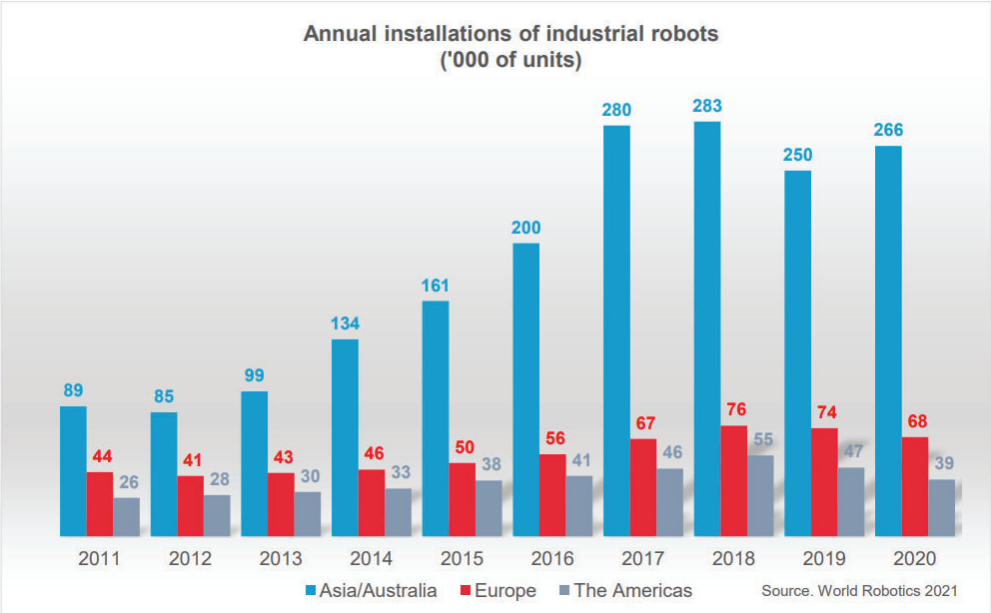
Service robot modularity and service robot module interoperability focuses on main issues of security, connectivity (from both hardware and software perspectives) and functionality to develop plug and play service robot module markets. The recently published standard ISO 22166-1 presents requirements and guidelines for implementing module-based designs that allow for easily configurable, application-specific service robots and service robot systems, tailored to individual customer requirements.

2.1.5 Business environment, medical robotics

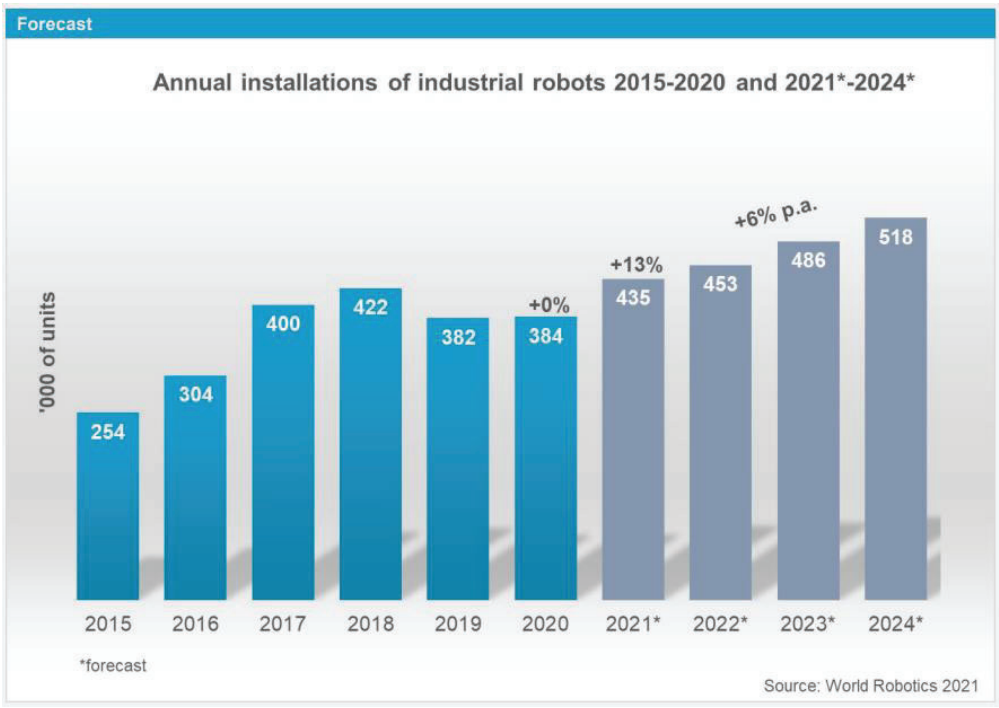
Medical robotics includes requirements for invasive and non-invasive clinical interventions which involve medical electrical equipment and medical electrical systems rather than the industrial or non-medical service robotics concepts. This requires building on existing standards for medical electrical equipment and systems and how basic safety and essential performance requirements for medical robotics can be aligned with existing standards, such as the IEC 60601 family of medical standards. Such specifications demand new standards, and the standardization work has followed the growth in these emerging medical robot applications. Medical robotics is handled by IEC/TC 62 SC62A and SC62D, and ISO/TC 299 in a joint working group (JWG 5).

2.2 Quantitative indicators of the business environment

The robotics world market statistics, based on data from 40 countries, is annually reported by the International Federation of Robotics (https://ifr.org/worldrobotics). The latest data on installations of industrial robots are as follows:

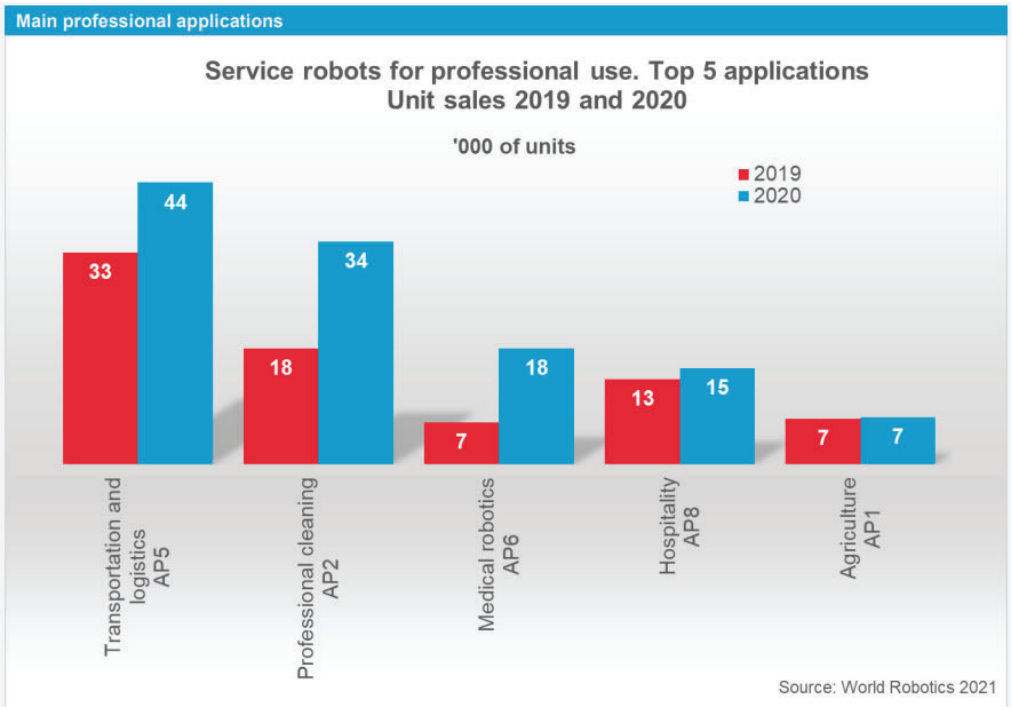


The industrial robotics market is expected to see continued growth in the coming years with new applications and new technologies being introduced:



Note: p.a. means per annum, i.e. per year

The latest data and trends for service robotics for professional use from the International Federation of Robotics can be seen in the figure below. Please note that medical robotics is seen as part of the service robotics market by IFR whereas we see it as a separate market and deal with it in collaboration with IEC. Transportation on public roads and sidewalks, and agriculture is handled by other TC's.



3. BENEFITS EXPECTED FROM THE WORK OF THE ISO/TC

3.1 General benefits

The main benefit expected from the work of ISO/TC 299 is to enable market growth of robotics while assisting in the safe use of robots in all applications.
Standardization in this field aims at developing high quality, easy to use standards to enable the growth of robotics without compromising safety. Standards developed are in the fields of

- safety for industrial and service robots and their integration
- performance and testing criteria
- modularity and inter-operability
- non-safety related requirements for related components as well as interfaces
- vocabulary and characteristics

The standards provide global robot and robot module manufacturers, integrators, users and others with requirements and guidance on how to apply and use robotics in different applications and environments. Furthermore, business is simplified by improved predictability of features, interfaces, and aspects of compatibility.

3.2 Benefits for the industrial robotics field

Rapidly developing capabilities of robots and robot systems makes it imperative to have safety requirements and guidance to protect personnel in industrial environments. With advances in technology and broadening of applications, standards need to provide up-to-date and useful guidance and requirements.

In the past, the primary means of protecting workers was by separating them from the robot system and/or stopping the robot application before humans could come close to hazardous situations. With improved safety technology, there are now an increasing number of applications where humans can work in close proximity with active robot systems without physical safeguarding. In response to this, the ISO/TS 15066 was developed to provide safety guidance for collaborative applications. This process continues with incorporation of the contents of ISO/TS 15066 into ISO 10218-1,2 as well as an anticipated update of ISO/TS 15066.

Due to the market demand and development in areas such as warehousing, logistics and e-commerce, mobile industrial robotics is growing rapidly. This is driving the market need for safety requirements for industrial mobile manipulators and mobile robot systems.

A series of standardization activities have been defined where, following the release of the ISO 10218 series, work will continue on supplemental documents such as Technical Reports and Technical Specifications to encompass technological advancements. The content of these supplemental documents can then be considered for inclusion in future revisions of the ISO 10218 series.

The active participation by so many member nations results in standards that reduce costs in the design and manufacturing of robots and robot applications. Due to a wide adoption of the ISO 10218, Part 1 and Part 2, a robot system could be the same solution in e.g. Europe, Japan, Korea, USA, and Canada. In the past, there were vastly different requirements for these regions, while now there remain only minor differences.

3.3 Benefits for the service robotics field

The service robotics market has in the last years reached a similar size as the industrial robotics market and is still growing at high rates. As technology emerges, robots for existing applications become more skilled and/or can be offered at lower prices. On the other hand, many new applications exit the research labs and are offered as products. As a result, the service robotics domain has a large variety of different technical solutions and manufacturers with a different technical and operational background. The common enabling feature of service robots is autonomy.

Standards issued by TC 299 help to find common ground in this highly heterogeneous environment. While ISO 13482 currently uses mobile servant robots, personal carrier robots and physical assistant robots as examples, the hazards and means for risk reduction provided in the standard are of a general nature and can also be applied to other robots. In the same way the guidance and requirements for control system design and safety-related control system functions are highly valuable to all manufacturers dealing with the safety of robotic technology.

Also in the areas of performance and modularity, standards of ISO/TC 299 are mostly application-agnostic and are therefore of high value for manufacturers. In addition, TC 299 can act as a first stop for other standardization committees dealing with autonomous products.

TC 299 also acts as a forum for service robotics stakeholders who want to ensure that development of standards for the sector is appropriate and widely acceptable. This applies especially in applications where service robots enter sensitive areas and interact with vulnerable persons, for example in domestic and healthcare environments.

Some of the key new domains are healthcare, physical and cognitive assistive systems, domestic and consumer products, professional cleaning robots, etc. In all these cases, robots and humans will co-inhabit the same space for providing the wide variety of services. Note that not all the application areas mentioned above are covered by current service robot standardization activities in TC 299.

3.4 Social, safety, health, environmental, or cultural issues

The robotics domain continues to evolve, and ISO/TC 299 needs to monitor, anticipate, and act on future market needs for standardization. This could include the following areas:

- application requirements and guidance for:
  - integration of robot systems to all sectors
  - understanding requirements for safe use of robot systems in existing and emerging application domains
  - methodologies for testing, verification, and validation
- reduction of energy requirements and environmental impact of robotics
- safety aspects where a variety of humans with wide-ranging capabilities use robots or robotic systems
- social, cultural, and ethical aspects when automation and robotics are used to address human labor shortage
- healthcare and medical applications where robots are used to improve the health, diagnosis, treatment, rehabilitation, assistance, and quality of life for humans (safety of these applications are dealt with by JWG 5).

4. REPRESENTATION AND PARTICIPATION IN THE ISO/TC

4.1 Membership

At the time of writing there were 28 participating countries/ISO member bodies and 13 observing countries/ISO member bodies participating in the work of ISO/TC 299:

Countries/ISO member bodies of the ISO/TC 299

4.2 Analysis of the participation

4.2.1 General description of stakeholders

Participation within ISO/TC 299 Robotics standardization is well reflected by the overall adoption of robot solutions on the market.

Historically, participation has been concentrated among developed countries, as these were the early adopters of the technology, with focus on manufacturing industries. Today with increased investments and research, and the current deglobalization trend, automation and robotics is expected to have continued growth, both in terms of new application areas and new markets. As the market for robotics continues to grow, we welcome increased participation from more areas of the world.

The standardization work within ISO/TC 299 is performed through a good global participation with experts from all relevant interest groups such as robot manufacturers, robotic integrators, robot system users, regulatory representatives, other standardization organizations, governmental and non-governmental organizations, and academia.

4.2.2 Stakeholders within the industrial robotics market

WG 3 on industrial safety has healthy participation levels overall. Some 20 member bodies provide over 140 technical experts, with approximately 55 attendees at working group meetings and providing comments. Even during the COVID-19 pandemic, when meetings were all virtual, most meetings had over 50 participants.

WG 9 on electrical interfaces for industrial robot end-effectors started mid-2022.

The experts consist of a diverse mix from the main interest groups, with no group being dominant.

4.2.3 Stakeholders within the service robotics market

The service robotics sector has developed and now comprises several working groups focusing on providing standards for safety, vocabulary, performance, and interoperability of service robotics.

Three working groups have been created jointly with IEC/TC 62 to develop collateral and particular standards to fit into the IEC 60601 family of medical standards to cover medical robots.

Overall, the experts represent the main interest groups, but TC 299 would welcome further increased participation from market interest groups.

The number of experts in the service robotics working groups is growing and at time of writing comprised:

- WG 2, “Service robot safety” had over 70 experts from 13 countries
- WG 4, “Service robot performance” had over 70 experts from 18 countries
- WG 6, “Modularity for service robots” had over 70 experts from 15 countries
- WG 7, “Management systems for service robots” had around 40 experts from 9 countries.

4.2.4 Stakeholders within the medical robotics market

There is one joint working group between ISO and IEC, that deals with safety for medical robotics. The number of experts in this joint working group at time of writing comprised:

- JWG 5, “Medical robot safety” had more than 80 experts from 17 countries during the core collateral and particular standardization work.

4.2.5 Stakeholders for common robot standardization work

Some activities within ISO/TC 299 deal with topics that are common to both industrial and service robotics.

These activities are performed with experts in the following groups:

- AG 1, “Communications group” has 10 members from 6 countries
- WG 1, “Vocabulary and characteristics” has around 40 experts from 11 countries
- WG 8, “Validation methods for collaborative applications” has over 50 experts from 10 countries. The work targets both industrial and service robotics, although at present data is only available for working adults
- SG 1, “Common robotics safety standard” has around 40 experts from 13 countries

5. OBJECTIVES OF THE ISO/TC AND STRATEGIES FOR THEIR ACHIEVEMENT

5.1 Defined objectives of the ISO/TC

The overall objective of standardization within ISO/TC 299 is to ensure availability of a consistent and coherent package of international standards in the overall robotics sector for companies, organizations, and individuals to meet current and foreseen requirements.

ISO/TC 299 aims to be the focal point at the international level for the identification of needs and development of standardization documents for robotics. Cooperation with other ISO and IEC committees and other SDOs (Standard Development Organizations) is being organized to address the fact that robotics is a multi-disciplinary area reaching into many sectors, and thus multiple technical committees. Hence co-operation is essential to maximize impact and lessen overlaps and conflicts. When other committees develop robotic related standards in their specific application areas, they should be encouraged to recognize and harmonize with the standards developed by TC 299.

Our ambition is to:

- develop standards that are used globally and correspond to needs from the market
- publish standards that are easy to use, understand, implement, verify, and validate
- be the natural focal point for all standardization efforts in and around robotics
- promote robotics and the corresponding standards throughout global markets

5.2 Identified strategies to achieve the ISO/TC's defined objectives

ISO/TC 299 work is being performed with the expectation that the resulting standards and documents will be used by the different stakeholders and other SDOs. Hence, we strive to have requirements and guidelines that are consistent, concise and non-ambiguous.

To reach the objectives, ISO/TC 299 has defined the following strategies:

- develop standards and documents that are based on identified market needs and that are consistent, concise as well as easy to understand, use, and implement
- attract experts with deep knowledge in robotics and associated domains (design, implementation, and use) who are also aware of the business and market needs
- maintain a high level of participation from all stakeholder groups to ensure latest developments are incorporated and market needs are addressed.
- create new working groups as the market need arises to develop new needed standards
- identify and address issues related to gaps and overlaps
- coordinate with other technical committees, groups, and organizations to ensure that the development of standards is as efficient as possible
- actively seek liaison relationships to share knowledge and coordinate activities, for using robots as systems or machines generically or in specific application sectors
- actively monitor the standardization efforts by other TCs and SDOs to encourage them to recognize and harmonize with the standards developed by TC 299

Most of the drafting work is done in drafting groups outside of formal meetings. The drafting work is shared for later review at the formal working group meetings. Philosophical issues are also discussed at these meetings, where consensus is achieved. There must be, and is, a high degree of respect and collaboration among all participants.

6. FACTORS AFFECTING COMPLETION AND IMPLEMENTATION OF THE ISO/TC WORK PROGRAMME

Robotics is a fast-growing area, and stakeholders within ISO/TC 299 can have difficulty sustaining technical expertise and consistent funding. New work items strain the ability of member bodies to provide appropriate resources, as often the same resources are needed for multiple work items. The cost of hosting and attending meetings can limit the ability for many member bodies, delegates, and liaisons to participate. Participants who have the necessary expertise are commonly very busy in their normal work. Thus, the time available to work on the development of ISO standards can be limited, delaying the production of drafts and the reviews of and comments on new proposals. Slow development of standards might result in decreased relevance and interest and/or lower quality of the deliverables. Rapid development, on the other hand, can sometimes put too high burden on the experts that are required to provide the high-quality deliverables.

Safety projects developed under the Vienna Agreement with ISO and CEN, where ISO is in the lead, can be negatively impacted by late input by, and availability of, HAS Consultants.

As has been experienced in the virtual-only meeting situation during the pandemic, there are significant challenges with online meetings, but there are also opportunities. Short online meetings are relatively easy to organize but are mostly useful to report or discuss a limited amount of information. Often many online meetings are needed to achieve what just one face-to-face meeting would accomplish. Online meetings facilitate the participation of experts who have difficulty to travel to participate in physical meetings. However, timing on-line meetings to enable global participation has proven to be difficult, and sometimes meetings might have to be repeated. Hybrid meetings have also been shown to be challenging requiring very good technical equipment and setup.

Robotics, especially service robotics, is a fast-growing sector with many new applications entering the market. We have observed the creation of new committees, working groups and chair positions. This threatens to fragment the standardization for robotics. Therefore, the support of the ISO TMB should be sought to monitor the creation of new structures related to robotics and autonomy not only within ISO, but also in IEC. This also underlines the need to strive for unity within TC 299, by creating a common understanding of scopes and key definitions so that an efficient communication outside the TC is possible.

The above factors will have to be managed continuously. The experiences gained, especially over the last few years, can help optimize our standardization work by having a mix of online, hybrid, and face-to-face meetings depending on the different needs in the different working groups as well as the access to experts.

7. STRUCTURE, CURRENT PROJECTS, AND PUBLICATIONS OF THE ISO/TC

The scope of ISO/TC 299 reads
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- WG 8, Validation methods for collaborative applications
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TC 299 projects are prioritized and developed based on market needs and availability of experts.

Revisions of ISO 10218-1, ISO 10218-2 and ISO 13482 are currently being developed under the Vienna Agreement between ISO/TC 299 and CEN/TC 310 "Advance Automation Technologies and their Application", with ISO in lead, and with the target to reach harmonization with the EC Machinery Directive.

Information on ISO online

Link to the TC's page on ISO's website: **ISO/TC 299 on ISO Online**

Click on the tabs and links on this page to find the following information:
- About (Secretariat, Committee Manager, Chair, Date of creation, Scope, etc.)
- Contact details
- Structure (Working groups)
- Liaisons
- Meetings
- Tools
- Work program (published standards and standards under development)

Reference information

Glossary of terms and abbreviations used in ISO/TC Business Plans

General information on the principles of ISO's technical work