published by
International Federation of Robotics
Frankfurt, Germany
Update January 2025

IFR International Federation of Robotics

INFORMATION PAPER

WORLD ROBOTICS R&D PROGRAMS

IFR International Federation of Robotics

Inhalt

Introduction

Most countries invest in robotics – mainly on a government level. This trend has been strengthened in recent years. Through diversification and the establishment of robot technologies, investment in new robot technologies has become larger than before, and the application spectrum of such R&D on robotics is now broader. For more than ten years, a very challenging environment – influenced by AI, IoT, Big Data and 5G telecommunication – has been driving our daily life, including robots.

Within IFR, there have been continuous requests and discussions on robotics R&D programs and funding. IFR's Research Committee carried out a survey and concluded that the gathering of such information and materials on robotics R&D from each country makes sense for anyone who is involved as well as interested in robotics. The most efficient way to share such material seems to be publishing it to the IFR website directly, for easy public access. Updates will be provided from time to time in case of any update by individual countries. The survey and the summary made accessible will be extended to more countries over time.

The 1st version of World Robotics R&D Programs was introduced in an IFR press release in June 2020. Since then, dozens of countries have updated their robotics R&D programs, and information on several new programs has been gathered from each country. The 2nd version, World Robotics R&D Programs 2021, included such updates as well as further new program information. The 3rd version, World Robotics R&D Programs 2022, covers materials mostly collected during 2022. *The latest 4th version of World Robotics R&D Programs again includes updated and new information collected in 2024.*

Work scope: The contents for extract and summary will be restricted to officially government-driven robotics R&D programs in each country.

Classification: Every document and material will be classified and summarized into continent, region and country.

Executive summary: Each country will have its own characteristics of robot programs based on its specific background and history, for instance with cultural, mental and industry in focus. In this section, current as well as historical robot programs will be briefly summarized.

Summary: The robotics R&D program of each country will be summarized into five pages mostly. Several big programs in one country can be separately summarized, for instance, Artemis Lunar Program, IRAS program by NSF and so on. The original material is linked into every summary and one click leads to the original material on the Internet.

Appendix: Some documents and materials are not easily accessible online, especially from most Asian countries. Another problem is that documents are usually in the respective official languages of the countries. The Appendix will provide the original documents on the IFR website directly and all documents will be translated into English.

Update and revision: Any update and revision will occur in an efficient way in case the following occurs:

- announcement of the new program of any country
- update and revision of the current program in each country
- any correction or partial updates of any document

Visitors are also cordially requested to let us know about any kind of related information and opinions. We will be pleased to implement any improvements with your support.

***Exchange rate reference date**: December 1, 2024.*

Work team:

Officially, this series of work is handled by IFR Research Committee.

All communication, including the delivery of documents and information is to be directed at each person at Korea Institute of Medical Microrobotics (KIMIRo):

- First point of contact:
  Jenny Kim
  jh@kimiro.re.kr
  +82-62-530-5230 (office)
  +82-10-4995-9136 (mobile)
- The person in charge of South Korea and China:
  Taeksu Lee. Ph.D.
- The person in charge of US (DoD) and UK:
  Kim Tien Nguyen, Ph.D.
- The person in charge of Singapore, Australia, Sweden, Switzerland, US (NSF), US (NASA):
  Van Du Nguyen, Ph.D.
- The person in charge of Japan, Italy, Canada:
  Cao Xuan Hiep, Ph.D.
- The person in charge of EU, Germany:
  Daewon Jung, M.Sc.

- The supervisor of all work:
  Jong-Oh Park, Dr.-Ing.
  President, KIMIRo
  Vice Chair, Research Committee of IFR
  jop@kimiro.re.kr
  +82-62-530-5231 (office)
  +82-10-3211-2795 (mobile)

Classification

Every document is classified into region and country. Every country has its own regional code as follows:

Region	No.	Country / Region	Note
Asia	A01	China	Updated
	A02	Japan	Updated
	A03	Korea	Updated
	A04	Chinese Taipei	
	A05	Thailand	
	A06	India	
	A07	Singapore	New
	A08	Indonesia	
	A09	Malaysia	
	A10	Vietnam	
	A11	Australia	New
EU	E00	EU	Updated
	E01	Germany	Updated
	E02	Italy	Updated
	E03	France	
	E04	United Kingdom	Updated
	E05	Spain	
	E06	Turkey	
	E07	Sweden	Updated
	E08	Benelux	
	E09	Austria	
	E10	Denmark	
	E11	Switzerland	Updated
	E12	Czech Republic	
	E13	Poland	
	E14	Russia	
America	U01	USA	Updated
	U02	Canada	Updated
	U03	Mexico	

IFR International Federation of Robotics

Executive summary

Basically, each country plans and allots budgets per program, but some ambiguity exists in terms of the duration of such programs across nations. There are also external controls. These should be taken into consideration with a review of the following:

- China:
  - The Chinese government provided 45.2 million USD (329 million CNY) in general funding and 44.5 million USD (324 million CNY) for the Key Special Program on Intelligent Robots in 2023 and 2024. The other programs are not included, primarily due to difficulty in accessing governmental sources.
  - Ranked third globally in robot density (for industrial robots) and active in the global humanoid robot market.
- Japan:
  - A budget of 334 million USD (50 billion JPY) was allocated to robotics-related projects in the Moonshot Research and Development Program over a period of five years from 2020 to 2025.
  - The Japanese government provided more than 660 million USD (99 billion JPY) in support in 2023. The figure is 6 billion JPY less than that of the previous year.
- Korea:
  - The Korean government allocated 163 million USD (230 billion KRW) in funding for the 2023 Action Plan for the Intelligent Robot.
  - The Korean government is planning to budget 128 million USD (180 billion KRW) in 2024 for the 4th Basic Plan for Intelligent Robots.
- European Union:
  - The European Commission is expected to provide a total of 183.5 million USD (174.0 million EUR) for the robotics-related work program (2023-2025) in Cluster 4 under Horizon Europe.
  - The European Space Agency is planning to provide feasibility study funding (max: 0.53 million USD (0.50 million EUR)) for Commercial Applications of Space-Enabled Robotics in 2024.
- Germany:
  - The German government will provide approximately 69.12 million USD (70 million EUR) annually until 2026 (total budget: 369.19 million USD (350 million EUR) for five years).
- United Kingdom:
  - The UK's funding for robotics in 2023 and 2024 is around 28.8 million USD. This amount has been invested into three programs, including Made Smarter Innovation, Transforming Food Production, and the Driving the Electric Revolution Challenge, all of which are affiliated with the Industrial Strategy Challenge Fund.
- United States of America:
  - The budget for Intelligent Robotics and Autonomous Systems (IRAS) R&D programs at the National Science Foundation (NSF) was 53.8 million USD in 2023 (supplemental funding: 4.6 mil. USD) and 69.9 million USD in 2024.
  - (DoD) In the 2023 and 2024 fiscal years, the DoD defense budget invested 10.3 billion USD in FY23 (approximately 1.21% of the total DoD budget and 3.7% of the RDT&E and procurement budget) and a requested amount of 10.2 billion USD (approximately 1.21% of total DoD budget and 3.2% of RDT&E and procurement budget) agency-wide for autonomy and robotics technologies.
  - (NASA) For the Artemis program, the US government is planning to allocate a budget of 53 billion USD for 2020 through 2025. In 2023, approximately 10.67 billion USD was granted for NASA's Artemis I mission.

China

China's development of industrial robots began in 1972 and gained momentum with R&D efforts in spraying, spot-welding, arc-welding, and transport robots during the 7th Five-Year Plan (1986-1990). The 863 Program, launched in 1986, provided substantial government funding for robot-related R&D, marking a pivotal moment in China's robotics industry.

In the 1990s, welding robots became a focus, with investments in nine industrialization hubs and seven R&D centers. Key manufacturers like Shenyang Siasun, Harbin Boshi Automation, and Beijing Research Institute of Automation emerged.

Made in China 2025, which was launched in 2015, prioritized innovation in advanced robots and mechanical tools. The 13th Five-Year Plan (2016-2020) promoted innovation in manufacturing and integrated AI into robotics development. The Robot Industry Development Plan (2016-2020) aimed to strengthen China's robotics industry, focusing on areas including welding, cleaning and industrial robots, and human-machine cooperation. Core components, including high-precision reducers, motors, and sensors, were also targeted for development.

As part of national science and technology initiatives, key projects like Intelligent Robots were launched between 2017 and 2021 with significant funding. In 2020, the Ministry of Science and Technology allocated 9.13 million USD (66.4 million CNY) to the program. In 2022, Intelligent Robots received 43.4 million USD (316 million CNY) under the 14th Five-Year Plan, marking the robotics industry as one of China's key sectors for the next five years.

In 2023-2024, the 14th Five-Year Plan (FYP: 2021-2025) for the National Economic and Social Development of the People's Republic of China was announced by the Central Committee of the Communist Party of China, in which the robotics industry was included in eight key industry categories for the next five years. In order to implement arrangements of national science and technology innovation during the 14th FYP, Intelligent Robots has thus far been launched under the National Key R&D Plan. It is according to the deployment of this program that the annual project declaration guides for 2023 and 2024 were released. Intelligent Robots received 45.4 million USD (330 million CNY) in 2023 and 44.7 million USD (325 million CNY) in 2024 under the 14th Five-Year Plan. Access to documents on robotics R&D programs funded by the Chinese government is still quite limited. The fact remains, however, that China's robot density ranks third worldwide as of 2023, and dozens of Chinese humanoid robots have already been released in the global market.

Japan

In Japan, the national R&D program on robotics is planned and funded by the Economic Revitalization Policy and Science, Technology, and Innovation Policy.

In February 2015, the Japanese government announced the New Robot Strategy (the headquarters for the nation's economic revitalization) based on the revised 2014 Japan Revitalization Strategy as a key policy of the Abenomics Growth Strategy. After this strategy was announced, the robot-related budget for the 2016 fiscal year stood at 258.7 million USD (29.4 billion JPY), an increase of 83% over the previous fiscal year. The budget for the 2019 fiscal year is 332.6 million USD (37.8 billion JPY). The New Robot Strategy presented action plans in five sectors to pursue over five years (2016-2020): manufacturing; service; nursing and medical; infrastructure, disaster response, and construction and; agriculture, forestry, fishery, and food industry.

As of 2020, follow-up measures are in progress. Additional funding of 17.6 million USD (2 billion JPY) for 2019 (up from 0.88 billion USD (100 billion JPY) for 2018) was allocated to the Moonshot Research and Development Program to address the concerns of population decline and aging. These projects aimed to develop robots that could enhance the human body's physical and mental limitations and AI robots that are able to evolve alongside humans.

From 2021 through 2022, the New Energy and Industrial Technology Development Organization (NEDO), a national R&D agency, launched projects related to robotics and AI technology to cope with the explosive spread of COVID-19, thereby broadly affecting socioeconomic activities worldwide and brought about unprecedented change to the daily lives of individuals. These projects focus on developing new industrial robots and self-driving robots to strengthen supply chains and maintain logistics services with 79.81 million

USD (9.07 billion JPY) in funding for 2021 and 67.48 million USD (7.68 billion JPY) for 2022.

In December 2023, the Cabinet Office (CAO) decided on Moonshot Goal 10: Realization of a dynamic society in harmony with the global environment and free from resource constraints, through diverse applications of fusion energy, by 2050 in the Moonshot Research and Development Program. Ten Moonshot Goals (MS goals) were decided in the area of society, environment, and economics, of which the first (Overcoming limitations of body, brain, space, and time) and third (Coevolution of AI and robots) are robot-related. The Ministry of Economy, Trade and Industry (METI) and NEDO launched robotics R&D projects with 640 million USD (99 billion JPY) in funds for 2023.

Korea

Korea's robotics industry evolved through multiple stages of government-industry collaboration. Initially, in 1978, welding robots were introduced in car manufacturing, and independent R&D began without government support. In 1987, the government initiated the Common Core Technology Development Project to support the development of manufacturing robots. Funding decreased drastically, however, during the Asian Financial Crisis of 1997. By 2002, intelligent robots emerged, for which the government ramped up support, establishing the robotics industry as a key growth sector by 2003. From 2002 to 2007, the government invested 345.5 million USD (486.5 billion KRW) into R&D and market creation.

The Intelligent Robot Development and Supply Promotion Act was passed in 2008, followed by the First Intelligent Robot Basic Plan (2009-2013) in 2009. These focused on three key areas: manufacturing robots, new market creation (e.g., education, cleaning, surveillance), and assuming a leading position in terms of technology (e.g., medical, traffic, wearable robots). The government invested 540.3 million USD (760.7 billion KRW) into all three, resulting in a boost in corporate sales and technological development.

The Second Basic Plan (2014-2018) focused on specialized services, such as disaster response and healthcare robots, and emphasized the merging of robotics with sectors such as manufacturing, automobile, and defense. The government allocated 77.7 million USD (109.45 billion KRW) in 2014. This figure increased to 120.5 million USD (169.7 billion KRW) by 2018.

In May 2023, the Action Plan for the Intelligent Robot was released by the Ministry of Trade, Industry, and Energy (MOTIE). Its purpose was as follows:

- Expand the market size of the robotics industry to 10.7 billion USD (15 trillion KRW) by 2023.
- Increase the number of companies valuing at least 71.0 million USD (100 billion KRW) that specialize in robotics to 20 by 2023 at the latest.
- Increase the number of manufacturing robots in operation to 700,000 (cumulative) by 2023.

The total funding provided for 2023 was 163 million USD (230 billion KRW).

In January 2024, the government announced an investment of 128 million USD (180 billion KRW) in the 4th Basic Plan for Intelligent Robots to support the development of the robotics industry as a core industry for the Fourth Industrial Revolution, as well as innovation in manufacturing and services.

Singapore

In August 2016, the National Robotics Program (NRP) was officially established in Singapore as part of the Research, Innovation, and Enterprise Initiative, which is grounded in the Robotics R&D Taskforce convened in 2014 for the goal of identifying opportunities for the country in robotics. NRP aims to catalyze differentiated robotics capabilities in Singapore through the funding of use-inspired research and use-driven development and is a multi-agency national platform hosted by A*STAR (The Agency for Science, Technology, and Research), which oversees the research, development, and translation of robotics enablers and solutions. NRP also seeks to develop capabilities in robotics for societal and economic impacts, going beyond technologies to include growing the local talent pool, identifying applications and shaping Singapore's robotics environment. In its early days, NRP funded robotics R&D projects through two funding initiatives (FI): Robotics Enabling Capability Technology (RECT) and Robotics Domain Specific (RDS). RECT focuses on building applicable robotics technologies, inspired by potential use in domain sectors that Singapore is keen to develop, whereas RDS co-funds projects with public agencies in Healthcare, Built Environment, and Environmental Services to innovate robotics solutions for each's problems and use cases. This two-prong system has since been changed to one FI to fund both capability-building and translation projects under the RoboCluster initiative. Since the start of NRP, 11.3 million USD (15.1 million SGD) has been provided on average per year for robotics R&D projects.

In March 2024, the Singaporean government announced that it will be providing 44.8 million USD (60 million SGD) for NRP for the goal of technology translation. A key pillar of NRP's efforts in this area is the RoboCluster initiative, which is comprised of robotics innovation clusters aligned with prioritized R&D focus areas and industry sectors: namely, manufacturing, logistics, facilities management, healthcare, aviation, and maritime. Through RoboCluster, NRP will bring together public R&D institutions such as A*STAR and Institutes of Higher Learning, end-users, robotics and automation companies (including Singapore-based foreign companies), trade associations, VCs, and government agency stakeholders to align and synergize robotics R&D capability-building with industry needs, foster collaborations and catalyze a larger volume of translation from R&D to adopted robotics products.

In 2024, the NRP announced the National Robotics Technology Vistas, outlining nine focus areas of robotics R&D: Assistive Robotics, "Universal" End Effectors, Reconfigurable Robotics, Navigation & Perception, Human-Robot-Interaction, System Capabilities, Trusted Robotics, Data-Driven Robotics, and Multi-Robot Systems. The strategy showcases the key R&D activities in each of the focus areas together with analyses of associated challenges and an envisioning of future developmental over the short-, medium-, and long-terms.

Australia

In Australia, funding for robotics-related R&D projects has been provided via key initiatives such as the Next Generation Technologies Fund, CRC for Trusted Autonomous Systems, Advancing Space: Australian Civil Space Strategy 2019-2028, and CSIRO Robotics and Autonomous Systems Group. In addition, as with other fields, robotics research projects are funded by the Australian Research Council.

In January 2022, the Australian government unveiled the Robotics and Automation on Earth and in Space Roadmap 2021-2030, a key priority area under the Australian Civil Space Strategy 2019-2028 that is the third in a series of technical roadmaps aiming to be achieved by the Australian Space Agency. The roadmap is considered an important milestone on the road to creating 20,000 new jobs and tripling the size of Australia's civil space sector to 7.8 billion USD (12 billion AUD) by 2030.

In August 2022, the Australian government pledged an investment of 0.65 billion USD (1 billion AUD) in critical technologies as part of the National Reconstruction Fund to support home-grown innovation and value creation in the AI, robotics, and quantum industries.

In May 2023, the government updated its list of Critical Technologies in the National Interest, including seven critical technology fields, of which one is related to robotics (Autonomous systems, robotics, positioning, timing, and sensing).

In May 2024, Australia's first National Robotics Strategy was released with the goal of responsibly developing and using robotics/automation technologies to strengthen competitiveness, boost productivity and support local communities. The government stressed that the strategy will help to build a stronger and more unified robotics industry and harness the benefits of robotics and automation across Australia. It is believed that developing, manufacturing, and using such technologies will improve productivity, grow the economy, help revive domestic manufacturing, and combat major challenges like climate change, aging population, geopolitical risks, labor market pressures, and rising costs of living.

The National Robotics Strategy sets out goals and objectives organized around four themes that represent areas of focus: 1) National Capability; 2) Increasing Adoption; 3) Trust, Inclusion, and Responsible Development and Use; and 4) Skills & Diversity.

European Union

Framework Programs (FPs) have been abbreviated as FP1~FP7, with “FP8” replaced with “Horizon 2020”.

The European Union has implemented multi-year programs since 1984 to fund R&D. These programs transitioned from durations of five to seven years starting with FP7.

FP7 (2007-2013) emphasized technological development, particularly in robotics, supporting 130 projects with a large fund of approximately 565.1 million USD (536 million EUR). This program advanced technologies such as perception, action-cognition, and intelligent systems. Other funds for robotics-related elements amounted to 179.2 million USD (170 million EUR).

Horizon 2020, the eighth EU Framework Program, ran from 2014 to 2020 and covered a range of research and innovation themes, one of which was robotics. It was structured into three work phases: 2014-2015, 2016-2017, and 2018-2020. Robotics projects within Horizon 2020, shaped by consultations in the SPARC program, span multiple areas, including Information and Communication Technologies (ICT), Future and Emerging Technologies (FET), and societal challenges. The program provided approximately 738.1 million USD (700 million EUR) for various robotics research projects with a focus on the manufacturing, healthcare, transportation, and agricultural sectors.

The 2014-2015 phase allocated 165.6 million USD (157 million EUR) to 36 projects aiming to improve robot robustness, flexibility, and autonomy across industries. The 2016-2017 phase, with a budget of 127.6 million USD (121 million EUR), expanded into areas such as human-robot interaction and navigation, helping to apply research outcomes to practical applications. The final phase, 2018 to 2020, focused on digitizing industries with robotics, advanced AI and cognitive technologies, and human-robot cooperation with 164.5 million USD (156 million EUR) in funding.

Horizon Europe (2021-2027) was built on Horizon 2020 for the goal of supporting research and innovation for a future of environmental conscientiousness, digital sophistication and healthier humans. The Strategic Research, Innovation, and Development Agenda (SRIDA) focuses on advancement in AI, data, and robotics and sets goals and priorities for research and innovation, with robotics under Cluster 4: Digital, Industry, and Space (Work Program 2023-2025: Cluster 4: Digital, Industry, and Space was announced on April 17, 2024). Robotics-related R&DI projects will focus on the digital transformation of the manufacturing and construction sectors, autonomous solutions that alleviate the burden of human workers, enhanced cognition, and human-robot collaboration based on research in digitization, AI, data sharing, advanced robotics and modularity. The robotics-related work program 2023-2025 in Cluster 4 will provide 183.5 million USD (174.0 million EUR) in funding (total).

Commercial Application of Space-Enable Robotics is a new program by the European Space Agency (ESA). Announced on March 7, 2024, it supported feasibility studies with a maximum of 0.53 million USD (0.50 million EUR) in funds and demonstration projects (funding by case assessment) for commercial applications that integrate satellite technologies with autonomous robotics systems.

Germany

In 2006, Germany’s High-Tech Strategy (HTS) was introduced to help the country become a global leader in innovation. It aimed to quickly turn good ideas into products and services and thereby foster collaboration among companies, universities, and research institutions. A key part of this strategy is Industry 4.0, an initiative that focuses on robotics R&D as a means of maintaining Germany’s leadership in digital products and their manufacturing.

From 2009 to 2014, the AUTONOMIK program funded 46.4 million USD (44 million EUR) for robot-related projects in manufacturing, logistics, and assembly. It explored smart tools and autonomous systems and led to the development of the AUTONOMIK für Industrie 4.0 program (2013–2017), which received the same amount of funding and aimed to combine industrial production technologies with info-communication technologies. The projects explored areas such as human-robot interaction and cognitive features for autonomous systems.

In 2016, the PAiCE program, with 52.7 million USD (50 million EUR) in funding, continued the work of AUTONOMIK and focused on digital platforms for industry, especially in robotics. PAiCE supports service robotics in logistics, manufacturing, and other fields.

The High-Tech Strategy 2025, adopted in 2018, set a goal of investing 3.5% of Germany's GDP annually in R&D until 2025. The affiliated Together Through Innovation program was launched in 2020, with the Federal Ministry of Education and Research (BMBF) slated to provide approximately 73.8 million USD (70 million EUR) annually until 2026 for robotics-related research.

Italy

The Italian government contributes to research funds that are managed by the EC, and Italian researchers actively participate in the European HORIZON 2020 ICT, NMBP, and other programs that involve robotics. As part of the FP7 (2007-2013) program, 16.5% of funding for robotics projects was awarded to Italian institutions.

In December 2020, the National Program for Research 2021-2027 was approved and extended through public consultation to public and private stakeholders and interests as well as civil society. The National Research Program (PNR), provided for by Legislative Decree 204/1998, is a document that guides research policies in Italy, the realization of which public players contribute to through the coordination of the Ministry of University and Research. Robotics is one of the primary areas of research and innovation in PNR 2021-2027, as indicated below:

- Robots increasingly more pervasive and personal
- Six priority areas for the overall supply chain, from fundamental research to application: 1) Robotics in a hostile environment; 2) Robotics for Industry 4.0; 3) Robotics for inspection and maintenance of infrastructure; 4) Robotics for the agro-food sector; 5) Robotics for health; 6) Robotics for mobility and autonomous vehicles

After the COVID-19 pandemic, Italy launched the National Recovery and Resilience Plan as part of the NextGenerationEU program, an 819 billion USD (750 billion EUR) recovery package agreed to be provided by the EU in response to the pandemic. Italy's plan includes investments worth 209 billion USD (191.5 billion EUR), financed through the Recovery and Resilience Facility.

Some activities of national relevance on robotics were launched in Italy, including the following:

- RobotHeart: RoboHeart is a national exhibition on industrial robotics, automation, related technologies and solutions, components, systems, and AI.
- National Course on Industrial Automation and Robotics: The Italian Association of Robotics and Automation (SIRI) has a long tradition of organizing the annual National Course on Industrial Automation and Robotics. In 2024, the 47th run, titled "Industrial Robotics: Between Regulation and Innovation," was held in Ancona.
- Ph.D program in robotics and intelligent machines: The new National Doctorate (https://drim.i-rim.it/en/) is characterized by an interdisciplinary and international outlook and strong industrial vocation for the advanced training of the country's young talent in the areas of robotics and intelligent machines.

United Kingdom

The UK recognizes robotics as a transformative technology for enhancing productivity and economic growth that is driven by advancements in microelectronics and data processing. It was anticipated that automation and robotics would provide significant economic benefits over the next decade in the following ways:

- 233.2 B USD (183.6 B GBP) of value to the UK industry
- 19 B USD (15 B GBP) of cost savings for consumers
- 127,000 workplace injuries avoided

This has resulted in significant amounts of funding becoming available from UK Research and Innovation (UKRI)-related organizations to support the R&D and commercialization of Robotics and Autonomous Systems (RAS) technologies. In 2016, the Industrial Strategy Challenge Fund (ISCF) was announced with four challenging themes and 22 programs, of which two of the themes and four of the programs are related to robotics R&D. In 2022, the biggest instance of funding for robotics research (Robots for a Safer World) was 142 million USD (112 million GBP), which was invested into 153 projects and 212 organizations and complemented by over 745 million USD (500 M GBP) in industry-matched funding.

Funding for robotics in 2023 and 2024 has focused on several significant initiatives and challenges across two themes (Clean Growth, Future of Mobility) and three programs (Made Smarter Innovation, Transforming Food Production, Driving the Electric Revolution), reflecting the country's strategic priorities in innovation and technology development. Total funding for robotics in 2023 and 2024 was approximately 28 million USD (22 million GBP).

Sweden

Vinnova, a Swedish public innovation agency, promotes robotics and automation by funding R&D projects across multiple sectors. It established the VINNVÄXT program in 2001 to support regional sustainable growth, with notable funding recipients including Robotdalen (2003) and Automation Region (2016). In addition to VINNVÄXT, Vinnova collaborates with universities, research institutes, and private companies to advance robotics, AI, and automation by supporting a large number of innovative projects.

Switzerland

- Switzerland’s research funding, driven by SNSF and Innosuisse, supports industry-academia collaboration in both basic and applied sciences. NCCR Robotics, which was active from 2010 to 2022, advanced robotics research and bolstered the nation’s global competitive edge. Its legacy continues through Innovation Booster Robotics, a program launched in 2022 that focuses on innovation in medical and mobile robotics via networking and technology transfer.

United States

Robotics R&D programs managed by the United States in 2020 were mainly reviewed in the key categories of “Space Robotics,” “Military Robotics and Autonomous Systems,” and “Ubiquitous Collaborative Robots.”

The National Aeronautics and Space Administration (NASA), the US’ premier space robotics R&D organization, has been promoting the Mars Exploration Program (MEP). MEP is a long-term mission on exploring Mars with NASA funds. At the beginning of the 21st century, MEP missions concentrated on the “Follow the Water” goal (e.g., Mars Odyssey (2001), Mars Exploration Rovers (2003), Mars Reconnaissance Orbiter (2005), and Mars Phoenix Lander (2007)). Since then, MEP has moved away from “Follow the Water” to a characterizing of the climate and geology of Mars with Curiosity, the Mars Science Laboratory’s rover (2011), and Mars Atmosphere and Volatile Evolution (2013). In September 2013, NASA launched Opportunity, another rover, for scientists/researchers to propose and develop exploratory instruments, including the Sample Caching System for storing Martian soil. MEP instruments were selected in July 2014 after an open competition based on the scientific objectives set out in 2013. Mars 2020 has been carried out by MEP with a planned launch on July 17, 2020, and a touchdown in Mars’ Jezero crater on February 18, 2021. The rover in the Mars 2020 program is based on the design of Curiosity but with extra scientific instruments embedded in it to explore a site likely to have been habitable. The budget for MEP in 2017 was comprised of 647 million USD from the US government and a NASA fund of 408 million USD for Mars Rover 2020 and 239 million USD for other missions/data analysis, respectively. In 2019, MEP funded approximately 604.5 million USD, with NASA supporting 348 million USD for Mars 2020 and 253.5 million USD for other missions/data analysis, respectively.

Following the Mars exploration program, NASA launched Artemis, a lunar program, in May 2019. The purpose of Artemis is to send astronauts to the lunar surface by 2024 and construct promising capabilities for Mars missions post-2024. Artemis' missions can be divided into two phases: Phase 1, from 2020 until 2024, and Phase 2, from 2025 to 2029 (ant.). Phase 1 focuses on getting systems in place to support the first human lunar surface landing since the 1960s. It will proceed through three steps: Artemis I (the first launch of the SLS and Orion spacecraft), Artemis II (taking a crew on a flight around the moon), and Artemis III (taking a crew to the Gateway and then down to the lunar surface). Phase 1 also includes lunar research for the goal of studying polar volatiles and the geology of the South Pole-Aitken Basin and landing at a lunar swirl to make the first-ever direct magnetic measurement. Phase 2 comprises the capabilities necessary to establish a sustainable human presence on and around the moon. However, in November 2021, plans to send astronauts to the moon by 2024 were canceled. On November 16, 2022, Artemis I was successfully carried out with the launch of the first unmanned flight of the SLS and Orion, completing a mission that included a distant retrograde orbit around the moon. Artemis II was planned for September 2025, with Artemis III delayed to September 2026. The total budget for Artemis adds up to 53 billion USD for fiscal years 2021-2025.

The DoD manages many programs on developing unmanned military systems and robotic vehicles. Ever since the RDE Focus of the US Secretary of Defense was released in 2010, "Autonomy" has become the DoD's Science & Technology (S&T) priority. The DoD annually releases progress reports and plans associated with the development of military autonomous vehicles and the integration of such vehicles/systems with each department. Key research focuses include Machine Perception, Reasoning and Intelligence (MPRI), Human/Autonomous System Interaction and Collaboration (HASIC), Scalable Teaming of Autonomous Systems (STAS), Test, Evaluation, Validation, and Verification (TEVV), with core technologies including sensors/payloads, navigation/control, weapons, comms/data management, autonomy, propulsion/energy, and mobility. The DoD invested 9.6 billion USD in autonomous systems in 2019, with funding spread across the Navy, Army, Air Force, and various agencies. Budgets for unmanned systems have decreased slightly in recent years, with 7.54 billion USD allocated in the 2021 fiscal year and 8.2 billion USD proposed for the 2022 fiscal year.

In the 2023 fiscal year, the DoD defense budget allocated 10.3 billion USD (approximately 1.21% of the total DoD budget and 3.7% of RDT&E and procurement budget) and a requested agency-wide fund of 10.2 billion USD (approximately 1.21% of total DoD budget and 3.2% of RDT&E and procurement budget) for autonomy and robotics technologies.

For fundamental robotics R&D, the National Robotics Initiative (NRI) was launched in 2011 (the US government has since advanced the NRI from NRI-1.0 to NRI-2.0). Initially, the goal of NRI-1.0 was to accelerate the development and use of robots in the United States through innovative robotics research and applications emphasizing the realization of such co-robots working in symbiotic relationships with human partners. Since NRI-2.0 was released in 2016, the NRI's goals have focused on research on the fundamental science, technologies, and integrated systems needed to achieve ubiquitous collaborative robots and to assist humans in every aspect of life with "Ubiquity: Seamless integration of co-robots." The budget of NRI-2.0 in 2019 was funded with 35 million USD for foundational (FND) and integrative (INT) projects in multiple agencies of the federal government. The US government supported NRI-2.0 with 32 million USD in 2020.

In 2020, the United States released the 2020 US National Robotics Roadmap on the implementation of robots for purposes of economic growth, improved quality of life, and empowerment of people. Based on this roadmap, R&D programs related to Intelligent Robotics and Autonomous Systems (IRAS) have been launched to advance intelligent robotic systems, including R&D in robotics hardware and software design and applications, machine perception, cognition and adaptation, mobility and manipulation, human-robot interaction, distributed and networked robotics, and autonomous systems. IRAS strategic priorities and related key programs aim to promote safe and efficient human-robot teamwork, improve validation and verification of robotic and autonomous systems, and advance intelligent physical systems. The IRAS budget accounts for 4% of the FY 2021 budget of 6.5 billion USD requested by the president for federal agencies' Networking and Information Technology Research and Development (NITRD)-related R&D. NRI-3.0, which was released in 2021 as part of IRAS efforts to support fundamental research in the United States to advance robotics integration, supports research on this area for the benefit of humans in terms of safety and independence. The main goals of NRI-3.0 are to strengthen the robotics research community, foster innovation and workforce development, accelerate progress, demonstrate novel capabilities, build environments (ecosystems) for innovation, and, above all, to promote original and integrated approaches to the challenges of accountability, interoperability, ethical operation, and trust which will be engendered by integrated functional and ubiquitous robots. On May 3, 2022, the NSF announced the termination of NRI-3.0, which had over 250 million USD invested in more than 300 pioneering research projects over its 12-year lifespan.

The budget for IRAS R&D programs at NSF was 53.8 million USD in 2023 (supplemental funding: 4.6 million USD) and 69.9 million USD in 2024 according to the NITRD in the 2024 fiscal year. Funding was provided via different programs, such as Human-Centered Computing (HCC); Mind, Machine, and Motor Nexus (M3X); Cyber-physical Systems (CPS); Dynamics, Control and Systems Diagnostics (DCSD); Foundational Research in Robotics (FRR); Robust Intelligence (RI); Smart Health and Biomedical Research in the Era of AI and Advanced Data Science, Disability and Rehabilitation Engineering; America's Seed Fund; Partnerships for Innovation; Broadening Participation in Computing (BPC); the NSF Research Traineeship Program; Energy, Power, Control, and Networks; Perception, Action & Cognition (PAC); Mechanics of Materials and Structures (MOMS); Science of Learning and Augmented Intelligence; and Research on Innovative Technologies for Enhanced Learning (RITEL).

Canada

In Canada, the national R&D program for robotics is planned and funded by Innovation, Science and Economic Development Canada and the Canadian Space Agency.

Canada's R&D program is propped up by two pillars: In March 2019, the Canadian Space Agency, which launched a new national space strategy in March 2019, and The National Research Council Canada, which announced the National Research Council Canada Strategic Plan 2019-2024 in February 2020.

Space robotics is the number one R&D player among Canadian manufacturing industries. In 2018, the aerospace manufacturing industry invested 1 billion USD (1.4 billion CAD) in R&D, contributing close to 25% of total manufacturing R&D in Canada and achieving over five times higher R&D intensity than the manufacturing average.

Canadarm* is a government-led robotics R&D program that is regarded as Canada's best-known contribution to the field. A manipulator able to withstand the harsh radiation levels of outer space, it was first used by the crew of the Columbia, the NASA space shuttle, in 1981. On subsequent missions, Canadarm2 and Dextre were used to construct and maintain the International Space Station. The third Canadarm's letter of interest, "Lunar Gateway Robotics_Canadarm3," was announced on July 26, 2019. In it, the CSA proposed to include the following elements: 1) the eXploration Large Arm and its tools (XLA); 2) the eXploration Dexterous Arm (small arm or XDA); 3) various robotic interface fixtures, platforms, and receptacles and; 4) ground segment and robotic integration. To contribute an AI-enabled robotics system to Gateway, a US-led lunar outpost, the Canadian government pledged 152 million USD (209 million CAD) in 2019 in funding to be devoted from 2019 until 2024 to develop Canadarm3 under a policy entitled "Canada Reaches for the Moon and Beyond." On June 27, 2024, Minister of Innovation, Science and Industry François-Philippe Champagne announced that MDA Space, a Brampton-based company, will receive 730 million USD (999.8 million CAD) to continue work on Canadarm3 and begin detailed design, construction and testing. This milestone marks the last steps in finalizing the design, construction and testing of the Canadarm before delivering it to Gateway.

Canadarm3 and Dexter have led to the development of many technologies, such as neuroArm and IGAR. Canadarm3, which incorporates advanced AI technologies, is expected to open the door to a new level of robotics.

IFR International Federation of Robotics

Summary

A01 China

Title	"The 14th Five-Year Plan" for Robot Industry Development
Region	China
Issued by	Ministry of Industry and Information Technology (MIIT), National Development and Reform Commission (NDRC), Ministry of Science and Technology (MST), (In addition to the above institutions, 12 other institutions participated)
Announcement	December 21, 2021
Term of validity	2021 - 2025
Budget	
Key words	
Related website	http://www.gov.cn/zhengce/zhengceku/2021-12/28/content_5664988.htm
Background	◦ In 1972, China began research on industrial robots. ◦ In 1986, for high-tech R&D, 863 program was announced and R&D for industrial robot applications was promoted. ◦ In the 1990s, welding robots R&D was prioritized, and investment was made in nine robot industrialization hubs and seven R&D hubs. ◦ The 10th FYP (2001-2005) included counterterrorism ordnance disposal robots, hazardous assignment robots, and human-like and bionic robots. ◦ The 11th FYP (2006-2010) included key technologies for intelligent controls and human-robot interaction. ◦ The 12th FYP (2011-2015) was labeled "for intelligent manufacturing," and demanded that Chinese manufacturing firms use more robots and integrate information technology. ◦ The 13th FYP (2016-2020) a manufacturing innovation strategy encompassing the convergence of the manufacturing industry and ICT was promoted, and the term 'Artificial Intelligence' appeared in use. ◦ In 2016, the Robot Industry Development Plan (2016-2020) was announced, with the aims of completing the robot industry system, expanding industrial scale, strengthening technological innovation capacity, improving core parts production capacity, and improving application integration capacity. ◦ The 14th FYP (2021-2025) for National Economic and Social Development of the People's Republic of China was announced by the Central Committee of the Communist Party of China and Robot industry is included in 8 key industries for the next 5 years.
Goal	◦ Focus on making breakthroughs in core technologies ◦ Strive to consolidate industrial foundation and enhance effective supply ◦ Expand market applications ◦ Improve the stability and competitiveness of the industrial supply chain ◦ Continue to improve the industrial development ecology
The latest R&D project	Key Special Program on Intelligent Robots of 2019
The key targets of the latest R&D project	◦ New-type mechanism / material / driving / sensing / control and bionics ◦ Learning and cognition of intelligent robots ◦ Human-machine natural interaction and collaboration ◦ Enhancing the robot's integration with new-generation information technology ◦ Making reserves of basic cutting-edge technologies for the growth of robot intelligence level

Contents

1. Development Objectives

Technology and Products	◦ Breakthroughs in a number of core robot technologies and high-end products ◦ Achievement of the leading level of comprehensive performances of complete robots in the world ◦ Achievement of the highest international standards of the performances and reliability of key parts in the world
Industry Scale	◦ Average annual operating profit growth rate of 20% or more in the robot industry
Corporate body	◦ Establishment of a group of leading companies with international competitiveness ◦ Establishment of a number of specialized and new “little giants” enterprises with great innovation ability and growth potential
Industrial Clusters	◦ Establishment of 3-5 industrial clusters with international influence
Application Density	◦ Double the density of manufacturing robots

2. Main Tasks

2.1.1. Improvement of industrial innovation capacity

Overcoming difficulties in core technology R&D	◦ Necessity of development of national strategies and industries to make breakthroughs in robot system development, operating systems and other common technologies. ◦ Requirement to understand the development trend of robot technology for R&D of advanced technologies such as biometric recognition and cognition, bio-mechanical-electrical convergence, etc. ◦ Enhancement of robot intelligence and networking, functional security, network security, and data security through the integration and applications of new technologies such as AI, 5G, big data and cloud computing.
Establishment and improvement of an innovation system	◦ Strengthening the research on cutting-edge and common technologies, accelerating the transfer and transformation of innovative achievements, and establishing an effective industrial technology innovation chain ◦ Encouraging backbone enterprises to jointly carry out collaborative robot R&D projects; promote standardization and modularization of software and hardware systems; and improve the efficiency of new product development. ◦ Strengthening the construction of technology centers for development of key and application technologies.

2.1.2. Implementation of overcoming obstacles in robot core technology

Common technologies	◦ Robot system development technology, robot modularization and reconfiguration technology, robot operating system technology, robot lightweight design technology, information perception and navigation technology, multi-task planning and intelligent control technology, human-robot interaction and autonomous programming technology, robot cloud-edge-end technology, robot safety and reliability technology, rapid calibration and precision maintenance technology, multi-robot cooperative operation technology, robot self-diagnosis technology, robot self-diagnosis technology, etc.
Cutting-edge technologies	◦ Robot bionic perception and cognition technology, electronic skin technology, robot bio-mechanical-electrical fusion technology, human-robot natural interaction technology, emotion recognition technology, skill learning and developmental evolution technology, material structure function integration technology, micro-nano operation technology, soft body robot technology, robot cluster technology, etc.

2.2.1. Establishment of the foundation for industrial development

Compensating for the shortcomings of industrial development	◦ Promoting joint efforts of production, academia and research institutions to make up for the shortcomings of special materials, core components and processing technologies; to improve the functionality, performance and reliability of key robot components; to develop robot control software and core algorithms; and to improve the functionality and intelligence of robot control systems.
Establishment of standard systems	◦ Establishment of a national robot standardization organization to play the role of a national technological standard innovation base (robot); and to continuously promote robot standardization. ◦ Establishment of a robot standard system to revise standards related to robot function, performance, and safety; and to strengthen standardization, application, and promotion of scientific and technological achievements.
Improvement of testing and certification capabilities	◦ Strengthening testing and certification capacities of enterprises to consolidate product testing and improve quality and reliability of products. ◦ Improvement of the testing capabilities to satisfy the needs of enterprises for testing and certification services. ◦ Necessity of China's robot certification system.

2.2.2. Implementation of improving key robot foundation

High performance reducer	◦ Development of advanced manufacturing technologies and techniques for RV reducers and harmonic reducers to improve the accuracy retention (life) and reliability of reducers, reduce noise, and achieve mass production. ◦ Study on the basic theories of new high-performance precision gear transmission devices to make breakthroughs in precision/super-precision manufacturing technologies and assembly processes.
High performance servo drive system	◦ Development of high-precision, high-power density robot-specific servo motors, high-performance motor brakes, and other core components.
Smart controller	◦ Development of controller hardware systems with high real-time function, high reliability, multi-processor parallel working capacity or multi-core processor shall realize standardization, modularization, and networking. ◦ Breakthroughs in multi-joint high-precision motion solving, motion control, and intelligent motion planning algorithms to improve the intelligence of the control systems as well as safety, reliability and ease of use.
Intelligent integrated joint	◦ Development of modular robot joints integrating mechanism/drive/control and servo motor drive, high-precision harmonic drive dynamic compensation, high-precision real-time data fusion of composite sensors, modular integration, and other technologies.
New sensors	◦ Development of products such as 3D vision sensors, 6D force sensors and joint torque sensors and other force sensors, large view single- and multi-line LIDARs, intelligent hearing sensors, and high-precision encoders.
Intelligent end actuators	◦ Development of the end actuators for intelligent picking, flexible assembly, and rapid switching.

2.3. Expansion of the supply of high-end products

	Goal: Development of advanced intelligent products	
	Type of robots	Functions (Fields)
Industrial robots	◦ Welding robots	◦ Automotive, aerospace, rail transit and other fields
	◦ Vacuum (cleaning) robots	◦ Automatic handling, intelligent movement, and storage for the semiconductor industry
	◦ Robots with explosion-proof function	◦ Production of civil explosives
	◦ Logistics robots	◦ Unmanned forklifts, sorting, and packaging operation

	◦ Collaborative robots	◦ Large-load, lightweight, flexible, dual-arm, mobile for 3C, automotive parts, and other fields
	◦ Mobile operation robots	◦ Movement anywhere in the work areas for transfer, grinding and assembly.
Service Robots	◦ Agricultural robots	◦ Orchard weeding, precision plant protection, fruit and vegetable pruning, picking, harvesting and sorting ◦ Livestock and poultry breeding such as feeding, inspection, silt removal, netting attachment and disinfection
	◦ Mining robots	◦ Extraction, support, drilling, inspection, and heavy-duty auxiliary transport operations
	◦ Construction robots	◦ Intelligent production of building components, measurement, material distribution, steel processing, concrete pouring, floor and wall decoration, component installation, and welding operations
	◦ Medical rehabilitation robots	◦ Medical rehabilitation robots for surgery, nursing, examination, rehabilitation, consultation, and distribution
	◦ Elderly assistance robots	◦ Walking aid, bathing aid, article delivery, emotional companionship, and intelligent prosthesis
	◦ Home service robots	◦ Housekeeping, education, entertainment, and security
	◦ Public service robots	◦ Interpretive guides, catering, delivery, and mobility
Special Robots	◦ Underwater robots	◦ Underwater exploration, monitoring, and operation and deep-sea mineral resources development
	◦ Security robots	◦ Security patrol, anti-smuggling security inspection, anti-riot, investigation and evidence collection, traffic management, border management, and security control
	◦ Robots for operations under dangerous conditions	◦ Firefighting, emergency rescue, safety inspection, nuclear industry operation, and marine fishing
	◦ Health and epidemic prevention robots	◦ Test sampling, disinfection and cleaning, indoor distribution, auxiliary lifting, auxiliary rounding and checking, and critical care auxiliary operations

2.4.1. Expansion of the depth and breadth of applications

- Encouraging users and robot enterprises to jointly carry out technical testing and verification; support the implementation of key components verification of robot machine enterprises; and enhance the testing and verification capabilities of public technical service platforms.
- Encouraging robot system integrators to focus on specific scenarios and production processes in breakdown fields.
- Establishment of a robot application promotion platform to ensure the accurate matchmaking between production and demand.

2.4.2. Implementation of "Robots+" application

	Fields	Goal
Development of industrial applications	◦ Automotive, electronics, machinery, light industry, textiles, building materials, medicine, public services,	◦ Development and promotion of new robot products for high-end application market and intelligent

	warehousing and logistics, intelligent home, education, and entertainment.	manufacturing.
Expansion of emerging application	◦ Mining, petroleum, chemical, agriculture, electric power, construction, aviation, aerospace, shipping, railroads, nuclear industry, ports, public safety, emergency rescue, medical rehabilitation, and elderly & disabled assistance	◦ Development of robot products and solutions based on specific scenarios to carry out pilot demonstrations and expand application space.
Enhancement of special applications	◦ Sanitary ware, ceramics, photovoltaic, smelting, casting, sheet metal, hardware and furniture, key links such as glazing, fettling, polishing, grinding, welding, spraying, handling, and palletizing	◦ Formation and replication of specialized customized solutions to create a unique service brand and form a new competitive advantage.

2.5. Optimization of the industrial organization structure

Development of the high-quality enterprises	◦ Encouraging backbone enterprises to use mergers and acquisitions, joint ventures, and other ways for developing ecologically dominant robot enterprises with core competitiveness. ◦ Encouraging enterprises to develop subdivision industries and strengthen their specialized and differentiated development in the complete robots, parts and system integration.
Facilitating efforts to improve, strengthen, and stabilize the chain	◦ Encouraging backbone enterprises to focus on weak links such as key parts and high-end complete products. ◦ Enhancement of international industrial security cooperation to promote diversification of the supply chain of the robot industry.
Creating clusters with special benefits	◦ Promotion of a reasonable regional layout to guide resources and innovation factors and cultivate advantageous clusters.

3. Safeguarding Measures

3.1. Strengthening the coordination and coordinating the promotion

- Coordinating the resources and capabilities of industrial management, science and technology, finance and other functional departments to enhance policy synergies with users and support the innovative development of the robotics industry
- Use of bridging capabilities of industry associations and intermediaries to enhance dynamic monitoring of the robotics industry

3.2. Expansion of fiscal and financial support

- The support from major national science and technology projects and key national R&D programs for the development and application of robots.
- Optimization of the pilot work for insurance compensation mechanism for first (set) major technical equipment to fully play the purchasing role of governments and promote the applications of innovative robot products.
- Encouraging cities with production-finance cooperation to expand the inputs in the robot industry.
- Guiding of financial institutions to innovate service modes for financing based on receivables and supply chain.

3.3. Creating a good market environment

- Supporting the third-party testing and certification institutions to build their capacities to improve their market recognition and international influence.
- Protecting intellectual property rights and strengthening the punishment for infringement of intellectual property rights

3.4. Improvement of the talent guarantee system

- Strengthening the training of robot science and technology talents to support universities and research institutes for developing high-end professional, technical and composite talents.

◦ Encouraging universities and enterprises to jointly conduct education programs; develop a group of modern industrial colleges; promote order cultivation and modern apprenticeship systems; and develop the talents badly needed by the industry. ◦ Science publicity efforts for improving the robot qualities of the youth. 3.5. International exchange and cooperation ◦ Encouraging enterprises, academic institutions, and industrial organizations to carry out international exchanges in technologies, standards, testing certification, intelligent properties, and talent development. ◦ Encouraging foreign enterprises and institutions to establish R&D facilities and education centers in China. ◦ Supporting domestic enterprises to establish R&D organizations in developed countries for strengthening international technical cooperation and accelerating the promotion of our robots in international markets.

Title	**Guidelines for the "Key Special Program on Intelligent Robots of 2024"**
Region	China
Issued by	Ministry of Science and Technology of the People's Republic of China
Announcement	July 31, 2024
Term of validity	2024
Budget	About 45.2 million USD (about 329 million CNY)
Key words	Fundamental Frontier Technologies, Common Key Technology, Industrial robots, Service robots, Specialty robots
Related website	https://www.gov.cn/zhengce/zhengceku/202408/content_6967574.htm http://119.23.232.167:8888/SRManager/upload/20240812163924205/%E2%80%9C%E6%99%BA%E8%83%BD%E6%9C%BA%E5%99%A8%E4%BA%BA%E2%80%9D%E9%87%8D%E7%82%B9%E4%B8%93%E9%A1%B92024%E5%B9%B4%E5%BA%A6%E9%A1%B9%E7%9B%AE%E7%94%B3%E6%8A%A5%E6%8C%87%E5%8D%97.pdf
Background	In order to implement the arrangements of national science and technology innovation during the "14th Five-Year Plan", the Key Special Program of "Intelligent Robots" has been launched under the National Key R&D Plan. According to the deployment of this key special program implementation plan, the annual project declaration guide for 2024 is released.
Goal	Development of an intelligent robotics system suitable for China's national conditions; Promoting continuous innovation of technology and products; Realizing the advanced industrial chain, high-end products and system application; Promoting the high-quality development of China's robot technology and industry; Supporting the independent development of the main fields of the national economy, the country's major needs, people's life and health, and other related industries
The latest R&D project	
The key targets of the latest R&D project	◦ Fundamental Frontier Technologies ◦ Common Key Technology ◦ Industrial robots ◦ Service robots ◦ Specialty robots

IFR International Federation of Robotics

Contents

1. Fundamental Frontier Technologies

1.1. Flexible Electronic Robot (FER) with Multimodal Motion

Research content	Evaluation criteria
◦ Fundamental theory of trans-domain multimodal adhesive mobile FER, and key tech. ◦ Trans-domain multimodal adhesive mobile FER	◦ Large deformation FER system ◦ Flexible deployment of water/air multidomain sensors ◦ Inventing 2 key tech.

1.2. Generative AI-Driven Robot Swarm 3D Environment Collaborative Exploration (CE)

Research content	Evaluation criteria
◦ Building, training, and optimizing generative AI models ◦ Embodied intelligent theoretical methods ◦ Low-latency, jam-resistant communication modules ◦ Robot swarm CE system driven by generative AI	◦ International leadership in CE efficiency and multi-tasking support

1.3. Wearable Immersive Haptic Feedback Interactive (HF) System for Human-Machine Interaction

Research content	Evaluation criteria
◦ High-frequency HF mechanism, the fusion mechanism of multimodal haptic sensing ◦ Integrated design method of high-density active HF drive array and user-friendly mechanical interface, etc. ◦ Wearable immersive HF human-machine interaction system integrating haptic perception, feedback, and active control	◦ ≥10 categories of haptic perception behavior recognition and ≥2 typical application scenarios ◦ Inventing >2 key tech.

1.4. Embodied Perspective on the Generation and Evolution of Universal Robot Behaviors

Research content	Evaluation criteria
◦ Cognitive mechanisms ◦ Large-scale robot behavior generation model and realistic behavior simulation platform ◦ Embodied behavior learning and development capabilities	◦ Novel brain-inspired decision mechanism model with originality. ◦ Knowledge graph and inference framework ◦ First-person multimodal behavioral dataset and the behavior generation generative model ◦ Verification in ≥ 5 typical scenarios and inventing 2 key tech.

1.5. Intelligent-Driven Integrated Bionic Robot Theory and Method

Research content	Evaluation criteria
◦ Advancement of embodied intelligence from artificial circuits	◦ Prototype of an intelligent controlled hybrid life-like robot ◦ Completing closed-loop control verification (≥ 2 types of robot actions) ◦ Inventing > 2 key tech.

1.6. Intelligent Microbot Technology with Sensing and Actuation Integration

Research content	Evaluation criteria
◦ In situ micro-sensing technologies and single-unit integrated sensor-drive-control systems	◦ Integrated sub-micron robotic unit with sensing, actuation, and control functions, compliance with national radio management regulations ◦ Autonomous completion of micromanipulator in sensing, control and operation with invention of > 2 key tech.

1.7. Highly Flexible and Adaptive Humanoid Walking Robot (HFAHWRs) Design Theory

Research content	Evaluation criteria
◦ Design method of HFAHWRs, the mechanism of low-energy movement and biomimetic flexible joints based on human anatomy, with high-performance	◦ Maintaining normal walking speed under various conditions with flexible mechanical property ◦ Inventing > 2 key tech.

1.8. Human-like Robotic System Based on Human Anatomy and Neurophysiology

Research content	Evaluation criteria
◦ New actuator mimicking the dynamic characteristics of human muscles and a lightweight robot system with a human-like skeletal structure ◦ Neural-inspired operation strategies, multi-muscle coordinated control methods	◦ Inventing > 2 key tech.

1.9. New Concept Robots in AI

Research content	Evaluation criteria
◦ New principles, methods, and forms by integrating information, mechanical, and sensor technologies with robotics ◦ Improvement of the robot's information fusion, decision-making, task execution, and environmental adaptation abilities	◦ Prototype AI robotic system with innovative concepts and its potential applications in relevant fields ◦ Specific task objectives and system evaluation criteria ◦ Publishing ≥ 5 high-level academic papers

1.10. Multi-mode New Concept Robotics

Research content	Evaluation criteria
◦ Integrating multi-disciplines to study new principles, methods and forms ◦ Enhancing a robot's diverse ability	◦ A prototype with originality and ≥ 1 single technology ◦ Designing specific task objectives and system evaluation criteria ◦ Publishing ≥ 5 high-level academic papers

2. Common Key Technology

2.1. High-Force-to-Weight Ratio (HFWR) Integrated Linear Servo Joint (LSJ)

Research content	Evaluation criteria
◦ Design, manufacturing, control challenges, and test specifications of HFWR_LSJ ◦ Servo joints with different performance levels	◦ New lightweight design method ◦ Development of design software and integrated LSJ ◦ Application on ≥ 3 typical types of robots

2.2. Surgical Robot Force Sensing and Feedback Technology

Research content	Evaluation criteria
◦ High-resolution force perception system and mapping method	◦ Cartesian force perception detection range ◦ Integrating the technology into surgical robots ◦ ≥ 2 Class III medical device product registration certificates

2.3. Autonomous Operation of Mobile Robots with 2 Arms Based on Multimodal Fusion Perception

Research content	Evaluation criteria
◦ End-to-end mapping mechanism from human actions to robot actions. ◦ Autonomous mobile, precise positioning and accurate navigation in complex environments, whole-body coordinated motion strategy generation	◦ Robot prototype with 7 DOF-2 arms and human-like upper limb configuration. ◦ ≥ 3 long-term sequence task scenarios.

2.4. Intelligent Robot Information Security Protection Technology

Research content	Evaluation criteria
◦ Security threat mechanisms and vulnerabilities of controllers and their components ◦ Attack path identification, calculation methods, and security mechanism solutions and verification ◦ Multi-variable behavior trust and lightweight security protection technologies	◦ Prototype verification of ≥ 10 types of multi-axis synchronisation, speed and acceleration control and teaching ◦ Software for vulnerability correlation reasoning and attack path analysis ◦ Breakthrough in the behavioral anomaly detection and sensitive data protection ◦ Robot "cloud-edge-end" security protection system ◦ Platform verification of the robot

2.5. Natural Semantic Interaction and Task Decision for Cloud-Edge Collaborative Intelligent Robots (CECIRs)

Research content	Evaluation criteria
◦ Multi-modal environmental perception technologies, semantic expression technologies of environmental information, etc. ◦ Real-time CECIRs multimodal interaction inference system and its hardware and software, as well as rapid adaptation in heterogeneous robot perception and cognition	◦ Integrating multi-modal environmental perception software with Intelligent Brain Wharf hardware and software system ◦ Multimodal human-computer interaction system and an intelligent machine brain platform, as well as multi-modal cloud-end collaborative algorithms

2.6. Key Technologies for Cloud-Edge (CE) Collaborative Maintenance of Industrial Robot Clusters

Research content	Evaluation criteria
◦ "Diagnosis-prediction-decision-control" functionally integrated industrial robot maintenance big model ◦ Industrial robot cluster "CE-end" collaborative intelligent maintenance system (IMS)	◦ Distributed database and an IMS ◦ Case library of the full life cycle degradation of key components of industrial robots, as well as the first industrial robot maintenance big model integrating the functions of "diagnosis-prediction-decision-control" ◦ Submission of a draft of a technical standard or group standard

2.7. Key technologies for Verifying the Safety and Effectiveness of Medical-Surgical Robots (MSRs)

Research content	Evaluation criteria
◦ Dynamic environment modelling of hard tissue typical surgical procedures, key operational behaviors, etc. ◦ Safety assessment of human/force/position interaction, remote teleoperation, and robot navigation in confined spaces ◦ Standard for classifying MSR autonomy levels and detecting behavior in disturbed environments ◦ Intelligent motion simulation platform with a high-fidelity clinical environment, as well as a standard system	◦ Intelligent motion simulation platform for detecting surgical operations in hard tissue robotic surgery ◦ > 5 typical operations in dynamic and static environments and remote simulation testing with delay ◦ Standard for detecting the operating behavior and performance testing ◦ Report on the economic feasibility, based on clinical application data at the level of a metropolitan area and patent applications for inventions: ≥ 3

3. Industrial Robots

3.1. Autonomous Sewing (AS) Robot Technology and Systems

Research content	Evaluation criteria
◦ Multi-variety flexible fabric shape detection, layered picking and precise feeding and cutting, etc. ◦ Knowledge bases for fabric piecing, bag opening, etc. ◦ Intelligent robot sewing process software package and AS operation equipment and systems	◦ ≥ 4 types of operations and a sewing process software package and their quality evaluation system ◦ ≥ 50 sets of application of AS operation robot system

3.2. Autonomous Intelligent Arc Welding Robot Technology and System

Research content	Evaluation criteria
◦ Workpiece identification, localization, feature extraction, and real-time tracking using composite vision in unstructured environments ◦ Multi-robot coordination, autonomous path planning, multimodal perception fusion, real-time welding quality monitoring, and knowledge-based welding process training, as well as a large vertical model	◦ Support intelligent interaction, the welding quality compliance rate of the autonomous intelligent welding robot system and ≥ 3 application links

3.3. High-speed Ultra-precision Hybrid Bonding Robot

Research content	Evaluation criteria
◦ High-speed, high-stability coordinated control between wafer transport robots and bonding platforms	◦ Repeated positioning error of wafer transfer manipulator and ≥ 10 invention patents ◦ Validation of the wafer-to-wafer hybrid bonding process and domestication of core technology modules

3.4. Mobile high Performance Intelligent Work Robot (IWR) System

Research content	Evaluation criteria
◦ Multi-functional composite optimization design of mobile heavy load arm-extending robots, high-precision self-adaptive disturbance control of electro-hydraulic proportional system, etc. ◦ Mobile heavy-load arm-extending robot system	◦ ≥ 3 intelligent operations and high efficiency

3.5. Key Technologies and Application Demonstration of Robotic Disassembly of New Energy Vehicle Batteries

Research content	Evaluation criteria
◦ Automated separation and precise recycling of multi-stage lithium battery components. ◦ Safe, efficient automatic battery dismantling robots with multi-group separation, pollutant control, and modular process software ◦ Migratory, man-machine interactive battery dismantling robot systems driven by intelligent control ◦ Accurate identification and automated battery disassembly, material handling, and storage	◦ Robotic energy battery disassembly system with modular process software ◦ Reduced overall energy consumption and CO_2 emission by 70% and 80% ◦ Application of 5 robotic battery disassembly lines

4. Service Robots

4.1. Development and Application Demonstration of an Operational Nursing Robot System

Research content	Evaluation criteria
◦ Modular design method of 2-arm care robots and grasping modules ◦ Operational care robots and networked monitoring systems	◦ Operational 2-armed care robot system ◦ > 5 applications of the same type of generalization experiments ◦ Networked monitoring system ◦ Application in 10 communities or nursing homes

4.2. Intelligent Robotic Systems for Brain Function Rehabilitation

Research content	Evaluation criteria
◦ Highly compatible joint self-calibrating embodied morphing system targeting abnormal posture and movement. ◦ Temporal-spatial coordinated control of the human-machine dynamic system and the bidirectional mutual learning method ◦ Establishment of the "brain-muscle-movement"-machine interface rehabilitation system as well as a rehabilitation training robot with embodied motor-cognitive coordination.	◦ Movement-cognitive synergy, covering ≥ 2 central nervous system diseases ◦ Improved clinical therapeutic ◦ 2 medical device product registration certificates and promotion

4.3. Human-Machine Integrated Cardiopulmonary Assistive Wearable Robot

Research content	Evaluation criteria
◦ Bipolar phase assistance with variable impedance and anchor point structure design method without joint attachment and multimodal fusion ◦ Exoskeleton-based wearable robot with artificial muscles	◦ Bipolar support for in/exhalation and combined breathing patterns of chest and abdomen

4.4. Miniature Flexible Surgical Robot for Paediatric Cranio-Neurological Surgery

Research content	Evaluation criteria
◦ Miniature, flexible, dexterous surgical manipulator with integrated structure perception for surgery in delicate tissues and narrow cavities ◦ Target tissue recognition, tumor marking, danger zone warning, and shared safety control in surgery	◦ Completion of animal testing and clinical trial verification ◦ Class III medical device product registration certificate

4.5. Artificial Intelligence-Assisted Remote Orthopedic Operations Surgical (ROS) Robot

Research content	Evaluation criteria
◦ High-precision system modeling and force-feedback mechanism generation, as well as task learning and autonomous generation	◦ Development of an AI-assisted ROS robotic system ◦ ≥ Class III medical device product registration certificate

4.6. Surgical Robotics for Complex Soft Tissue Dissection and Advanced Operations

Research content	Evaluation criteria
◦ Multi-layer composite robots for minimally invasive channels and flexible support structures	◦ Development of soft tissue modeling, real-time guidance, and coordinated control in confined spaces ◦ ≥ 3 types of surgical scenarios, ≥ 10 animal studies and 2 clinical studies

4.7. Theory and Methods of Drug Delivery (DD) Micro-Needle Robots (MNRs)

Research content	Evaluation criteria
◦ Digestive tract MNRs ◦ Robot environmental response, group control, dynamic DD, and gastrointestinal (GI) microneedle prototypes	◦ ≥ 2 types of biocompatible and controlled degradable GI tract-driven MNRs ◦ ≥1 type of robot swarm DD model ≥ 1 type of mother-and-child DD robot model, ≥ 4 types of macromolecular DD functions across the GI tract barrier ◦ Completion of preclinical large animal efficacy and safety verification and Phase I clinical trial

5. Specialty Robots

5.1. Technologies and Applications of Operational Scientific Research Robots for High-Altitude Environments

Research content	Evaluation criteria
◦ Operation of flying robots in extreme environments ◦ Improvement of the adaptability, usability and intelligence of the robot	◦ A range of electric vertical take-off and landing operational robots ◦ Detachable, retrievable surface sampling device with miniaturized, high-precision modeling and data acquisition and collecting ≥ 5 types of samples ◦ Lightweight sample drilling, and automatic and remote-control drilling modes ◦ Compliance of RF with national RF management regulations

5.2. An In-Situ Structural Monitoring System for Aircraft Engine Based on Macro-Micro Intelligent Robots (MNIRs)

Research content	Evaluation criteria
◦ Engine inspection and path planning, as well as aircraft engine on-wing in-situ inspection device based on MNIRs	◦ Comprehensive on-wing in-situ inspection solution ◦ 2 sets of macro-continuum deployment robots and a micro-image capture and transmission module ◦ Positioning error of one robot length and a software package ◦ ≥ 4 models of 2 major engine categories

5.3. Amphibious Cross-domain Special Robots for Complex Environment Surveillance

Research content	Evaluation criteria
◦ Stable cross-domain switching, efficient propulsion systems and their integrated platforms	◦ 3D cross-domain mobility and a multi-mode detection payload ◦ Application in ≥ 2 typical scenarios

5.4. Development and Validation of Reconfigurable Underwater Operating Robots

Research content	Evaluation criteria
◦ Rapid reconfiguration, precise docking, multi-source navigation, and damage detection of underwater platforms in confined spaces, etc. ◦ Reconfigurable wireless autonomous underwater robot prototype	◦ Reconfigurable untethered autonomous underwater robots ◦ Reconfiguring autonomously into ≥ 3 functions or configurations and ≥ 6 underwater detection units ◦ Untethered robot for safe deployment and retrieval through openings no larger than 1 meter ◦ Reconfigurable underwater robot with shape-adaptive control and omnidirectional attitude accuracy within 5 degrees ◦ Detecting > 3 kinds of typical defects in water-filled confined spaces under pressure ◦ ≥ 3 underwater confined space engineering projects

5.5. Autonomous Inspection and Operation Robots for Permanent Subsea Installations

Research content	Evaluation criteria
◦ Design of a mother-daughter (MD) submersible with a stationary autonomous underwater vehicle (AUV) and deformable vehicle, and AUV-based autonomous inspection and status assessment of submarine cables ◦ Autonomous AUV docking with base stations, wireless power replenishment, near-field communication, and multi-task operation of deformable underwater vehicles in complex marine environments ◦ Permanently deployed AUVs and DPUs	◦ MD AUVs and transformable underwater robots (TRU) ◦ TRU for of delicate operations and ≥3 demonstration applications ◦ Compliance of RF with national RF management regulations

5.6. Autonomous Inspection and Evidence Collection Robot with Integrated Vision and Olfactory Sensors

Research content	Evaluation criteria
◦ Modeling of multimodal fusion of visual and olfactory sensors ◦ Robot with autonomous inspection and evidence collection capabilities	◦ Autonomous inspection and evidence collection robot system with integrated vision and olfaction, in hazardous environments ◦ Application in ≥ 3 typical scenarios

5.7. Development and Demonstration Application of Ultra-large Loading Robots for Open-pit Mines

Research content	Evaluation criteria
◦ Large-scale operation of loading robots in complex mining environments and different operating conditions	◦ Development of a 55 m^3 or larger wheel loader robot

◦ Achievement of at least 5 invention patents accepted or granted in all cases, without further explanation in 'Evaluation Criteria'.

Title	**Guidelines for the "Key Special Program on Intelligent Robots of 2023"**
Region	China
Issued by	Ministry of Science and Technology of the People's Republic of China
Announcement	August 23, 2023
Term of validity	2023
Budget	About 45.2 million USD (about 329 million CNY)
Key words	Core components and algorithms, Industrial robots, Service robots, Specialty robots
Related website	http://www.chmia.org/detail.html?id=17&contentId=2528 http://119.23.232.167:8888/SRManager/upload/20230607145621485/%E2%80%9C%E6%99%BA%E8%83%BD%E6%9C%BA%E5%99%A8%E4%BA%BA%E2%80%9D%E9%87%8D%E7%82%B9%E4%B8%93%E9%A1%B92023%E5%B9%B4%E5%BA%A6%E9%A1%B9%E7%9B%AE%E7%94%B3%E6%8A%A5%E6%8C%87%E5%8D%97%E5%8F%8A%E2%80%9C%E6%8F%AD%E6%A6%9C%E6%8C%82%E5%B8%85%E2%80%9D%E6%A6%9C%E5%8D%95.pdf
Background	In order to implement the arrangements of national science and technology innovation during the "14th Five-Year Plan", the Key Special Program of "Intelligent Robots" has been launched under the National Key R&D Plan. According to the deployment of this key special program implementation plan, the annual project declaration guide for 2023 is released.
Goal	Development of an intelligent robotics system suitable for China's national conditions; Building an intelligent robot technology system suitable for China's national conditions and promoting continuous innovation in technology and products; Achievement of advanced industrial chain, high-end products and system applications; Supporting independent development of the industries/fields related to national economy, major national needs and people's life and health.
The key targets of the latest R&D project	◦ Core components an algorithms ◦ Industrial robots ◦ Service robots ◦ Specialty robots

Contents

1. Core components and algorithms

1.1. Online identification of robotic system parameters and dynamics modeling

Research content	Evaluation criteria
◦ Research on high-precision offline identification of robot parameters, fast online load identification, and dynamics modeling of rigid-flexible coupled systems ◦ Establishment a parameterized model system ◦ Application verification in high-end domestic robots	◦ Development of a new method for online robot parameter identification, dynamics modeling, and software

1.2. Integrated chip for robot joint drive and control

Research content	Evaluation criteria
◦ Research on multi-functional highly integrated chips and digital-analog hybrid design, a high-performance modular chip, etc.	◦ Pioneering > 2 servo control algorithms and ≥ 2 types of motors ◦ Realization of the large-scale application of the special robot control chip in the industrial robots and service robots

1.3. R&D and application of special chips for robot controllers

Research content	Evaluation criteria
◦ Research on robot-specific chip architecture integrating sensing, computing, specialized instruction sets, and multi-axis motion control, etc. Realization of the chip in high-precision real-time control systems	◦ Development of robot-specific control chip and motion control hardware IP algorithm library ◦ Realization of multi-channel/-axis robot motion planning and real-time control ◦ Pioneering adaptive support for 5 types of motors and application of multi-vendor motors

1.4. Robotic hypoid gear reducer

Research content	Evaluation criteria
◦ Research on high-precision hypoid gear meshing theory, tooth profile modification, and kinematic simulation, etc. ◦ Development of hypoid gear reducer, and realize large-scale application in robots	◦ Development of 3 types of high-precision, high reduction ratio hypoid gear reducers

1.5. Intelligent harmonic reducer for robots

Research content	Evaluation criteria
◦ Research on in-situ MEMS sensor design ◦ Development of specifications and large-scale application of intelligent reducers	◦ Development of intelligent speed reducer products with torque self-awareness and >3 functions

1.6. Multi-heterogeneous robot autonomous collaborative detection technology

Research content	Evaluation criteria
◦ Research on bio-self-organizing networks ◦ Development of a multi-robot cooperative detection system for underground unstructured spaces	◦ Development of a multi-robot cooperative detection system for unstructured 3D environments

1.7. Software platform for robotics process knowledge map generation and offline programming

Research content	Evaluation criteria
◦ Research on knowledge extraction and modeling based on process data, knowledge map generation ◦ Establishment of a software platform ◦ Promoting popularization and application	◦ Support knowledge map generation and offline programming for ≥ 4 processes

1.8. Robot human-robot interaction safety and test verification

Research content	Evaluation criteria
◦ Research on safety evaluation of robot human-robot interaction under biomechanical constraints, etc. ◦ Development a safety test	◦ Establishment of a safety assessment system and technical indexes ◦ Pioneering exoskeleton robot human-machine interaction safety testing system technical specifications and 2 national, industry or related group evaluation specifications

2. Industrial robots

2.1. Theory of design of drive-perception integrated soft robots

Research content	Evaluation criteria
◦ Research on the basic theory of soft-body robots, adaptable to the environment, and the mechanism of continuous variable stiffness, etc. ◦ Development of the principle prototype of soft robots, adaptable to the environment and tasks	◦ Development of new principles, technologies and methods related to soft body structures ◦ Development of > 2 types of functional actuation units ◦ Pioneering > 2 typical operation task scenarios and verifying them in simulated environment ◦ Inventing > 2 advanced frontier technologies first

2.2. Autonomous intelligence and swarm intelligence emergence in multi-robot co-manufacturing

Research content	Evaluation criteria
◦ Research on robot self-perception, self-learning, self-adaptation, and autonomous closed-loop technologies ◦ Multi-machine swarm intelligence emergence and feedback mechanisms, research on self-organization and collaborative planning technologies ◦ Multi-machine robot general intelligence interpretation, group collaborative evolution and intelligence ◦ Research on safe self-learning technologies	◦ Development of > 2 kinds of autonomous operation intelligent robot test prototypes, ◦ Development of > 2 kinds of swarm intelligence emergence robot cluster systems ◦ Establishment of an evaluation index system for typical scene tasks ◦ Realization of > 2 advanced cutting-edge technologies invention

2.3. Natural robot interaction and communal collaboration in dynamic unstructured environments

Research content	Evaluation criteria
◦ Research on human-centered human-machine-object interaction in dynamic environments and multi-modal fusion of visual, auditory, and tactile inputs ◦ Breakthroughs in the technologies of reconfiguration modeling of human-machine shared environment and efficient mutual assistance and action planning ◦ Pioneering safety mechanisms ◦ Experimental validation under typical scenarios of 3C assembly and other operational tasks.	◦ Development > 3 types of comprehensive collaborative robot systems ◦ Development of an evaluation index system for human-machine-object interaction and collaboration in typical scene tasks ◦ Pioneering functions of transition cooperation assembly, human-machine collaboration item delivery, dynamic environment active obstacle avoidance and passive compliance ◦ Achievement of > 2 advanced cutting-edge technologies invention

2.4. Rapid reconfiguration technology for automated robotic production lines

Research content	Evaluation criteria
◦ Research on modularized design methods and task-driven methods ◦ Breakthroughs in multi-protocol adaptive interaction and efficient interconnection between robots/equipment/manufacturing execution systems, dynamic configuration and combination optimization of heterogeneous manufacturing units, production line simulation, reconfiguration and rapid line access and other key technologies ◦ Development of mobile work robots suitable	◦ Development of highly stable, high-speed and dexterous robot manufacturing cell ◦ Development of an automated reconfigurable robot production line for the manufacture of consumer electronics ◦ Application validation in domestic consumer electronics and other products manufacturing backbone enterprises.

2.5. Research, development and application of heavy-duty industrial robots

Research content	Evaluation criteria
◦ Research on joint modeling and integrated co-design of electromechanical control parameters coupling, etc. ◦ Development of 500kg-class domestic heavy equipment industrial robot to conduct process research on the strategic needs of national key industries	◦ Development of tandem multi-joint heavy-duty robots ◦ Application verification for national key industries (aviation, aerospace and shipping)

3. Service robots

3.1. New concept robotics for medical-industrial crossover

Research content	Evaluation criteria
◦ Research on new principles, new methods and new forms to enhance the robot's environmental adaptability, task performance or intelligent decision-making ability ◦ Realization of the innovative	◦ Formation of a new concept robot for medical-industrial crossover with original characteristics ◦ Development of system prototypes, and demonstrate potential applications in related important fields, specific task objectives and system assessment indicators designed independently by the declared project team ◦ Breakthroughs, >2 single technology, in improving the

design of new concept medical-industrial convergence robots	robot's environmental adaptability, task operation ability or intelligent decision-making ability

3.2. Theory and methods of behavior enhancement based on brain-computer intelligence integration

Research content	Evaluation criteria
◦ Research on the basic theories of highly biocompatible and minimally invasive central nerve signal sensing, advance prediction, control switching of biomechanical systems, hybrid intelligent decision making, and dynamic games of multiple behavioral enhancement groups ◦ Research on the control modes of bi-directional brain control and simultaneous control of the brain and behavioral enhancement of intelligent robots ◦ Building a prototype of a robot integrating brain-machine intelligence and behavioral enhancement	◦ Proposing the behavioral enhancement technology ◦ Development of > 3 types of minimally invasive self-expanding high-throughput neuro-electrodes ◦ Validation of the group gaming system framework on ≥ 1 model animal. ◦ Invention of ≥ 2 advanced cutting-edge technologies

3.3. Drug-targeted delivery field-controlled micro- and nanorobotics (MNRs) and drive-control systems

Research content	Evaluation criteria
◦ Research on the basic theories and realization methods of highly biocompatible MNRs ◦ Exploring the multi-mode movement and collective control mechanism of MNRs, and make breakthroughs in targeted drug delivery, multi-response composite therapy, and degradation/recovery in the in vivo chamber of large animals	◦ Breakthroughs in field-controlled MNRs systems for in vivo targeted drug delivery to large animals ◦ Achievement of in vivo testing ◦ Inventing ≥2 advanced cutting-edge technologies

3.4. Flexible robot technology for complex manipulation with variable internal diameter natural cavity

Research content	Evaluation criteria
◦ Research on flexible robot configuration with large bending curvature adaptation and trans-lumen capability, force sensing interaction sensing, modeling, etc. ◦ Development of a prototype of robotic system, the operation procedures and specifications of the robot ◦ Ethical reporting completion ◦ Animal experiments and efficacy evaluation ◦ Validation of the technology and its function in biliary-pancreatic duct intervention surgery and other scenarios	◦ Development of a flexible variable internal diameter lumen complex operation robot system ◦ Submission of third-party evaluation reports

3.5. Continuum robotics for injection sampling in confined spaces

Research content	Evaluation criteria
◦ Research on the generation of compact and precise continuum mechanisms under multiple constraints, 3D modeling of complex orifices, etc. ◦ Development of a prototype of the robotic system, flexible movement and precise operation under multiple constraints in narrow and curved orifices ◦ Establishment of robotic operation procedures and standards and ethical reporting ◦ Animal experiments and validity evaluation	◦ Development of a continuous robotic system with functions ◦ > 10 cases of homologous animal experiments ◦ Third-party evaluation reports

3.6. Heterogeneous tissue debridement and excision robotics

Research content	Evaluation criteria
◦ Research on the multi-instrument collaborative skillful debridement and resection operation mechanism, accurate sensing, etc. ◦ Development of a prototype robot system ◦ Establishment of robot operation procedures and standards ◦ Ethical reporting completion	◦ Development of a robot system for removing heterologous tissue in complex scenes ◦ A third-party evaluation report submission

3.7. Luminal surgery robot autonomous suture operation technology

Research content	Evaluation criteria
◦ Research on the vision-based tactile virtual force accurate generation, hand-eye coordinated calibration, etc. ◦ Development of the prototype of a high-efficiency laparoscopic surgical autonomous suturing robot system ◦ Establishment of the operation process and specifications of autonomous suturing robots ◦ Animal experiments and effectiveness evaluation ◦ Validation of the technology and function in laparoscopic surgical scenarios of parenchymal organs.	◦ Development of a highly efficient laparoscopic autonomous suture surgical robot system ◦ A third-party evaluation reports submission

3.8. Highly compatible care and rehabilitation robot technology and system for the disabled elderly

Research content	Evaluation criteria
◦ Research on the design of high-compatibility care and rehabilitation robot mechanisms with multi-position support, multi-rotation centers, intent detection, and comprehension, etc. ◦ Establishment of an intelligent information platform	◦ Development of a highly compatible care and rehabilitation robot system with functions for the elderly with reversible disabilities ◦ > 10 cases of clinical validation completion

3.9. Tumor radiation therapy robot system with real-time precise control of position in movable target area

Research content	Evaluation criteria
◦ Research on the body surface and in vivo tumor target area associated with motion modeling ◦ Establishment of the body surface monitoring under the target area motion prediction model, real-time high-precision tracking of micro-motion on the surface of the body, etc. ◦ Pioneering robotic clinical operation specifications and radiotherapy operating room compatibility ◦ Realization of accurately control the active target area positioning posture of tumor radiotherapy robot system in real time ◦ Research on the robot system operation specifications, clinical diagnosis and treatment specifications, and conduct product registration	◦ Development of real-time accurate control of active target area position and posture ◦ Achievement of NMPA Class III medical device registration certificate in the whole system

3.10. Bone tumor removal robotic system

Research content	Evaluation criteria
◦ Research on CT/MR-based multimodal image fusion, feature recognition, segmentation and other key technologies ◦ Development of a bone tumor resection robotic system, and its supporting power unit and surgical tools, to complete product testing and clinical trials specified in NMPA ◦ Research on the operation standards and clinical diagnosis and product registration	◦ Development of a robot system for bone tumor resection with intelligent planning of heterogeneous surfaces and precise tissue resection ◦ Achievement of the registration certificate of Class III medical device of NMPA in the whole system ◦ The number of clinical cases stipulated by NMPA

4. Specialty robots

4.1. Bionic new concept robotics

Research content	Evaluation criteria
◦ Research on new types of drive, mechanism, new principles, new methods and new forms to enhance the robot's environmental adaptability, task operation ability or intelligent decision-making ability ◦ Realization the innovative design of bionic new concept robots	◦ Development of system prototypes ◦ Demonstration of potential applications in related important fields, with specific task objectives and system assessment indicators designed independently by the declared project team ◦ Breakthrough innovation, ≥ 1 technology, in improving the robot's environmental adaptability, task operation ability or intelligent decision-making ability

4.2. Principles and technology of micro-nano manipulation (MNM) for robotic precision assembly

Research content	Evaluation criteria
◦ Research on the principle of flexible precision transmission ◦ Breakthroughs in nonlinear compensation of ultra-high-precision motion creation ◦ Pioneering to form the theory and design method ◦ Development of the principal prototype of MNM robot	◦ Establishment of new principles and technologies for MNM of robots for precision assembly ◦ Development of a prototype of MNM robots to realize typical MNMs. ◦ Inventing ≥ 2 advanced cutting-edge technologies

4.3. Dynamic scheduling and optimization of autonomous mobile robot cluster systems (AMRCSs)

Research content	Evaluation criteria
◦ Research on multi-intelligence high-precision navigation and distributed collaborative sensing technology in complex dynamic environments, large-scale real-time scheduling of AMRCSs, and optimization of collaborative operation based on data-driven and deep learning ◦ Development of the dynamic scheduling and optimization method	◦ Pioneering dynamic scheduling and optimization methods

4.4. Robot technology for high-temperature and strong impact load operation of smelting furnace

Research content	Evaluation criteria
◦ Research on the strong impact load on the robot transmission structure of the mechanical role and failure mechanism ◦ Research on severe working conditions of strong impact class operation robot mechanism design and unloading method, instantaneous high torque high power motors, and other key technology research	◦ Development of a strong impact load operation robot system ◦ National, industry or related group standards: ≥ 2

4.5. Demonstration of underwater cable-laying robotic systems and applications for offshore new energy power plants

Research content	Evaluation criteria
◦ Research on load analysis on the cable laying operations in different soils under high pressure environments ◦ Development of a submarine cable-laying robotic system adapted to various soil substrates and conduct application validation in typical scenarios	◦ Development of submarine cable-laying robotic system applying to different soil substrates ◦ Application demonstration in offshore new energy power generation field cable laying and construction ◦ National, industry or related group standards: ≥ 1

◦ Achievement of at least 5 invention patents accepted or granted in all cases, without further explanation in ‘Evaluation Criteria’.

A02 Japan

Title	New Robot Strategy – Japan's Robot Strategy	
Region	Japan	
Issued by	The Headquarters for Japan's Economic Revitalization	
Announcement	January 23, 2015	
Term of validity	2016 – 2020	
Budget	640 million USD (99 billion JPY) for 2023	
Keywords	New Robot Strategy, Robot R&D project, METI	
Related website	New Robot Strategy	https://www.meti.go.jp/committee/kenkyukai/seizou/robot_competition/pdf/001_se02_00.pdf
	Robot R&D project budget	https://www.jara.jp/e/various/projects/img/Major_Robot_Projects_in_Japan_(as_of_July_2024).pdf
Background	◦ Research and development of humanoid robots in Japan began in the 1970s, centered on universities and companies, and accelerated with the developmen t of IT technology in the 1990s. ◦ In 1995, the Japanese government began supporting the research and develo pment of humanoid robots. ◦ With ASIMO and HRP, Japan was recognized as being the world leader in hu manoid robots. ◦ The revised 2014 Japan Revitalization Strategy mentions a "New Industrial Revolution Driven by Robots" (Robot Revolution) consisting of the utilization of robot technologies to solve social issues. ◦ In September 2014, the Government of Japan established a Robot Revolution Realization Council. ◦ In January 2015, the council compiled the results of the expert meetings into a report titled "New Robot Strategy – Japan's Robot Strategy ". ◦ Since 2015, Japan has been investing in the development of intelligent robots with AI and IoT as part of the New Robot Strategy.	
Goal	◦ To make Japan the robot innovation hub in the world ◦ To achieve a society with the highest level of robot utilization in the world ◦ To realize the daily life that robots exist all over Japan ◦ To formulate business rules on the premise of interconnection among robots a nd of autonomous accumulation and utilization of data by such robots ◦ To globally standardize Japan's robot technologies	

Contents

1. Definition of Robot Revolution.

- Turning what used not to be positioned as a robot in conventional manners into robots through the advancement of sensor and AI technologies.
- Utilizing robots in the actual site of manufacturing as well as various scenes of daily life.
- Forming a society where new added value, convenience and wealth are created through the reinf orcement of global competitiveness in the field of manufacturing and service as well as settlement of social issues.

2. Five-year Action Plan

2.1. Cross-cutting Issues

- Establishment of "Robot Revolution Initiative (RRI)"
- Technology Development toward the Next Generation
- Policy on the Global Standardization of Robotics
- Field-Testing of Robots
- Human Resource Development
- Implementation of Robot Regulatory Reform
- Expansion of Robot Award
- Consideration of Robot Olympic (World Robot Summit)

2.2. Particulars by Sector

Industry	Key measures	KPI by 2020
Manufacturing	◦ Promote the utilization of robot in labor-intensive work such as parts processing and assembly ◦ Pursue the sophistication of production systems utilizing robots and IT ◦ Robot Introduction Demonstration Project to expand the system integrators market	◦ Increase the rate of robotization: 25% for large-scale companies, 10% for SMEs ◦ Expansion of the system integrators market (system integrators: intermediate between the user and the manufacturer) ◦ Double the market size in the manufacturing sector from 528 million USD (60 billion JPY) to 1.05 billion USD 120 billion JPY)
Service	◦ Develop system integrators for matching demand for and supply of Robots ◦ Automation of the object-based process regarding use of robots in the service industry	◦ 20-fold increase of the market scale from 528 million USD (60 billion JPY) to 10.5 billion USD (1.2 trillion JPY) ◦ Increase of about 30% in use of robots for picking, screening, and checking operations ◦ A collection of about 100 example cases
Nursing	◦ Development of nursing care robot of the key areas (transfer aids, mobility aids, toilet aids, or monitoring systems as well as bath aids) ◦ Enhanced flexibility in the application for additional nursing care robot covered under the public insurance system	◦ Expansion of domestic market scale of surgical robot to 440 million USD (50 billion JPY) ◦ Increase the awareness of nursing robot technology when providing care and undergoing care (current 59.8%, 65.1% to 80%)
Medical	◦ Spread of minimal invasive, precise-motion surgical robots and similar medical devices	◦ 100 cases of support to put medical care-related equipment using robot technology
Infrastructure, Disaster Response, and Construction	◦ Supporting technological development ◦ Encouraging introduction of robots into worksite ◦ Improving market environment.	◦ Rate of adoption of computer-aided construction technology up to 30% ◦ Inspection and repair for 20% of key and aging domestic infrastructures using sensors, robots ◦ Realization of construction efficiency at harsh disaster sites
Agriculture, Forestry, Fishery, and Food Industry	◦ Work automation utilizing an automated GPS cruising system ◦ Mechanize and automate labor extensive operations	◦ Achieving the field installation of self-propelled tractors ◦ 20 types of new robots contributing to energy cut

3. Follow-up Progress for Cross-cutting Issues regarding Robot R&D

3.1. Projects in the Robotics and Artificial Intelligence Fields

◦ In "New Robot Strategy", a robot is widely defined as a system that executes tasks by utilizing digital and network technology, advanced sensors, and artificial intelligence, and the strategy aims at the following targets.

◦ The Major Projects in the Robotics and Artificial Intelligence Fields are carried out by New Energy and Industrial Technology Development Organization (NEDO).

3.2. Moonshot Program

◦ The Moonshot Research and Development Program was launched in 2020 by the Cabinet Office (CAO) to promote high-risk, high-impact R&D aiming to achieve ambitious Moonshot

Goals and solve issues facing future society such as super-aging populations and global warming.
- The Moonshot Research and Development Program sets ambitious goals to attract people, and promotes challenging R&D projects with the aim of resolving difficult societal issues while bringing together the wisdom of researchers from all over the world.
- To realize "Human Well-being", ten Moonshot goals (MS goals) were decided in the area of society, environment, and economics. 10 goals have been decided until December 26, 2023.

4. Robotics R&D projects budgets FY2023 by sectors

Sector	Project	Budget (M USD)	Budget (B JPY)	Ministry
Manufacturing & Service (68.382 M USD)	Development of integrated technologies that will be the core of next-generation artificial intelligence and robots https://www.nedo.go.jp/content/100957527.pdf	7.036	1.089	METI
	Realization of Advanced Air Mobility Project: ReAMo https://www.nedo.go.jp/content/100957668.pdf	19.706	3.050	METI
	Innovative Robot R&D Platform Construction Project https://www.meti.go.jp/main/yosangaisan/fy2023/pr/ip/sangi_10.pdf	11.823	1.83	METI
	Development of Technology for Building a Chiplet Design Platform https://www.nedo.go.jp/english/activities/activities_ZZJP_100255.html	3.230	0.5	METI
	Digital Infrastructure Development Project for Digital Transformation of Industries https://www.nedo.go.jp/content/100956472.pdf	15.183	2.35	METI
	Research and Development Utilizing Wireless Communication Technologies to Reinforce the Dynamic Capabilities of the Manufacturing Industry https://www.nedo.go.jp/content/100958052.pdf	5.020	0.777	METI
	Development of AI-Based Innovative Remote Technologies https://www.nedo.go.jp/content/100957099.pdf	2.391	0.37	METI
	Project to Construct a Basis for Research and Development of Innovative Robots https://www.nedo.go.jp/content/100958455.pdf	3.993	0.618	METI
Nursing & Medical (104.145 M USD)	Support project for the introduction of robots in the field of welfare for people with disabilities https://www.mhlw.go.jp/wp/yosan/yosan/23syokan/dl/01-02.pdf	17.444	2.7	MHLW
	Accelerating the development of nursing care robots https://www.mhlw.go.jp/wp/yosan/yosan/23syokan/dl/01-02.pdf	57.502	8.9	MHLW
	Project for strengthening advanced research and development and development systems for medical	25.779	3.99	AMED

	devices, etc. https://www.amed.go.jp/program/list/12/01/005.html			
	Project for promoting the development of robotic nursing care devices, etc. https://www.amed.go.jp/program/list/12/02/003.html	3.424	0.53	AMED
Infrastructure, Disaster Response, Construction (442.577M USD)	Fukushima Robot test field https://www.meti.go.jp/main/yosan/yosan_fy2023/pr/fu/fukko_03.pdf	59.441	9.2	METI
	Project to promote practical development of regional reconstruction https://www.meti.go.jp/main/yosangaisan/fy2023/pr/fu/fukko_02.pdf	383.136	59.3	METI
Agriculture, Forestry, Fishery (24.55 M USD)	Measures to promote the development and social implementation of cutting-edge technologies such as smart agriculture https://www.maff.go.jp/j/budget/pdf/r5hosei_pr39.pdf	24.551	3.8	MAFF

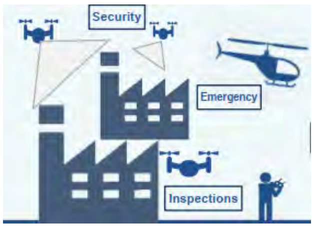
Title	**Projects in the Robotics and Artificial Intelligence Fields**	
Region	Japan	
Issued by	New Energy and Industrial Technology Development Organization	
Announcement	2018~2022	
Term of validity		
Budget	Robotics-related projects for 2023: 30.732 million USD (4.758 billion JPY)	
Keywords	Projects in the Robotics and Artificial Intelligence Fields, Moonshot program	
Related website	Projects in the Robotics and Artificial Intelligence Fields 2023	https://www.nedo.go.jp/introducing/yosan.html https://www.nedo.go.jp/english/activities/robotsandartificialintelligence.html
	Moonshot program	https://www8.cao.go.jp/cstp/english/moonshot/top.html
Background	Projects in the Robotics and Artificial Intelligence Fields 2023 ◦ As Japan presses ahead to achieve the smarter human-centered Society 5.0 with extensive adoption of artificial intelligence ◦ The practical application of relevant technologies with priority in the prioritized areas of productivity, health, medical services and welfare and mobility are encouraged. ◦ Japan has high expectations for robot and AI technologies to realize safe and secure living and accomplish projects, especially as remote, non-face-to-face, and non-contact situations are becoming more important in the pandemic Moonshot program ◦ Japan is now faced with many difficult issues, such as an aging and declining population, extreme natural disasters, and global climate change. These issues should be addressed and resolved by science and technology so that Japan may bring a better future to society. ◦ Considering Japan’s declining birthrate and aging population, development of robots is important to realize a society free from the limitations of body, brain, space, and time and allow people with various backgrounds and values to actively participate in society and work in dangerous or understaffed sites	
Goal	Projects in the Robotics and Artificial Intelligence Fields 2023 ◦ To facilitate the advancement of robotic technologies for deployment in sectors where their utilization is currently limited, including high-mix, low-volume production environments and delivery services. ◦ To develop AI systems that evolved alongside humans, pioneering innovative	

<table>
<tr><td></td><td>remote technologies leveraging AI, and creating next-generation AI applications that utilize quantum and AI hybrid technologies
◦ To explore future technology seeds and form the basis of industrial development

<u>Moonshot program</u>
◦ To tackle important social issues including shrinking and aging societies, global climate change and extreme natural disasters by pursuing disruptive innovations in Japan and promoting challenging R&D based on revolutionary concepts. The program's research aims to achieve nine ambitious Moonshot Goals</td></tr>
<tr><td colspan="2">Contents</td></tr>
</table>

1. Projects in the Robotics and Artificial Intelligence Fields 2023

<table>
<tr><th>Project title</th><th>Content</th></tr>
<tr><td>
Project to Construct a Basis for Research and Development of Innovative Robots</td><td>◦ Period: 2020 – 2024
◦ Budget<table><tr><td>2021</td><td>2.42 million USD (275 million JPY)</td></tr><tr><td>2022</td><td>4.48 million USD (510 million JPY)</td></tr><tr><td>2023</td><td>3.992 million USD (0. 618 billion JPY)</td></tr></table>◦ Target:
- Development of elemental technologies for industrial robots: Creation of innovation strengthening of international competitiveness.
- Promotion of robot introduction by building a robot-friendly environment: Coexistence of humans and robots fostering acceptance of robots.
◦ Research items:
1. Handing-related Technology
2. Remote Control Technology
3. New Robot Materials Technology
4. General-purpose motion planning technology
5. Realization of delivery service by automated delivery robots
◦ Website: https://www.nedo.go.jp/english/activities/activities_ZZJP_100188.html</td></tr>
<tr><td>
Development of Integrated core technologies for next-generation AI and robots</td><td>◦ Period: 2018 – 2023
◦ Budget:<table><tr><td>2021</td><td>14.52 million USD (1.65 billion JPY)</td></tr><tr><td>2022</td><td>12.32 million USD (1.4 billion JPY)</td></tr><tr><td>2023</td><td>7.04 million USD (1.09 billion JPY)</td></tr></table>◦ Target:
- To reduce the time for deploying artificial intelligence technologies to 1/10th of the current situation in the focused areas of productivity and mobility
- Establish common base technologies to enlarge the application fields of artificial intelligence technologies
◦ Research items:
1. Research, development, and demonstration for the implementation of (1) business analysis, identification of issues and data collection/accumulation/processing, (2) development and application of artificial intelligence modules, (3) demonstration in actual fields and (4) establishment of an evaluation system and feedback on the development/application of new artificial intelligence technologies using productivity, spatial movements and other issues targeting priority areas
2. Development of (1) technologies to accelerate the deployment of AI technologies in business inventory, analysis, and improved</td></tr>
</table>

<table>
<tr><td></td><td>efficiency; (2) AI technologies that assist the generation of hypotheses to realize a management simulation system; (3) AI technologies supporting work-related decision-making
◦ Website: https://www.nedo.go.jp/content/100905869.pdf</td></tr>
<tr><td>

Realization of Advanced Air Mobility Project: ReAMo Project</td><td>◦ Period: 2022 – 2026
◦ Budget:<table><tr><td>2022</td><td>25.7 million USD (2.93 billion JPY)</td></tr><tr><td>2023</td><td>19.7 million USD (3.050 million JPY)</td></tr></table>◦ Target:
- Development of performance evaluation methods, and low-altitude traffic management technologies among drones, Drones and Advanced Air Mobilities (AAMs) (eVTOLs) and conventional aircrafts.
◦ Research items:
1. Development of performance evaluation methods
2. Development of traffic management technologies
◦ Website: https://www.nedo.go.jp/activities/ZZJP2_100181.html</td></tr>
</table>

** Reference : 2021 Projects in Robotics and Artificial Intelligence, https://svrobo.org/svr-reports-publications/*

2. Moonshot Research and Development Program

◦ Period: 2020-2050
◦ Budget:

Goal 1	220 million USD (25 billion JPY) for 5 years
Goal 3	220 million USD (25 billion JPY) for 5 years

Key points of the Moonshot Research and Development

◦ **Key points of the Moonshot Research and Development Program:**

- The government sets ambitious goals and concepts for societal issues that are difficult to tackle but will have profound impact once resolved.
- Opens call for domestic and foreign top-class researchers as Project Managers (PM) under the direction of the Program Director (PD) who oversees multiple projects.
- Builds a portfolio overlooking the program and promotes challenging R&D without fear of failure.
- Reviews a portfolio flexibly by stage-gates and actively encourages utilization of the R&D results.
- Establishes the most advanced research support system by utilizing a data management infrastructure.

◦ **Goal:**

- Goal #1: Realization of a society in which human beings can be free from limitations of body, brain, space, and time by 2050.
- Goal #2: Realization of ultra-early disease prediction and intervention by 2050.
- Goal #3: Realization of AI robots that autonomously learn, adapt to their environment, evolve in intelligence and act alongside human beings, by 2050.
- Goal #4: Realization of sustainable resource circulation to recover the global environment by 2050.

- Goal #5: Creation of the industry that enables sustainable global food supply by exploiting unused biological resources by 2050.
- Goal #6: Realization of a fault-tolerant universal quantum computer that will revolutionize economy, industry, and security by 2050.
- Goal #7: Realization of sustainable care systems to overcome major diseases by 2040, for enjoying one's life with relief and release from health concerns until 100 years old.
- Goal #8: Realization of a society safe from the threat of extreme winds and rains by controlling and modifying the weather by 2050.
- Goal #9: Realization of a mentally healthy and dynamic society by increasing peace of mind and vitality by 2050.
- Goal #10: Realization of a dynamic society in harmony with the global environment and free from resource constraints, through diverse applications of fusion energy, by 2050.

2.1 .Goal #1: Realization of a society in which human beings can be free from limitations of body, brain, space, and time by 2050.

◦ Target:
- To overcome the challenges of a declining birthrate, aging population and associated labor shortage
- To realize a society free from the limitations of body, brain, space, and time.

◦ Outline:

Cybernetic avatar infrastructure for diversity and inclusion	
	◦ Development of technologies and infrastructure to carry out large-scale complex tasks ◦ Development of technologies and infrastructure that allow one person to operate more than 10 avatars for one task
Cybernetic avatar life	
	◦ Development of technologies that will allow anyone willing to augment their physical, cognitive, and perceptional capabilities to the top level, and spread of a new lifestyle that will be welcomed by society, by 2050 ◦ Development of technologies that will allow anyone willing to augment their physical, cognitive, and perceptional capabilities for specific tasks, and proposal of a new lifestyle that will be welcomed by society, by 2030.

◦ R&D projects: Selected in FY2022:

Project title	Overview
Structuring Spatio-temporal Environmental Information in the Body Using In-body Cybernetic Avatars	◦ This project aims to develop an in-body Cybernetic Avatar (in-body CA) that can visualize the state of health in the body. ◦ structure spatio-temporal environmental information in the body by distributing and coordinating multiple types of millimeter-, micro-, and nanoscale in-body CAs to realize health monitoring and ultra-minimally invasive diagnostics. ◦ By 2050, it will be useful for health maintenance, diagnosis, and disease prevention, and will be used by people in their daily lives, thereby contributing to a society of health and longevity
Realization of a Society that can Use Cybernetic Avatars Safely and Securely	◦ This project aims to create core technologies on CA Teleoperator authentication, CA authentication and CA notarization that proves and certifies that the teleoperator can publicly use the CA under the law to build a CA infrastructure ensuring safety and security. ◦ Research E^3LSI (Ethical, Economic, Environmental, Legal, and Social Issues) to be tackled for realization of CA lifestyle, and create

IFR International Federation of Robotics

	opportunities for proposals and discussions both domestically and internationally. ◦ Aim to develop a new dimension of jurisprudence such as AI, robotics, and avatar law, by 2050.
Reliability-ensuring Cybernetic Avatar Infrastructure Allowing Interactive Teleoperation	◦ This project aims to develop a reliability-ensuring infrastructure that enables remote control of various CAs even when unstable communication conditions such as jitter (time lag and fluctuation of signals), latency, and communication failures occur. ◦ Develops area optimization technology for wireless sections and network optimization technology including wired sections to maintain interactive connections between operators and multiple CAs to the maximum extent. ◦ Build a reliability-assuring infrastructure that will enable CA remote control underwater, undersea, and in space by 2050.
Creating A Society Whose Citizen's Health is Monitored by Remote Control of Intracellular Cybernetic Avatars	◦ This project aims to develop intracellular Cybernetic Avatars that extend the body's own immune capabilities. ◦ By remotely controlling multiple intracellular Cybernetic Avatars, doctors, and specialists will be able to patrol the body, inspect the malignant state of disease-causing cells, remove them if necessary, and keep the body in good condition at all times. ◦ By 2050 we aim to realize a safe and secure daily life and an increase in healthy life expectancy watched over by intracellular Cybernetic Avatars.

◦ Website: https://www.jst.go.jp/moonshot/en/program/goal1/index.html

2.2. Goal #3: Realization of AI robots that autonomously learn, adapt to their environment, evolve in intelligence and act alongside human beings, by 2050

◦ Target:
  - To develop AI robots that autonomously make judgements and act in environments where it is difficult for humans to act
  - To develop automated AI robot systems that aim to discover impactful scientific principles and solutions, by thinking and acting in the field of natural science
  - To develop AI robots that humans feel comfortable with, have physical abilities equivalent to or greater than humans, and grow in harmony with human life

◦ Outline:

	◦ Development of AI robots that humans feel comfortable with, have physical abilities equivalent to or greater than humans, and grow in harmony with human life, by 2050. ◦ Development of AI robots that behave well with humans under certain conditions and allow over 90% of people to feel comfortable with them, by 2030.
	◦ Development of an automated AI robot system that aims to discover impactful scientific principles and solutions, by thinking and acting in the field of natural science, by 2050. ◦ Development of an automated AI robot system that aims to support the process of discovery for scientific principles and solutions to specific problems by 2030.

- Development of AI robots that autonomously make judgements and act in environments where it is difficult for humans to act by 2050.
- Development of AI robots that operate unattended under human supervision in specific circumstances by 2030

- R&D projects selected in FY2022:

Project title	Overview
Intelligent Multi Agents for Exploration and Settlement in Unknown and Unexplored Areas	◦ This project aims to develop an evolutionary swarm intelligence of many small robots with simple functions by updating and expanding the common functions, and adding new robots. ◦ Invent a construction system of activity bases for the robots. ◦ Aim to realize a future Lunar town by the evolutionary swarm intelligence and the swarm robots.
Awareness AI Robot System for leading proactive behavior improvement	◦ This project aims to develop Awareness AI to support our proactive lives based on our individual requirements, social roles, and hopes for the future. ◦ By 2050, we will create a society where everybody can live proactively according to their best-fit social role and hopes for the future through the awareness of AI support.
Self-Evolving AI Robot System for Lunar Exploration and Human Outpost Construction	◦ This project aims to develop a self-evolving AI robot system for lunar exploration and human outpost construction. ◦ Core technologies will be established that effectively utilize the materials brought to the moon, reconfiguring the modules depending on the tasks, and repairing parts using the resources obtained on the moon. ◦ By 2050, exploration and resource utilization on the moon will be promoted to realize sustainable outposts for human presence in space.
New Life Spheres Opened up by AI Robots	◦ This research project aims to realize biospheres in which humans can be active for a long period of time by conducting research and development toward the construction of a base system with smart technology, behavior-modifying technology, etc., while developing and utilizing AI robot technology for the elements backcasted by this achievement.

- Website: https://www.jst.go.jp/moonshot/en/program/goal3/index.html

A03 Korea

Title	**The 4th Basic Plan for Intelligent Robots**
Region	Korea
Issued by	Ministry of Trade, Industry and Energy, Related Departments Jointly
Announcement	January 16, 2024
Term of validity	2024 - 2028
Budget	128 million USD (180,000,000,000 KRW)
Key words	◦ 4 Robot industries: Manufacturing, Service, Robot Parts, Market Players ◦ 3 Key areas of competitiveness: technology, manpower, and enterprise ◦ Global Expansion ◦ 4 Components to build infrastructures: Framework, Safety, Commercialization, Culture
Related website	https://www.motie.go.kr/kor/article/ATCLc01b2801b/69079/view
Background	◦ Intelligent Robot Development and Supply Promotion Act (June 2008) ◦ 'The 1st Intelligent Robot Basic Plan (2009-2013)' was announced in 2009. The core strategy of the plan was to select three product groups by the time of market formation and to focus promotion policies accordingly. The three product groups selected were: 1) Market Expansion (Manufacturing Robots); 2) New Market Creation (Education, Cleaning, Surveillance and Reconnaissance Robots) and; 3) Technology Leadership (Medical (Surgery), Traffic/Transportation, Silver, Housework, Wearables, Underwater/Aerospace, Biomimetic Robots). ◦ 'The 2nd Basic Plan for Intelligent Robots (2014-2018)' was announced in 2014. It promoted large-scale R&D projects in robot fields for specialized services such as 'Disaster Response Robots and Robot Health Town' and reinforced investments in core robot parts. The seven key areas are: 1) manufacturing; 2) automobiles; 3) medical and rehabilitation; 4) culture; 5) defense; 6) education and; 7) marine. ◦ 10years extension of 'Intelligent Robot Development and Supply Promotion Act' (June 2018) ◦ Robot application sector is concentrated and competitiveness of robot industry
Goal	◦ To develop the robot industry as a core industry in the fourth industrial revolution ◦ To support innovation in manufacturing and services
The latest R&D project	2020 Smart factory supply and diffusion business
The key targets of the latest R&D project	Enhancing Competitiveness of SMEs Manufacturing Sites

Contents

1. Robot Industry and Market in Korea
- Ranking No. 1 in the world in terms of robot density in the manufacturing industry.
- Heavily reliant on foreign-made core parts and others
- Lower than expected the penetration of service robots

1.1. Current Status of Robot Industry in Korea
- The size of the domestic robot industry, as of 2021, is 4.0 billion USD (5.6 trillion KRW), and the localization rate of parts is 44%
- Manufacturing robots (51.2%) and robot parts (32.6%) account for about 84% of the total market size, while the share of service robots* is still in its infancy.
  * Service robot market share (%): (2018) 11.5 → (2019) 11.9 → (2020) 15.6 → (2021)16.2

Manufacturing robot	◦ Concentrated in large industries such as automotive and electric and electronics industries ◦ No. 1 in robot density in the world
Service Robot	◦ The service robot market is still only one-third of the size of the manufacturing robot market. ◦ Aside from cleaning and food serving robots, logistics and cooking robots are still in the early stages.
Robot Parts	◦ About two-thirds of the technological competitiveness in sensor and software, compared to the leading countries such as Japan and Germany.
Market Players	◦ About 99% of the 2,500 robotics companies are SMEs, and about 70% are companies with sales of less than 0.7 million USD (1 billion KRW) (13 large companies and 20 medium-sized companies).

1.2. Diagnosis and Implications of Robot Industry in Korea

- Urgent need to dramatically improve technology, manpower, and corporate competitiveness, which makeup the foundation of the robotics industry
- Promote the spread of manufacturing and service robots for market expansion and economic innovation in the robot industry
- Strengthen strategic inter-company, inter-national, and inter-regional cooperation
- Create a favorable industry environment by redesigning robot-friendly systems and programs

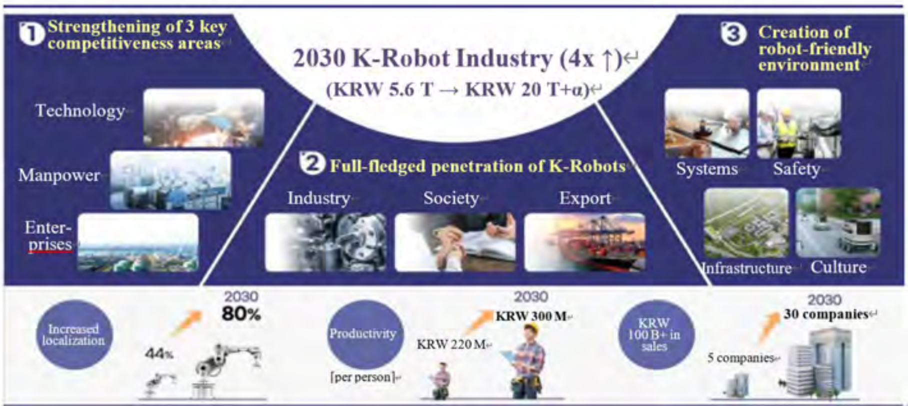
Technology	◦ Preferred Imported products for some of the key parts in the robot manufacturing process.
Work Force	◦ About 35,000 employees in the robotics industry (2021) ◦ The demand for workers increase to 50,000 by 2031 (3.8% annual increase, KIAT, April 2023
Market	◦ Low utilization rate of robots among SMEs ◦ Lack of support for the penetration of intelligent and advanced manufacturing robots
Business environment	◦ Need for support for investment funds, R&D, supply chain cooperation, etc.
Infrastructure	◦ Some obstacles (existing systems designed around people and lack of safety standards) to enter the robotics market

< Technology Level by Major Robot Parts>

Classification	Current Level	Major Items	Current Situation
Sensing	◕	RGBD, force, torque, and tactile sensors, 2D･3D lidar, etc.	▪ Localization and mass production of unit sensors underway ▪ Need to gain competitiveness in the AI-incorporated high value-added sensor module market
Control	◕	Single-axis, motion, and remote controller, PLC, etc.	▪ The level of each control technology is good ▪ Heavy reliance on foreign-made semiconductors such as computation, communication, power, etc. and poor price competitiveness
Drive	◑	Reducer, servomotor, pneumatic drives, grippers, etc.	▪ Localization and mass production of reducers, motors, etc. underway ▪ Inferior to Japanese products in terms of performance and price competitiveness; China is quickly catching up
Software	○	Gripping, object recognition, autonomous driving software, simulator, etc.	▪ Low localization rate of software and large technology gap compared to leading countries ▪ Good expertise of software developers, but insufficient number of developers

* Relative gap compared to leading countries for each part: (○) large gap, (◑) intermediate gap, (◑) small gap

2.『K-Robot Economy』 Leading the Global Market



Task	Strong public-private cooperation centered on **three major strategies** (2.1 billion USD (3 trillion KRW)+ a in public-private joint investment by 2030)
1. Strengthen 3 key areas of competitiveness	▪ [Technology] Secure 8 key technologies [5 in hardware & 3 in software] ▪ [Manpower] Train 15,000 professionals in the fields of AI, software, etc. ▪ [Companies] Nurture 150 robotics companies [Robot Specialty]
2. Power the global expansion of K-Robots	▪ [Domestic market development] Distribute 1 million units in the manufacturing and service industries by 2030 ▪ [Overseas market development] Support companies in the areas of overseas certifications, ODA, and international R&D
3. Build infrastructure tailored to the robotics industry	▪ [Framework] Overhaul the Intelligent Robot Act and pursue regulatory reform for market entry ▪ [Safety] Strengthen safety nets by establishing a robot-specific insurance program, etc. ▪ [Commercialization] Establish testbed facilities for market entry ▪ [Culture] Promote a social consensus along with the dissemination of robots

3. Strengthening three key areas of competitiveness (technology, manpower, and enterprise)

3.1. Technology

- Secure 8 key technologies
- Gain competitiveness in key parts and software technology to strengthen the domestic robot supply chain, while promoting technological collaboration between suppliers and users
- Devise an R&D roadmap with concrete initiatives and schedules for technological development for advanced robots over the next decade (first half of 2024) and pursue robot R&D expansion as an inter-ministerial effort (about 128 million USD (180 billion KRW) in 2023)
- Intensive investment to develop source and application technologies with the goal of improving the technology independence rate of five key parts in 2030 (44%→80% or greater)

< Technological Development of 5 Key Parts (Proposed)>

Field	Reducer	Servo motor	Gripper	Sensor	Controller
Source Technology	▪ Durable materials ▪ Heat treatment technology	▪ High power structure ▪ Low speed, high precision	▪ Operation in dynamic environment ▪ Flexible interaction	▪ High-definition RGB ▪ Low-cost lidar	▪ Bin-picking operations ▪ Robotic equipment integration
↓ Modularization – Integration					
Application Technology	▪ High power driver (reducer + servo motor) ▪ Intelligent controller (sensor + controller) ▪ Smart gripper (gripper + controller) ▪ Robotic hand integrated with tactile sensors (sensor + gripper) ▪ Intelligent driving module (sensor + reducer + servo motor)				

	▪ Lightweight high-precision robot (integration of all five types of parts)

◦ Development of essential software technologies that are optimized for robots and enhance mobility, autonomy, and intelligence

<Technological Development of 5 Key Parts (Proposed)>

Autonomous movement software	Autonomous operation software	HRI
▪ Movement based on a pedestrian map ▪ Spatial cognition based on semantic information ▪ Atypical environment response	▪ Flexible process response and cognition ▪ Gripping of atypical objects ▪ Human-level task intelligence	▪ Care robots for seniors living alone
↓ Linking with New Business		
▪ Last mile delivery robots ▪ Indoor and outdoor patrol robots	▪ Manufacturing robots for atypical assembly process ▪ Household service support robots	▪ Care robots for seniors living alone ▪ Rehabilitation robots for persons with disabilities

◦ Creation of a technological ecosystem based on openness and cooperation between buyers and suppliers such as parts and software companies and robot manufacturing companies
◦ Pursue and support the discovery of joint R&D projects based on specific joint technology needs with leading countries in the field of robotics technology (5.0 million USD (7 billion KRW) in 2024)
◦ Prepared a company-led Advanced Robot R&D Roadmap through industry demand and expert group reviews and secured more than 30 technologies (2024)
◦ Active involvement in the development of standards by international standard organizations (ISO/IEC) to keep pace with environmental changes and technological advances (Korea Agency for Technology and Standards (KATS) and National Radio Research Agency (RRA))

< Examples of Joint R&D>

Country	Field	Participants
United States	Softbot	◦ US Department of Defense – MOTIE (Example: Softbot Joint Research Working Group)
	Manufacturing, Logistics, Healthcare	◦ MassRobotics – MOTIE (Joint R&D in key areas of the robotics industry)
Israel	Logistics, Agriculture & Animal Husbandry, and Health	◦ Israeli Ministry of Economy and Industry – MOTIE (Example: Lighthouse Program)
Germany	Human-Robot Collaboration	◦ German Federal Ministry of Economics and Technology – MOTIE (Joint R&D in a key area of the robotics industry)
Japan	Social Robots	◦ Japanese Ministry of Economy, Trade and Industry – MOTIE (Moonshot R&D project, etc.)

3.2. Workforce
◦ Training 15,000 professionals in the fields of AI, software, etc.
◦ Focusing on convergence robotics education in AI and software in high demand among robotics companies and proactively prepare a system to supply professional manpower

3.3. Companies
◦ Nurturing 150 robotics companies [Robot Specialty]
◦ Prioritizing the growth of key companies spearheading the innovation of the domestic robot industry, and create a business ecosystem characterized by active founding of startups and domestic and foreign investment

4. Power the global expansion of K-Robots

4.1. Domestic Market Development
- Distributing 1 million units in the manufacturing and service industries by 2030
- (Industrial Utilization: Approx. 680,000 units) Supply robots to industrial fields where it is possible to improve competitiveness by enhancing productivity, mitigating labor shortages, and improving the working environment with high-tech robots with priority
- (Social Utilization: About 320,000 units) Intensive dissemination of advanced robots in the areas of the public sectors directly related to quality of life and safety to create results that people can experience in their daily lives.

4.2. Overseas Market Development
- Support companies in the areas of overseas certifications, ODA, and international R&D
- Utilize intergovernmental cooperation channels such as the Korea-Saudi Vision 2030, the Korea-U.S. Supply Chain and Commercial Dialogue (SCCD), and the Korea-UAE Investment Platform to discover projects in the field of robotics
- Promote VC entry of robot manufacturing companies with increasing global demand based on demand analysis of each robotics field such as logistics and serving robots
- Assist in domestic testing and certification processes required for exporting robots in connection with overseas testing institutions* and expand the use of domestic testing and certification bases

5. Build infrastructure tailored to the robotics industry

5.1. Framework
- Overhaul the Intelligent Robot Act and pursue regulatory reform for market entry
- Completely overhaul the framework Intelligent Robot Act to flexibly deal with technological progress and industry changes
- Improvements focusing on the Advanced Robot Regulatory Innovation Plan (March 2, 2023): 51 initiatives in four areas (1. mobility, 2. safety, 3. assistance in collaboration, and 4. robot-friendly environment)
- Redesign the subsidy system to strengthen the robotics industry ecosystem by enhancing benefits for the people, improving technological capabilities, promoting investment, creating jobs, etc.

5.2. Safety
- Strengthen safety nets by establishing a robot-specific insurance program, etc.
- Establish a safety response system to achieve zero accidents by using robots
- Introduce robot insurance (mutual aid) against accidents involving robots

5.3. Commercialization
- Establish testbed facilities for market entry
- Establishment of large-scale testbed infrastructure for demonstration of robots' work performance, durability, and safety in actual and virtual environments (2024 to 2028, approx. 142 million USD(200 billion KRW))

< Components of Each Test Field Environment (Proposed)>

Public Convenience	Logistics	Everyday Living	Commerce
Outdoor driving environment, parking lots, etc.	High-tech logistics environment, last-mile delivery, etc.	Office space, home space, etc.	Food courts, hotels, smart hospitals, etc.

- Creation of a “robotics cluster” for channeling the capabilities of the robot industry in the region with local robotics companies, universities, and related organizations playing central roles
- Promote cooperation between large companies and SMEs in the field of SI to strengthen the competitiveness of robotic SI for robotic system design and engineering, production, maintenance, and repair

5.4. Culture
- Promote a social consensus along with the dissemination of robots
- Preparation of Robot Ethics Guidelines for the coexistence of robots and humans
- Strengthen public relations and communication efforts to encourage people to accept robots

6. Future Plans

6.1. Implementation System

- Strengthening of the function of the Robot Industry Policy Council to coordinate and link the policies of various industries as a deliberative body for important matters
- Formation of the Advanced Robot Economy Taskforce with industry-university-research institute experts and operation of subcommittees for each topic to discover policies, promote collaboration, and strengthen public-private communication (2024~, quarterly meetings)

< Advanced Robot Economy TF (1st Vice Minister of Industry, Private Expert)>

Technology	Region	Regulatory	International Cooperation	Other
▪ Establish and implement the R&D roadmap ▪ Discover new tasks and coordinate the tasks of each ministry	▪ Analyze the robot industry by region and link them together ▪ Discover the demand for collaboration between regions and provide support	▪ Operate the Public-Private Council for Regulatory Improvement ▪ Check the implementation of the proposed initiatives and discovery of new tasks	▪ Discover international cooperation needs and match entities ▪ Analyze global robot industry trends	▪ Operate a TF for each issue in line with industry demand

Title	**2023 Action Plan for the Intelligent Robot**
Region	Republic of Korea
Issued by	Ministry of Trade, Industry and Energy, Related departments Jointly
Announcement	July 14, 2023
Term of validity	
Budget	163 million USD (230 billion KRW)
Key words	Intelligent robot, manufacturing robot, service robot, robot parts
Related website	https://www.motie.go.kr/kor/article/ATCLc01b2801b/68705/view
Background	The implementation plan of 2021 for the 3rd basic plan (2019-2023)
Goal	◦ Expand the market size of the robotics industry (KRW 15 trillion by 2023) ◦ Increase the number of companies specializing in robotics valued at over KRW 100 billion (at least 20 companies by 2023) ◦ Increase the number of manufacturing robots in service (700,000 in cumulative total by 2023)

Contents

1. Analysis of Key Performance in 2022

1.1. Increased Penetration of Manufacturing Robots in the Three Key Manufacturing Areas

◦ Development of standard robot models

- Development and dissemination of standard process models including the three major manufacturing industries (root, textile, food and beverage)

< Standard Process Models Developed in 2022>

Industry type		Process	Title of the standard model
Root (19)	Automotive (4 models)	Transport & Loading	Automotive Parts Loading/Unloading of Multiple Injection Molding Machines Using Articulated Robots
		Transport & Loading	Automotive Parts Insertion of Non-Aligned Metal Materials for Press Machines
		Assembly & Disassembly /Transport &	Automotive Parts High-Speed Fastening of Small Objects and Dynamic Rack Loading

		Loading	
		Testing & Inspection	Automotive Parts Non-Contact High-Speed Inspection of Small Metal Items
	Machine (4 models)	Testing & Inspection	Mechanical Parts of Gas Filters Product Function Inspection
		Assembly & Disassembly	Mechanical Parts of HVAC Systems PCB Bolting and Assembly
		Processing/ Machining	New Parts for Automotive Engines Machining of Aluminum Castings
		Processing/ Machining	Auto Body and Special Equipment Exterior Parts Blanking
	Metal & Plastic (6 models)	Transport & Loading	Metal/Automotive Loading/Packing of Welded Parts
		Post-Processing/ Machining	Aluminum Casting Post-Machining (Cutting) Process for Gravity Castings
		Processing/ Machining	Metal Machining_3D Vision-based Multi/Non-Aligned Setting Machine Tending and Precision Machining
		Injection Molding	Metal Machining Post-Injection Molding Machining
		Testing & Inspection	Inspection and Packaging of Painted Products
		Post-Processing/ Machining	Post-Machining of Gantry-Type Large Auto Body Parts
	Electric & Electronic (5 models)	Transport & Loading	Semiconductor Manufacturing Parts and Device Transfer
		Processing/ Machining	Semiconductor Manufacturing Parts / Device Processing / Machining
		Testing & Inspection	Semiconductor Manufacturing Functional Inspection
		Assembly & Disassembly	Small Electronics Manufacturing Assembly & Combination
		Transport & Loading	Small Electronics Manufacturing Product Packaging and Loading
Textile (4 models)		Assembly & Disassembly	Footwear & Parts Display of Coating Work Guide
		Desorption/ Detachment	Footwear & Parts Loading/Unloading of Manufactured Products
		Assembly & Disassembly	Footwear & Parts Input of Reinforcement Materials
		Post-Processing/ Machining	Footwear & Parts Alignment and Packaging of Manufactured Products
Food & Beverage (4 models)		Desorption/ Detachment	Franchise F&B Input in Processing and Post-Processing Process
		Transport & Loading	Franchise F&B Transport & Loading
		Assembly & Disassembly	Franchise F&B Assembly & Disassembly
		Testing & Inspection	Franchise F&B Weighing and Packaging Incasing
New (10 models)	Vessel (3 models)	Transport & Loading and Machining	Medium-Sized RC Processing Robot Process Model for Vessels
		Processing/ Machining	Vessel Weld Recognition Robot Process Model

		Processing/ Machining	Pipe (Plasma) Cutting Robot Process Model
	Aviation (3 models)	Processing/ Machining	Aircraft Parts Manufacturing Composite Material Cutting (Side)
		Processing/ Machining	Aircraft Parts Manufacturing Flat Plate Drilling
		Assembly & Disassembly	Aircraft Parts Manufacturing Flat Plate Riveting
	Bio & Chemical (4 models)	Transport & Loading	Heavy Cargo Chemicals ((1) Drum, (2) Film Roll) Transport and Loading Processes
		Testing & Inspection	Biomaterial Weighing, Transport, and Loading Processes
		Assembly & Disassembly	Bio/Medical Device ((1) Ampoule, (2) Dental Porcelain, (3) Suction Tube (4) Wet Wipes Cap) Assembly Process
		Transport & Loading	Biopharmaceutical Transport and Loading Processes

1.2. Intensively Nurturing Four Major Types of Service Robotics

◦ Technical development for commercialization with a focus on solving pending social issues

- Initiatives in 2022 related to the top four service robotic fields, i.e. Care, Wearables, Healthcare, Logistics.

◦ Technical Development in Ten Key Fields in "Niche Markets"

- Development of technology to deal with social issues and satisfy the on-site needs of individual ministries

< Main Details of Projects by Ministry >

Government department	Description	2022 budget
Ministry of Agriculture, Food and Rural Affairs (MAFRA)	Development of intelligent agricultural robots for smart greenhouses	1.5 M USD (2.1 B KRW)
	Development of a robot for harvesting horticultural crops based on multi-robot collaboration	0.71 M USD (1 B KRW)
	Creation of a high-tech unmanned automated agricultural production demonstration complex	5.3 M USD (7.5 B KRW)
Ministry of Trade, Industry and Energy (MOTIE)	(New) Development of a remote inspection robot system for cableway facilities (wire rope and cutting wheel)	0.71 M USD (1 B KRW)
	(New) Development of human-robot collaboration technology for dismantling multi-variety EV battery packs that need to be disposed of	0.78 M USD (1.1 B KRW)
	(New) Safety robot technology capable of detection and response by being operated wirelessly in a small space	0.85 M USD (1.2 B KRW)
Ministry of Environment (MOE)	Development of non-face-to-face collection and treatment technology for high-risk medical waste	1.6 M USD (2.3 B KRW)
Ministry of Oceans and Fisheries (MOF)	On-site demonstration and commercialization of underwater construction robots	2.0 M USD (2.8 B KRW)
Defense Acquisition Program Administration (DAPA)	Development of complex signal-based human-machine high-speed synchronization control technology	1.3 M USD (1.8 B KRW)
	(New) Development of multi-robot collaboration planning technology	0.5 M USD (0.7 B KRW)
National Policy Agency (NPA)	Development of gas molecule identification technology for dealing with risk factors for the public	0.36 M USD (0.5 B KRW)
National Fire Agency (NFA)	Development of efficient response technology for chemical terrorism such as harmful gases	1.2 M USD (1.7 B KRW)
Rural Development Administration (RDA)	Robotics technology for hydroponic cultivation, fruit and vegetable cultivation monitoring, fruit-thinning, and harvesting	1.1 M USD (1.6 B KRW)

	Development of intelligent mowers for apple orchards	0.14 M USD (0.2 B KRW)
	Research on the application of robot safety technology for the development of agricultural robots	0.07 M USD (0.1 B KRW)
	Development of fruit enlargement and harvest period diagnosis technology for machine harvesting to lower the need for manpower	0.07 M USD (0.1 B KRW)
Coast Guard	Development of autonomous underwater vehicles (AUVs) for prompt response in the event of a marine accident	3.3 M USD (4.6 B KRW)

1.3. Strengthening the foundations of the robotics industry's ecosystem

◦ Development of technology related to 3 key components and 4 types of software and support for performance evaluation and certification

◦ Infrastructure:
To promote the commercialization of innovative technologies and support the establishment of a safe utilization environment

◦ Convergence with Other Industries:
To support for the development and demonstration of next-generation robotics technology fused with other technologies

◦ Human Resource Development:
Operation of education and training courses centering on convergence with other industries and human-robot collaboration to nurture innovative manpower to perform practical work

2. Direction of Implementation in 2022

Objectives	◦ To lead industrial innovation through the intelligentization of manufacturing sites based on robots ◦ To address social issues using robots and integrate robot services into people's daily lives ◦ To pave a foundation for the creation of innovative fields such as new technologies and new businesses

3. Implementation Plan in 2023

3.1. Plan to Expand the Penetration of Manufacturing Robots in the Three Major Manufacturing Industries

◦ Development of Standard Process Models
- Developing three major +α fields and robot-equipment convergence models

◦ Supplement of Manufacturing Robots
- Providing packages that include consulting, prior distribution, user training, etc. based on n the developed standard process models and the needs of individual companies

< Demonstration of Prior Supply of Manufacturing Robots >

1. Development of Standard Models		2. Pre-emptive distribution		3. User training		4. Proliferation of private autonomous activities
3 +α fields (Root, Textiles, F&B, Aviation, Ships, Bio & Chemical) Development of standard model	➔	Demonstration and distribution of the standard models that have been developed	➔	Training employees on how to use the robots before and after their introduction	➔	Provision of financial and lease / rental support and promotion of the user network

◦ Employee Training
- Providing training packages for the employees of companies adopting standard process models and train robotic SI experts and operators using training centers

< Robot Vocational Innovation Center >

		
Robot Vocation Innovation Center (Gumi)	Cobot Lab	Manufacturing Robot Lab

◦ Dissemination in the Private Sector
- Continued operation of financial, investment, and purchase support programs and support for the revitalization of used robot transactions through the operation of the Refurb Center

3.2. Plan to Intensively Nurture Four Major Types of Service Robotics
◦ Developing new technologies in the field of care and safety that reflect the needs in the field to address social issues such as demographic changes and industrial accidents

< Key Projects for the Development of Robotics Technology
to Boost the Self-Reliance of Vulnerable Groups >

Field	Description	2023 budget
Care	Development of three types of care robots (excretory assistance, mobility assistance, pressure ulcer prevention)	0.53 M USD (0.75 B KRW)
Assisted living	Development of mobile living assistance robots that understand people's daily behavior	0.50 M USD (0.7 B KRW)
Mobility assistance	Development of a simple riding-type robotic system for the elderly, persons with disabilities, and patients to stand, change posture, and move about indoors	0.50 M USD (0.7 B KRW)

◦ Demonstration & Distribution
- Pursuing large-scale robot distribution and demonstration projects based on verification of robotics solutions for solving problems in the field as well as data management and integrated control

◦ Regulatory Improvement
- Announcing the Advanced Robot Regulatory Innovation Plan (March 2023) and amendments to the Intelligent Robot Act (April 2023) with a focus on improving regulations concerning promising fields of robotics

◦ Development of technologies in key ten fields for niche markets
- Development of technology to deal with social issues and satisfy the on-site needs of individual ministries

Department	Description	2023 budget
MAFRA	Development of intelligent agricultural robots for smart greenhouses	1.5 M USD (2.1 B KRW)
	Creation of a high-tech unmanned automated agricultural production demonstration complex	5.3 M USD (7.5 B KRW)
MOTIE	Development of a remote inspection robot system for cableway facilities (wire rope and cutting wheel)	1.1 M USD (1.51 B KRW)
	Development of human-robot collaboration technology for dismantling multi-variety EV battery packs that need to be disposed of	1.2 M USD (1.65 B KRW)
	Safety robot technology capable of detection and response by being operated wirelessly in a small space	1.1 M USD (1.6 B KRW)
	(New) Robotics platform for agricultural work capable of continuous	1.1 M USD

	fruit harvesting and multi-transport robot control	(1.5 B KRW)
MOE	Development of non-face-to-face collection and treatment technology for high-risk medical waste	1.6 M USD (2.3 B KRW)
DAPA	Development of complex signal-based human-machine high-speed synchronization control technology	0.92 M USD (1.3 B KRW)
	Development of complex signal-based human-machine high-speed synchronization control technology	0.92 M USD (1.3 B KRW)
	(New) Development of garment-type flexible wearable robot technology for optional articulated assistance	0.28 M USD (0.4 B KRW)
NFA	Development of efficient response technology for chemical terrorism such as harmful gases	1.3 M USD (1.9 B KRW)
RDA	Robotics technology for hydroponic cultivation, fruit and vegetable cultivation monitoring, fruit-thinning, and harvesting	1.1 M USD (1.6 B KRW)
	Development of intelligent mowers for apple orchards	0.14 M USD (0.2 B KRW)
	Development of fruit enlargement and harvest period diagnosis technology for machine harvesting to lower the need for manpower	0.09 M USD (0.12 B KRW)
Coast Guard	Development of autonomous underwater vehicles (AUVs) for prompt response in the event of a marine accident	5.1 M USD (7.18 B KRW)

◦ Supporting for Export
- Providing assistance to the destination country and support for acquiring overseas standard certifications required by the destination country

3.3. Plan to Strengthen the Ecosystem of the Robotics Industry
◦ Development of Technology
- Providing the technological development and performance certification of three next-generation key components and 4 types of software

Field	Description	2023 budget
Intelligent Controller	Development of a reducer that can respond to various system requirements and applies a new tooth type	0.53 M USD (0.75 B KRW)
	Development of integrated drive and steering drive modules for autonomous mobile robots (AGVs, AMRs)	0.63 M USD (0.9 B KRW)
Self-driving Sensor	Development of solid state FMCW LiDAR with a volume of 300cc or less for harsh indoor and outdoor driving environments (snow, smoke, dust, etc.)	0.71 M USD (1 B KRW)

◦ Build a foundation for safety certification of collaborative robots to help sharpen their competitiveness
* Portion of collaborative robots to all manufacturing robots: 4% in 2018 to 33% in 2025 (M&M, 2019)
** The establishment of an international standard certification system is expected to reduce costs and shorten the certification period compared to overseas certification systems
◦ To provide support for new projects of field assessment (decelerator, lidar, etc.) by collaboration with domestic and international robot manufacturer and domestic part manufacturer
◦ To establish a foundation of meister robotization centered on the four key fields (metal processing, automotive parts, electric & electronic, and textiles) based on big-data

A07 Singapore

Title	**National Robotics Technology Vistas: Strengthening Differentiating Capabilities that Matter**
Region	Singapore
Issued by	National Robotics Programme (NRP)
Announcement	Aug 2016
Term of validity	2016 ~ 2024
Budget	11.3 million USD per year on average (15.1 million SGD per year)
Key words	Assistive Robotics; “Universal” End Effectors; Reconfigurable Robotics; Navigation & Perception; Human-Robot Interaction; System Capabilities; Trusted Robotics; Data-Driven Robotics; Multi-Robot Systems
Related websites	https://www.nrp.gov.sg/
Background	◦ Oct.2014. The Robotics R&D Taskforce was convened to identify opportunities for Singapore in robotics. ◦ Aug.2016. NRP was officially established as part of the Research, Innovation and Enterprise (RIE) initiative. NRP aims to catalyze differentiated robotics capabilities in Singapore through the funding of use-inspired research and use-driven development ◦ NRP is a multi-agency national platform hosted by A*STAR(*) that oversees the research, development and translation of robotics enablers and solutions in Singapore. ◦ Mar.2024. Announcement of 60 million SGD (44.8 million USD) for NRP with technology translation as its key focus. A key plank of NRP's effort to drive this is its RoboClusters (**) initiative. ◦ 2024 announcement of the National Robotics Technology Vistas, outlining 9 Robotics R&D focus areas. (*) A*STAR: The Agency for Science, Technology and Research is Singapore's lead public sector R&D agency.
Goal	NRP seeks to develop capabilities in robotics for societal and economic impacts. By capabilities, the program goes beyond technologies to include growing the local talent pool, identifying applications and shaping the robotics ecosystem in Singapore.
NRP Initiative	**RoboClusters
The key targets of NRP initiative	◦ RoboClusters are robotics innovation clusters aligned with prioritized R&D focus areas and industry sectors – namely manufacturing, logistics, facilities management, healthcare, aviation and maritime. ◦ Through the RoboClusters, NRP will bring together public research and development (R&D) institutions such as A*STAR and Institutes of Higher Learning (IHLs) (including NTU, NUS, SUTD and SIT)***, end-users, robotics & automation companies (including foreign companies based in Singapore), trade associations, VCs and government agency stakeholders to align and synergize robotics R&D capability-building with industry needs, foster collaborations as well as catalyze greater translation from R&D to adopted robotic products. *** NTU – Nanyang Technological University, NUS – National University of Singapore, SUTD – Singapore University of Technology and Design, SIT – Singapore Institute of Technology

Contents

1. Overview

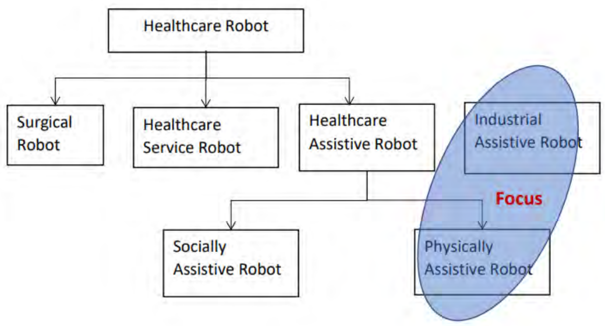
◦ At the start of NRP's journey, it funded robotics R&D projects through 2 funding initiatives (FI): Robotics Enabling Capability Technology (RECT) and Robotics Domain Specific (RDS). RECT FI focuses on building Robotics technologies applicable, inspired by potential use in domain sectors that Singapore is keen to develop; whereas RDS FI co-funds projects with public agencies in

Healthcare, Built Environment, and Environmental Services to innovate robotic solutions for their problem statements and use cases. This has since been changed to one FI to fund both capability building projects and translation projects for the 6 sectors mentioned under RoboClusters initiative.

- 9 Robotics R&D focus areas are (the first 6 areas are existing and the last 3 are new R&D focus areas):
    1. Assistive Robotics
    2. “Universal” End Effectors
    3. Reconfigurable Robotics
    4. Navigation & Perception
    5. Human-Robot-Interaction
    6. System Capabilities
    7. Trusted Robotics
    8. Data-Driven Robotics
    9. Multi-Robot Systems

2. Robotics R&D focus areas

2.1. Assistive Robotics

<table>
<tr><td>Definition</td><td colspan="2">Assistive robots constitute a category of robots that share a work area and interact with humans. NRP focuses on healthcare physically assistive robots and industrial assistive robots


Classification of Assistive Robotics</td></tr>
<tr><td>Focus on / Main Points</td><td colspan="2">◦ Mobility Assistive robot – provides transfer, driving and balance assistance, such as wheelchair, prosthetics, exoskeletons (wearable devices)
◦ Upper-limb function assistive robot – assists with manipulation tasks such as grasping, feeding, cooking, grooming, bathing & showering, dressing activities
◦ Industrial assistive robots - assists workers manual work in sectors such as manufacturing, logistics, healthcare</td></tr>
<tr><td>Challenges</td><td colspan="2">The key focus is on enablers such as mechanisms, actuators, sensors and systems to meet the following challenges:
◦ Human ability intelligence – to quantify and provide personalized assistance to cater for users with large variability in physical, sensory and cognitive abilities
◦ Robot intelligence – to understand human intention and perform collaborative tasks with the human when the combined system interacts with the environment
◦ Task intelligence – to assess how well the robot could and has assisted the user in task accomplishment with safety compliance
These capabilities would enable co-adaption between the human and the robot, and iteration toward an optimal human-robot collaboration to complete physical tasks in the environment</td></tr>
<tr><td rowspan="2">Vision</td><td>Short term (0-3 years)</td><td>Both the robotic hardware and HRI technology for mobility assistive robot and upper-limb assistive robot should reach the maturity level that can be deployed in structured environment such as hospitals and care centers</td></tr>
<tr><td>Medium term (4-5 years)</td><td>Both the robotic hardware and HRI technology for mobility assistive robot should reach the maturity level that can be deployed in less structured environment such as home and community</td></tr>
</table>

	Long term (6-10 years)	The HRI interaction paradigm will shift more towards intent understanding and natural interaction such as speech and motion

2.2.Reconfigurable Robotics

Definition	Reconfigurable robots refer to a class of robots capable of changing their morphology with a provided level of autonomy to execute tasks, adjust to new situations, or recover from faults. An autonomous self-reconfigurable robot is a robot that can modify its shape supported by the sensing, planning, control, autonomy, and execution system.	
Focus on / Main Points	Examples of reconfigurable robots are: ◦ Tetris inspired tiling class of robots for STEAM-based learning ◦ Staircase-cleaning robot that can ascend and descend while cleaning ◦ Reconfigurable legged robot designed for drain inspection ◦ Reconfigurable robot that can perform rolling, crawling, and climbing ◦ Development of a modular reconfigurable mobile robot, and scalable and customizable manipulators ◦ A modular configurable humanoid robot ◦ Developing modular configurable mechanisms and manipulators	
Challenges	◦ Creating robots that are more adaptable, durable, and effective in meeting the demands of workers and people daily in either work or home situations, while keeping the hardware system as simple as possible ◦ Finding an appropriate reconfigurable shape for a given particular task ◦ New AI systems to improve the decision-making ability ◦ Expand beyond the existing applications such as inspection and maintenance, toward new application domains ◦ Establishing cooperative motions involving large scale modules	
Vision	Short term (0-3 years)	Developments of reconfigurable robots with a low degree of reconfigurability targeting specific application domains, conditional autonomy in reconfiguration and limited social engagements
	Medium term (4-5 years)	Having reconfigurable robots with a high degree of reconfigurability, high autonomy in reconfiguration, close social engagements
	Long term (6-10 years)	Having reconfigurable robots with a very high degree of reconfigurability, fully autonomy in reconfiguration, and natural social engagements

2.3.“Universal” End-Effectors

Definition	End-effectors are the last link in a robot arm, which holds the key to carry out the intended task for the robot. The “universal” robot end-effectors refer to as a collection of various grippers of similar morphology and having a spectrum of material properties from rigid, hybrid to soft materials, and grippers with additional sensing elements, such as tactile, force, and perception to provide an “intelligent” grasp.	
Focus on / Main Points	◦ Integrated end-effector with visual and tactile perceptions ◦ End-effector for healthcare logistics: commonly encountered in hospital operations, environment cleaning, hospitality logistics ◦ Soft & hybrid grippers for food & beverage and healthcare applications: for food assembly, fruits picking and physical interaction with patients ◦ Advanced digital fabrication for hybrid grippers using 3D printing	
Challenges	◦ Design methodology for soft and hybrid grippers morphology ◦ Embedding sensors into grippers to have stable and reliable performance with reasonable cost ◦ Soft material safety and hygiene for human and food related applications ◦ Processing local information on the edge ◦ Suitable use cases with appropriate return-of-investment	
Vision	Short term (0-3 years)	Embarking on system approach design and embarking on cost-down and mass manufacturing technology for soft and hybrid grippers for rapid robotic application development

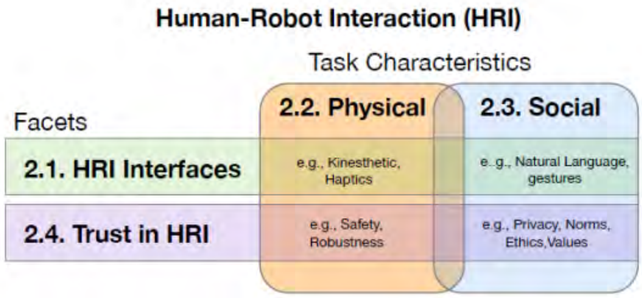
	Medium term (4-5 years)	Having new end-effector standards & communication framework. Sensors standardization for grippers and sustainable design for robotic grippers
	Long term (6-10 years)	Shifting to intelligent grippers that not only integrate grasping planning but also some part of motion planning of the robot arms and mobile base to reduce the effort of system integration programming.

2.4.Navigation & Perception

Definition	Navigation & perception are the foundational requirements for robot mobility so that the robots can move autonomously to perform tasks that are useful and beneficial. Navigation includes technologies to localize itself, path and motion planning, while perception for navigation includes object and environment understanding, and other relevant tasks such as people following, map creation and update, and performing desired behavior such as following social norms, giving way to other priority users, handling emergency situations and many other situations encountered as robots move in areas with more people	
Focus on / Main Points	◦ Autonomous Mobile Robots ◦ Delivery and service robots ◦ Cleaning robots ◦ Inspection and maintenance robots ◦ Security and patrol robots	
Challenges	◦ Environmental challenges: all terrain and weather perception, crowded and dynamic environment, feature scarcity and repetitive environment ◦ Technological challenges: Safe and effective navigation in indoor and outdoor environments, social awareness navigation, multi-robot collaborative navigation, rapid deployability and scalability, map integrity and update	
Vision	Short term (0-3 years)	Developing more accurate and robust sensor fusion techniques that combine various sensor types; developing new frameworks that build semantic maps, detect static and mobile objects in the environment; Enabling the robot with the capability and intelligence to complete its task unaided
	Medium term (6-10 years)	Learning from and adapt to its surrounding environment while performing navigation and completing task; ability to predict human motion and behavior, and to interact with human; ability to actively manipulate its surrounding objects and to operate in new environment without complete onsite mapping
	Long term (11-15 years)	Moving from single robot navigation and perception to heterogeneous robot teams to provide diverse capabilities; hence navigation and perception capabilities will be required various tasks such as complex 3D trajectory planning, cooperative mapping, search and rescue, collaborative manipulation

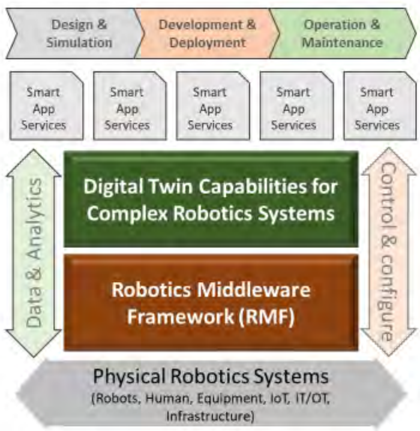
2.5.Human-Robot-Interaction (HRI) & Trusted Robotics

Definition	◦ HRI is a critical technology for service robots as it enables the interaction between the robots providing the service with the human receiving the service ◦ Trusted Robotics: (i) Trustworthy Robots, the robustness, safety, and security associated with the robot; (ii)Human-Robot Trust, the attitude of humans regarding the trustworthiness of the robot

<table>
<tr><td>Focus on / Main Points</td><td colspan="2">

◦ HRI Interfaces; Physical human-robot interaction; Social HRI; Trustworthy HRI and Human-robot trust</td></tr>
<tr><td>Challenges</td><td colspan="2">◦ Research challenges: Perception and understanding of humans and contexts; safety, robustness, and long-term interaction; trustworthy robots that humans trust; physical interaction; human-robot communication and coordination
◦ Development Challenges: lack of robust and reliable sensing modules, interfaces, and robot platforms to carry out HRI research; lack of standard and real-world datasets, evaluation metrics, and domains to validate the effectiveness and reusability of developed HRI technologies
◦ Other challenges: Talent, standardization</td></tr>
<tr><td rowspan="3">Vision</td><td>Short to medium term (0-5 years)</td><td>Service robots, such as delivery robot, receiving task orders and serving humans in dynamic and human rich environment</td></tr>
<tr><td>Long term (6-10 years)</td><td>Service robots work alongside trained users and untrained people operating in the same space</td></tr>
<tr><td>Very long term (>10 years)</td><td>Robot caregivers in homes</td></tr>
</table>

2.6.System Capabilities

<table>
<tr><td>Definition</td><td>System capabilities are horizontal technologies that enable, simplify, optimize, and speed up the design, development, validation, deployment, operation, management, and maintenance of complex robotics systems that are increasingly needed and deployed across various industrial sectors and application domains. They could also include infrastructure to support the operations or deployment of robotics solutions</td></tr>
<tr><td>Focus on / Main Points</td><td>◦ Robotics middleware framework (RMF): interoperability technologies to support multiple economic sectors in Singapore, such as healthcare, manufacturing, logistics, facilities management and aviation
◦ Digital twining technologies that can support the full life cycle of complex robotics systems, from analysis, design, development, deployment, operation, to de-commission


RMF and digital twin capabilities for complex robotics systems</td></tr>
</table>

Challenges	◦ Key technical challenges: A more scalable system architecture; support of time-sensitive applications; robust handling of traffic and robot job orders for cluttered environment; flexibility in dispatching and recalling of job orders; framework and algorithms to support co-simulation and convergence of production and supporting robotics, fleets (quantity, specs, boundary constraints, etc.), and integration with and leveraging decentralized computing and intelligence ◦ Non-technical challenge: Sustaining Singapore's efforts to enhance and promote robotics interoperability by working with like-minded partners to close gaps in standards and drive further development, innovation and deployment of enabling solutions and infrastructure	
Vision	Near term (0-3 years)	The adoption of RMF platform technology will accelerate beyond the healthcare sector in Singapore to manufacturing, logistics and aviation sectors
	Medium term (4-5 years)	RMF will gain more traction with more and more successful large-scale use cases demonstrated. Developing significant digital twin for robotics systems capabilities
	Long term (6-10 years)	RMF will be the dominant robotics interoperability platform with wide adoption around the world. Digital twin for robotics platform technologies will be expanded to support the full lifecycle of robotics systems

2.7.Data-Driven Robotics (DDR)

Definition	DDR is the approach of utilising data (including big data) to learn and improve robot policies or models at the levels of individual robots, fleets or even system-of-systems. Robotics can be data-driven in multiple ways. For example, data is used to train and fine-tune models for planning, perception and action (Foundation Models for Robotics - VLA). Also, the coordination or scheduling of multiple robots can also be driven by data (rather than human intuition, heuristics or mathematical models)	
Focus on / Main Points	◦ DDR system engineering: continuous closed-looping learning, with robots gathering and curating data while performing their tasks, potentially sharing the data, and the data is exploited to improve or update the models or policies used by the robots ◦ Sim-to-real: corresponding data from both simulation and the real world can be compared, and the models or simulators learn from the data and updated in order to minimize the gap ◦ Human modeling: Models of human physiology, perception, psychology and behavior ◦ Data-sharing frameworks: both technical research and policy research	
Challenges	◦ Key technical challenges: The key technical challenges or questions for DDR revolve around three main themes: data, learning and modeling/simulation ◦ Non-technical challenge: data-related issues such as privacy, ownership and security, the lack of trust in data-driven robot	
Vision	Near term (0-3 years)	Developing a few pilot DDR systems as part of a larger system engineering effort; establishment of a framework for scalable, replicable, efficient and effective end-to-end data collection, curation and maintenance pipelines; establishment of a framework for DDR system engineering
	Medium term (4-5 years)	Development of a generalizable framework for DDR systems. Developing/refining Robotics Foundation Models for multiple sectors and the capabilities to conduct high-quality data collection and generation.
	Long term (6-10 years)	DDR to flourish at the system level nationally, with national-level sharing of robot experience databases and models

2.8.Multi-Robot Systems (MRS)

Definition	Organized operation of a fleet of robots so that they can cooperatively work together to achieve certain objectives in more cost-effective or/and efficient & robust manners.

	(This area is currently under review to identify availability of good commercial use cases.)	
Focus on / Main Points	◦ Development of autonomous robots working together in swarms to perform tasks such as environmental monitoring, search and rescue, and surveillance ◦ Use of a team of ground-based robots that can work together to carry out tasks in a manner that mimics human collaboration to carry out complex tasks ◦ Developing advanced algorithms and control systems to coordinate the actions of multiple robots in real-time through collaborative mapping of the environment	
Challenges	◦ Key technical challenges: Modelling, dynamics, optimization, sensing & control; planning, path finding, optimization, tasking & decision making; human-multi-robot interaction and multi-manipulation; bioinspiration and warming intelligence; multi-scale applications; deep learning; reinforcement learning, AI in MRS; heterogeneous/homogeneous surface/air/ground/underwater MRS ◦ Other challenges: Large and accessible spaces for these systems to be tested and fine-tuned; regulatory clearance and support	
Vision	Near term (0-3 years)	Single-location, single-domain, heterogeneous MRS operation
	Medium term (4-5 years)	Single-location, multi-domain, heterogenous MRS operation Multi-location, single-domain, heterogeneous MRS operation
	Long term (6-10 years)	Multi-location, multi-domain, heterogeneous MRS operation

IFR International Federation of Robotics

A11 Australia

Title	Australian Governmental Key Actions Related to Robotics	
Region	Australia	
Issued by	The Blueprint and Action Plan for Critical Technologies: Department of Industry, Science and Resources	
Announcement	May 19, 2023, List of Critical Technologies in the National Interest	
Term of validity		
Budget		
Key words	Advanced robotics; Autonomous systems operation technology; Drones, swarming and collaborative robots;	
Related websites	The Blueprint for Critical Technologies	https://www.industry.gov.au/sites/default/files/2022-08/ctpco-blueprint-critical-technology.pdf
	The Action Plan for Critical Technologies	https://www.industry.gov.au/publications/list-critical-technologies-national-interest
Background	◦ November 17, 2021, announcement of the Blueprint and Action Plan for Critical Technologies, which sets out a vision and strategy for protecting and promoting critical technologies in the national interest. The Blueprint for Critical Technologies articulates Australia's strategy for maximizing the opportunities offered by critical technologies as well as managing the risks. The Action Plan for Critical Technologies practically demonstrates Australia's value-add in critical technologies to industry, academia, and international partners. ◦ January 2022, announcement of Robotics and Automation on Earth and in Space Roadmap 2021-2030, which is a key priority area under the Australian Civil Space Strategy 2019-2028. ◦ August 2022, announcement of investing 0.65 billion USD (1 billion AUD) in critical technologies as part of the National Reconstruction Fund to support home-grown innovation and value creation in areas like AI, robotics and quantum. ◦ May 19, 2023, updated list of Critical Technologies in the National Interest. 7 critical technology fields of which one is related to robotics: Autonomous systems, robotics, positioning, timing and sensing. ◦ May 2024, release of Australia's first National Robotics Strategy	
Goal	To develop robots capable of performing complex manual tasks usually performed by humans, including teaming with humans and/or self-assembling to adapt to new or changed environments	

Contents

1. List of Critical Technologies in the National Interest

1.1. Overview of Critical technologies in the national interest: 7 Categories with 37 example technologies

List of 7 Categories:
- Advanced manufacturing and materials technologies
- AI technologies
- Advanced information and communication technologies
- Quantum technologies
- Autonomous systems, robotics, positioning, timing and sensing
- Biotechnologies
- Clean energy generation and storage technologies

Example of technologies related to robotics:
- Advanced robotics
- Autonomous systems operation technology
- Drones, swarming and collaborative robots

- Advanced imaging technology
- Advanced sensor technologies
- Satellite and positioning technologies
- Advanced aerospace technologies, including propulsion, hypersonics and guidance systems

1.2. Key Australian Government Actions

Initiatives	Period	Budget *	Related technologies
National Collaborative Research Infrastructure Strategy:	2018 - 2029	2.6 billion USD (4 billion AUD)	Advanced robotics, Autonomous systems operating technology, Drones, swarming and collaborative robotics
Advancing Space: Australian Civil Space Strategy	2019 - 2028	1.56 billion USD (2.4 billion AUD)	
Next Generation Technologies Fund	2015 - 2026	474.5 million USD (730 million AUD)	
Defense CRC for Trusted Autonomous Systems	2019 – 2025	32.5 million USD (50 million AUD)	
The Medical Research Future Fund	2024/25-2033/34 (3rd 10-year investment)	14.3 billion USD (22 billion AUD) (6.5 billion AUD for 3rd 10-year investment)	

** The budget is for the whole program, not only for robotics*

2. Other Key projects related to robotics in Australia

2.1. Key projects related R&D projects supported by Australian Research Council

Project title	Summary
Robotics & Automation for Plant-based Production of Pharmaceutical Peptides	◦ Application: The aim of the project is to produce peptide-based drugs in plants. This is significant because peptides are viewed as exciting new generation drugs that are potentially safer and more effective than traditional 'small molecule' drugs ◦ Funding: 602,360 USD (904,669.00 AUD) ◦ Period of duration: 2024-2027 ◦ Related scheme: Linkage Projects ◦ Website: https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/LP230200765
Insect-Inspired Flapping Wing Robots: Autonomous Flight Control Systems	◦ Application: This project aims to design a novel control scheme for insect-inspired, flapping-wing, micro aerial vehicles. ◦ Funding: 357,989 USD (537,655.00 AUD) ◦ Period of duration: 2024-2026 ◦ Related scheme: Discovery Projects ◦ Website: https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DP240101140
Advancing Policy Design for Robots in Public Spaces	◦ Application: This project explores how policy design can ensure robots operate safely in public space and protect public interests. It will develop a feasible, flexible, and replicable method for incorporating citizen experience and insights into policy design to manage the growing presence of robots in Australian public spaces. ◦ Funding: 419,508 USD (630,048.00 AUD) ◦ Period of duration: 2024-2026 ◦ Related scheme: Discovery Projects ◦ Website: https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DP240102432

Human Models for Accelerated Robot Learning and Human-Robot Interaction	◦ Application: his project aims to develop novel approaches to teach robots to proficiently interact with humans in a safe and low-cost manner ◦ Funding: 369,802 USD (555,846.00 AUD) ◦ Period of duration: 2024-2026 ◦ Related scheme: Discovery Projects ◦ Website: https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DP240101458
Fast Precision Robust Control of Resonant Flexible Systems	◦ Application: The project aims to produce new control system design tools to enable fast precision control of advanced engineering systems incorporating flexible structures ◦ Funding: 393,571 USD (591,095.00 AUD) ◦ Period of duration: 2023-2026 ◦ Related scheme: Discovery Projects ◦ Website: https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DP230102443

2.2. Key projects related infrastructure projects supported by ARC

Project title	Summary
ARC Research Hub in Intelligent Robotic Systems for Real-Time Asset Management	◦ Application: This hub aims to transform the way assets and infrastructure are managed by developing new capabilities for intelligent robotic systems for inspection, monitoring, and maintenance ◦ Funding: 3.25 million USD (5.0 million AUD) ◦ Period of duration: 2022-2027 ◦ Related scheme: Industrial Transformation Research Hubs ◦ Website: https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/IH210100030
ARC Industry Transformation Research Hub for Resilient and Intelligent Infrastructure Systems (RIIS) in Urban, Resources and Energy Sectors	◦ Application: RIIS will deliver transformational technologies to address Australia's critical infrastructure needs. It will integrate advances in sensor technology, connectivity, data analytics, machine learning, robotics, smart materials, and reliable models. ◦ Funding: 3.237 million USD (4.980 million AUD) ◦ Period of duration: 2022-2027 ◦ Related scheme: Industrial Transformation Research Hubs ◦ Website: https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/IH210100048

Title	**Australia's National Robotics Strategy**
Region	Australia
Issued by	Department of Industry, Science and Resources
Announcement	28 May 2024
Term of validity	
Budget	
Key words	National Capability; Increasing Adoption; Trust, Inclusion, and Responsible Development & Use; Skills & Diversity
Related websites	https://www.industry.gov.au/publications/national-robotics-strategy
Background	◦ In 2018 and 2022, industry peak body Robotics Australia Group released 'Robotics Roadmaps' for Australia. These showed the breadth of expertise in Australia and helped raise the profile of cutting-edge Australian capabilities.

	◦ In December 2022, the minister appointed the National Robotics Strategy Advisory Committee to help guide Australia's strategy for emerging automation technologies. ◦ To develop the National Robotics Strategy, the Australian Government consulted extensively across Australia with industry, academia and the wider community. Guided by the National Robotics Strategy Advisory Committee, the strategy draws on public submissions, workshops and one-on-one interviews. (workshop and public consultation in 2023). ◦ The minister announced the statement and list of Australia's vision and priorities for critical technologies which including robotics on 19 May 2023 ◦ The National Robotics Strategy, the first plan for Australia's robotics ecosystem was released on 28 May 2024. ◦ The Australian government highlighted that it will help to build a stronger, more unified robotics industry and harness the benefits of robotics and automation across Australia. And developing, manufacturing and using these technologies in Australia will: ✓ improve productivity ✓ grow the economy ✓ help revive Australian manufacturing ✓ combat major challenges like climate change, our ageing population, geopolitical risks, labor market pressures and the cost of living.
Goal	Responsibly developing and using robotics and automation technologies to strengthen competitiveness, boost productivity and support local communities.
Contents	

1. Overview of Australia's robotics opportunity

Classify	Contents
Expertise	◦ World leading adoption of robotics and automation in Australian mining. - The Australian mining industry has over 700 autonomous haulage trucks, with more in production. The country's resources sector will continue adopting a range of robotics and automation technologies in the coming decades, to improve worker safety in hazardous underground environments, including: ✓ smaller cooperative autonomous vehicles ✓ smarter sensors to detect and track ore ✓ better use of information to manage and to optimize mining operations ✓ developing skills in systems integration and digital technologies for completely autonomous mines ◦ Besides underground mines, robots are used in assembly lines and in dangerous settings like emergency response operations and field robots in agriculture.
Barriers	◦ Attracting early-stage and long-term capital are barriers because of the upfront expense of robotics and automation hardware. ◦ Australia is also not a large-scale manufacturer of many robotics components, meaning industry and developers need to import from overseas suppliers.
National Interest	◦ In 2023, the Australian Government released the Critical Technologies Statement and updated the List of Critical Technologies in the National Interest. ◦ Critical technologies are important enablers of robotics and automation. Intelligent robots can rely on machine learning algorithms, advanced information and communications technologies such as semiconductors and radiofrequency communications. Robotics and automation technologies are also used in developing other critical technologies.

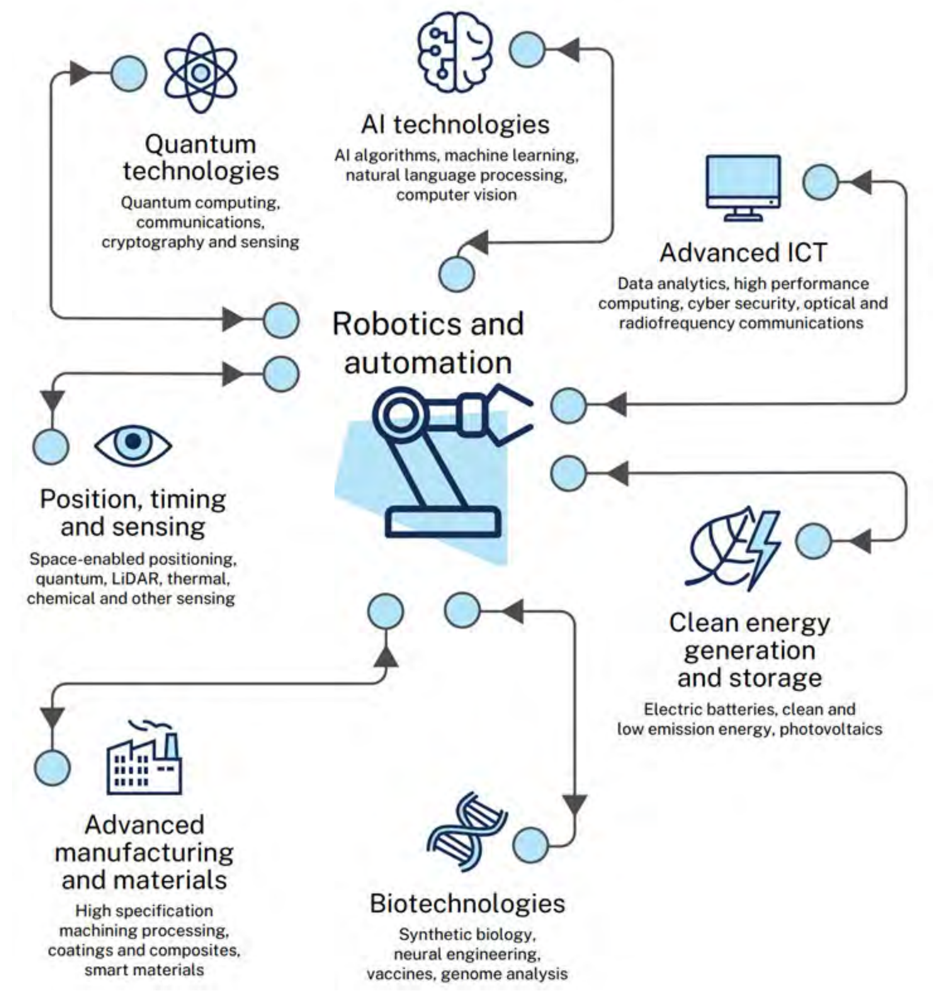


Figure 1. Critical technologies in the national interest
that are enabled by or used in robotics and automation.

National Investment	◦ National Reconstruction Fund: Total 10 billion USD (15 billion AUD) of which 0.65 billion USD (1 billion AUD) for critical technologies including robotics and 0.65 billion USD for additive manufacturing. ◦ Industry Growth Program. ◦ Future Made in Australia.

2. National Vision: The National Robotics Strategy is a national framework to grow Australia's robotics and automation ecosystem and realizes the government's vision**:**

Australian industries are responsibly developing and using robotics and automation technologies to strengthen competitiveness, boost productivity and support local communities

To achieve this vision, the strategy sets out goals and objectives organized around 4 themes that represent areas of focus indicated in the following table:

Theme	1. National Capability	2. Increasing Adoption	3. Trust, Inclusion, and Responsible Development & Use	4. Skills & Diversity
Goals	To have a strong, collaborative robotics & automation ecosystem recognized for its strengths	To integrate robotics and automation technologies into their operations in ways that benefit workers and communities	Robotics and automation technologies designed and adopted are safe to use alongside workers, and are secure and inclusive by design	Australians contribute to and benefit from the development and adoption of robotics and automation
Objectives	◦ To boost research and development, commercialization and scaling up ◦ To use government's purchasing power to grow domestic demand	◦ To raise awareness of robotics and automation technologies ◦ To support and incentivize businesses ◦ To Improve digital and tele-communications infrastructure	To ensure regulatory and legal frameworks enabling and applying to automation technologies are fit for purpose	◦ To strengthen pathways into robotics-related careers ◦ Monitor and plan for workforce changes
Outcomes	Improved access to robotics facilities that encourage collaboration, innovation and commercialisation	Increased adoption of robotics and automation throughout the economy	◦ Trust and ensure robotics and automation technologies, ◦ A deeper understanding of the social impacts of robotics	◦ Improved STEM and digital literacy ◦ Improved diversity and inclusivity in the robotics ecosystem and workplaces ◦ Clear pathways attract talent
Indicators of Success	◦ Improved performance ◦ Growth in the size ◦ Growth in employment	◦ Increased robot density ◦ Growth in the number of new applications and uses for robotics ◦ Increased uptake of Australian-made robotics solutions	◦ Improved performance on measures of regulatory transparency and compliance ◦ Reduced work-related injuries ◦ Increased energy efficiency	◦ Increased number of robotics-related job ◦ Increased enrolments and completions in robotics-related STEM courses and number of robotics-related training and education programs
Supporting Government Initiatives	◦ Future made in Australia ◦ National Reconstruction Fund ◦ Industry growth program	◦ Future made in Australia ◦ National Reconstruction Fund ◦ Industry growth program	◦ Interim government response ◦ 2023–2030 Australian Cyber Security Strategy	◦ Supporting a thriving ◦ Skilled and diverse STEM workforce ◦ TAFE Technology Fund

IFR International Federation of Robotics

E00 EU

Title	**Horizon Europe Work Programme 2023-2025 (7. Digital, Industry and Space)**	
Region	European Union	
Issued by	European Commission	
Announcement	Work Program 2023-2025: 17 April 2024 (Final ver.)	
Term of validity	First call: Work Program 2021-2022 (Horizon Europe: 2021-2027)	
Budget	Robotics-related Work Program 2023-2025: 183.5 million USD (174.0 million EUR)	
Key words	Strategic Research, Innovation and Deployment Agenda (SRIDA), Horizon Europe, Work Program 2023-2025, Cluster 4: Digital, industry and space	
Related website	Strategic Research, Innovation and Deployment Agenda (SRIDA)	https://bdva.eu/wpfd_file/strategic-research-innovation-and-deployment-agenda-srida-for-the-ai-data-and-robotics-partnership/
	Horizon Europe	https://ec.europa.eu/info/horizon-europe_en
	Cluster 4: Digital, industry and space	https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/cluster-4-digital-industry-and-space_en#policy-and-strategy
	Horizon Europe Work Program	https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/how-to-participate/reference-documents;programCode=HORIZON
Background	◦ Horizon Europe is the 9th European Framework Program for research and innovation running from 2021-2027. ◦ The budget for Horizon Europe is set at 100.73 billion USD (95.5 billion EUR). ◦ The first Horizon Europe Strategic Plan (2021-2024) which sets out key strategic orientations for the support of research and innovation, was adopted on 15 March 2021. ◦ The robotics-related work programs have been drafted by the commission and the final version was announced on 17 April 2024.	
Goal	◦ To accelerate the twin green and digital transition of the manufacturing and construction sectors ◦ To create a new green, flexible and digital way to build and produce goods by digitization, AI, data sharing, advanced robotics and modularity ◦ To make the jobs of the humans working in the manufacturing and construction sectors more attractive and safer, and point the way to opportunities for upskilling	
The latest R&D project	Horizon Europe Work Program 2023-2025: Digital, Industry and Space (17 April 2024 - Final ver.)	
The key targets of the latest R&D project	◦ AI enhanced robotics systems for smart manufacturing ◦ AI, DATA and Robotics for the Green DEAL ◦ AI, DATA and Robotics at work ◦ Pushing the limit of robotics cognition ◦ European Network of Excellence Centres in Robotics ◦ AI, Data and Robotics for Industry optimization ◦ Increased robotics capabilities demonstrated in key sectors ◦ European coordination, awareness, standardization & adoption of trustworthy European AI, Data and Robotics	
Contents		

1. Strategic Research, Innovation and Deployment Agenda (SRIDA)

◦ SRIDA is the EU's new Public Private Partnership (PPP) to strengthen the AI, Data and Robotics infrastructure and ecosystem. This is built on the work of the five organisations:
- European Robotics Association (euRobotics)
- Big Data Value Association (BDVA)
- Confederation of Laboratories of Artificial Intelligence in Europe (CLAIRE)
- European Laboratory for Learning and Intelligent Systems (ELLIS)
- European Association for Artificial Intelligence (EurAI)

◦ The implementation of the Partnership will target both the Digital Europe Programme to build up AI capacity & infrastructure and Horizon Europe for research & innovation. The Partnership will be based on five strategic Investment Areas (IA):
- Mobilising the European AI, Data and Robotics Ecosystem
- Skills and Acceptance
- Innovation and Market Enablers
- Guiding Standards and Regulation
- Promoting Research Excellence

◦ The robotics-related 11 partnerships have been initially identified and will be prioritised in identifying synergies, aligning roadmaps, and defining specific collaboration actions.
- Innovative Health
- Health and Care Systems Transformation
- High Performance Computing
- Key Digital Technologies
- Photonics
- Made in Europe
- Processes4Planet - Transforming the European Process Industry for a sustainable society
- Globally competitive Space Systems
- Transforming Europe's Rail Systems
- Connected, cooperative and Automated Mobility (CCAM)
- EIT Digital-KIC

** Reference : SRIDA: AI, Data and Robotics Partnership, https://svrobo.org/svr-reports-publications/*

2. Horizon Europe

◦ Horizon Europe is the EU's key research and innovation framework program with a budget of 94.30 billion USD (95.5 billion EUR) for seven years (2021-2027).
- to strengthen the EU's scientific and technological bases
- to boost Europe's innovation capacity, competitiveness, and jobs
- to deliver on citizens' priorities and sustain socio-economic model and values

◦ This first Horizon Europe strategic plan defines the strategic orientations for EU's research and innovation investments over the period 2021-2024.

◦ Horizon Europe program structure

Specific Program Implementing Horizon Europe & EIT (Exclusive focus on civil applications)		
Pillar I: Excellent Science	Pillar II: Global Challenges & European Industrial Competitiveness	Pillar III: Innovative Europe
◦ European Research Council ◦ Marie Skłodowska-Curie ◦ Research Infrastructures	◦ Clusters - Health - Culture, Creativity & Inclusive Society - Civil Security for Society	◦ European Innovation Council ◦ European Innovation Ecosystems

	- Digital, Industry & Space - Climate, Energy & Mobility - Food, Bioeconomy, Natural Resources, Agriculture & Environment - Non-nuclear direct actions of the Joint Research Centre	◦ European Institute of Innovation & Technology
Part: Widening Participation and Strengthening the European Research Area ◦ Widening participation & spreading excellence ◦ Reforming & Enhancing the European R&I system		

◦ Horizon Europe Pillar II: Robotics-related Program is embedded in the Pillar II.

CLUSTER 1: Health	CLUSTER 4:Digital, Industry & Space	CLUSTER 5: Climate, Energy & Mobility	CLUSTER 6: Food, Bioeconomy, Agriculture, …
◦ Innovative Health Initiative ◦ Global Health Partnership ◦ Transformation of health systems ◦ Chemicals risk assessment ◦ ERA for Health ◦ Rare diseases ◦ One-Health Anti Microbial Resistance ◦ Personalized Medicine ◦ Pandemic Preparedness	◦ Key Digital Technologies ◦ Smart Networks & Services ◦ High Performance Computing ◦ European Metrology ◦ **AI-Data-Robotics** ◦ Photonics ◦ Made in Europe ◦ Clean steel – low-carbon steelmaking ◦ Processes4Planet ◦ Global competitive space systems	◦ Clean Hydrogen ◦ Clean Aviation ◦ Single European Sky ATM Research 3 ◦ Europe's Rail ◦ Connected and Automated Mobility ◦ Batteries ◦ Zero-emission waterborne transport ◦ Zero-emission road transport ◦ Built4People ◦ Clean Energy Transition	◦ Circular Bio-based Europe ◦ Rescuing Biodiversity to Safeguard Life on Earth ◦ Climate Neutral, Sustainable & Productive Blue Economy ◦ Water4All ◦ Animal Health & Welfare ◦ Accelerating Farming Systems Transitions ◦ Agriculture of Data

3. Work Program 2023-2025: Cluster 4. Digital, Industry and Space

◦ The robotics-related work programs have been drafted by the commission and the final version was announced on 17 April 2024.

3.1. HORIZON-CL4-2023-DIGITAL-EMERGING-01-01: Novel paradigms and approaches, towards AI-driven autonomous robots (RIA)

◦ **Scope:**
- Development of robust and safe autonomy, including the development of risk averse systems or systems operating with low levels of communication or periods of communication denial.
- Mechanisms for advanced human interaction with systems capable of long-term autonomy.
- The development of collective autonomy using multiple collaborative robots
- The use of high-level sources of information such as semantic information or externally held knowledge of the working environment, to improve autonomy.

◦ **Expected Outcomes:**
- Interact safely and smoothly to support humans in their daily activities, based on a strong multidisciplinary approach, including the relevant Social Science and Humanities (SSH) dimension.
- Handle tasks autonomously, and safely, for a long period of time significantly beyond the current state of the art in each sector and service addressed.
- Address human and work interaction in high impact sectors under realistic conditions.

◦ **Specific conditions:**

Specific conditions	Features

Indicative budget	◦ The total indicative budget for the topic is 31.63 million USD (30 million EUR).
Type of Action	◦ Research and Innovation Actions.
Technology Readiness Level	Activities are expected to start at TRL 2-3 and achieve TRL 4-5 by the end of the project.

3.2. HORIZON-CL4-2023-DIGITAL-EMERGING-01-02: Industrial leadership in AI, Data and Robotics – advanced human robot interaction (IA)

◦ **Scope:**
- Development of innovative solutions to address major application-driven challenges, involving a large set of SMEs/ midcaps developing innovative solutions in order to boost the innovator community in Europe.
- Deployment of software engineering dedicated to human robot interaction

◦ **Expected Outcomes:**
- To reach the point where human robot interaction, extended in time and scope beyond the current state of the art, adds value and improves the quality of outcome for complex tasks; for example service tasks, or complex industry processing tasks or tasks in a healthcare setting.
- To validate AI, Data and Robotics at scale by demonstrating the potential of integrating these technologies to address challenges in key industries and develop solutions that address human robot interaction at all levels from physical interaction to social interaction in a variety of working environments.
- To make and exploit major advances in technology, to maintain Europe's excellence and ensure sovereignty of these key technologies expected to affect society by contributing to addressing major societal challenges by enhancing interactions between robots and people.

◦ **Specific conditions:**

Specific conditions	Features
Indicative budget	◦ The total indicative budget for the topic is 31.63 million USD (30.00 million EUR).
Type of Action	◦ Innovation Actions
Technology Readiness Level	◦ Activities are expected to start at TRL 3-5 and achieve TRL 6-7 by the end of the project

3.3. HORIZON-CL4-2024-DIGITAL-EMERGING-01-03: Novel paradigms and approaches, towards AI-powered robots– step change in functionality (RIA)

◦ **Scope:**
- Significant enhancement of navigation capabilities in order to enhance mobility (underwater, on the ground, in the air, in the body, in areas difficult to reach, on rough terrain, in unpredictable environments, in areas including people or other moving agents, etc.), particularly in highly dynamic and complex environments.

◦ **Expected Outcomes:**
- The robot systems operating in harsh complex and dynamic working environments can carry out sequences of complex functions to achieve a functional goal.
- In navigation to reliably and purposefully move between destinations within complex people centric environments that are occupied such as busy transport hubs, shopping malls or entertainment and sporting venues.
- In manipulation to reach human speed with equivalent dexterity, or manipulate objects beyond human capability, such as very small objects, or very precise manipulation tasks, or very big objects.

◦ **Specific conditions:**

Specific conditions	Features
Indicative budget	◦ The total indicative budget for the topic is 31.63 million USD (30.00 million EUR).
Type of Action	◦ Research and Innovation Actions.
Technology Readiness Level	◦ Activities are expected to start at TRL 2-3 and achieve TRL 4-5 by the end of the project.

3.4. HORIZON-CL4-2024-DIGITAL-EMERGING-01-04: Industrial leadership in AI, Data and Robotics boosting competitiveness and the green transition (IA)

◦ **Scope:**
- The added value of integrating either AI and Data, or AI, Data and Robotics technologies through large-scale validation scenarios reaching critical mass and mobilizing the user industry, while demonstrating high potential impact contributing to the European Green Deal objectives.
- Sectors and application domains with wide-scale deployment potential and maximum contribution to the green deal.

◦ **Expected Outcomes:**
- The creation of systems to address large scale challenges using combined robotics data and AI solutions that have significant impact on the objectives of the green deal. For example; in improving domestic energy consumption or in the cleaning up of contaminated land and waterways.

◦ **Specific conditions:**

Specific conditions	Features
Indicative budget	◦ The total indicative budget for the topic is 63.26 million USD (60 million EUR).
Type of Action	◦ Innovation Actions.
Technology Readiness Level	◦ Activities are expected to start at TRL 3-5 and achieve TRL 6-7 by the end of the project.

3.5. HORIZON-CL4-2023-HUMAN-01-02: Large Scale pilots on trustworthy AI data and robotics addressing key societal challenges (IA)

◦ **Scope:**
- Contributions for making AI and robotics solutions meet the requirements of Trustworthy AI, based on the respect of the ethical principles, the fundamental rights including critical aspects.
- Involvement of end-users in the requirement and validation of the pilots to ensure human-centric approach and maximize acceptance.

◦ **Expected Outcomes:**
- Strengthening EU's ecosystem of AI, Data and Robotics excellence and innovation in world class foundational and application-inspired and application-oriented research.
- Technology progress in AI addressing major challenges hampering the deployment of AI, Data and Robotics technologies.
- Robust and trustworthy AI, Data and Robotics technologies.

◦ **Specific conditions:**

Specific conditions	Features
Indicative budget	◦ The total indicative budget for the topic is 25.30 million USD (24 million EUR).
Type of Action	◦ Innovation Actions
Technology Readiness Level	◦ Activities are expected to start at TRL 3-5 and achieve TRL 6-7 by the end of the project.

Title	**Commercial Applications of Space-Enabled Robotics**	
Region	European Union	
Issued by	The European Space Agency	
Announcement	Commercial Applications of Space-Enabled Robotics: 03 March 2024	
Term of validity	First call: Commercial Applications of Space-Enabled Robotics 2024 (From ESA Business Applications)	
Budget	Feasibility studies: Max 0.53 million USD (0.5 million EUR) Demonstration projects: No max amount (Depending of wishes of the delegation)	
Key words	ESA Business Applications, ESA Space Solutions, Commercial Applications of Space-Enabled Robotics	
Related website	ESA Business Applications	https://business.esa.int/funding
	Commercial Applications of Space-Enabled Robotics	https://business.esa.int/funding/call-for-proposals-non-competitive/commercial-applications-space-enabled-robotics
Background	◦ ESA Business Applications offers funding to any proposals which intend to use space (satellite navigation, earth observation, satellite telecommunication, space weather, space technologies) to develop new commercial services. ◦ Commercial Applications of Space-Enabled Robotics is the robotics-related work programs that were funded by ESA Business Applications were announced on 03 March 2024.	
Goal	◦ To integrate satellite technologies with robotics for the benefit of our life. ◦ To expand the application of space technology in new markets and user communities.	
The latest R&D project	Commercial Applications of Space-Enabled Robotics: 03 March 2024	
The key targets of the latest R&D project	Satellite technologies and robotics for ◦ Maritime and Marine ◦ Health and Safety ◦ Energy and Utilities ◦ Transport and Logistics ◦ Smart Cities and Infrastructure ◦ Agriculture	

Contents

1. Commercial Applications of Space-Enabled Robotics

◦ The European Space Agency (ESA) offers funding and support to feasibility studies and demonstration projects for commercial applications that integrate satellite technologies with autonomous robotic system. This funding call consists of below six sub-themes:

1) Smart Cities and Infrastructure:
Support for the construction and maintenance of physical infrastructure, smart city solutions such as waste collection, street cleaning, delivery services, entertainment, and tourism services.

2) Energy and Utilities:
Autonomous infrastructure inspection and maintenance, environmental monitoring, remote installation and energy infrastructure operations

3) Transportation and Logistics:
Autonomous vehicles and precursor services, logistics automation solutions

4) Health and Safety:
Drone and robotics-based delivery of supplies, robotic guides for the visually impaired, search and rescue and disaster response

5) Maritime:

Autonomous surveys and mapping, maintenance of sea-based infrastructure and vessels, port operations automation and security, aquaculture farming, coastal monitoring

6) Agriculture:

Precision farming, Autonomous harvesting, Crop cultivation monitoring and optimization.

◦ Authorization of funding

	Feasibility Study	Demonstration Project
Activity Cost	Max. 530k USD (500k EUR) (Limited to acceptable cost)	Case by Case Assessment (Limited to acceptable cost)
ESA Co-Funding		
Baseline	Max. 50% of Company's cost	Max. 50% of Company's cost
Micro, Small and Medium-Enterprises	Max. 80% of Enterprise's cost	Max. 80% of Enterprise's cost
Universities and Research Institutes with no commercial interest in the product/service	Max. 100% of institute's cost and Max. 30% of activity cost	Max. 80% of institute's cost and Max. 30% of activity cost
Industry Co-Funding	Remaining part of the cost to carry out the activity	

**Reference : Commercial Applications of Space-Enabled Robotics, The European Space Agency, https://business.esa.int/funding/call-for-proposals-non-competitive/commercial-applications-space-enabled-robotics*

E01 Germany

Title	Together through Innovation	
Region	Germany	
Issued by	Federal Ministry of Education and Research	
Announcement	December 07, 2020	
Term of validity	2021-2026	
Budget	Total 369.19 million USD (350 million EUR)	
Key words	High-Tech Strategy 2025, Shaping technology for the people, Together through Innovation	
Related website	High-Tech Strategy 2025	https://www.hightech-strategie.de/en/index.html
	Together through Innovation	https://www.interaktive-technologien.de/
Background	◦ The first High-Tech Strategy (HTS) was launched in 2006 by the German go vernment as a comprehensive national strategy that defines the objectives a nd milestones of the Federal Government's research and innovation (R&I) po licy. ◦ With this strategy, the German High-Tech Strategy 2025 is the fourth edition and was adopted in September 2018. It has set itself the target of investing 3 .5 percent of GDP per annum in R&D by 2025. ◦ As part of the HTS 2025 missions, the ‘Shaping technology for the people’ w as launched. The mission of ‘Shaping technology for the people’ aims to use technological change for the benefit of society as a whole and in the world o f work.	
Goal	◦ To promote innovative research and development projects in human-technology interaction, which strengthen the independence and well-being of those in need of care, relieve nurses and care.	

Contents

1. Shaping technology for the people

- The High-Tech Strategy (HTS) 2025 set the mid-term strategic orientation for German R&D and innovation activity. And as part of the HTS 2025 missions, the ‘Shaping technology for the people’ was launched.
- The mission “Shaping technology for the People” aims to use technological change in society as a whole and in the world of work for the benefit of people.
- Research topic: Digital assistance systems such as data glasses, human–robot collaboration, exoskeletons to support employees in their physical work, but also solutions for the more flexible organization of work processes or the support of mobile work.

1.1. Program line of the mission ‘Shaping technology for the people’

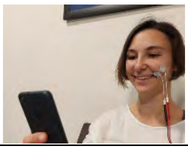
- Safety and health in the digital world of work: safety and health in the digitalized world of work
- Future of Work - Innovations for Tomorrow's Work, in particular through the establishment of ‘Regional Competence Centers for Labor Research’
- Together through Innovation: Interactive technologies (digital applications and platforms for assistance systems using virtual reality and mixed reality as well as AI) for health and quality of life
- Startups: Innovative startups for human-technology interaction: to support startups and spin-off activities in science
- Rural development program: Research projects on the opportunities, risks and effects of digitization in rural areas

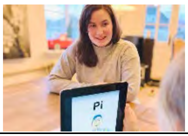
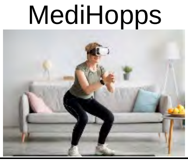
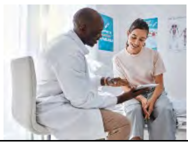
2. Together through Innovation (Miteinander durch Innovation)

- As part of the HTS 2025 mission 'Shaping technology for the people', the research program 'Together through Innovation' was launched in 2020.
- With the research program 'Together through Innovation', the Federal Ministry of Education and Research (BMBF) will provide around 69.12 million USD (70 million EUR) annually until 2026.
- Focus of the funding program
  - Healthcare and nursing care with researches on interactive technologies
- Program period: 2021-2026
- Related website: https://www.dlr.de/rm/desktopdefault.aspx/tabid-8432/

2.1. Robotics related project notice 1: SME innovative

- Since 2009, the BMBF has offered small and medium-sized enterprises (SEMs) the opportunity to submit project ideas for funding R&D projects twice a year.
- The current projects are thematically related to the research field of 'Digitally supported health and care' of the research program 'Together through innovation: Research program Interactive technologies for health and quality of life'.
- Related Website: https://www.interaktive-technologien.de/foerderung/bekanntmachungen/kmu-innovativ
- Robotics-related projects

Project title	Summary
MULTIPARTIES 	◦ Application: Enabling natural conversations in digital space ◦ Funding: 3.50 million USD (3.32 million EUR) ◦ Period of duration: 09/2022 - 02/2025
BIGEKO 	◦ Application: Barrier-free communication for the deaf. ◦ Funding: 2.77 million USD (2.63 million EUR) ◦ Period of duration: 03/2023 - 02/2026
SEPE 	◦ Application: Designing and implementing an interactive platform that speci alists and patients can use to collect medical data ◦ Funding: 2.09 million USD (1.98 million EUR) ◦ Period of duration: 09/2024 - 08/2027
DigiEat 	◦ Application: Developing personalized therapy modules that address the se nse of smell and synchronizes the eating scenarios with scent exposure sy stems ◦ Funding: 2.01 million USD (1.91 million EUR) ◦ Period of duration: 08/2024 - 07/2027
SISOPS 	◦ Application: Contactless interaction in the sterile area of operating rooms ◦ Funding: 1.99 million USD (1.89 million EUR) ◦ Period of duration: 01/2024 - 12/2026
FACErehab 	◦ Application: Treating facial nerve paralysis with biofeedback app ◦ Funding: 1.92 million USD (1.82 million EUR) ◦ Period of duration: 12/2023 - 12/2026
FRIENDS	◦ Application: Voice assistant to support people with mental illnesses. ◦ Funding: 1.91 million USD (1.81 million EUR) ◦ Period of duration: 03/2023 - 02/2026

	
LAOLA 	◦ Application: Interactive voice therapy with AI support ◦ Funding: 1.90 million USD (1.80 million EUR) ◦ Period of duration: 08/2022 - 07/2025
UNISON 	◦ Application: Recognizing heart failure by the voice ◦ Funding: 1.65 million USD (1.56 million EUR) ◦ Period of duration: 08/2022 - 07/2025
MSPEECHT 	◦ Application: Voice-based monitoring of multiple sclerosis ◦ Funding: 1.62 million USD (1.54 million EUR) ◦ Period of duration: 01/2024 - 12/2026
NoFreeze 	◦ Application: Researching and developing a system that detects Parkinson's-related freezing in real time by continuously analyzing the gait of the affected person ◦ Funding: 1.62 million USD (1.54 million EUR) ◦ Period of duration: 03/2023 - 02/2026
TactonomDuo 	◦ Application: Developing a mobile tool that makes it easier for blind and severely visually impaired people to access texts and graphic content of all kinds independently ◦ Funding: 1.57 million USD (1.49 million EUR) ◦ Period of duration: 08/2024 - 07/2027
MediHopps 	◦ Application: Supervised rehabilitation sports in virtual spaces ◦ Funding: 1.46 million USD (1.38 million EUR) ◦ Period of duration: 08/2022 - 07/2025
VERO 	◦ Application: Use AI to check health information available online ◦ Funding: 1.28 million USD (1.21 million EUR) ◦ Period of duration: 08/2024 - 07/2027
LLM4Anamnesis 	◦ Application: Automatically classify medical history texts using Large Language Models. ◦ Funding: 1.08 million USD (1.02 million EUR) ◦ Period of duration: 08/2024 - 07/2027
BIQ Screen 	◦ Application: Detect coronary heart disease quickly and easily ◦ Funding: 1.08 million USD (1.02million EUR) ◦ Period of duration: 02/2022 - 01/2025

2.2. Robot for assistance functions: interaction in practice (RA3)

◦ The funding is provided for the planning, construction and operation of competence centers for interactive robot assistants, which test existing robot assistants in practical non-industrial application.

- The focus of the projects is to holistically research the interaction between humans and robots or robotic systems and improve them with the knowledge gained.
- Related website: https://www.interaktive-technologien.de/foerderung/bekanntmachungen/ra3
- Robotics-related projects

Project title	Summary
Rokit 	◦ Application: Developing new design approaches and expanding existing te sting and inspection procedures for making many tasks in public spaces. ◦ Funding: 5.31 million USD (5.03 million EUR) ◦ Period of duration: 10/2022 - 10/2025
RuhrBots-RA3P2 	◦ Application: Testing and designing interactive assistance robotics in citizen -oriented application scenarios in city administration. ◦ Funding: 4.49 million USD (4.26 million EUR) ◦ Period of duration: 10/2022 - 09/2025
ZEN MRI 	◦ Application: Researching how robots can be integrated into public life in th e most beneficial way possible. ◦ Funding: 3.76 million USD (3.56 million EUR) ◦ Period of duration: 09/2022 - 08/2025
RimA 	◦ Application: Create the technological and economic basis for innovative ro botic components, services and applications for new robotic solutions in ev eryday life ◦ Funding: 2.82 million USD (2.67 million EUR) ◦ Period of duration: 08/2021 - 04/2025

2.3. START-interactive : Interactive technologies for health and quality of life

- The BMBF offers opportunities to the innovative start-up teams in cutting-edge research into interactive technologies for health and quality of life, and two funding modules are provided to the teams.
- Module 1 supports universities or research institutions to increase the maturity of the research content achieved and its potential for exploitation, and Module 2 is for young start-ups that have already been founded in research and development.
- Related website: https://www.interaktive-technologien.de/foerderung/bekanntmachungen/start-interaktiv
- Robotics-related projects

Project title	Summary
ARGUS 	◦ Application: Researching and developing a smart digital agent that enables blind people to shop for groceries just as easily as sighted people ◦ Funding: 1.93 million USD (1.83 million EUR) ◦ Period of duration: 08/2022 - 07/2025
SensEm 	◦ Application: Developing a digital citizen science toolkit that interactively supports people without scientific training in developing scientific questions for measuring environmental factors, designing, carrying out and evaluating measurements ◦ Funding: 1.16 million USD (1.1 million EUR) ◦ Period of duration: 03/2023 - 02/2025

E02 Italy

Title	Governmental Robotics R&D Programs	
Region	Italy	
Issued by	National Research Program 2021-2027	Ministry of University and Research
	Governmental Robotics R&D Programs	Summarized by Prof. Giuseppe Quaglia of the Polytechnic University of Turin (Politecnico di Torino)
Announcement	December 15, 2020	
Term of validity	2021-2027	
Budget		
Keywords	Robotics, National Research Program 2021-2027, Innova per l'Italia, Competence centers, MISE innovation projects, Robotics Olympics 2020	
Related website	National Research Program 2021-2027	https://www.mur.gov.it/sites/default/files/2021-01/Pnr2021-27.pdf https://www.mur.gov.it/sites/default/files/2021-08/4.AllegatoEsteso_Digitale.pdf
	National Recovery and Resilience Plan	https://www.italiadomani.gov.it/content/sogei-ng/it/en/home.html
	Artes 4.0	https://www.artes4.it/
	The AI Data Robotics Association (Adra)	https://adr-association.eu/projects
Background	◦ The National Research Programme (PNR), provided for by Legislative Decree 204/1998, is the document that guides research policies in Italy, to the realization of which the State administrations contribute with the coordination of the Ministry of University and Research. ◦ On 15 December 2020, the National Programme for Research 2021-2027 was approved and was extended through a public consultation, to public and private stakeholders and interests and to civil society. ◦ There are six major areas of research and innovation reflect the six clusters of Horizon Europe, the European Framework Programme for Research and Innovation 2021-2027 ◦ Robotics is included in the 4. Extended Annex "Digital, Industry, Aerospace" (page 94 ~ 123)	
Goal	◦ To allow maintaining a close relationship of the productive social fabric with the tools and environments of production, but also with the infrastructures for mobility and communications ◦ To maintain the operation of healthcare facilities ◦ To guarantee safety and reduce the natural risks associated with critical infrastructures ◦ To improve the inclusiveness of workstations and the quality of workers' life ◦ To reduce polluting emissions through the reduction of commuting thanks to the extension of smart working to professions involving physical labor	

Contents

1. Robotics in the National Research Program (PNR) 2021-2027

The PNR identifies robotics as a key technology for the present and the immediate future worth of investments to create the basis for technological leadership in a field that has enormous potential not only economically, but more generally socially. The critical areas of interest are no longer only industrial robots, but there is a growing interest and value in collaborative robotics and service robotics and their application fields, namely agriculture, logistics, healthcare, security, and utility. In this sense, PNR identifies six macro-areas (Articulation - ART) to be prioritized:

1.1 **Six macro-areas to be prioritized** for the entire supply chain, from fundamental research to application; 1. Robotics in a hostile environment, 2. Robotics for Industry 4.0, 3. Robotics for the inspection and maintenance of infrastructures, 4. Robotics for the sector agri-food, 5. Robotics for health, 6. Robotics for mobility and autonomous vehicles.

Priority areas	Background, Feature	Application
1.Robotics in a hostile environment	◦ The urgent need to be able to carry out work safely due to the CoViD-19 ◦ The need to physically separate the robot operator from the place where the robot is located at operation	◦ Activities in difficult environments to access like space or the bottom of the oceans ◦ Activities dangerous to humans like handling of toxic and nuclear waste or coping with epidemics (COVID-19) and natural and man-made disasters
2. Robotics for Industry 4.0	◦ Robots are preferred in flexible automation systems, where production must be able to change as market needs ◦ Repetitive operations in which the robot is now irreplaceable: loading, unloading, welding, painting, all tasks (increasing factory productivity, decreasing cycle times and relieving man) ◦ The sales figures for industrial robots in Italy: 9,800 units were sold in 2018, with a growth of 27% compared to the previous year (source SIRI). ◦ The Italian robotics market is the seventh worldwide and the second in Europe, behind the Germany ◦ Alongside traditional industrial manipulators, mobile robots are of increasing importance in industrial logistics.	◦ Robots in aerospace sector (drilling, riveting, positioning of pieces): the needs of very high precision and reliability pose interesting research challenges ◦ Robots in smart factory: a cyber-physical system inextricably linked to its digital representation, used for predictive maintenance, production monitoring and performance optimization ◦ Robots in digitize factories of Industry 4.0: as interconnected, highly digitized tools, equipped with their digital twins, capable of improving their performance and self-learning on the basis of analysis of the data collected in the production systems (artificial intelligence will increasingly have to combine with industrial robotics) ◦ Collaborative robotics: ✓ strong growth in the coming years ✓ counteracting the aging phenomenon of specialized professionals, new life to craftsmanship ✓ the aspects of safety, ergonomics and assistance to the operator in limiting exposure to risk on the equipment musculoskeletal are still only partially explored by research
3. Robotics for the inspection and maintenance of infrastructures	◦ Innovative robotic solutions for the inspection processes of tanks, exchangers, refining towers, turbines, offshore platforms, pipe-racks, subsea and surface ducts are today among the main targets of research and development centers of large companies	◦ Robotic solutions connected to the soft robotics ◦ Robotic solutions capable of carrying out surveys and inspections of civil works in an objective, repeatable and certified ◦ Robotic solutions allowing to implement continuous monitoring of critical infrastructures and integration with IoT distributed sensors for the long term
4. Robotics for the agro-food sector	◦ Increasing human population and need for agro-food products, the climate change, the fight against plant diseases, high labor costs and energy, as well as the increased demand for zero km products, are challenges	◦ Robotic solutions including robotic systems capable of carrying out dexterous and soft manipulations as well as locomotions in the different nature as required in the cultivation, harvesting and transport of agri-food products ◦ Robotics for the phase of cultivation, storage and conservation,

	◦ Undergoing a significant transformation in terms of automation and connectivity in the sense of Industry 4.0 and IoT	transformation, transport and sale ◦ Robotics for innovation of the agri-food manufacturing industry by offering solutions for the integration of workers (cobots and exoskeletons)
5. Robotics for health	◦ With reference to the prevention-diagnosis-treatment-convalescence path, robotic technologies can make a significant contribution, both to improving the quality of care, and to saving public health	◦ Prevention: telepresence devices, which can also be used in hospitals, to allow communication at distance, psychological support to patients, and to assist them without requiring direct staff intervention doctor ◦ Diagnosis: introducing systems, both local and remote, to carry out one more accurate and more extensive screening of patients, for example robotic biopsies and satellite centers for tele-ultrasound ◦ Robotic surgery systems (treatment): solutions must be sought which, while maintaining the quality of the robotic intervention, can drastically reduce the cost ◦ Observing medical prescriptions at home(convalescence): telepresence systems, specialized for this function, could ensure that the patient follows the prescriptions correctly
6. Robotics for mobility and autonomous vehicles	◦ The future model of personal mobility will be epitomized by the "robo-taxi": a fully autonomous vehicle that can be summoned, utilized, and released on-demand, following a specific route, in a service-based usage model akin to traditional public transportation. ◦ Recent analyses based on telematics data have shown that the contemporaneity of use of the current fleet of vehicles in circulation by Italians does not exceed 10% during peak hours on weekdays. ◦ This revolutionary shift towards full vehicle automation will be gradual yet swift, anticipated to be realized within 20–30 years.	◦ Vehicles for the mobility of people on the road: Primarily cars, but also includes buses and minibuses. ◦ Vehicles for the mobility of goods on the road: Encompasses trucks and commercial vehicles. ◦ Off-highway vehicles: Primarily refers to agricultural vehicles (specifically, in Italy, small tractors for intensive agriculture in vineyards, orchards, etc.), but also includes construction machinery and earth-moving equipment. ◦ Vehicles without onboard personnel (unmanned) or "terrestrial drones": Adaptable for goods mobility applications (such as last-mile delivery in urban and metropolitan centers) or for agricultural use (in which case, vehicles will be equipped and integrated with manipulative robotics systems to perform processing operations).

PNR 2021-2027 proposes three specific initiatives, which are considered of high priority, with a systemic approach, broad and open to desirable synergies with other areas:

- Strategic Framework Programme (Programma Quadro Strategico - PQS): Robotics for society is to accelerate the transition towards an increasingly productive, sustainable, responsible, safe, resilient, equitable and inclusive society through the promotion and deployment of the enabling technologies mentioned above for the following development pillars:
- National Robotics Community should be founded on the model of the National Institute of Nuclear Physics. The institute will be configured as a public research body supervised by the Ministry of Universities and Research and will harmonize with the current network of universities and

research centres.

- National PhD program with industrial vocation in Robotics and Intelligent Machines has to be established. The new National Doctorate (https://drim.i-rim.it/en/) characterized by an interdisciplinary and international outlook and a strong industrial vocation for the advanced training of the country's talented young people in Robotics.

1.2. **Enabling Technologies** that research must focus on to achieve results in these priority areas include:

- Intuitiveness and usability of human-robot interfaces, which enable the effective use of robots by people without specific training;
- The integration of natural and artificial intelligence and perception, which allows operators to make use of the increased capacities of the machines without being expropriated of their own indispensable cognitive and operational skills;
- The ability of robots to physically interact with the environment and with surrounding people with stability and safety;
- The creation of physical tools for right handling and locomotion in airborne, aquatic environments, and on soils of a different and uneven nature;
- Energy autonomy and resilience to imperfect communications in realistically situations encountered in field applications.

The development of these technologies will strengthen / simplify people's work (hostile environments, industrial and civil environments, medicine, agri-food) and / or save / increase the jobs that would be lost (artisans, new production companies, with robots and intelligent machines in Italy instead of abroad). The impact on the world of work will be immediate and positive, not only because great technological innovations have always increased jobs, but by virtue of the fact that robotics makes it possible to increase productivity and make economic activities on national soil that would otherwise remain delocalized.

2. National Recovery and Resilience Plan

The National Recovery and Resilience Plan (Piano Nazionale di Ripresa e Resilienza - PNRR) (https://www.italiadomani.gov.it/content/sogei-ng/it/en/home.html) is part of the NextGenerationEU programme, an 819 billion USD (750 billion EUR) recovery package agreed by the European Union in response to the CoViD-19 pandemic. Italy's Plan includes investments worth 209 billion USD (191.5 billion EUR), financed through the Recovery and Resilience Facility.

The PNRR is divided into seven missions and has three overarching objectives. The first is short-term in character and focuses on repairing the economic and social damage caused by the pandemic emergency. Second, from a medium/long-term perspective, the Plan addresses several weaknesses that have been weighing on Italy's economy and society for decades, including long-standing geographical divides, gender inequality, low productivity growth, and a low rate of capital investment. Finally, the Plan's resources will be directed towards promoting a thorough ecological transition.

The PNRR is structured into these seven missions:

- Digitalization, innovation, competitiveness, culture, and tourism
- Green revolution and ecological transition
- Infrastructure for sustainable mobility
- Education and research
- Inclusion and cohesion
- Health
- RePowerEU

These main thematic areas for intervention were identified in full coherence with the 6 pillars of the Next Generation EU. The missions are divided into components, intervention areas that address specific challenges, further composed of investments and reforms.

While none of the investments is explicitly dedicated to robotics, it is possible to find many investment areas where it is possible to apply robotics due to its multidisciplinary nature and being at the centre of the processes of innovation. As an example, robotics could be applied to the following investment topics.

Main investment	Goal	Funding
Digitalised hospitals and new beds	Upgrading hospital technological facilities, raising the digitalisation level of 280 level 1 and 2 healthcare facilities in the headquarters of the Emergency and Acceptance Departments (DEA), structural strengthening of the hospitals of the NHS through the adoption of a specific plan aimed at enhancing the existing facilities. Website: https://www.italiadomani.gov.it/content/sogei-ng/it/en/Interventi/investimenti/ammodernamento-del-parco-tecnologico-e-digitale-ospedaliero.html	4.42 billion USD (4.05 billion EUR)
Innovation and technology of Microelectronics	Encourage investments in tangible assets and strengthen the competitiveness of the production system by increasing the rate of digitalisation, technological innovation and internationalisation of high-tech sectors. Website: https://www.italiadomani.gov.it/content/sogei-ng/it/en/Interventi/investimenti/innovazione-e-tecnologia-della-microelettronica.html	0.37 billion USD (0.34 billion EUR)
A more digitalized manufacturing system and investments in advanced technology, research and innovation	To enhance basic and applied research, facilitate technology transfer and promote the digital transformation of manufacturing processes as well as the investment in intangible assets. Website: https://www.italiadomani.gov.it/content/sogei-ng/it/en/Interventi/investimenti/transizione-4-0.html	14.59 billion USD (13.38 billion EUR)
A more modern agriculture due to innovative ways of producing, processing and distributing materials.	Transform Italian agriculture into Agriculture 4.0: less pesticide use, less polluting machinery, digitalisation, and new technologies. And more modern systems for processing, storing and packaging of Made in Italy food products (in particular olive oil, the excellence of our territory), in order to improve the sustainability of production, reduce/eliminate waste and promote the reuse of production waste to create energy. Website:https://www.italiadomani.gov.it/en/Interventi/investimenti/Innovazione-e-meccanizzazione-nel-settore-agricolo-e-alimentare.html	0.6 billion USD (0.5 billion EUR)

3. Competence centers and Associations

3.1 Artes 4.0

- In June 2020, the highly specialized Competence Center on advanced robotics and artificial intelligence Artes 4.0 (https://www.artes4.it/en/) and the Digital Innovation Hub of Confindustria Sicilia formalized the collaboration to push the companies of this region towards new innovative and development dimensions through the use of 4.0 technologies.
- Artes 4.0 is an association with national coverage and international projection that links university partners to departments of excellence financed by the Mur (Ministry of University and Research), research institutions, highly qualified training institutes, foundations and a partnership of 95

IFR International Federation of Robotics

between large, small, medium and micro companies able to provide innovative, rapid solutions at the right quality/price to business customers.

3.2 Adra

- The AI, Data and Robotics Association (Adra, asbl) was founded on May 21, 2021, by five European organisations: BDVA, CAIRNE, ELLIS, EurAI and euRobotics. (https://adr-association.eu/about-us)
- Adra was created as the private side of the European Partnership on AI, Data and Robotics, one of the European Partnerships in Cluster 4 (digital, industry, and space) in Horizon Europe. The Partnership was officially launched when Adra signed an MoU with the European Commission on June 23, 2021.
- To deliver the greatest benefit to Europe from AI, Data and Robotics, this Partnership will drive innovation, acceptance and uptake of these technologies.
- In July 2022, Adra contributed to the launch of the Adra-ecosystem (Adra-e). Adra-e (https://adra-e.eu/) supports the AI, Data and Robotics Association and Partnership to create the conditions for a sustainable European ecosystem. It aims to
  - ✓ Support the update and implementation of the AI, Data and Robotics Strategic Research, Innovation and Deployment Agenda.
  - ✓ Map the AI, Data and Robotics landscape and infrastructures to deliver services and build connections between structured initiatives.
  - ✓ Increase innovation capacity and adoption of core AI, Data and Robotics technology with applications.
  - ✓ Raise awareness of the Adra association and partnership with citizens, businesses, public administrators, and educators.
  - ✓ Support the development of standards and regulations maintaining European technological sovereignty.

4. Activities of national relevance on robotics

4.1 RobotHeart

RoboHeart (https://www.bimu.it/en/robotheart-2/) is a national exposition on industrial robotics, automation, related technologies and solutions, components, systems and artificial intelligence. The large number of applications on show attract operators from all the main production sectors, including mechanics, automotive, logistics, food and beverage, pharmaceuticals, cosmetics, electronics, biomedics. The protagonists of this exhibition area are manufacturers, integrators, universities, research centres and start-ups.

4.2 National Course on Industrial Automation and Robotics

The Italian Association of Robotics and Automation (SIRI) has a long tradition of organizing the annual National Course on Industrial Automation and Robotics. In 2024 the 47th edition, titled “industrial robotics between regulation and innovation”, was held in Ancona.

4.3 Ph.D. program of national interest in Robotics and Intelligent Machines

- The new National Doctorate (https://drim.i-rim.it/en/) characterized by an interdisciplinary and international outlook and a strong industrial vocation for the advanced training of the country's talented young people in Robotics and Intelligent Machines. The industrial vocation of the proposed new National Doctorate has ample grounds:
  - ✓ To encourage technology transfer from the world of research to that of industry, particularly in emerging industrial sectors for the use of robotics
  - ✓ To allow industry to help direct the research of doctoral students to give research a focus that, without prejudice to scientific excellence, acts as an enabler for the technological transfer of results.
  - ✓ Allow doctoral students to spend periods within the companies participating in the training project.
  - ✓ Enable the emergence of not only purely scientific but also managerial skills to promote the evolution of robotics technology into a mature solution for industrial application.
- Encourage the entrepreneurship of PhD students, enabling forms of exploitation of research that envisage the foundation of innovative start-ups.

E04 UK

Title	**Industrial Strategy Challenge Fund (Robots for a Safer World)**
Region	UK
Issued by	◦ Innovate UK ◦ UK Research and Innovation
Announcement	2017 (revised 2023)
Term of validity	Annual revision
Budget	28 million USD (22 million GBP)
Key words	Robotics, innovation, industrial strategy
Related website	UKRI challenge fund: https://www.ukri.org/what-we-do/ukri-challenge-fund/ Challenge fund for research and innovation: https://www.gov.uk/government/collections/industrial-strategy-challenge-fund-joint-research-and-innovation
Background	Industrial Strategy Challenge Fund (ISCF) ◦ In 2016, the UK announced 'Challenge Fund" to strengthen science and innovation ◦ The fund includes 7.37 B USD (5.8 B GBP) investment in R&D ◦ The fund is delivered by UK Research and Innovation (UKRI). ◦ It covers 4 challenge themes, including Artificial Intelligence and data economy, aging society, clean growth, and the future of mobility ◦ There are 4 out of 22 programs related to robotic R&D.
Goal	To develop robotic solutions to make a safer working environment in industries such as off-shore energy, nuclear energy, space, and deep mining, increase productivity, and open up new cross-disciplinary opportunities, not currently available
The latest R&D project	Made Smarter Innovation (to 2025): deliver a resilient, flexible, more productive, and environmentally sustainable UK manufacturing sector
The key targets of the latest R&D project	◦ Smart connected factories ◦ Connected and versatile supply chains ◦ Adaptable, flexible manufacturing operations and skills ◦ New ways to design, test, and make products

Contents

1. In the UK, funding for robotics in 2023 and 2024 has focused on several significant initiatives and challenges across various sectors, reflecting the country's strategic priorities in innovation and technology development. Where the majority of the fund comes from the URKI challenge fund, which is divided into three main themes with 22 programs. There are 2 out of 4 themes and 4 out of 22 programs related to robotic research and development with a total budget of around 170.2 M USD (134 M GBP). However, funding for robotics in 2023 and 2024 is around 28 M USD (22 M GBP). The biggest funding for robotic research (Robots for a Safer World, 142 M USD (112 M GBP)) ended in early 2022.

Theme	Program	Total fund	Robotic sector	Managed by	Period
Future of mobility	Robots for a safer world	142 M USD (112 M GBP)	142 M USD (112 M GBP)	UKRI, IUK, EPSRC	2017-2022
Clean growth	Made smarter innovation	186.7 M USD (147 M GBP)	8.9 M USD (7 M GBP)	UKRI, IUK, EPSRC, ESRC	2020-2025
Clean growth	Transforming food production	132.7 M USD (104.5 M GBP)	16.5 M USD (13 M GBP)	UKRI, IUK, BBSRC	2019-2024
Future of mobility	Driving the electric revolution	101.6 M USD (80 M GBP)	2.7 M USD (2 M GBP)	UKRI, IUK	2019-2024

UKRI: UK Research and Innovation, IUK: Innovate UK, EPSRC: Engineering and Physical Sciences Research Council, ESRC: Economic and Social Research Council, BBSRC: Biotechnology and Biological Sciences Research Council.

2. Details of Robotic R&D in each program

2.1. Made smarter innovation

- This broad-scope challenge targets advancements in manufacturing through the development and integration of industrial digital technologies. It aims to support manufacturers and technology developers in proving ideas, developing prototypes, and scaling technology solutions.
- 5 key technologies in this challenge include
  - ✓ Artificial intelligence, machine learning and data analytics
  - ✓ Additive manufacturing
  - ✓ Robotics and automation
  - ✓ Virtual reality and augmented reality
  - ✓ Industrial Internet of Things and connectivity
- The ISCF investment in this program can be broken down into the following areas

Area	Amount	Content	Targets
Collaborative R&D	76 M USD (60 M GBP)	4 rounds have been invested	- Increase in GVA by 2.9 billion USD - Create thousands of highly skilled jobs - Raise productivity by 30% - Create a 4.5% decrease in carbon emissions - Create a 25% decrease in manufacturing waste - Allow the UK to shape the future of manufacturing
Innovation hubs	44.5 M USD (35 M GBP)	2 large innovation hubs	
Research centers	31.8 M USD (25 M GBP)	5 university-led research centres	
International	12.7 M USD (10 M GBP)	Eureka Global Stars	
Accelerators	7.6 M USD (6 M GBP)	Support startups develop ideas into prototypes and products	
Economic and social research	6.4 M USD (5 M GBP)	Address the human issues resulting from the diffusion of new technologies in industry	
Innovation network	1.9 M USD (1.5 M GBP)	Innovate UK Knowledge Transfer Network	
Standards	1.14 M USD (0.9 M GBP)	Implement guidance for emerging digital industries	

- Among 76 M USD (60 M GBP) invested in collaborative R&D through 4 rounds up to FY2024, there are around 8.9 M USD (7 M GBP) was invested in the robotics and automation sector

CR&D Round 1 – 3.54 M USD – Ended	
Name	**Content**
Transformative industrial digitization of UK frame-building	Using the latest automated, robotic technologies to design and join bicycle components together
Digital designer robot	Robots converse and assist humans in understanding objectives, designing, and offering advice.
DIALOG	Mobile manipulator robotic solutions for delivery in manufacturing
Rapid Sand-Casting Production	Low-cost automated rapid manufacturing
WeldZero	Intelligent welding robotic system solutions within a cyber-physical production system
CR&D Round 2 – 345,109 USD – Ended	
Name	**Content**
SORT-IT	Intelligent automation in the packaging supply chain
CR&D Round 3 – no robotics and automation-related project	
CR&D Round 4 – 4.1 M USD – Ongoing	
Name	**Content**
IntelliJeni	A modular, turnkey automated 3D printing solution.
SMART 2	A robot production line that can fully and automatically assemble sandwiches at the same speed and accuracy as manual operators.
FLORABOT	Digital and automation technologies for flower packing.

Electroformed component robotic manufacturing	Advanced robotic and automation in the electro-deposition process
AP2	Automated production for aerospace pallets
AMWire	Automated the wiring processes to double productivity and reduce the cost of manufacture
BROM-BOT	Using robotic and automation solutions to optimize bicycle production.
Adaptive Self Learning Robotic Linishing and Polishing	Able to process multiple parts without reprogramming. AI will also be used to optimize the use of abrasive consumables.
CAMPFIRE	Advanced 3D vision and force control robotic solutions allow robots to see and feel metal surfaces and adapt to the variability found in AM parts.
Dynamic, high-impact micro-optic security films using automated, high-precision alignment between micro-lenses and micro-images	Implement a novel automation technology for precision alignment and registration of fine lenses and micro-printed lines in moving web to a precision of ± 5μm

- Two innovation hubs had been created for developing, demonstrating, and testing digital solutions in manufacturing and supply chains as follows:

Made smarter innovation digital supply chain innovation hub	◦ Funding: 12.7 M USD (10 M GBP) ◦ The hub is designed to drive innovation for all potential users, including large and small technology providers and manufacturers. It will also form part of a national network, made up of clusters of test beds, living labs, and other developmental environments. ◦ Website: https://hub.digitalsupplychainhub.uk/
Smart manufacturing data hub	◦ Funding: 15.6 M USD (12.3 M GBP) ◦ The hub will support small and medium-sized manufacturers to capture and better utilize their data, helping them unlock key productivity, growth, and sustainability gains. Businesses in sectors spanning food and drink, aerospace, and many more will be supported to develop, test, and adopt the latest data-driven innovations. ◦ Website: https://smdh.uk/

- 31.8 M USD (25 M GBP) invested in the creation of 5 university-led research centers that help improve the manufacturing industry in the UK as follows:

Centre for People-Led Digitalisation (PLD)	◦ Led by: Bath, Nottingham, and Loughborough Universities (6.35 M USD (5 M GBP)) ◦ Content: This center aims to achieve the highest level of manufacturing productivity and create “needs-driven” processes by enhancing the digital knowledge, and awareness of manufacturers, and a people-led approach to digitalization. ◦ Website:https://www.madesmarter.uk/made-smarter-innovation/research-centres/centre-for-people-led-digitalisation/
Digital Medicines Manufacturing Research Centre (DM2)	◦ Led by: University of Strathclyde (6.35 M USD (5 M GBP)) ◦ Content: DM2 aims to accelerate digitalization in the pharma sector, transform medicines development and manufacturing productivity, revolutionize quality control, drive patient-centric supply, and enable the workforce of the future ◦ Website:https://www.madesmarter.uk/made-smarter-innovation/research-centres/digital-medicines-manufacturing-dm2-research-centre/
Research Centre for Smart, Collaborative Robotics (CESCIR)	◦ Led by: Loughborough University (6.1 M USD (4.82 M GBP)) ◦ Content: CESCIR will create a network of academia and industry, connecting stakeholders, identifying challenges or opportunities, reviewing progress, and sharing results. Open access models and data will enable wider academia to further explore the latest scientific advances. ◦ Website:N/I

Materials Made Smarter Centre (MMSC)	◦ Led by: University of Sheffield (5.1 M USD (4 M GBP)) ◦ Content: develop advanced digital technologies and tools to enable the verification, validation, certification, and traceability of materials manufacturing ◦ Website:https://www.madesmarter.uk/made-smarter-innovation/research-centres/materials-made-smarter-research-centre/
Connected Factories	◦ Led by: University of Nottingham (6.35 M USD (5 M GBP)) ◦ Content: proposes a radical new approach to building the manufacturing infrastructure of the future based on autonomous connected factories ◦ Website:https://www.madesmarter.uk/made-smarter-innovation/research-centres/research-centre-for-connected-factories/

2.2.Transforming food production

- This challenge supports new methods to produce food while reducing emissions and pollution. The funding will be invested in future food production systems, science and technology into practice, international opportunities, and investment ecosystems.
- A partnership program of this challenge with the Department for Environment, Food and Rural Affairs (Defra), a so-called farming innovation program, involving small and medium-sized enterprises, focusing on the following areas
  - ✓ Robotics
  - ✓ Artificial intelligence
  - ✓ Novel proteins
  - ✓ Vertical farming
  - ✓ Integrated supply chains
  - ✓ Autonomous growing systems
  - ✓ Precision agriculture
- There are 17 out of 92 funded projects developed the robotic and automation systems for transforming food production with a total of nearly 16.7 M USD (13 M GBP) funded thus far with 41 organizations involved

Project title	Amount	Contents
ReproTel	396,825 USD (312,461 GBP)	Automated the diagnostic, monitoring the health of cattle and robotic milking parlors
RAISD	1,638,752 USD (1,290,356 GBP)	Applied robotics and AI to automate key tasks in cow management and milking.
DAIRYVISION	637,277 USD (501,793 GBP)	Autonomous monitoring and management of dairy cows
PRUEX	238,002 USD (187,403 GBP)	A robot that applies accurate, timed doses positioned close to the floor of chicken sheds
Demeter	1,466,117 USD (1,154,423 GBP)	Berries picking and fruit data collection robots
Idaeus	617,057 USD (485,872 GBP)	Raspberry picking robots
The First Fleet	1,578,132 M USD (1,242,624 GBP)	The world's first fleet of robots that can carry out a wide variety of tasks in the field.
Robot Highways	3,098,472 USD (2,439,742 GBP)	Fleets of electric robotic and autonomous systems, powered by renewable energy, that pick, transport, and pack fruit, whilst gathering data to maximize yield, reduce waste, and minimize environmental impacts.
ScaleForImpact	1,085,850 USD (855,000 GBP)	Fundamental and underpinning technology that will enable growers to deploy hundreds of robots, delivering commercial services at a wider scale across the UK by 2024

SoSeRaH	644,282 USD (507,309 GBP)	Robot arms can replicate the movements of a human arm, and controls to move the arms and their grippers rapidly to a delicate object and handle it sensitively
Autonomous Robotic Weeder (in) Arable Crops	557,657 USD (439,100 GBP)	Development of an environmentally sensitive robotic weed control system for use across arable farms in the UK
Hands Free Farm	2,003,893 USD (1,577,869 GBP)	Create the technologies that are required to operate a farm autonomously, including swarm robotic skills, smart machines, and implements
A robot-enabled, data-driven machine vision tool for nitrogen diagnosis of arable soils	317,009 USD (249,614 GBP)	The system collects data using a mobile robot equipped with imaging sensors and applies Novel Big Data analytics/ machine learning/ AI to build up a picture of soil.
A Smart Robotic System for SmartFarm	632,203 USD (497,798 GBP)	Development of small robots for pest and disease detection and treatment, protect soil, and avoiding the damage caused by conventional heavy machinery
Development and field testing of the next generation of vision-guided weeding systems	885,263 USD (697,058 GBP)	The technology involved combines a precision hoe, guided by a vision system and machine learning for precise detection and localization of crop and weed plants

2.3.Driving the electric revolution

This challenge aims to be the catalyst for building more power electronics, machines, and drives (PEMD) products in the UK. The total budget for this challenge is relatively big 101.6 M USD (80 M GBP), but the investment into the robotic and automation sector is relatively small (about 7 M USD (5.5 M GBP)). However, there is 3.94 M USD (3.1 M GBP) invested in FY 23-24 divided into three following projects.

Project title	Amount	Contents
COCO	2,297,132 USD (1,808,766 GBP)	Enable automation of lamination stacking for novel rotor and stator.
FACTOREM	794,099 USD (625,275 GBP)	Focus on fast copper turns and robotic magnet placement
FASA	878,680 USD (691,874 GBP)	Optimized using robotic automation to reduce costs and boost output

3.The upcoming R&D Strategy on Robotics

- The robotics growth partnership committee appointed by the UK government is outlining the draft of the 10-year Smart Machines 2035 starting in 2025 which can be integrated into work and social communities by communicating and collaborating with devices, AI, other smart machines, and humans. There are four big goals to be achieved in this strategy:
  - ✓ Supply – developing the Ecosystems of innovation and business
  - ✓ Demand – Driving adoption and uptake
  - ✓ Talent – growing our world-leading research and skills
  - ✓ Trust – Developing regulation
- Website: https://iuk.ktn-uk.org/events/robotics-growth-partnership-strategy-consultation/

E07 Sweden

<table>
<tr><td>Title</td><td colspan="3">Key Robotics Programs in Sweden</td></tr>
<tr><td>Region</td><td colspan="3">Sweden</td></tr>
<tr><td>Issued by</td><td colspan="3">VINNOVA(Swedish governmental innovation agency)</td></tr>
<tr><td>Announcement</td><td colspan="3"></td></tr>
<tr><td>Term of validity</td><td colspan="3"></td></tr>
<tr><td>Budget</td><td colspan="3"></td></tr>
<tr><td>Keywords</td><td colspan="3">Industrial Robotics; Logistics; Service Robotics; Healthcare Robotics</td></tr>
<tr><td rowspan="7">Related website</td><td>VINNOVA
(Project database related on robotics)</td><td colspan="2">https://www.vinnova.se/en/apply-for-funding/funded-projects/?aoName=&current=&numberofhits=&q=robot</td></tr>
<tr><td>VINNVÄXT</td><td colspan="2">https://www.vinnova.se/en/m/ecosystems-for-innovative-companies/winegrowing/om-vinnvaxt/</td></tr>
<tr><td rowspan="2">Automation Region</td><td>Webpage</td><td>https://www.automationregion.com/</td></tr>
<tr><td>Funding information</td><td>https://www.vinnova.se/p/automation-region/
https://www.vinnova.se/p/automation-region2/
https://www.vinnova.se/p/automation-region3/</td></tr>
<tr><td rowspan="2">Robotdalen</td><td>Webpage</td><td>http://www.robotdalen.se/</td></tr>
<tr><td>Funding information</td><td>https://www.vinnova.se/p/robotdalen-2013-2019/
https://www.vinnova.se/p/robotdalen-2.0/</td></tr>
<tr></tr>
<tr><td>Background</td><td colspan="3">◦ Vinnova, the Swedish government agency for innovation, funds and supports various projects and initiatives related to robotics. This includes grants for research and development in robotics across different sectors.
◦ In 2001 Vinnova began to develop the framework for what became the VINNVÄXT-program which is a representative competition to promote sustainable growth in regions.
◦ In 2003, Robotdalen was appointed as one of the VINNVÄXT initiatives.
◦ In 2016, Automation Region was named one of the winners of VINNVÄXT.
◦ Not only VINNVÄXT-programs, Vinnova has supported numerous projects focusing on advanced robotics, AI, and automation, often in collaboration with universities, research institutes, and private companies. In this material, ten representative projects related to robotics will be cited.

* The progamme aims to promote sustainable regional growth by developing internationally competitive research and innovation environments in specific growth areas with funds of up to 0.9 million USD (10 million SEK) per year for a period of 10 years</td></tr>
<tr><td>Goal</td><td colspan="3"></td></tr>
<tr><td>The latest R&D project</td><td colspan="3">Winter-Hugo</td></tr>
<tr><td>The key targets of the latest R&D project</td><td colspan="3">Small, autonomous delivery robot for autonomous transport of light goods in difficult winter conditions</td></tr>
<tr><td colspan="4">Contents</td></tr>
</table>

1. The initiatives related to robotics of VINNVÄXT-program of Vinnova

1.1. Robotdalen

◦ One of Europe's leading robotics centres, covers an area some 100 km across and brings together researchers, developers, manufacturers and academia working in the field of robotics.
◦ Robotdalen is an innovation center with a commercial focus.
◦ Overview of Robotdalen

Coordinator	◦ Mälardalen University, Västerås
Funding	◦ 2003-2013: 0.9 million USD (10 million SEK) per year from VINNOVA,

	VINNVÄXT-program ◦ 2007-2013: Substantial funding (25% of its total funding), European Regional Development Fund ◦ 2013-2017: 2.18 million USD (24 million SEK) from VINNOVA ◦ 2017-2019: 0.5 million USD (6 million SEK) from VINNOVA
Program	◦ Business solutions, R&D, testbeds, award (Robotdalen Innovation Award)
Focus	◦ Industrial robotics, Logistics, Service robotics, Healthcare robotics
Representative projects	◦ Robot suit HAL (Hybrid Assistive Limb) ◦ FIREM (Fire Rescue in Mines) ◦ STRADA ◦ Poseidon

1.2. Automation Region

- Automation Region is a Swedish innovation cluster focused on automation technology, which includes robotics as a key component.
- The cluster is based in Västerås, Sweden, and brings together companies, universities, and other organizations to foster collaboration in automation and robotics.
- Overview of Automation Region

Coordinator	◦ Mälardalen University - Academy for innovation design & technology IDT
Funding	◦ 2016-2019: 18 million USD (SEK 20,000,000) ◦ 2019-2022: 25 million USD (SEK 28,000,000) ◦ 2023-2025: 13 million USD (SEK 15,000,000)
Program	◦ Business Development program, research and innovation
Focus	◦ Connected industry, intelligent system, flexible automation
Representative projects	◦ The robot lift ◦ Robotization and automation in the hospitality industry ◦ International Innovation Initiative – Electrification and Automation (pilot) ◦ Robot power 5.0

2. The projects related to robotics of Vinnova (Ongoing projects, ten projects only more than 5 million funds)

(1) Project title	agrifoodTEF
Funds	23 million USD (SEK 25,800,000)
Venture	Regeringsuppdrag Digital conversion
Call	-
Coordinator	RISE Research Institutes of Sweden AB
Project period	December 2022 - December 2027
Goal	To build a Swedish satellite within the agrifoodTEF network to promote the development and use of European AI and robot solutions that support more sustainable agriculture
(2) Project title	Agtech 2030 phase 2
Funds	16 million USD (SEK 18,000,000)
Venture	2016-05305-en
Call	-
Coordinator	Linköpings universitet - Linköpings tekniska högskola Inst för ekonomisk & Ind utveckling
Project period	January 2024 - December 2026
Goal	To become a leading innovation platform in agricultural technology with a focus on sustainability, mobilising regional, national and international expertise working on new applications of sensors, robotics, drones, AI, image analysis and visualisation, etc.
(3) Project title	Winter-Hugo

Funds	14 million USD (SEK 15,849,360)
Venture	Accelerate - FFI
Call	FFI - Accelerate the transition to sustainable road transport - spring 2024
Coordinator	Statens Väg- & Transportforskningsinstitut - Statens väg- & transportforskningsinstitut VTI
Project period	June 2024 - April 2027
Goal	To develop and evaluate two transport services using a small, autonomous delivery robot. The transport services are co-developed together with the users to generate knowledge about autonomous transport of light goods in difficult winter conditions. The system demonstrator "Winter-Hugo" is designed to accelerate development towards a more fossil-free and inclusive transport system, for rural areas, within the Accelerate sub-programme of FFI.
(4) Project title	AGRARSENSE
Funds	12 million USD (SEK 13,854,654)
Venture	Chips Joint Undertaking – an EU program to strengthen competitiveness in semiconductors
Call	-
Coordinator	Komatsu Forest ABVTI
Project period	January 2023 - December 2025
Goal	To develop technology and know-how which creates robust value chains and efficient technical solutions, everything from hardware to holistic data management that enables transparent, sustainable and improved productivity in agriculture and forestry
(5) Project title	Synergistic Human-Robot Collaboration in Extreme Environments: Simulation to Experimental Validation
Funds	0.8 million USD (SEK 9,000,000)
Venture	Advanced digitalization - Enabling technologies
Call	AI for advanced digitalization 2024
Coordinator	Kungliga Tekniska Högskolan - Kungliga Tekniska Högskolan Skolan f teknikvetenskap SCI
Project period	July 2024 - July 2027
Goal	To improve underwater operations by integrating autonomous underwater vehicles (AUVs) with divers to enhance safety and efficiency in extreme environments utilizing AI technologies such as real-time decisions, machine learning, computer vision, and reinforcement learning, the AUVs will support divers in defense, rescue, and law enforcement
(6) Project title	CitCom.ai
Funds	0.7 million USD (SEK 8,630,000)
Venture	Regeringsuppdrag Digital conversion
Call	-
Coordinator	RISE Research Institutes of Sweden AB - RISE AB - Digitala System
Project period	December 2022 - December 2027
Goal	To provide reality lab oriented conditions in test and experimental facilities, relevant for AI and robotics solutions targeting sustainable development of cities and communities by further developing and strengthening existing infrastructures and expertise
(7) Project title	Safety analysis and verification/validation of MachIne LEarning based systems
Funds	0.6 million USD (SEK 7,230,000)
Venture	Transport and mobility services - FFI
Call	Transport and mobility services - FFI - spring 2023
Coordinator	RISE Research Institutes of Sweden AB
Project period	September 2023 - November 2026

Goal	To develop enabling technologies and safety assurance framework for transport services enabled by small autonomous vehicles ("AMR"): transport robots and delivery robots.
(8) Project title	Flexible AI-controlled picking robot with a higher degree of autonomy
Funds	0.5 million USD (SEK 6,500,000)
Venture	Advanced digitalization - Enabling technologies
Call	Advanced and innovative digitalization 2023 - call two
Coordinator	Superintelligence Computing Systems SICSAI AB
Project period	October 2023 - October 2025
Goal	To develop the next generation AI controlled industrial pick-&-place robot with a higher degree of autonomy and flexibility to increase the percentage of automatic picking
(9) Project title	AIHURO-Intelligent människa-robot-samarbete
Funds	0.5 million USD (SEK 6,245,977)
Venture	Advanced digitalization - Enabling technologies
Call	Advanced and innovative digitalization 2022
Coordinator	Chalmers Tekniska Högskola AB - Chalmers Tekniska Högskola Inst f Elektroteknik
Project period	January 2023 - January 2026
Goal	To create a sustainable workplace where autonomous mobile collaborative robots and humans work together safely and efficiently by having the following research activities: (i) developing human-robot interaction strategies, (ii) developing the techniques for perception and forecasting of moving rigid-objects and humans, and (iii) developing on-line planning and control approaches for the mobile collaborative robots
(10) Project title	The Virtual PaintShop – AI-Boosted Automated Painting (AUTOPAINT)
Funds	0.4 million USD (SEK 5,450,000)
Venture	Advanced digitalization - Enabling technologies
Call	AI for advanced digitalization 2024
Coordinator	Stiftelsen Fraunhofer-Chalmers Centrum För Industrimatematik
Project period	September 2024 - August 2027
Goal	To revolutionize the surface treatment by novel digital workflows that take advantage of the available unique simulation technology and boost the performance by advanced AI algorithms

E11 Switzerland

Title	**Key Robotics Programs in Switzerland**	
Region	Switzerland	
Issued by		
Announcement	NCCR	1 December, 2010
	National Thematic Network Innovation Booster Robotics	2022
Term of validity		
Budget	NCCR (SNSF)	23 million USD (20,629,608 CHF) (2018-2021)
	National Thematic Network Innovation Booster Robotics (the Swiss Innovation Agency, Innosuisse)	(2022-2025)
Key words	Wearable Robots; Mobile Rescue Robots; Educational Robots; Medical and Mobile Robots	
Related website	Swiss National Science Foundation	http://www.snf.ch/en/researchinFocus/nccr/nccr-robotics/Pages/default.aspx#Funding
	NCCR-Robotics	https://nccr-robotics.ch/
	SNSF Grant Database (project database related on robotics)	https://data.snf.ch/grants?q=robotics&start=2023%3A%2a&funding-l3=43D1CBC6-54C6-2121-2150-158F60D8ABF4
Background	◦ In terms of public research support and funding, the Confederation finances the Swiss National Science Foundation (SNSF) and the Swiss Innovation Agency (Innosuisse). ◦ To enhance the scientific competitiveness of Switzerland, SNSF has so far launched four series (2001,2005,2010,2014) comprising 36 NCCRs in total. ◦ In 2010, NCCR Robotics was opened, and binds together experts from six world-class research institutions; - École Polytechnique Fédérale de Lausanne (EPFL) (leading house), - Eidgenössische Technische Hochschule Zürich (ETH Zurich) (co-leading house), - Universität Zürich (UZH), - Istituto Dalle Molle di Studi sull'Intelligenza Artificiale (IDSIA), - University of Bern (UNIBE), - The Swiss Federal Laboratories for Materials Science and Technology (Empa), - Universität Basel (UNIBAS) ◦ After 12 years of activity, NCCR Robotics officially ended on 30 November 2022. ◦ NCCR Robotics members applied for additional funding for the National Thematic Network Innovation Booster Robotics that was launched in 2022 and will continue supporting networking activities and technology transfer in medical and mobile robotics for the next 4 years*	
Goal	◦ NCCR "Robotics – Intelligent Robots for Improving the Quality of Life" encompasses a promising field of engineering which aims at developing new, human-oriented robotic technology. ◦ Innovation Booster Robotics acts as the central networking hub for the Swiss industry and academic actors in robotics and aims at making robotics a central pillar of the Swiss economy.	
The latest R&D project	LAROCARE-Laser-Assisted RObot-guided CArtilage REgeneration	
The key targets of the latest R&D project	Surgical robotics, laser surgery: Using robotic cartilage surgery to decrease the chondrocyte damage, prevent the formation of bony cysts, and select precisely the depth of cartilage resection.	
Contents		

1. NCCR Robotics

1.1. Three main strands of research: Wearable robotics, Rescue Robotics, Educational robotics

1.1.1. Wearable robotics

- Goal: To develop a novel generation of wearable robotic systems, which will be more comfortable for patients and more extensively usable in a clinical environment
- Representative project;
  - ✓ Rysen: A robotic body-weight support system to assist patients with leg impairments such as spinal cord injury and stroke.
  - ✓ MyoSuit: A textile-powered lower-limb exoskeleton which represents a new approach to exoskeleton technology designed to support people with leg weakness

1.1.2. Rescue Robotics

- Goal: To create robust and agile robots that can walk, fly and swim into unstructured environments and assist rescuers
- Representative project;
  - ✓ ANYMal: A quadrupedal robot which can perceive its environment, accurately localize, and autonomously plan its navigation path and carefully select footholds while walking with incorporated laser sensors and cameras
  - ✓ Machine learning for rescue robots: A project to give rescue robots the ability to walk unknown terrains using Machine Learning (ML)

1.1.3. Educational Robotics

- Goal: To create the robots for the classrooms of tomorrow, that will be used to teach robotics and many other subjects
- Representative project;
  - ✓ Thymio robot - a mobile robot increasingly used to teach robotics and programming
  - ✓ Cellulo - a small, inexpensive and robust robot that kids can move with their hands and use in groups

1.2. Funding

- Financing 2010-2021

	Time-frame	
Funding source	2014 - 2017	2018 - 2021
SNSF grant*	17.2 million USD (15,295,000 CHF)	12.5 million USD (11,150,000 CHF)
Funds of EPFL*	7.5 million USD (6,727,000 CHF)	7.1 million USD (6,350,000 CHF)
Funds of ETH Zurich*	5.1 million USD (4,600,000 CHF)	2 million USD (1,800,000 CHF)
Group funds of the project participants	5 million USD (5,055,707 CHF)	1.3 million USD (1,329,608 CHF)
External funds	0	0
Total	35.6 million USD (31,611,707 CHF)	23.2 million USD (20,629,608 CHF)

* contractually agreed funding

2. National Thematic Network Innovation Booster Robotics

2.1. Main research

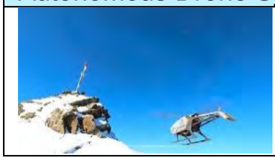
- Mobile robots and manipulators
- Medical and biomedical robots

2.2. Annual call granted by Innovation Booster Robotics

- Since 2022, IBR have funded almost more than ten projects every year. The first call is in April and the second call is in September. The funding amount for each project is 28,185 USD (25,000 CHF) and Implementation partner contribution is 8,455 USD (7,500 CHF).

- Call 5 – 2024

RoboPrint: Robotic arm assisted 5D bioprinter

	RoboPrint will develop a novel printing method that follows stress curves, enhancing structural strength and eliminating the need for supports.
AITHON Robotics – Access solution for hazardous tasks	
	AITHON is an aerial robotics project developing a drone capable of performing force intensive tasks at heights. The modular drone will allow customers in the construction industry to reduce their operating costs and extend the life of their structures through targeted deployments.
Improving the outcomes of Spontaneous Intracranial Hypotension (SIH) interventions.	
	The treatment of spontaneous intracranial hypotension (SIH) is a poorly addressed clinical challenge. This project's goal is to provide technological solutions to improve the outcomes of SIH interventions.
Visual SLAM Technology for Guiding Cleaning Carts in Shopping Centers	
	The project integrates advanced Visual SLAM technology into mall carts for autonomous navigation, transforming research into practical use. Robolem handles project management and construction. Key partners are ILT, OST, and Shoppi Tivoli for testing.
Inveel Robotic Skin – Empowering robots with the feeling of touch	
	The project aims to create a sensor-rich skin for robotic hands using Inveel's nanoelectrode printing, achieving unprecedented resolution in force and proximity sensing. This advanced skin mimics human tactile sensitivity, enabling precise perception and superhuman abilities like proximity detection, tested through tactile dexterous manipulation experiments.
Autonomous Drone System for Precise Localization of Avalanche Victim	
	The autonomous HT-100 helicopter system from ANAVIA, together with an innovative path planning algorithm, enables avalanche victims to be located as quickly as possible. Thanks to its high robustness and flight speed, the system is ideally suited for daily use in high alpine areas.

3. The projects related to robotics granted by Swiss National Science Foundation (Ongoing projects, five projects only more than 0.9 million USD (800,000 CHF)).

(1) Project title	LAROCARE-Laser-Assisted RObot-guided CArtilage REgeneration
Funds	3 million USD (3,196,469 CHF)
Call Full Title	Project funding (02.10.2023)
Coordinator	Georg Rauter, Universität Basel and others.
Project period	01.09.2024 – 30.04.2028
Goal	To improve the outcome of chondral and osteochondral defects regeneration using robotic cartilage surgery which could 1) decrease the chondrocyte damage that may occur from surgical instruments, 2) prevent the formation of bony cysts by improving the fit between recipient bed and graft, thus decreasing synovial fluid intrusion, and 3) select precisely the depth of cartilage resection, preserving the calcified layer for better outcomes.
(2) Project title	Electrostatic Muscles with High-Power and Force-Control for Musculoskeletal Robots
Funds	1 million USD (999,324 CHF)
Call Full Title	Projects MINT 2022 October
Coordinator	Robert Kevin Katzschmann, ETH Zurich - ETHZ
Project period	01.04.2023 – 31.03.2027
Goal	To create an integrated artificial muscle system based on our proposed Hydraulically-Amplified Low Voltage Electrostatic actuator (HALVE) technology, based on HASEL actuators
(3) Project title	Robot Orienteering in the Alps
Funds	1 million USD (998,920 CHF)
Call Full Title	Project funding (02.10.2023)
Coordinator	Marco Hutter, ETH Zurich - ETHZ
Project period	01.04.2024 – 31.03.2028
Goal	To develop a legged robot capable of autonomously navigating from random starting points to arbitrary destinations within Switzerland, surmounting the barriers presented by the Alps.
(4) Project title	'In SEA2 SpineBot' for Safe Intraoperative Intervertebral Stiffness Assessment
Funds	1 million USD (982,782 CHF)
Call Full Title	Projekte MINT 2023 April
Coordinator	Georg Rauter, University of Basel - BS
Project period	01.10.2023 – 30.09.2027
Goal	To develop a safe device to quantify the mechanical properties of AIS intraoperatively on patients scheduled for a surgical fusion using parallel robotics (a hexapod) in combination with Series Elastic Actuation (SEA).
(5) Project title	Encoding Multiple Physical Intelligences into Self-Assembled Micromachines
Funds	0.9 million USD (872,774 CHF)
Call Full Title	Ambizione 2022
Coordinator	Minghan Hu, ETH Zurich - ETHZ
Project period	01.01.2024 – 31.12.2027
Goal	To develop a directed self-assembly strategy to construct micromachines with various physical intelligences that can effectively perceive and adapt to a changeable microenvironment

U01 USA

Title	**Intelligent Robotics and Autonomous Systems (IRAS) Research Programs by National Science Foundation (NSF)**
Region	United State of America
Issued by	The Networking & Information Technology R&D Program and the National Artificial Intelligence Initiative Office (NITRD)
Announcement	November 2023
Term of validity	Annual Revision
Budget	53.8 M USD for 2023 (supplemental funding 4.6 M USD); 69.9 M USD requested for 2024
Key words	Intelligent Robotics and Autonomous Systems (IRAS)
Related website	https://www.nitrd.gov/ https://www.nsf.gov/eng/robotics.jsp
Background	IRAS R&D advances intelligent robotic systems that are increasingly autonomous; this includes R&D in robotics hardware and software design and application, machine perception, cognition and adaptation, mobility and manipulation, safe human-robot interaction, and distributed and networked robotics.
Goal	The IRAS Interagency Working Group (IWG) coordinates federal R&D in accelerating the development and use of IRAS in workplaces, hospitals, communities, and homes. IRAS targets R&D for robust, safe, ethical, resilient, and efficient robots and robotics systems that assist people in their work and everyday lives.
The latest R&D projects	Scalable Robot Validation and Data Creation with Compositional Generative Simulation (1) Unified Design, Modeling, and Control of Extensible Continuum Robots for Operation in Human Workspaces (2)
The key targets of the latest R&D projects	(1) Transform the robot development process by creating a powerful simulation framework that can automatically produce diverse, realistic virtual scenarios for training and evaluating robots (2) Develop a highly flexible robotic arm called Continuum Bioinspired Robotic Assistant to help people with daily tasks and improve their independent living skills
Contents	

1.Overview (Strategic priorities and associated key programs)

1.1. Advance safe, efficient human-robot teaming and interactions to increase performance and enable new capabilities

Program	Human-Centered Computing (HCC)
Funding	◦ Small Projects, OAC Core Projects: up to 0.6 M USD (up to 3 years) ◦ Medium Projects: 0.6 M to 1.2 M USD (up to 4 years)
Goal	HCC supports research in human-computer interaction (HCI), integrating knowledge across disciplines to design new computing systems to amplify diverse humans' physical, cognitive, and social capabilities to accomplish individual and collective goals; to assess benefits, effects, and risks of computing systems; and to understand how human, technical, and contextual aspects of systems interact to shape those effects.
Key focus	◦ Human-technology interfaces ◦ Computer graphics ◦ Computing for creativity ◦ Computer-mediated communication and collaboration

	◦ Assistive and adaptive technology ◦ Social impacts of computing ◦ Design ◦ Domain-specific HCI
Program	Mind, Machine, and Motor Nexus (M3X)
Funding	n/a
Goal	M3X program supports fundamental research that explores embodied reasoning as mediated by bidirectional sensorimotor interaction between human and synthetic actors. For the purposes of this program, embodiment is defined as the capacity to interact with physics-based environments.
Key focus	◦ Human and synthetic actors ◦ Sensorimotor interaction ◦ Embodied reasoning ◦ Physics-based environment

1.2. Improve robots and autonomous systems to robustly sense, model, plan, learn, and act appropriately to perform the required tasks including in complex and uncertain situations.

Program	Cyber-physical systems (CPS)
Funding	◦ Small Projects: up to 0.6 M USD (up to 3 years) ◦ Medium Projects: 0.6 M to 1.2 M USD (up to 3 years) ◦ Frontier projects: 1.2 M to 7 M USD (4 to 5 years)
Goal	To drive innovation and competition in a range of application domains including agriculture, aeronautics, building design, civil infrastructure, energy, environmental quality, healthcare and personalized medicine, manufacturing, and transportation
Key focus	Control, data analytics, and machine learning including real-time learning for control, autonomy, design, Internet of Things (IoT), mixed initiatives including human-in- or human-on-the-loop, networking, privacy, real-time systems, safety, security, and verification
Program	Dynamics, Control and Systems Diagnostics (DCSD)
Funding	n/a
Goal	DCSD program supports fundamental theoretical, computational, and experimental research that is knowledge-driven or inspired by applications, focusing on the modeling, analysis, diagnostics and control of the dynamic behavior of systems
Key focus	◦ Modeling: mathematical frameworks to understand and predict the behavior of dynamic systems ◦ Analysis: theoretical and computational tools for discovery and exploration of salient properties of dynamic systems ◦ Diagnostics: methods to relate underlying causes to observed behaviors of dynamic systems ◦ Control: methods to produce desired behavior, or mitigate undesired behavior, in dynamic systems
Program	Foundational Research in Robotics (FRR)
Funding	n/a
Goal	NSF's flagship robotics research program is the FRR program, which supports a broad range of projects to provide important new capabilities to the next generation of robots.
Key focus	Support research on robotic systems that exhibit significant levels of both computational capability and physical complexity
Program	Robust Intelligence (RI)
Funding	◦ Small Projects, OAC Core Projects: up to 0.6 M USD (up to 3 years) ◦ Medium Projects: 0.6 M to 1.2 M USD (up to 4 years)
Goal	RI encompasses foundational computational research needed to understand and develop systems that can sense, learn, reason, communicate, and act in the world; exhibit flexibility, resourcefulness, creativity, real-time responsiveness and long-term reflection; use a variety of representation or reasoning approaches; and demonstrate competence in complex environments and social contexts

Key focus	◦ Artificial intelligence (AI) ◦ Machine learning ◦ Computer vision ◦ Human language technologies ◦ Computational neuroscience

1.3. Advance a new generation of robots, such as nanorobots, wearable robots, soft robots, and biologically inspired robots.

Program	Smart Health and Biomedical Research in the Era of AI and Advanced Data Science
Funding	Projects: 1.2 M USD (up to 4 years)
Goal	Supports the development of transformative high-risk, high-reward advances in computer and information science, engineering, mathematics, statistics, behavioral and/or cognitive research to address pressing questions in the biomedical and public health communities
Key focus	◦ Develop novel methods to intuitively and intelligently collect, sense, connect, analyze and interpret data from individuals, devices and systems to enable discovery and optimize health ◦ Solutions to these complex biomedical or public health problems demand the formation of interdisciplinary teams that are ready to address these issues, while advancing fundamental science and engineering
Program	Disability and Rehabilitation Engineering
Funding	n/a
Goal	Supports fundamental engineering research that will improve quality of life of persons with disabilities through development of new technologies, devices, or software combined with advancement of knowledge regarding healthy or pathological human motion, or advancement in understanding of injury mechanisms
Key focus	◦ Neuroengineering ◦ Rehabilitation robotics ◦ Brain-inspired assistive or rehabilitative systems ◦ Theoretical or computational methods and novel models of functional recovery including the development and application of artificial physiological systems

1.3. Advance the role of robotics in improving the resilience of critical infrastructure: (a) to respond to failures or incomplete or corrupted information; and (b) to assist in national response to critical and unexpected events including national disasters and emergencies

Program	America's Seed Fund
Funding	Up to 2 M USD/project (Phase 1: up to 0.305 M USD; phase 2: up to 1.35 M USD; phase 2b: up to 0.5 M USD)
Goal	Fosters innovation in robotic applications in healthcare and next-generation automation.
Key focus	◦ Human assistive technologies and bio-related robotics ◦ Human-machine interfaces and control/architecture ◦ Robotics applications ◦ Robotics in agile manufacturing, and co-robots ◦ Underground or underwater robotics for low-visibility, poor-connectivity or hidden topography ◦ Other robotics technologies
Program	Partnerships for Innovation
Funding	0.55 M USD (up to 2 years)
Goal	Performs translational research and technology development, catalyze partnerships, and accelerate transition of discoveries from laboratory to marketplace for societal benefit
Key focus	◦ Translational research toward proof-of-concept of a future product, process or service ◦ Technology scale-up

	◦ Demonstration of commercial potential

1.4. Promote ethical standards and broader participation in robotics

Program	Broadening Participation in Computing (BPC)
Funding	1) New Alliances: ◦ 0.75 M USD (up to 3 years) for new proposal ◦ 1.2 M USD (up to 5 years) for existing proposal 2) Demonstrations: 0.3 M USD (up to 2 years) 3) Supplements: < 0.2 M USD
Goal	Seeks to increase the participation of underrepresented groups in computer science and engineering
Key focus	Three categories of awards: Alliances, Demonstration Projects, and Supplements.
Program	NSF Research Traineeship Program (NRT)
Funding	◦ NRT Track 1: 3 M USD (up to 5 years) ◦ NRT Track 2: 2 M USD (up to 5 years) ◦ NRT Track 2 planning grant: 0.1 M USD/year (up to 2 years)
Goal	Shapes and supports highly effective training of STEM graduate students in high priority interdisciplinary or convergent research areas through the use of comprehensive traineeship models that are innovative, evidence-based, and aligned with changing workforce and research needs
Key focus	◦ Catalyze and advance cutting-edge interdisciplinary or convergent research in high priority areas ◦ Increase the capacity of U.S. graduate programs to produce diverse cohorts of interdisciplinary STEM professionals with technical and transferable professional skills for a range of research and research-related careers within and outside academia ◦ Develop innovative approaches and knowledge that will promote transformative improvements in graduate education

2.Other key robotics related programs at NSF

Program	Energy, Power, Control, and Networks
Funding	n/a
Goal	Supports research in modeling, optimization, learning, adaptation and control of networked multi-agent systems; higher-level decision making; and dynamic resource allocation and risk management
Key focus	Control Systems ◦ Distributed control and optimization ◦ Networked multi-agent systems ◦ Stochastic, hybrid, nonlinear systems ◦ Dynamic data-enabled learning, decision and control ◦ Cyber-physical control systems ◦ Applications (biomedical, transportation, robotics)
Program	Perception, Action & Cognition (PAC)
Funding	◦ 0.35 M to 0.6 M USD for most projects ◦ 0.5 M to 0.715 M USD for CAREER projects
Goal	PAC supports empirically grounded, theoretically engaged and methodologically sophisticated research in a wide range of topic areas related to human perceptual, motor, and cognitive processes and their interactions
Key focus	◦ Wide range of perspectives and a variety of methodologies (including computational modeling if the goal is to expand explanatory theories of human perception, action, or cognition) ◦ Examine human behavior in realistic (or real-world) scenarios, with more inclusive subject populations than have been used historically
Program	Mechanics of Materials and Structures (MOMS)
Funding	n/a

Goal	MOMs support fundamental research in mechanics as related to the behavior of deformable solid materials and structures under internal and external actions
Key focus	◦ Advances in fundamental understanding of deformation, fracture, and fatigue as well as contact and friction ◦ Structural response, including, advances in the understanding of nonlinear deformation, instability and collapse, and wave propagation ◦ Mechanics at the intersection of materials and structures, such as, meta-materials, hierarchical, micro-architectured and low-dimensional materials are also encouraged
Program	Science of Learning and Augmented Intelligence
Funding	n/a
Goal	Supports potentially transformative research that develops basic theoretical insights and fundamental knowledge about principles, processes and mechanisms of learning, and about augmented intelligence
Key focus	◦ Learning in individuals and in groups, across a wide range of domains at one or more levels of analysis, including molecular and cellular mechanisms ◦ Brain systems ◦ Cognitive, affective and behavioral processes ◦ Social and cultural influences
Program	Research on Innovative Technologies for Enhanced Learning (RITEL)
Funding	0.9 M USD (up to 3 years)
Goal	RITEL supports early-stage research in emerging technologies for teaching and learning that respond to pressing needs in authentic (real-world) educational environments
Key focus	Future-oriented exploratory and synergistic research in emerging technologies (including, but not limited to, artificial intelligence (AI), robotics, and immersive or augmenting technologies) for teaching and learning

3.Key R&D Robotics Projects

3.1.FY 2023

Project title	Summary
Mcity 2: An Integrated Automated Testbed for Autonomous Transportation Research	◦ Period: 2022.Oct – 2026.Sep ◦ Funding: 5.118 M USD ◦ Funding scheme: M3X, FRR ◦ Target: The Mcity augmented reality testbed integrates three components: (1) a physical test facility, (2) a mobility data center, (3) an augmented naturalistic diving simulator. The Mobility Data Center will make available sensor data sharing messages broadcast by roadside units in the Ann Arbor Living Laboratory publicly to the research community. Such data will be used to develop a naturalistic driving environment simulator that users can test their algorithms before deployment at the physical Mcity Test Facility, with a blend of real and virtual fellow road users.
SBIR Phase II: A Novel Human Machine Interface for Assistive Robots	◦ Period: 2023.Jan – 2024.Dec ◦ Funding: 1.0 M USD ◦ Funding scheme: Seed Fund ◦ Target: Develop a compact and low-cost optical sensor for detecting gesture commands from disabled users and to translate the gestures to assistive robots. Research items: Enhancing the reliability, usability, and compatibility of the sensor as an embeddable component for wearable assistive robots. Generate probabilistic graphs that represent the distribution of superstructures formed for an arbitrary set of manufacturing conditions; Design a sensor module to optimally monitor different muscle activities on the arm.
SBIR Phase II: Robotic Forest	◦ Period: 2023.Jan – 2024.Dec ◦ Funding: 1.0 M USD ◦ Funding scheme: Seed Fund

Inventory and Mapping	◦ Target: This Small Business Innovation Research (SBIR) Phase II project will advance knowledge in the fields of robotics and forestry. Research items: Development of algorithms, software, and hardware for intelligent, decentralized, autonomous multi-UAV systems that can coordinate in a dense forest; New forest sampling and tree volume techniques that leverage the ability to measure vast quantities of trees in precise detail, relative to manual measurements.

3.2.FY 2024

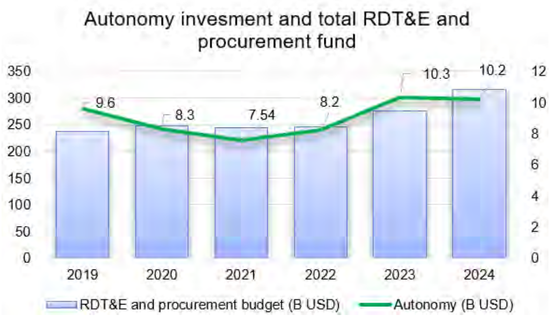
Project title	Summary
Scalable Robot Validation and Data Creation with Compositional Generative Simulation	◦ Period: 2024.Sep – 2027.Aug ◦ Funding: 1.034 M USD ◦ Funding scheme: FRR ◦ Target: transform the robot development process by creating a powerful simulation framework that can automatically produce diverse, realistic virtual scenarios for training and evaluating robots. Research items: Develop a generative model for long-horizon interactive behaviors of non-robot participants; Develop a model for generating dynamically- and geometrically-consistent image and multimodal sensor observations.
Hardware and Control Co-Design of Compliant Actuators for Energy-Efficient Humanoid Robots	◦ Period: 2025.Jan – 2028.Dec ◦ Funding: 1.215 M USD ◦ Funding scheme: FRR ◦ Target: This project will establish a systematic framework for the design and control of humanoid robots with an energy-efficient compliant actuator, which combines a Quasi-Direct-Drive (QDD) motor and Unidirectional Parallel Spring (UPS). Research items: Research on quantifying the performance of humanoid robots with QDD motors and UPS; Research on simultaneously optimize hardware and control parameters for improved energy efficiency and agility; Research on bridging the simulation-to-reality gap in humanoid control to achieve agile and efficient locomotion.
Unified Design, Modeling, and Control of Extensible Continuum Robots for Operation in Human Workspaces	◦ Period: 2024.Sep – 2028.Aug ◦ Funding: 1.314 M USD ◦ Funding scheme: FRR ◦ Target: Develop a highly flexible robotic arm called Continuum Bioinspired Robotic Assistant to help people with daily tasks and improve their independent living skills. The research aims to advance the field of soft robotics, continuum robots, and manipulation control. Research items: Integrate a modular system architecture with customizable design algorithms; Incorporate advanced proprioceptive sensing and real-time smooth inverse kinematics; Introduce advanced control strategies, including clothoid-based visual servoing and model predictive control, to ensure accurate and safe interaction with the environment.
Responsive Robotic Cilia Metasurfaces for Local Fluid Manipulation	◦ Period: 2024.Aug – 2028.July ◦ Funding: 1.262 M USD ◦ Funding scheme: FRR ◦ Target: This project seeks to design and fabricate micrometer-scale cilia metasurface robot building blocks capable of sensing their environment, performing computation, and actuating a fluid flow in response to environmental changes, to convert this platform into a robot by developing and integrating low power and robust optical, chemical, and thermal sensors as well as the ability to program the control circuits. Research items: Designing, fabricating, and testing low power and robust optical, chemical, and thermal sensors; Designing, fabricating, and iterating (light) programmable low power CMOS control circuits.

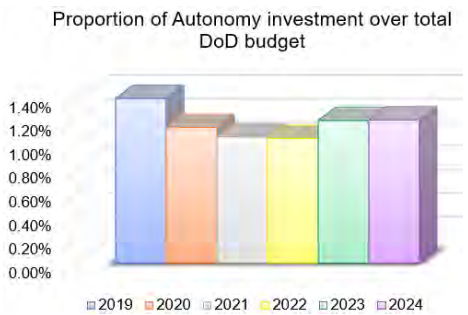
Title	**US DoD Budget For Unmanned System**
Region	United States of America
Issued by	United States Department of Defense (DoD)
Announcement	March 2023
Term of validity	Annual revision
Budget	10.3 B USD invested in 2023, and 10.2 B USD planned in 2024
Key words	Unmanned system, Robotics, Research, Development, Test & Evaluation (RDT&E)
Related website	https://www.defense.gov/ https://comptroller.defense.gov/Budget-Materials/Budget2023/ https://comptroller.defense.gov/Budget-Materials/Budget2024/
Background	Current United States national security and defense strategies involve responding to growing international competition and threats from terrorists, and regional dictators. Unmanned systems and robotics are key technology areas that enable the U.S. to counter the range of evolving threats posed on the modern battlefield.
Goal	To invest in space and cyber warfighting domains, modernize air, maritime, and land domains, innovate more rapidly to strengthen the nation's competitive advantage, and sustain the forces and readiness.

Contents

1. Overview of DoD funding for autonomy and robotics technologies

The DoD defense budget for autonomy and robotics technologies in fiscal years (FY) 23 and FY24 observes the continuous uprising of invested amount after the COVID-19 pandemic with 10.3 billion USD invested in FY23 (approximately 1.21% of the total DoD budget, and 3.7% of RDT&E and procurement budget) and a requested amount of 10.2 billion USD (approximately 1.21% of total DoD budge, and 3.2% of RDT&E and procurement budget) for unmanned system across all agencies.





Fiscal Year	Funding	Contents
2023	10.3 billion USD	4.487 billion USD for procurement of autonomy system
		5.84 billion USD for RDT&E of autonomy system
2024	10.2 billion USD	3.74 billion USD for procurement of autonomy system
		6.52 billion USD for RDT&E of autonomy system

1.1. The DoD FY 23 enacted budget and FY 24 request budget built upon five strategic priorities

Priorities	Contents
1. Transform the Foundation of the Future Force	◦ Drive competitive advantage by acquiring effective capabilities to d eter and, if necessary, defeat pacing threats. ◦ Modernize and sustain the nuclear deterrent and protect against c hemical and biological threats. ◦ Deliver and optimize the Department's enterprise, information, and technology infrastructure to drive mission effectiveness.

2. Make the Right Technology Investments	◦ Build a strong foundation for future science and technology through modernized laboratories and test facilities ◦ Collaborate with public/private sector partners in support of innovative, interoperable solutions ◦ Leverage technology innovation to build enduring performance advantage
3. Strengthen Resiliency and Adaptability of Our Defense Ecosystem	◦ Shape a 21st century Defense Industrial Base (DIB) ◦ Reduce operation and sustainment costs to maximize readiness ◦ Enhance the DoD's ability to combat 21st-century climate, energy, and environmental challenges ◦ Enhance the DoD's cybersecurity posture ◦ Increase the resiliency of C3 capabilities ◦ Engage in co-development, research, testing, and evaluation with Allies and partners.
4. Take Care of our People and Cultivate the Workforce We Need	◦ Cultivate Talent Management ◦ Change the culture ◦ Promote the health, wellbeing, and safety of the force and families
5. Address Institutional Management Priorities	◦ Accelerate the path to an unmodified audit opinion ◦ Optimize budget to execution and foster a high integrity funds control environment ◦ Modernize DoD Business Systems ◦ Accelerate the adoption of trusted data and analytics across the Department

1.2. The DoD autonomy roadmap

Autonomy can transform the DoD by expanding operational capabilities with improved safety, effectiveness, and manpower efficiencies. The DoD autonomy roadmap includes three terms.

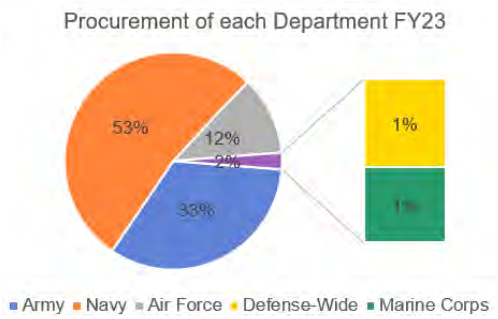
Current state: Machined-assisted operations	◦ Threat identification, action recommendation ◦ Cueing analysts from fused sensor data ◦ Extending human range ◦ Logistical operation ◦ AI adoption into defense operation
Mid-term (2025 – 2028+): Man-Unmanned teams	◦ Heterogeneous swarms ◦ Man-unmanned teaming ◦ Implementation of responsible AI
Long term: Fully autonomous	

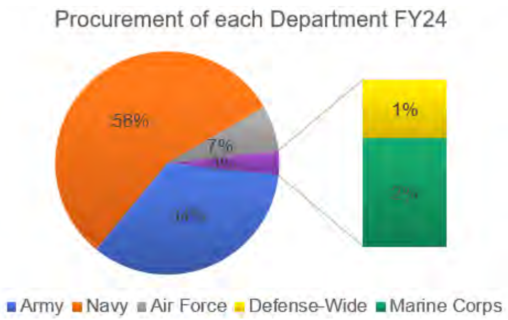
2. DoD funded Autonomy and Robotic related Programs

◦ It is noted that the proportion of RDT&E increased in FY23 and FY24 with 57% and 64% compared to 55% in FY22.
◦ The FY23 and FY24 funding for new procurement and research, development, test, and evaluation (RDT&E) efforts in automation and robotics is separated into 5 and 8 military agencies and departments, respectively. The three main departments (Air Force, Army, and Navy) account for over 80% of that total funding (8.6B in FY23 and 8.5B in FY24).
◦ In FY23 and FY24 the funding for autonomy and robotics technologies is distributed by domain with approximately 2.3 and 2.47 B USD related to the air domain, 1.69 and 2.17 billion USD related to the ground domain, 0.97 and 0.93 billion USD for surface maritime and 0.15 and 0.19 billion USD for subsurface maritime, respectively. Despite the increase in total funding in FY23 and FY24, the RDT&E funding for the air domain has decreased by 30% in comparison with FY22.
◦ The total procurement funding for programs that support UxV relative to domains supported in FY 23 and FY 24 indicates that UAV-related programs dominated the other funding-related programs with 3.3 and 2.36 billion USD, followed by the maritime surface with 386 and 427 million USD, ground with 230 and 288 million USD, and maritime subsurface with 49.7 and 62 million USD, respectively.

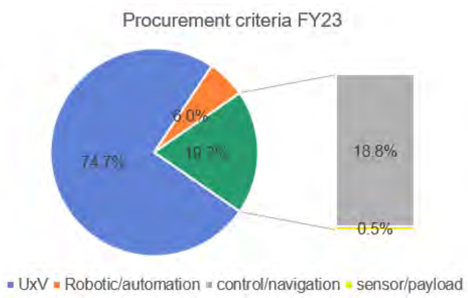
2.1. Unmanned System Procurement

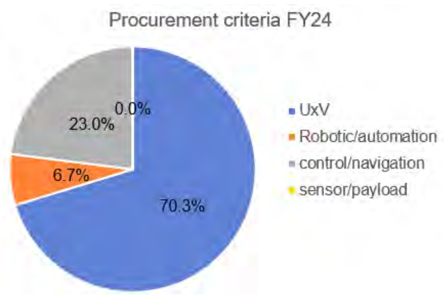
◦ The Navy received the highest budget with 2.3 and 2.08 B USD to procure Autonomy and Robotics-related technologies in FY23 and FY24. The Army accounts for the second highest budget receiver with 1.19 and 0.91 B USD, followed by Air Force (528 and 247 million USD), Marine Corps (50 and 85 million USD), and Defense-wide (59.8 and 46 million USD) in FY23 and FY24, respectively.





◦ The procurement criteria figure below reveals some highlights of FY23 and FY24. Procuring UxV is the most funding in FY23 and FY24 with 3 B USD and 2.26B USD, respectively. The next highest technology procurement is the control/navigation systems with 0.84 and 0.86 B USD in FY 23 and 24 respectively. Robotic/automation system procurement accounts for the third most investment with 0.27 and 0.25 B USD. There is a significant decrease in investment in sensor/payload technology with only 21.4 M USD invested in FY23 and no investment found in FY24.



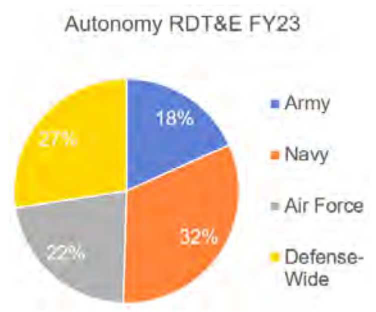


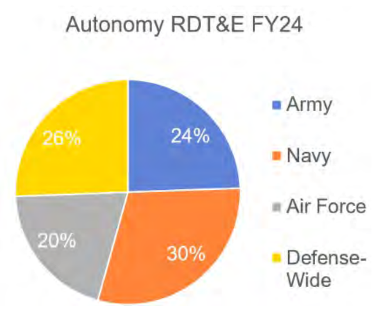
UxS/UxV	Main items	Funding	Contents
UAS	MQ-9 Reaper/Marine group 5 UAS	438.6 million USD (FY 2023) 303.6 million USD (FY 2024)	◦ With 248.6 M USD invested in USAF and SOCOM for in-service aircraft, support equipment, and facilities. ◦ Nearly 190 MUSD each year fund for procurement of 5 MQ-9 for Marine Corps
	MQ-4C Triton RQ-4	788.6 million USD (FY 2023) 510 million USD (FY 2024)	◦ Production of 3 (FY23) and 2(FY24) MQ-4C Triton UAS and 1 main operating base - mission control system each year ◦ 42.1 M USD invested in the modernization of RQ-4
	MQ-1C Gray Eagle	483 million USD (FY 2023) 13.6 million USD (FY 2024)	◦ Procurement of 12 MQ-1C gray eagle (FY23) ◦ Procurement of critical Avionics and Datalinks (FY24)
	MQ-25	882.9 million USD (FY 2023) 749 million USD (FY 2024)	◦ Procurement of 4 (FY23) and 3 (FY24) MQ-25 UAS. ◦ Funds the Unmanned Carrier Aviation Mission Control System program, which builds, integrates, installs, and sustains the systems required to operate the MQ-25.
	Other procurements of UAS including ◦ MQ-8: 9.8 MUSD (FY23), 16.2 M USD (FY24) ◦ RQ-21: 6.6 M USD (FY23) ◦ Small UAS: 10.6 MUSD (FY23), 24.8 M USD (FY24)		

	◦ Future UAS family: 53.5 M USD (FY24) ◦ - Unmanned ISR: 43.7 MUSD (FY23), 27M USD (FY24)		
UUV	Small and medium UUV	49.8 million USD (FY 2023) 62 million USD (FY 2024)	Funds for support equipment in UUV

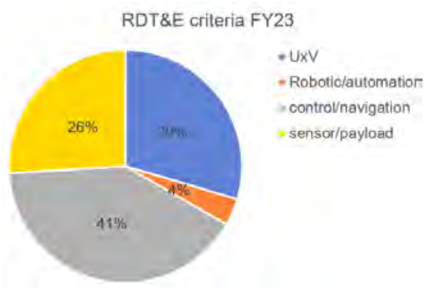
2.2. Unmanned Systems RDT&E

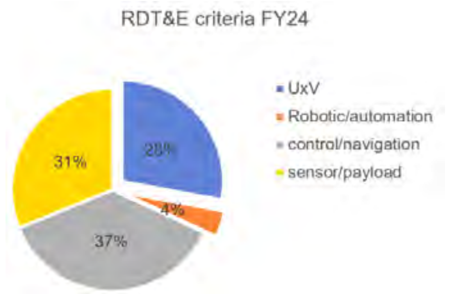
◦ The navy still leads all services with 1.88 billion USD (FY23) and 1.95 B USB (FY24) for unmanned systems and autonomy RDT&E followed by Defense-Wide (1.6 B USD in FY23 and 1.67 B USB in FY 24), the Army (1.07 billion USD in FY23, and 1.59 B USD in FY24), Air Force (1.29 B USD in FY23 and 1.3 B USD in FY24).





◦ The RDT&E criteria investment pie chart below shows the proportions of the RDT&E funding parsed by unmanned and autonomous technologies. Among these, technology research that improves the navigation/control system arguably has the highest level of support accounting for 41% and 37% of investment in FY23 and FY24, respectively. The unmanned system is the second most significant funding in FY23 with 1.72 B USD, however, becomes the third most funding in FY24 with 1.8 B USD. On the other hand, the RDT&E on sensor/payload accounts for the third most funded criteria in FY23 with 1.5 B USD and then becomes the second highest RDT&E investment with 2 B USD. The Robotics/automation technology stays last with a 4% investment over FY23-24





UxS/UxV	Main items	Funding	Contents
UAS	MQ-25 Stingray	254.4 million USD (FY 202) 220 million USD (FY 2024)	Ground control station and flighting test of 3 (FY23) and 4 (FY24) engineering development models, and 3 (FY23) and 2(FY24) system demonstration test articles
	MQ-9s Reaper	285.7 million USD (FY 2023) 244.2 million USD (FY 2024)	Funds the continued development, testing, and integration of USMC-unique sensors and SOF-peculiar emerging technology mission kits, weapons, and modifications on platforms, GCS, and training systems

	MQ-4C Triton RQ-4	233.6 million USD (FY 2023) 313.7 million USD (FY 2024)	Modernization and software development for multi-intelligence capabilities and correction of deficiencies identified during testing.
USV	LUSV MUSV	404 million USD (FY 2023) 379.5 million USD (FY 2024)	Continues development work in USV core capabilities of system autonomy, sensors and perception, and Command, Control, Communications, Computer & Intelligence (C4I)
UUV	LUUV Small/medium UUV	242 million USD (FY 2023) 292.5 million USD (FY 2024)	Development of the Barracuda expendable mine neutralizer (extra-large UUV), medium class UUV Razorback, Medusa UUV
UGV	UGV Robotics developments Ground robotics	163 million USD (FY 2023) 180.5 million USD (FY 2024)	Develop the Army's robotic combat vehicles (RCV) prototypes and enabling technologies for robotic vehicles deployed in combat environments

Title	**Artemis Lunar Program**
Region	United States of America
Issued by	National Aeronautics and Space Administration (NASA)
Announcement	May, 2019
Term of validity	2020 - 2029
Budget	53 billion USD from 2021 to 2025
Key words	Lunar exploration, Spacecraft, Manned spaceship
Related website	https://www.nasa.gov/specials/artemis/ https://www.nasa.gov/sites/default/files/atoms/files/america_to_the_moon_2024_artemis_20190523.pdf https://www.nasa.gov/sites/default/files/atoms/files/artemis_plan-20200921.pdf https://oig.nasa.gov/wp-content/uploads/2024/02/IG-22-003.pdf https://www.nasa.gov/nasa-fiscal-year-2024-budget-request/ https://www.nasa.gov/fy-2025-budget-request/
Background	Artemis is the twin sister of Apollo and goddess of the Moon in Greek mythology. Now, she personifies the path to the Moon as the name of NASA's program to return astronauts to the lunar surface. When they land, Artemis astronauts will step foot where no human has ever been before: the Moon's South Pole. With the horizon goal of sending humans to Mars, Artemis begins the next era of exploration.
Goal	To land "the first woman and the next man" on the lunar South Pole-Aitken Basin.

Contents

1. Introduction of the Artemis Lunar Program

◦ The Artemis Lunar Program is a new crewed spaceflight program by NASA, the U.S. commercial aerospace industry, and international partners including ESA (now representing 22 countries), Canada, Japan, and Russia.

◦ The goal is to land "**the first woman and the next man**" on the lunar South Pole-Aitken Basin. The initial Artemis lunar exploration is planned for the South Pole, on the rim of the Aitkin Basin, at a location that will have a line of sight to Earth and the Gateway.

◦ The Artemis mission concept as stated by NASA is to:

- ✓ Demonstrate new technologies, capabilities, and business approaches needed for future exploration, including Mars.
- ✓ Establish American leadership and a strategic presence on the Moon while expanding U.S.

global economic impact.

- ✓ Broaden our commercial and international partnerships.
- ✓ Inspire a new generation and encourage careers in Science, Technology, Engineering and Mathematics (STEM).

1.1. Summary of Artemis Lunar Program

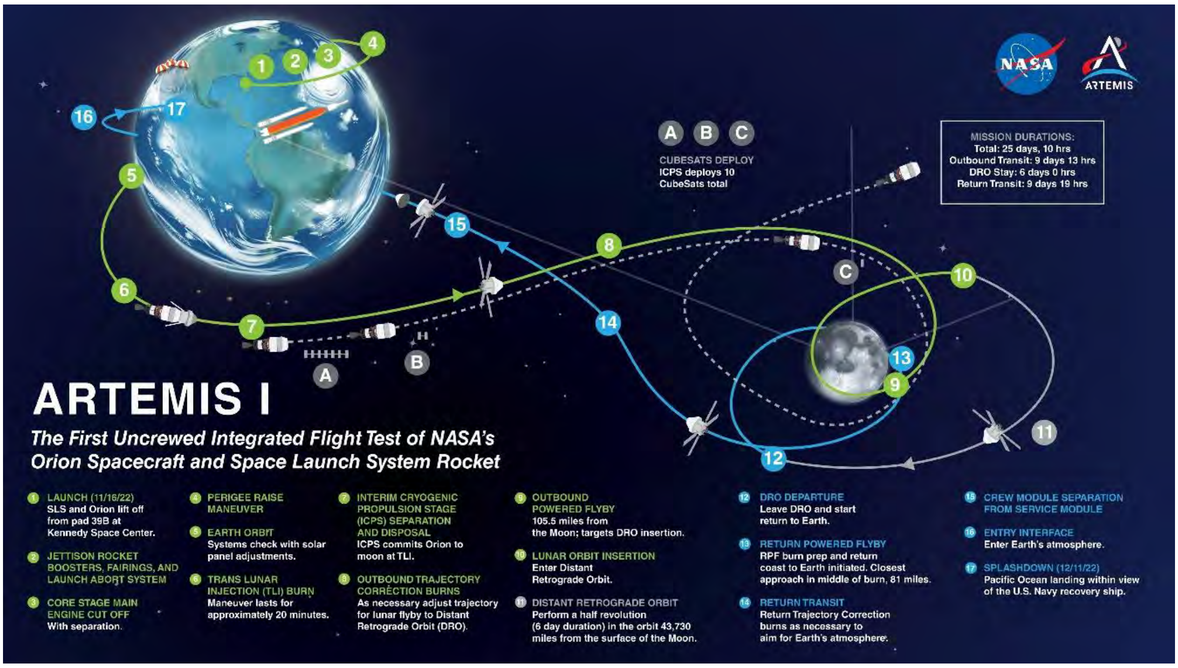
Mission (Launch date)	Goals	Main Technology Elements
Artemis I (16 Nov. 2022)	The first in a series of increasingly complex missions that will enable human exploration at the Moon and future missions to Mars	◦ Uncrewed flight ◦ SLS Block 1 ◦ Orion Mission Facts: Duration: 25 days, 10 hours, 53 minutes; Total distance traveled: 1.4 million miles; Re-entry speed: 24,581 mph (Mach 32); Splashdown: Dec. 11, 2022
Artemis II (Sep. 2025)	The first crewed flight test of the Space Launch System (SLS) and the Orion spacecraft around the Moon	◦ Crew Flight (4) ◦ SLS Block 1 ◦ Orion/ML1
Artemis III (Sep. 2026)	Sending the first humans to explore the region near the lunar South Pole.	◦ Crew Flight ◦ SLS Block 1 ◦ Orion/ML1 ◦ HLS Crewed/Lunar Demo ◦ xEVA Surface Suits ◦ HLS Uncrewed Lunar Demo Gateway PPE/HALO Launch
Artemis IV (Sep. 2028)	Debut humanity's first lunar space station, a larger, more powerful version of the SLS rocket, and new mobile launcher.	◦ Crew Flight ◦ SLS Block 1B ◦ Orion/ML2 ◦ I-Hab to Gateway ◦ Gateway Logistics Services ◦ Sustain HLS Crewed Lunar Demo ◦ xEVA Surface Suits Sustaining HLS Uncrewed Lunar Demo
Artemis V (Mar. 2030)	The first crewed flight of the Blue Moon lander and co-manifested delivery of the ESPRIT Refueling Module to the Lunar Gateway	◦ Crew Flight ◦ SLS Block 1B ◦ Orion/ML2 ◦ ESPRIT to Gateway ◦ Sustaining HLS Uncrewed Lunar Demo ◦ xEVA Surface Suits LTV
Artemis VI (Mar. 2031)	Lunar landing with the delivery of the Crew and Science Airlock module	◦ Crew Flight ◦ SLS Block 1B ◦ Orion/ML2 ◦ Airlock to Gateway ◦ Gateway Logistics Services ◦ Gateway External Robotics System ◦ TBD Sustaining HLS Services xEVA Surface Suits
Artemis VII (Mar. 2032)	Lunar landing with the delivery of the Habitable Mobility Platform (Lunar Cruiser) to the surface	◦ Crew Flight ◦ SLS Block 1B ◦ Orion/ML2 ◦ Gateway Operations ◦ TBD Sustaining HLS Services ◦ xEVA Surface Suits Pressurized Rover

2. Moon to Mars Objectives (Elements included in FY 2025-2029 Budget Request)

Category	Technology Elements	Goals
Science	Commercial Lunar Payload Services (CLPS)	To allow rapid acquisition of lunar delivery services from American companies for payloads that advance capabilities for science, exploration or commercial development of the Moon.
	Volatiles Investigating Polar Exploration Rover (VIPER)	To scout for ice on the surface of the Moon to create resource maps intended to help inform future missions.
	Lunar Trailblazer	To determine the form, abundance, and distribution of water on the Moon and the nature of the lunar water cycle
Lunar and Mars Infrastructure	In Situ Resource Utilization (ISRU)	To harness local natural resources at mission destinations, instead of taking all needed supplies from Earth, to enhance the capabilities of human exploration.
	Fission Surface Power	To design a fission power system that could enable robust operations on the Moon and Mars.
	Lunar Infrastructure Foundational Technologies (LIFT-1 and LIFT-2)	To provide ample lunar oxygen for future astronauts and lunar bases part of the Artemis program.
	Cryogenic Fluid Management (CFM)	To store, transfer, and measure ultra-cold fluids – such as liquid hydrogen, liquid oxygen, and liquid methane.
Transportation and Habitation	Orion	To carry the crew to space, provide emergency abort capability, sustain the crew during the space travel, and provide safe re-entry from deep space return velocities.
	SLS	To send Orion, astronauts, and cargo directly to the Moon in a single launch.
	Exploration Ground System (EGS)	To develop and operate the systems and facilities needed to process and launch rockets and spacecraft for NASA's Artemis missions, especially, assembly, launch, and recovery of rockets and spacecraft.
	Gateway	To be a multi-purpose outpost supporting lunar surface missions, science in lunar orbit, and human exploration further into the cosmos.
	Spacesuits	To protect and support astronauts as they reach iconic heights during forays in low-Earth orbit, the Moon, and worlds beyond.
	Lunar Terrain Vehicle (LTV)	To travel around the lunar surface, conducting scientific research during the agency's Artemis campaign at the Moon and preparing for human missions to Mars.
	Pressurized Rover	To explore, conduct science research, and live and work on the lunar surface by providing a home for astronauts away from the base camp for extended periods of time.
	Human Landing System (HLS)	The mode of transportation that will take astronauts to the lunar surface as part of the Artemis program
	Nuclear Propulsion	To revolutionize space travel by developing and demonstrating higher performance propulsion systems to achieve the agency's ambitious science and exploration goals.
Operation	Space Communication	To build and maintain a scalable integrated mission

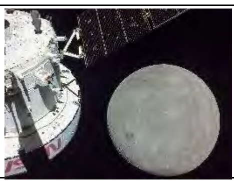
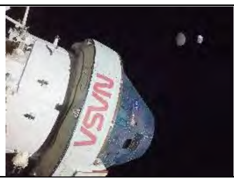
	and Navigation (SCaN)	support infrastructure that can readily evolve to accommodate new and changing technologies, while providing comprehensive, robust, cost-effective and exponentially higher data rate space communications services.
	Deep Space Network	To support interplanetary spacecraft missions, plus a few that orbit Earth
	Lunar Exploration Ground Segment (LEGS)	To provide direct-to earth communication and navigation services for missions operating from 36,000 km in the GEO to cis Lunar and beyond out to 2 million km.
	Lunar Communication Navigation and Relay Service (LCNRS)	To enable a robust communication and navigation infrastructure around the Moon

3. Summary of Artemis I (Launched Nov. 2022)



Artemis I Mission Map

◦ Summary of the Artemis I mission

Uncrewed Test Flight	Successfully conducted the first uncrewed flight of the SLS and Orion spacecraft
Launch Success	Achieved a historic launch from Kennedy Space Center
Lunar Orbit	Completed a mission that included a distant retrograde orbit around the Moon, demonstrating the spacecraft's capabilities
System Testing	Validated critical systems and technologies necessary for future crewed missions, including life support and navigation
Data Collection	Gathered valuable data on Orion's performance during the mission, contributing to the safety and reliability of future flights

Long Duration Spaceflight	Demonstrated Orion's ability to operate in deep space for an extended period, with a mission lasting over 25 days
Reentry and Recovery	Successfully re-entered Earth's atmosphere and safely splashed down in the Pacific Ocean on December 11, 2022
International Collaboration	Highlighted partnerships with international space agencies and commercial partners, showcasing global cooperation in space exploration
Preparation for Artemis II	Laid the groundwork for subsequent crewed missions, with Artemis II scheduled to carry astronauts around the Moon
Inspiration for Future Exploration	Renewed interest in lunar exploration and set the stage for establishing a sustainable human presence on the Moon and beyond

4. Artemis II (Planned launch no earlier than Sep. 2025)

Artemis II Mission Map

◦ Summary of the planned Artemis II mission

Launch	◦ Vehicle: SLS Block 1 ◦ Launch Site: Kennedy Space Center, 39B ◦ Trajectory: The SLS will launch Orion into a LEO for 90 minutes, then fire again to place Orion in a highly-eccentric orbit with a period of about 23.5 hours.
Earth Orbit and Systems Checking	◦ Orbit: Highly-eccentric orbit ◦ Duration: About 24 hours ◦ Activities: The crew will turn control of Orion back to mission controllers perform, verify spacecraft system performance in the space environment, assess the performance of the life support systems, checkout the communication and navigation systems to confirm they are ready for the trip to the Moon
Translunar Injection (TLI)	◦ Maneuver: After the systems checkout, the Orion spacecraft will perform the next propulsion move, called TLI burn using its service module, providing the last push needed to put Orion on a path toward the Moon.

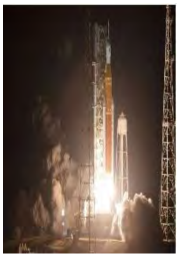
	◦ Trajectory: Outbound trip of about four days and around the backside of the Moon.
Lunar Flyby	◦ Altitude: Approximately 4,600 miles beyond the far side of the Moon. ◦ The crew will be able to see the Earth and the Moon from Orion's windows, with the Moon close in the foreground and the Earth nearly a quarter-million miles in the background.
Return Trajectory	◦ Maneuver: After the lunar flyby, Orion spacecraft harnesses the Earth-Moon gravity field to assist in its return to Earth. ◦ Trajectory: a maneuver known as a free-return trajectory.
Re-entry and Splashdown	◦ Re-entry Phase: Orion spacecraft will re-enter Earth's atmosphere. ◦ Splashdown: In the Pacific Ocean and Orion and the crew will retrieved. ◦ Duration:10 days for the entire mission.

5. Main Funding Entities

5.1. Deep Space Exploration Systems

Budget Authority (M USD)	FY 2022	FY 2023	FY 2024	2024 Request			
				FY 2025	FY 2026	FY 2027	FY 2028
Deep Space Exploration System	6,855.1	7,468.9	7,971.1	8,130.5	8,293.1	8,459.0	8,628.2

Programs related to robotics in Deep Space Exploration System

Common Exploration Systems Development		
	2,506 M USD	SLS to focus on successful completion of Artemis II and preparation required for Artemis III and IV, which includes the Block 1B configuration and other upgrades
	1,225 M USD	Orion program to finalize assembling and testing the Artemis II crew vehicle and to deliver the system to Exploration Ground Systems at Kennedy Space Center
	794 M USD	EGS to complete preparations for Artemis II; and develop the ground systems, such as the Mobile Launcher 2, required for assembly, test, and launch of SLS Block 1B on Artemis IV
Artemis Campaign Development		
	1,881 M USD	HLS program to develop and deploy multiple landing systems that will transport the first woman and first person of color to the Moon to conduct lunar science, technology demonstrations, and logistics to enable an enduring presence
	914 M USD	Gateway development to support human lunar landings and surface activities
	380 M USD	xEVA and Human Surface Mobility Program to develop the surface suits, pressurized rover, lunar terrain vehicle, and other systems for lunar exploration
	60 M USD	Advanced Exploration Systems to develop technologies for long duration mission that have common needs for both lunar and Mars missions
Human Exploration Requirements & Architecture		
	33 M USD	Collaborate with programs across NASA to design the roadmap for future long-term human exploration
	16 M USD	Conduct trade studies to reduce risk and identify required technologies to be utilized as part of the Artemis Campaign and act as precursor systems for future missions to Mar
Mars Campaign Development		

	132 M USD	Habitation Systems to continue developing key technologies to enable the crews to live and work safely in space, with an initial focus on lunar missions. Activities include life support systems, logistics reduction, food and crew health systems, and radiation measurements and protection
	18 M USD	Crew Health and Performance to continue developing countermeasures such as exercise equipment to maintain crew fitness on long missions; diagnostic sensors for remote medical care; and models of human physiology to predict crew fatigue and injuries when performing extravehicular activities
	6 M USD	Exploration Capabilities Core Technology to continue building upon and advancing technologies that will foster a sustainable presence on the Moon and Mars and enable a lasting presence utilizing reusable systems
	4 M USD	Robotic Precursors to continue developing small robotic spacecraft and remote sensing instruments to search for lunar resources

5.2. Space Operations

Budget Authority (M USD)	FY 2022	FY 2023	FY 2024	2024 Request			
				FY 2025	FY 2026	FY 2027	FY 2028
Space Operations	3,974.9	4,250.0	4,534.6	4,625.3	4,717.8	4,812.2	4,908.4

5.3. Space Technology

Budget Authority (M USD)	FY 2022	FY 2023	FY 2024	2024 Request			
				FY 2025	FY 2026	FY 2027	FY 2028
Space Technology	1,100.0	1,200.0	1,391.6	1,419.4	1,447.8	1,476.8	1,506.3

5.4. Science

Budget Authority (M USD)	FY 2022	FY 2023	FY 2024	2024 Request			
				FY 2025	FY 2026	FY 2027	FY 2028
Science	7,610.9	7,795.0	8,260.8	8,426.0	8,594.5	8,766.4	8,941.7

U02 Canada

Title	Key Robotics Programs in Canada	
Region	Canada	
Issued by	National Research Council Canada Strategic Plan 2019-2024	A New Space Strategy for Canada
Announcement	February 2020	March 6, 2019
Term of validity	2019-2024	2019~
Budget		
Key words	National Research Council Canada (NRC) Strategic 2019-2024, Robotics, Canadarm3	
Related website	National Research Council Canada Strategic Plan 2019-2024	https://nrc.canada.ca/sites/default/files/2020-02/NRC-5yr-strategy-e.pdf
	A New Space Strategy for Canada	https://www.asc-csa.gc.ca/pdf/eng/publications/space-strategy-for-canada.pdf
	Canadarm3	https://www.asc-csa.gc.ca/eng/canadarm3/about.asp
Background	NRC Strategic 2019-2024: ◦ February, 2020, announcement of the NRC strategic plan for next five-year strategic plan from 2019 to 2024. ◦ Operating within the broad frame of the Government of Canada's Innovation and Skills Plan. ◦ Emerging science and cutting-edge innovations are rapidly redefining industry business models, research, lifestyles, community obligations, and societal needs, and the NRC must adapt to ensure the well-being of Canada and Canadians. A New Space Strategy for Canada: ◦ From pioneering satellite communications technologies to building the "Canadarm" and space-based radar systems, Canada has been making key contributions to space science and technology for over six decades. ◦ Canada's commitment to participating in the Lunar Gateway forms the cornerstone of Exploration, Imagination, Innovation: A New Space Strategy for Canada. ◦ On February 28, 2019, the Government of Canada announced an investment of 1.4 billion USD (1.9 billion CAD) over 24 years for the next generation of smart, AI-powered space robotics for the U.S.-led Lunar Gateway. ◦ Canada's space sector currently employs 10,000 highly skilled workers, generates 4.0 billion USD (5.5 billion CAD) in Canada's economy annually, and averages 1.5 billion USD (2 billion CAD) in export sales. Morgan Stanley expects the global space market to triple in size to 1.1 trillion USD (1.5 trillion CAD) by 2040	
Goal	NRC Strategic 2019-2024: ◦ To enhance three core roles: advancing scientific and technical knowledge; supporting business innovation; and providing science-based policy solutions for government. ◦ To adapt Canada's approach to tackle the world's most pressing challenges, such as climate change, aging populations and economic crises, and to capitalize on the opportunities presented by the digital economy and disruptive technologies. ◦ To reinforce Canada's research strengths, and better position Canada as a partner for new forms of collaboration with government, industry, and academia.	

	A New Space Strategy for Canada: ◦ Funding the development and demonstration of lunar science and technologies in fields that include AI, robotics and health. ◦ Investing in satellite communications technologies for broadband, including connectivity in rural and remote regions. ◦ Exploring how the delivery of healthcare services in isolated communities can be improved through lessons learned in space. ◦ Leveraging the unique data collected from Canada's space-based assets to grow businesses and conduct cutting-edge science, including about the impact of climate change on Earth's atmosphere.

Contents

1. Robotics Snapshot in Canada

In January 2023 Canadian Robotic Council released What We Heard Report outlining the strengths, weaknesses, opportunities, and threats as follows:

Strengths:	**Weaknesses:**
◦ Strong academia-industry collaboration has created a robust start-up community and talent pipeline ◦ Canada is well positioned in Agriculture and Healthcare segments ◦ Recently founded firms are strongly aligned with future trends	◦ Lack of domestic robotics customer base ◦ Lack of large businesses bottlenecks professionals with combined business/robotics experience ◦ Critical connections between robotics and other sectors remain unexplored or underpenetrated
Opportunities:	**Threats:**
◦ Robust start-up community offers opportunity to reshape industry landscape ◦ Growing opportunity for robotics within the logistics and transportation industry to relieve pain points created from supply chain disruptions ◦ Wider adoption of robotics is expected as recent workforce challenges is driving automation in new industries	◦ 105 of Canada’s firms are likely to see competitiveness decline due to pricing pressures/commoditization from China ◦ Proximity to the US, and lack of dedicated ‘scale up’ capital reduces industry scaling, as foreign acquisition capture domestic differentiated firms ◦ Public perception of robotics remains stuck in a ‘fear-mongering’ posture, significantly reducing uptake rate

(Canadian Robotics Council 2022 Symposium What We Heard Report)

2. Robotics Related Focus Area in the National Research Council Canada Strategic Plan 2019-2024

The NRC’s five areas of strategic focus

◦ To achieve these goals over the next five years, NRC has set a series of integrated, cross-NRC initiatives that leverage NRC’s strategic platforms and the work of NRC research centers, as well as a visionary “moonshot” that sets an ambitious but attainable goal for the future. NRC has identified five areas of strategic focus for the organization, in which one area (number 3) is related to robotics, which is described as follows:

◦ Focus area number 3: Innovating the everyday

Digitalization and artificial intelligence, robotics and automation, sensors and Wi-Fi are changing the everyday lives of Canadians, unlocking economic opportunity, and bringing faster communications links and the features of networked electronic life to remote communities. The NRC has significant expertise in digital and other technologies that touch the daily lives of Canadians.

◦ Strategies to accomplish goals

- Leverage current capabilities and develop new capabilities in cybersecurity, Internet of Things, and robotics
- Develop AI Design Cluster facility

- Support computer vision in advanced manufacturing
- Build collaboration centers in Montréal, Fredericton, Waterloo, and Toronto
- Leverage collaboration centers for DT programs and research goals
- Continue to build and maintain collaborations with other research centers and programs across the NRC
- Build and maintain excellence in digital technologies research through the AI for Design program, and research in multimedia analytic technologies and Canadian languages technologies
- Support government supercluster programs in digital technologies and AI

3. Robotic in a New Space Strategy for Canada

Canada will invest 1.4 billion USD (1.9 billion CAD) to develop and contribute an advanced, next-generation, AI-enabled deep-space robotic system. This smart robotic system will perform critical operations on the Gateway and support the deployment of science and technology experiments. It will consist of a large and small robotic arm to allow the system to walk end-over-end, traversing around the Gateway, and it will be highly autonomous, allowing it to make decisions and undertake operations without the presence of astronauts.

3.1.Canadarm3

Canadarm3 will be Canada's contribution to the US-led Gateway, a lunar outpost that will enable sustainable human exploration of the Moon. This robotic system will use cutting-edge software to perform some tasks around the Moon autonomously and without human intervention.

Robotic system components	Delivery date	Status	Budget
◦ A large, 8.5-metre-long arm ◦ A smaller, more dexterous arm ◦ A tool and on-orbit replaceable unit caddy	No earlier than 2029	In development	730 million USD (999.8 million CAD)

3.2.Rover

The Canadian rover will land on the south pole of the Moon. It will have an onboard suite of scientific payloads: several Canadian and one American. The rover will have the ability to:

- Drive into and operate inside of permanently shadowed regions for up to one hour
- Survive lunar nights, which can last up to 14 Earth days at less than −200 °C
- Use multiple modes of communications
- Maximize lunar surface operations and scientific data return
- Provide panoramic imagery and video of the lunar surface

Robotic system components	Delivery date	Status	Budget
◦ 4-wheel skid-steer system ◦ Lithium battery ◦ Stereo cameras for navigation ◦ Scientific payload	No earlier than 2026	In development	30.32 million USD (43 million CAD)

4.Other Key Project related to robotics in Canada over 3.6 million USD (Over 5 million CAD)

Project Title	Summary	Total Budget
Arrangement between the European Space Agency and the Government of Canada	**Agreement Date:** Jan 1, 2020 - Jan 1, 2030 **Description:** The European Exploration Envelope Program (E3P) is an optional program of the European Space Agency. E3P encompasses ESA's human and robotic space exploration activities, such as the operation and utilization of the International Space Station, selected space science activities, Moon and Mars missions and some associated technology development.	41.231 million USD (58.474 million CAD)

	Website: https://search.open.canada.ca/grants/record/csa-asc,003-2019-2020-Q3-00003,current	
ATTAscale	**Agreement Date**: Apr 15, 2020 - Mar 31, 2026 **Description:** This investment in research and development will further advance and test ATTAbotics' robotic warehouse technologies and support capacity expansion. Website: https://search.open.canada.ca/grants/record/ic,033-2020-2021-Q2-814598,current	23.974 million USD (34 million CAD)
Building a Robust Workforce Infrastructure with General Machine Intelligence	**Agreement Date:** Sep 1, 2021 - Sep 1, 2024 **Description:** his project will build a robotic workforce (General Purpose Robots) with various commercial applications such as labor and in industries such as healthcare and manufacturing Website: https://search.open.canada.ca/grants/record/ic,033-2022-2023-Q2-815594,current	21.153 million USD (30 million CAD)
Deploy & operate	**Agreement Date:** May 1, 2022 - May 31, 2024 **Description:** Build & Operate will create the software necessary to automate production using a number of third-party collaborative robots on manufacturing floors, including those of Fanuc, Doosan, Universal Robots, Kinova & Epson, allowing for a seamless transition of the robot from the simulated environment to the work environment (DEPLOY). Website: https://search.open.canada.ca/grants/record/nrc-cnrc,172-2022-2023-Q4-997979,current	5.429 million USD (7.7 million CAD)
Next-Generation Autonomous Robotic Cleaning Systems Platform	**Agreement Date:** Aug 1, 2023 - Sep 30, 2024 **Description:** IRAP support will help us create a new generation of hardware and software technology platforms which can be applied to an autonomous multi-robot fleet as independent modules. These modules will enhance R&D timelines for future robotic devices and open our products to more markets. website: https://search.open.canada.ca/grants/record/nrc-cnrc,172-2023-2024-Q4-1011615,current	4.239 million USD (6.013 million CAD)
Project Envol	**Agreement Date:** Aug 15, 2021 - Mar 31, 2034 **Description:** This project aims to commercialize an innovative process that optimizes and automates the production of black soldier flies by using new harvesting methods, a customized optical sorter, robotic conveyors and a vertical storage system. Website: https://search.open.canada.ca/grants/record/aafc-aac,235-2021-2022-Q4-00103,current	4.23 million USD (6.0 million CAD)
New Robotic Platform for	**Agreement Date:** Sep 18, 2023 - Mar 31, 2026 **Description:** The development and deployment of robotic solutions remain a major challenge for most companies,	3.948 million USD

Medical Purpose ◦	regardless of the markets. Kinova intends to address this challenge by developing a modular robotic platform called the Link Platform. This new platform will build on the success of the Kinova Link 6 Cobot and evolve towards a multipurpose modular platform. Website: https://search.open.canada.ca/grants/record/nrc-cnrc,172-2023-2024-Q4-1012709,current	(5.6 million CAD)	

Appendix

A01 China

"The 14th Five-Year Plan" for Robot Industry Development

Contents

Robotics is known as the "crown jewel of manufacturing", and its R&D, manufacturing and application are important symbols of a country's technological innovation and high-end manufacturing level. At present, the robot industry is booming and greatly changing the way of production and life styles of human beings, providing a powerful driving force for our economic and social development. In order to accelerate the high-quality development of the robot industry, this plan is formulated in accordance with the *14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of the Vision 2035*.

I. Current Situations

Since the "13th Five-Year Plan", through continuous innovation and deepened application, China's robot industry has shown a good development momentum. With the rapid growth of the industry, the average annual compound growth rate reached about 15%, and the revenue of the robot industry exceeded 100 billion yuan in 2020 with an output of industrial robots of 212,000 units (sets). Breakthroughs have been made in a faster way in motion control, high-performance servo drives and high precision reducers to continuously improve the technical level, and significant improvement has been made in overall machine functions and performance. The integrated applications have been greatly expanded. In 2020, the robot density in the manufacturing industry reached 246 units/10,000 people, which is nearly twice of the average level of the world. Service robots and special robots have been widely used in such fields of logistics, education, entertainment, housekeeping, security and health-care.

At present, the new round of technological revolution and industrial transformation has been accelerated, the new generation information technologies, biological technologies, new energies and new materials have been deeply integrated with robot technologies, and the robot industry has witnessed a window for updating and leapfrog development. The world's major Industrially developed countries have taken robot industry as the frontier and focus of their technologies and have sped up the arrangement for the industry. China has started its high-quality development to build a modern economic system and create better lives for its people, urgently requiring the support from emerging industries and technologies.

Robots, as the important carriers of new technologies and key equipment for modern industries, will guide the digital development and intelligent updating of the industries to constantly create new industries, models and patterns. As important tools for production and lives of human beings and helpful assistants for the aged, robots could improve the production and living standards, so as to promote the sustainable social and economic development.

In front of new situation and requirements, the next five years or even a longer period will be a strategic period for China's robot industry to become self-sustaining and to move to the next generation. We must seize the opportunity to meet the challenges and solve the issues related to insufficient technical accumulation, weak industrial foundation and shortage of high-end product supply, so as to promote our robot industry to the mid- and high-end stages.

II. General Requirements

(I) Guiding Ideology

Guided by Xi Jinping's thought of socialism with Chinese characteristics in the new era, we shall fully follow the spirit of the 19th CPC National Congress and the 2nd, 3rd, 4th, 5th and 6th Plenary Sessions of the 19th CPC Central Committee based on the new development stage, realize the new development concept in a complete, accurate and comprehensive way, build a new development pattern, coordinate development and security, take the high-end intelligent development as the orientation, meet the industrial transformation and consumer upgrading needs, adhere to the principle of "innovation-driving, application-driving, basic upgrading and integrated development", focus on making breakthroughs in core technologies, strive to consolidate industrial foundation and enhance effective supply, expand market applications, improve the stability and competitiveness of the industrial chain supply chain, continue to improve the industrial development ecology, promote the high-quality development of the robot industry, so as to provide strong support for building a strong manufacturing country and a healthy China and creating a better lives for the people

(II) Development Objectives

By 2025, China will develop into the source of the global robot technology innovations, the concentration land for high-end manufacturing processes and the new highland for integrated applications of robots. Breakthroughs shall be made in a number of core robot technologies and high-end products, the comprehensive performances of complete robots shall reach the leading level in the world and the performances and reliability of key parts shall reach the level of the similar products in the world. The average annual growth rate of operating income of the robot industry shall surpass 20%. A group of leading enterprises with international competitiveness shall be established, a great number of specialized and new "little giant" enterprises with great innovation capacity and growth potential shall be built, and 3-5 industrial clusters with international influence shall be created. The density of manufacturing robots shall be doubled.

By 2035, the comprehensive strength of China's robot industry shall reach a leading international level, and robots shall become an important part of economic development, people's lives, and social governance.

III. Main Tasks

(I) Improve industrial innovation capacity

Efforts for overcoming difficulties in core technology R&D shall be strengthened. Focus shall be placed on national strategies and industrial development needs to make breakthroughs in robot system development, operating systems and other common technologies. The development trend of robot technologies shall be understood to research and develop such cutting-edge technologies as bionic perception and cognition and bio-mechanical-electric fusion. The integration and applications of new technologies such as AI, 5G, big data and cloud computing shall be promoted to improve robot intelligence and networking, and strengthen functional security, network security and data security.

An innovation system shall be established and improved. The functions of key robot laboratories, engineering (technology) research centers, innovation centers and other R&D institutions shall be fully used to strengthen the researches on cutting-edge and common technologies, speed up the transfer and transformation of innovative achievements, and build an effective industrial technology innovation chain. Backbone enterprises shall be encouraged to jointly carry out collaborative robot R&D projects, promote standardization and modularization of software and hardware systems and improve the efficiency of new product development. Enterprises shall be supported to strengthen the construction of technology centers to develop key technologies and application technologies.

Column 1 Action of Overcoming Core Robot Technology Difficulties

01 Common Technologies

Robot system development technology, robot modularization and reconfiguration technology, robot operating system technology, robot lightweight design technology, information perception and navigation technology, multi-task planning and intelligent control technology, human-robot interaction and autonomous programming technology, robot cloud-edge-end technology, robot safety and reliability technology, rapid calibration and precision maintenance technology, multi-robot cooperative operation technology, robot self-diagnosis technology and robot self-diagnosis technology.

02 Cutting-edge Technologies

Robot bionic perception and cognition technology, electronic skin technology, robot bio-mechanical-electrical fusion technology, human-robot natural interaction technology, emotion recognition technology, skill learning and developmental evolution technology, material structure function integration technology, micro-nano operation technology, soft body robot technology, robot cluster technology, etc.

(II) Consolidate the foundation for industrial development

The shortcomings of industrial development shall be made up. Joint efforts among production, academic and research institutions shall be promoted to make up for the shortcomings of special materials, core components and processing technologies, to improve the functionality, performance and reliability of key robot components, to develop robot control software and core algorithms, and to improve the functionality and intelligence of robot control systems.

The standard system shall be further constructed. A national robot standardization organization shall be built to better play the role of the national technical standard innovation base (robotics) in innovating technical standards, and continue to promote robot standardization. A sound robot standard system shall be established to accelerate the research and formation of standards that are urgently needed, revise the standards related to robot functions, performances and safety, and strengthen the transformation of scientific and technological achievements to standards and the applications and promotion of the standards. International standardization work shall be actively participated in.

Testing and certification capabilities shall be improved. Enterprises shall be encouraged to strengthen their testing and certification capacities to consolidate product testing and improve quality and reliability of products. The testing capabilities of the robot testing and assessment center shall be improved to meet the needs of enterprises for testing and certification services. The construction of China's robot certification system shall be promoted.

Column 2 Action of Improving Key Robot Foundation

01 High Performance Reducer

Advanced manufacturing technologies and techniques for RV reducers and harmonic reducers shall be developed to improve the accuracy retention (life) and reliability of reducers, reduce noise, and achieve mass production. The basic theories of new high-performance precision gear transmission devices shall be researched to make breakthroughs in precision/super-precision manufacturing technologies and assembly processes, and develop new high-performance precision reducers.

02 High Performance Servo Drive System

High-performance servo drive controls, servo motor structure design, manufacturing processes, self-tuning and other technologies, the development of high-precision, high-power density robot-specific servo motors and high-performance motor brakes and other core components shall be optimized.

03 Smart Controller

Controller hardware system with high real-time function, high reliability, multi-processor parallel working capacity or multi-core processor shall be developed to realize standardization, modularization and networking. Breakthroughs shall be made in multi-joint high-precision motion solving, motion control and intelligent motion planning algorithms to improve the intelligence of the control systems as well as safety, reliability and ease of use.

04 Intelligent Integrated Joint

Modular robot joints integrating mechanism/drive/perception/control shall be developed, and servo motor drive, high-precision harmonic drive dynamic compensation, high-precision real-time data fusion of composite sensors, modular integration and other technologies shall be researched to achieve high-speed real-time communication, joint force/torque protection and other functions.

05 New Sensors

Products such as 3D vision sensors, 6D force sensors and joint torque sensors and other force sensors, large view single- and multi-line LIDARs, intelligent hearing sensors and high-precision encoders shall be developed to meet the intelligent development needs of robots.

06 Intelligent End Actuators

Efforts shall be made to develop the end actuators for intelligent picking, flexible assembly and rapid switching to meet the diversified robot operation needs.

(III) Increase the supply of high-end products

For the manufacturing, mining, construction, agriculture and other industries as well as the needs for home services, public services, medical and health care, assistance for the elderly and disabled and special environment operations, advantageous resources shall be concentrated to promote the R&D and applications of industrial robots, service robots and special robots, expand the robot product series and improve the performance, quality and safety of robot, so as to promote the high-end intelligent development of the products.

Column 3 Action of Developing Innovative Robot Products
01 Industrial Robots Efforts shall be made to develop high-precision and high-reliability welding robots for automotive, aerospace, rail transit and other fields; vacuum (cleaning) robots for automatic handling, intelligent movement and storage for the semiconductor industry; robots with explosion-proof function for the production of civil explosives; AGVs and unmanned forklifts; logistics robots for sorting and packaging operations; large-load, lightweight, flexible, dual-arm, mobile and other collaborative robots for 3C, automotive parts and other fields; and mobile operation robots that can move anywhere in the work areas for transfer, grinding and assembly, achieve any position and attitude in space, and have flexible gripping and operating capabilities.
02 Service Robots Efforts shall be made to develop robots for orchard weeding, precision plant protection, fruit and vegetable pruning, picking, harvesting and sorting; agricultural robots for livestock and poultry breeding such as feeding, inspection, silt removal, netting attachment and disinfection; mining robots for extraction, support, drilling, inspection and heavy-duty auxiliary transport operations; construction robots for intelligent production of building components, measurement, material distribution, steel processing, concrete pouring, floor and wall decoration, component installation and welding operations; medical rehabilitation robots for surgery, nursing, examination, rehabilitation, consultation and distribution; elderly assistance robots for walking aid, bathing aid, article delivery, emotional companionship and intelligent prosthesis; home service robots for housekeeping, education, entertainment, and security; and public service robots for interpretive guides, catering, delivery, and mobility.
03 Special Robots Efforts shall be made to develop robots for underwater exploration, monitoring, operation and deep-sea mineral resources development; security robots for security patrol, anti-smuggling security inspection, anti-riot, investigation and evidence collection, traffic management, border management and security control; robots for operations under dangerous conditions such as firefighting, emergency rescue, safety inspection, nuclear industry operation and marine fishing; and health and epidemic prevention robots for test sampling, disinfection and cleaning, indoor distribution, auxiliary lifting, auxiliary rounding and checking, and critical care auxiliary operations.

(IV) Expand the depth and breadth of applications

Users and robot enterprises are encouraged to jointly carry out technical testing and verification, support the implementation of key components verification of robot machine enterprises and enhance the testing and verification capabilities of public technical service platforms. Robot system integrator shall be encouraged to focus on specific scenarios and production processes in breakdown fields, and develop advanced and applicable system solutions that are easy to promote. The establishment of a robot application promotion platform shall be supported to ensure the accurate matchmaking between production and demand. The development of robot application scenarios and product demonstration and promotion shall be promoted. The development of robot access standards, product certification or registration in the fields of medical care, elderly care, power supply, mining, and construction shall be accelerated. Enterprises are encouraged to establish product experience centers to accelerate the promotion of robots for home services, education, entertainment, interpretive guides, delivery, catering and other applications. New rental service platforms shall be explored and established to encourage the development of new business models such as intelligent cloud services.

Column 4 Action of “Robots +” Application

01 Deep Development of Industrial Applications

In the fields with larger-scale applications, such as automotive, electronics, machinery, light industry, textiles, building materials, medicine, public services, warehousing and logistics, intelligent home, education and entertainment, focus shall be placed on developing and promoting new robot products to develop high-end application market, and promote intelligent manufacturing and life.

02 Expansion of Emerging Applications

In the fields with initial applications and potential demands, such as mining, petroleum, chemical, agriculture, electric power, construction, aviation, aerospace, shipping, railroads, nuclear industry, ports, public safety, emergency rescue, medical rehabilitation and elderly & disabled assistance, robot products and solutions shall be developed based on specific scenarios to carry out pilot demonstrations and expand application space.

03 Strengthen Special Applications

In specific subdivision scenarios, links and fields, such as sanitary ware, ceramics, photovoltaic, smelting, casting, sheet metal, hardware and furniture, key links such as glazing, fettling, polishing, grinding, welding, spraying, handling and palletizing, specialized and customized solutions shall be formed and replicated to create special service brands and form new competitive advantages.

(V) Optimize the industrial organization structure

High-quality enterprises shall be developed. Backbone enterprises shall be encouraged to use mergers and acquisitions, joint ventures and other ways to develop ecologically dominant robot enterprises with core competitiveness. Enterprises shall be encouraged to develop subdivision industries and strengthen their specialized and differentiated development in the complete robots, parts and system integration to create a number of specialized new “little giant” enterprises and single champion enterprises.

Promote the efforts to improve, strengthen and stabilize chains. Backbone enterprises shall be encouraged to focus on weak links such as key parts and high-end complete products to work with supporting enterprises to accelerate the R&D of precision gears, lubricants, coders, core software, engineering verification, iteration and updating. The collaborative innovations throughout the upstream, midstream and downstream of the industrial chain shall be supported to integrate the development of small, medium and large enterprises and build a good industrial ecology. International industrial security cooperation shall be strengthened to promote diversification of the supply chain of the robot industry.

Clusters with special advantages shall be created. A reasonable regional layout shall be promoted to guide resources and innovation factors to areas with good industrial base and high development potential, and cultivate advantageous clusters with strong innovation capability and good industrial environment. The clusters shall be supported to strengthen technological innovations, focus on subdivision fields, provide specialized robot products and system solutions, improve public services such as technology transformation, inspection and testing, talent training, and develop special cluster brands.

IV. Safeguarding Measures

(I) Strengthen the coordination and coordinate the promotion

The resources and strength of departments for industry management, science and technology, finance, and other functions shall be coordinated to strengthen policy synergy with users and support the innovative development of the robot industry. Local governments shall be encouraged to develop targeted policies and measures to coordinate and solve major problems in the robot industry, and guide the enterprises to do a good job in safe production and environmental protection. The bridging function of industry associations and intermediary organizations shall be used to strengthen the dynamic monitoring of the robot industry, timely feedback on the implementation of the planning process and put forward proposals.

(II) Increase fiscal and financial support

The supports from major national science and technology projects and key national R&D programs for the development and application of robots shall be strengthened. The pilot work for insurance compensation mechanism for first (set) major technical equipment shall be optimized to fully play the purchasing role of governments and promote the applications of innovative robot products. Tax policies for R&D expense credits shall be implemented. The active inputs of various industrial funds shall be promoted to support the eligible enterprises to be listed. Cities with production-finance cooperation shall be encouraged to increase the inputs in the robot industry. Financial institutions shall be guided to innovate service modes for financing based on receivables and supply chain.

(III) Create a good market environment

The *Specification and Conditions for Industrial Robots* shall be improved to improve the implementation and adoption of robots. The third-party testing and certification institutions shall be supported to build their capacities to improve their market recognition and international influence. The protection of intellectual property rights shall be strengthened and the punishment for intellectual property infringements shall be increased. Market bidding procurement activities shall be regulated to prohibit any discriminatory terms. Research on robot ethics and laws and regulations shall be carried out.

(IV) Improve the talent guarantee system

The training of robot science and technology talents shall be strengthened to support universities and research institutes to develop high-end professional, technical and composite talents. The new engineering majors shall be promoted to encourage universities and enterprises to jointly conduct education programs, develop a group of modern industrial colleges, promote order cultivation and modern apprenticeship systems, and develop the talents badly needed by the industry. Vocational skill upgrading action shall be carried out to support enterprises to provide their employees with skill improvement and job transfer training. Supports shall be provided to hold various robot competitions. Science publicity efforts shall be made to improve the robot qualities of the youth.

(V) Deepen international exchange and cooperation

Enterprises, academic institutions and industrial organizations shall be encouraged to carry out international exchanges in technologies, standards, testing certification, intelligent properties and talent development. Foreign enterprises and institutions shall be encouraged to establish R&D facilities and education centers in China. Domestic enterprises shall be supported to establish R&D organizations in developed countries to strengthen international technical cooperation and accelerate the promotion of our robots in international markets. The multi-bilateral cooperation mechanisms shall be fully used to promote the "going out" of our robot products and solutions and achieve win-win cooperation.

Declaration Guidelines

for 2024 Key Special Project of "Intelligent Robotics"

In order to implement national science and technology innovation systems during the 14th Five-Year Plan, the Intelligent Robots Key Special Project under the national key research and development program has been launched. Following the arrangement of the implementation program for this key special project, we are now releasing the Project Declaration Guidelines for 2024.

The overall objectives of this special key project are: to build an intelligent robot technology system suitable for China's national conditions, promote continuous innovation of technology and products, realize the advanced industrial chain, high-end products and system applications, promote the high-quality development of China's robot technology and industry, and support the independent development of the main fields of the national economy, the country's major needs, people's life and health, and other related industries.

Adhering to the principles of problem orientation, step-by-step implementation and focus, the 2024 guideline release focuses on 5 technological directions, including fundamental frontier technologies, common key technologies, industrial robots, service robots and special robots, and proposes to launch 36 guideline tasks according to the three levels of basic research, common key technologies and application demonstration, and allocates RMB 324 million in government funds. Among them, focusing on the direction of fundamental frontier technologies, it is proposed to deploy 2 guide tasks for young scientists, and to arrange government funding of 12 million yuan in total with 2 million yuan for each project. Unless otherwise specified, the ratio of matching funds to government support funds for Common Key Technology projects should be no less than 2:1, and the ratio for demonstration projects applied under the leadership of enterprises should be no less than 3:1.

The projects will be uniformly declared according to the research directions under the secondary headings (e.g. 1.1) of the guidelines Except in special cases, each guideline task is intended to support one project at a time, with an implementation period of not more than 3 years. The research content of the submitted projects must include all research content and evaluation indicators listed in the secondary headings in the guidelines. The number of topics for the basic research projects cannot exceed 4 and the total number of projects for each participating unit cannot exceed 5; the number of topics for the common key technology and application demonstration projects cannot exceed 5 and the total number of projects for project participating organizations cannot exceed 8. Each project has a project leader, and each topic within the project has a topic leader.

It is not required that the Young Scientist Project to fully cover the content of the guidelines, and no topic is required under such project. The total number of participating units in the project shall not exceed three. The project has a project leader born on or after January 1, 1984, and in general, the age restrictions for other team members are the same as above.

1. Fundamental Frontier Technologies

1.1 Flexible Electronic Robot with Multimodal Motion (Basic Research Category)

Research content: In response to the demand for dynamic large-deformation monitoring of large engineering structures and equipment surfaces in harsh underwater environments, this project will study the fundamental theory of trans-domain multimodal adhesive mobile flexible electronic robots, and research key technologies such as "drive-sense-control" integrated flexible circuits suitable for high-frequency vibration and large-deformation surfaces, as well as intelligent control of the robot's non-destructive attachment and directed movement on complex engineering surfaces. The project will also develop trans-domain multimodal adhesive mobile flexible electronic robots that enable flexible deployment across water/air domains, conduct research on experimental methods and test capabilities, and verify the results.

Evaluation index: Develop a large deformation flexible electronic robot system that can measure physical quantities such as stress/strain, acceleration, etc. The deformation rate of the flexible sensing part shall be ≥500%, and the vibration frequency that can be measured shall be ≥50 Hz; the robot as a whole can pass through a narrow slot <1 cm, and the moving speed of the attached robot is ≥0.5 cm/s; realize the deployment of the flexible electronic robot on the surface and underwater, with the attachment and detachment time ≤1 s, the surface roughness ≥500μm, and the ability to stably attach in an environment with the wave height of 2m and the current of 1m/s. Complete flexible deployment of water/air multidomain sensors and apply experimental verification. At least 2 key technologies shall be invented or reach the international leading level, and supporting materials shall be provided; and no less than 5 invention patents shall be applied/authorized.

Keywords: flexible electronics, multimodal motion robots, cross domain adhesion motion, intelligent control

1.2 Generative Artificial Intelligence-Driven Robot Swarm 3D Environment Collaborative Exploration (Basic Research Category)

Research content: In response to the demand for intelligent collaborative exploration by robot swarms in complex and unknown three-dimensional dynamic environments in the field, this project aims to study the construction, training, optimization, and real-time engineering of generative artificial intelligence models for collaborative task planning in robot swarms, as well as the development of embodied intelligent theoretical methods for exploring unknown environments with safety and trustworthiness that can be generalized. It also includes the research and development of low-latency/jam-resistant lightweight communication modules and dedicated communication mechanisms for sharing three-dimensional environmental data among the robot swarm, as well as the design of human-machine friendly interaction interfaces and efficient command and control technologies. The project aims to develop a robot swarm collaborative exploration system driven by generative artificial intelligence, conduct experimental verification in scenarios such as field search and rescue, and achieve improvements in collaborative exploration efficiency and general multitask support capabilities.

Evaluation index: The scale of 3D exploration field test cluster should be not less than 20 units, the success rate of complex scene collaborative exploration should be not less than 95%, the success rate of task reasoning should be not less than 85%, the number of generalizable scenarios should be not less than 100, the average collision number of embodied navigation models per 1000 meters should be less than 3 times, the 3D environment reconstruction error within a 1000 cubic meter area under satellite navigation jamming conditions should be less than 10 cm, The weight of the communication module should not be more than 200 g, the bandwidth in mountainous and forest areas with no line-of-sight of 2 km should be not less than 10 Mbps, the radio frequency used should comply with the national radio management regulations, and the number of voice and other human-friendly interaction modes should be not less than 4, and the cluster system should have the ability to operate autonomously after the instruction. The 3D environment exploration technology of the cluster should reach the international leading level in terms of collaborative exploration efficiency, general multi-tasking support capability, and provide supporting materials. Apply for not less than 5 invention patents.

Keywords: Generative AI, robot swarms, intelligent collaborative exploration, cluster-friendly interaction, embodied intelligence.

1.3 Wearable Immersive Haptic Feedback Interactive System for Human-Machine Interaction (Basic Research Category)

Research content: In response to the low density and poor wearability of existing haptic feedback systems, this study investigates the high-frequency haptic feedback mechanism and the fusion mechanism of multimodal haptic sensing. It also studies the integrated design method of high-density active haptic feedback drive array and user-friendly mechanical interface, and key technologies such as haptic encoding and bidirectional human-machine interaction based on haptic feedback array and bio-interface. A wearable immersive haptic feedback human-machine interaction system integrating haptic perception, feedback, and active control will be developed and experimentally verified.

Evaluation index: Develop at least two active haptic feedback drive devices with a natural frequency ≥ 600 Hz and a power density ≥ 1,000 W/kg; The spatial resolution of the wearable haptic feedback system should be ≤8 mm, and the array size should be ≥ 30, with a maximum output force of at least 100 mN, and the operating bandwidth should be not less than 300 Hz; Realize at least 10 categories of haptic perception behavior recognition, including dynamic force, sliding direction, etc., with an accuracy rate of not less than 90%; Have biological interface such as electromyography (EMG) and bidirectional haptic information transmission with the haptic feedback system, with a human-machine interface, with an accuracy rate of not less than 90%; have a biological interface such as electromyography (EMG) and bidirectional haptic information transmission with the haptic feedback system, with a human-machine interaction delay of not more than 1 second; complete at least two typical application scenarios. At least 2 key technologies shall be invented or reach the international leading level, and supporting materials shall be provided; and no less than 5 invention patents shall be applied/authorized.

Keywords: Active haptic feedback drive, dynamic tactile information encoding, multimodal tactile sensing skin, human-computer interaction interface

1.4 Embodied Perspective on the Generation and Evolution of Universal Robot Behaviors (Basic Research Category)

Research content: In response to the demand for complex task skills and general autonomous behaviors for robots in dynamic open scenes, this research investigates the cognitive mechanisms of human-like embodied behavior development and imitation learning, the neural decision mechanisms for generating general behaviors, the knowledge representation and reasoning methods for task skills and embodied behaviors, and the construction of a multimodal embodied behavior data set. It also develops a large-scale robot universal behavior generation model and a highly realistic interactive robot behavior simulation platform to support efficient training, virtual-to-real transfer, and generalization of embodied behaviors, and to achieve embodied behavior learning and development capabilities that integrate perception, planning, and execution. Demonstrate and verify typical scenarios using physical robots as the platform.

Evaluation index: Develop a novel brain-inspired decision mechanism model with originality, construct a knowledge graph and inference framework for tasks and behaviors, and build a first-person multimodal behavioral dataset (≥10,000 hours, ≥10 categories of scenarios, ≥5 categories of behaviors, ≥30 types of job skills); the behavior generation generative model can generate ≥30 types of job skills, the generation and execution response time is ≤0.5s, the accuracy rate of known type behavior generation is ≥95%, and the accuracy rate of unknown type behavior generation is ≥75%; the interactive robot simulation platform covers ≥ 5 types of machine-human models, the simulation accuracy for tasks and behaviors is not less than 95%, and the concurrent support for real-time simulation environment is not less than 10, and at least 5 typical scenarios in the fields of medical care and rehabilitation, agile housekeeping, flexible assembly operations are used for experimental verification, with a task success rate of ≥95% and a robot action execution error rate of ≤5%. At least 2 key technologies are achieved for the first time or reach the international leading level in similar technologies, and supporting materials are provided; apply for not less than 5 invention patents.

Keywords: skill learning, embodied behavior development, generative behavior models, imitation learning, robot behavior simulation platform

1.5 Intelligent-Driven Integrated Bionic Robot Theory and Method (Basic Research Category)

Research content: In response to the shortcomings of traditional silicon-based intelligent and electromechanical drive in robot decision-making and execution, this project aims to promote embodied intelligence from artificial circuits to life-essential closed-loop systems, explore the embodied intelligent generation paradigm of life-like robots, study the principles and technologies of intelligent drive integration to build life-like robots, develop biomechanical hybrid tissue fabrication and life-support technologies for large-scale tissue culture, research high-throughput bidirectional interactive 3D bioelectric interface devices, study information interaction and intelligent drive closed-loop control methods of brain-like intelligent drive-integrated robots, and develop a life-fusion robot system platform based on biological neural networks and life-like drivers. Develop an intelligent-driven integrated life-like robot with the principle of integration and carry out experimental verification in typical tasks.

Evaluation index: Develop a prototype of an intelligent controlled hybrid life-like robot; Cultivate a large-scale life-like actuator with a volume of not less than 0. 5 cm^3, including a tree-like structure of a blood vessel network with a pumpable diameter of 100 micrometers (main trunk) - 10 micrometers (branches); have at least 128 three-dimensional neural electrode points; achieve at least 2 types of robot actions, including crawling and swimming, and complete closed-loop control verification for autonomous obstacle avoidance navigation, with the accuracy of life-like intelligent control decision based on brain-like organs not less than 90%, and the accuracy of life-like actuator task completion not less than 80%. At least 2 key technologies shall be invented or reach the international leading level, and supporting materials shall be provided; and no less than 5 invention patents shall be applied/authorized.

Keywords: life-like robot, 3D vital interface, closed-loop control, embodied intelligence

1.6 Intelligent Microbot Technology with Sensing and Actuation Integration (Basic Research Category)

Research content: In response to the needs of miniaturization, intelligence, and integration of robots, research on in situ micro-sensing technologies for various physical and biochemical information, sub-millimeter precision driving and micromanipulation technologies, and microchip technologies for wireless communication, control, and power transfer for sub-millimeter robots; Develop single-unit integrated sensor-drive-control systems for sub-millimeter robots, achieve intelligent closed-loop control, signal readout, and wireless control functions based on microchips, and conduct experimental verification in typical cell sensing and manipulation scenarios.

Evaluation index: Develop an integrated sub-micron robotic unit with sensing, actuation, and control functions; the sensor size is less than 500 microns, integrating at least three typical sensing elements such as force sensors, chemical sensors, and electrophysiological sensors, with a sensing error ≤ 10%; the micromanipulation element size is less than 800 microns, with a motion control accuracy of better than 5 μm, an output force ≥ 1 mN, and the ability to perform at least 3 typical micromanipulation and stimulation methods on cells; the chip area (including the antenna) is not more than 1 mm^2, with an upward wireless communication data rate ≥ 10 kbps and a downward wireless communication data rate ≥ 100 bps, with a communication and power supply distance ≥ 5 mm, with a wireless power gain ≥ -40 dB, and the radio frequency used should comply with national radio management regulations; the micromanipulator is ≥ 5 mm from the external control device and can autonomously complete sensing, control, and operation, with a control feedback response time ≤ 5s and a steady-state error ≤ 10%; the total volume of the robot is less than 1 mm^3, and its sensing, driving, and control functions are verified on a cell chip; at least two key technologies are achieved through original innovation or reach the international leading level in similar technologies, and supporting materials are provided; at least 5 invention patents are applied for.

Keywords: sub-micron robots, sensor control integration, micro-actuators

1.7 Highly Flexible and Adaptive Humanoid Walking Robot Design Theory (Basic Research Category)

Research content: In response to the problems of poor mobility and low driving and transmission efficiency in traditional humanoid robots, this study aims to research the design method of high-flexibility and adaptive humanoid walking robots, the mechanism of low-energy movement based on human leg and foot skeletal muscle mechanics, and the key technologies of biomimetic flexible joint design based on human anatomy and morphology, high-performance driving and power transmission based on human muscle, and self-adaptive learning of rigid-flexible coupling systems. The goal is to develop and experimentally verify a highly flexible and adaptive humanoid walking robot with natural motion, low energy consumption, and strong adaptability.

Evaluation index: Develop a highly flexible and adaptive humanoid walking robot system that can maintain a normal walking speed continuously on flat, uneven, uphill, and downhill roads under various conditions, and can adapt autonomously between different road conditions. The single joint should have at least 4 degrees of freedom, the ankle-knee-hip single leg should have at least 12 degrees of freedom, and the degree of similarity between the freedom of movement and the trajectory of each degree of freedom and the human body should be 80% or more. Each joint should have a flexible mechanical property with variable stiffness in each degree of freedom, and the stiffness ratio of each degree of freedom should be more than 5; the maximum load of a single artificial muscle driving unit should be not less than 30 kg, and the contraction frequency should be not less than 2 Hz; the leg length range should be 0.8 to 1.1 m, the walking speed should be not less than 5 km/h, and the energy consumption CoT on flat roads should be no more than $1J \cdot kg^{-1} \cdot m^{-1}$, which is 50% or more lower than that of the existing representative humanoid robots. At least 2 key frontier technologies shall be invented or reach the international leading level, and supporting materials shall be provided; and no less than 5 invention patents shall be applied/authorized.

Keywords: Humanoid walking, skeletal muscle flexibility system, low-energy motion

1.8 Human-like Robotic System Based on Human Anatomy and Neurophysiology (Basic Research Type)

Research content: In response to the need for high-precision operation and efficient, safe human-robot collaboration in complex general-purpose scenarios, this research will investigate a new type of actuator that mimics the dynamic characteristics of human muscles, develop a lightweight robot system with a skeletal structure similar to that of the human body, investigate neural-inspired operation strategies and multi-muscle coordinated control methods for robot tasks involving muscle-skeletal systems, and investigate neural-inspired multimodal sensory cognition and empathetic decision-making methods for safe and efficient robot-human collaboration tasks. This research will also build and experimentally verify a human-like robotic system with skeletal structure, sensory cognition, decision-making, and muscle control mechanisms.

Evaluation index: Develop a muscle-like actuator with a power density of more than 150 W/kg, a force control accuracy of more than ±0.5 N, and dynamic characteristics similar to biological muscles; develop a lightweight humanoid musculoskeletal robot arm with a single-arm load-to-weight ratio of more than 1.5, a repeat positioning accuracy of more than 5 mm, no fewer than 28 degrees of freedom, no fewer than 31 actuators, a length of more than 0.65 m, and a weight of no more than 1. 5 kg; complete assembly tasks with part tolerances of 1/5 or less of the repeat positioning accuracy; achieve a recognition accuracy of 98% or more for multimodal signal-based emotional recognition; complete human-robot collaboration tasks based on intention prediction, emotional understanding, and empathetic decision making, improving the speed of completion of human-robot collaboration tasks by 20% or more; build a user evaluation scale for human-robot collaboration, improving the user's overall satisfaction with the safety, efficiency, etc. Build a user evaluation scale for human-robot collaboration that improves the user's overall satisfaction with the safety, efficiency, etc. of collaboration by 30% or more; make at least 2 breakthroughs in key technologies or achieve international leadership in similar technologies and provide supporting materials; apply for at least 5 invention patents.

Keywords: Musculoskeletal System, Multi-Muscle Motion Control, Humanoid Operations

1.9 New Concept Robots in Artificial Intelligence (Basic Research Category, Young Scientist Project)

Research Content: In response to the trends in disciplines such as large models, generative artificial intelligence, embodied intelligence, and brain-inspired intelligence, this project aims to explore new principles, methods, and forms by integrating information, mechanical, and sensor technologies with robotics. The goal is to improve the robot's information fusion perception ability, intelligent decision making ability, task execution ability, or environmental adaptation ability, and to develop innovative designs for new concept robots with artificial intelligence.

Evaluation index: Develop a prototype of a new concept artificial intelligence robotic system with originality, demonstrate and verify its potential applications in relevant important fields, and design specific task objectives and system evaluation criteria for the submitted project. Compared to existing technologies in the field, at least one single technology has a breakthrough innovation in improving the robot's information fusion perception ability, intelligent decision making ability, task execution ability, or environmental adaptation ability. At least 5 high-level academic papers should be published, and at least 5 invention patents should be applied for.

Note: The number of projects to be supported is 3.

Keywords: artificial intelligence, new concept robots

1.10 Multi-mode New Concept Robotics (Basic Research Category, Young Scientist Project)

Research Content: Focusing on the international academic frontier of multi-mode robots, this research integrates physics, chemistry, materials, life sciences, and robotics from various disciplines to study new principles, methods, and forms that can enhance a robot's environmental adaptation ability, task execution ability, or intelligent decision-making ability through structural evolution, morphological transformation, and mechanical intelligence. The goal is to achieve innovative design of multi-mode new concept robots.

Evaluation index: Develop a prototype of a multi-mode new concept robotic system with originality, demonstrate and verify its potential applications in relevant important fields, and design specific task objectives and system evaluation criteria for the submitted project. Compared to existing technologies in the field, at least one single technology has a breakthrough innovation in improving the robot's environmental adaptability, task performance, or intelligent decision-making ability: at least 5 high-level academic papers have been published, and at least 5 invention patents shall be filed.

Note: The number of projects to be supported is 3.

Keywords: Multi-Mode, New Concept Robot

2. Common Key Technology

2.1 High-Force-to-Weight Ratio Integrated Linear Servo Joint (Common Key Technology Category)

Research content: In response to the urgent need for highly integrated high-force-to-weight ratio linear servo joints in areas such as humanoid robots and mechanical arms, this project aims to solve the design, manufacturing, and control challenges of high-force-to-weight ratio linear servo joints by conducting research on multi-material lightweight integrated and topology optimization design, high-precision high-frequency force-position hybrid control with multi-sensor fusion, high-reliability manufacturing of high-speed and heavy-duty friction pairs with wear resistance, fatigue resistance, and self-lubrication, etc. A complete set of design, manufacturing, control, and test specifications for high force-to-weight ratio linear servo joints will be established. Servo joints with different performance levels will be developed and validated through typical applications.

Evaluation index: Propose a new lightweight design method for the drive-control integrated linear servo joint, develop design software; develop integrated linear servo joints with output forces of 0.5±0.1 kN, 4.0±0.5 kN, 8±1 kN, and 11±2 kN, with weight coverage of 0.3-2.6 kg, a machine force-to-weight ratio ≥ 5000 N/kg, servo-control repeat positioning error ≤ 0.03 mm, and a service life ≥ 6 million times; carry out application verification on at least 3 typical types of robots, including humanoid robots, mechanical arms, and quadruped robots, with installation of at least 1,000 sets; apply for no less than 5 invention patents.

Keywords: Linear servo joint, integrated design, force-to-weight ratio, force-position hybrid control, low friction

2.2 Surgical Robot Force Sensing and Feedback Technology (Common Key Technology Category)

Research content: To solve the problem of lack of precise force perception and interaction in surgical robots, this research focuses on developing a high-resolution force perception system for master-slave soft tissue manipulation robots; researching the mapping method for Cartesian force and torque as well as gripping force that is precise and continuous between the master and slave ends; and researching a real-time force interaction model that coordinates time, space, and force information to achieve precise perception and feedback of surgical robot operating forces in scenarios such as laparoscopy, vascular intervention, and microsurgery.

Evaluation index: Conduct research on the common key technologies of surgical robot force interaction, with Cartesian force perception detection range of ≥±20N, Cartesian force perception measurement error of ≤ 2%FS, grasping force perception range of 0~20N, grasping force perception error of ≤ ±2%FS; force feedback delay of ≤ 60 ms, force feedback mapping isotropic error of ≤ ±10%, force feedback fluctuation rate of ≤ ±10%; The overall technical readiness level is ≥7; integrate the technology into surgical robots for laparoscopic, vascular interventional and microsurgical applications, conduct clinical trials ≥20 cases, apply for at least 2 Class III medical device product registration certificates and apply for more than 10 invention patents, and achieve commercial installation of 50 units or more.

Keywords: surgical robot, tactile force feedback

2.3 Autonomous Operation of Mobile Robots with Two Arms Based on Multimodal Fusion Perception (Common Key Technology Category)

Research content: In response to the requirements of intelligent and humanoid operation of mobile manipulation robots in unstructured scenes, explore the end-to-end mapping mechanism from human actions to robot actions, study the key technologies of autonomous mobile, precise positioning and accurate navigation in complex environments, whole-body coordinated motion strategy generation for dual-arm mobile robots, visual servo precise operation control with hand-eye coordination, and smooth interactive operation control of dual-arm robots, etc., to face the uncertainty of operation tasks and establish robust planning frameworks and corresponding calibration and evaluation techniques. Develop a prototype 7-degree-of-freedom dual-arm humanoid mobile operating robot with upper limb configuration and verify its application in no less than 3 long-term task scenarios.

Evaluation index: Autonomous positioning translation error ≤ 2 cm, rotation error ≤ 1°; Mobile operation scene semantic mapping single frame semantic rendering accuracy mIoU ≥ 94%, map reconstruction depth error ≤0.5 cm; Real-time dynamic obstacle avoidance ability, path planning success rate of 92% or more, navigation accuracy better than 1.5%; Single task success rate of more than 80% under human demonstration ≤ 45 times; End-effector operation precision better than 0.4 mm, end-effector interaction force control error ≤3%; robot prototype with 7 degrees of freedom dual arms and human-like upper limb configuration; tested and applied in at least 3 long-term sequence task scenarios (such as autonomous completion of weighing, titration and spectral testing tasks to synthesize products, autonomous operation of unmodified analytical instruments, and autonomous completion of pipetting, shaking, centrifugation combined operation of biochemical experiments); apply for at least 5 invention patents.

Keywords: two-arm mobile robot, multimodal fusion navigation, whole body coordinated motion, two-arm collaborative planning, dexterous operation control

2.4 Intelligent Robot Information Security Protection Technology (Common Key Technology Category)

Research content: Investigate the information security protection needs brought about by robot interoperability and interoperability in the "cloud-edge-end" platform architecture, study the security threat mechanisms and vulnerability characteristics of controllers and their components, research the use, identification and calculation methods of attack paths, as well as the forward and inverse solutions of security mechanisms and security verification methods; develop multi-variable behavior trust technology for industrial distributed control patterns; developing lightweight security protection technologies for distributed secure control loops, coordinated control and communication behaviors of collaborative mechanisms; Investigating security coordination and rapid verification of cloud edge end scenarios under teaching behavior patterns, while achieving sensitive data awareness and key data element hiding based on security modes; developing low-latency hardware-level industrial security encryption technology and protection modules and universal kits; completing functional and performance verification and scaled application verification.

Evaluation index: Complete prototype verification of 10 or more types of multi-axis synchronisation, speed and acceleration control and teaching, covering at least 10 mainstream control protocols; develop software for vulnerability correlation reasoning and attack path analysis; the influence rate of trusted mechanisms in motion control mode should not exceed 5% under the condition of 1000 Hz control program frequency; hardware-level cryptographic module supports national encryption algorithms, supports transparent transmission mode, supports plug-in integration with robot controllers, supports 3 or more bus interfaces, and meets the second-level requirements of the National Cryptography Administration; break through the behavioural anomaly detection and sensitive data protection of multi-device, multi-brand and cross-region sharing and interconnection, and the security suite capabilities reach the leading level in the domestic market, supporting 2 or more robot operating systems; develop a robot "cloud-edge-end" security protection system, complete the platform verification of the robot, and the security level reaches SL2 level; The authentication delay of cooperative operation is ≤ 500 ms, the communication delay is ≤ 200 ms; formulate or revise no less than 1 industry/national standard; verify at least 2 application scenarios, and the number of robots (sets) online in each scenario is no less than 100; apply for no less than 5 invention patents.

Keywords: robot safety, information security, data anonymisation

2.5 Natural Semantic Interaction and Task Decision for Cloud-Edge Collaborative Intelligent Robots (Common Key Technology Category)

Research content: In response to the natural language semantic interaction and task decision needs of cloud-edge collaborative robots in manufacturing scenarios, research multi-modal environmental perception technologies, semantic expression technologies of environmental information, multi-modal fusion behavior prediction, multi-modal human-machine interaction technologies, cloud-edge collaborative intelligent decision technologies, multi-modal cloud-edge collaborative methods, and human-machine hybrid augmented intelligence technologies; Develop a real-time cloud-edge collaborative intelligent robot multimodal interaction inference system and hardware and software systems that integrate perception, cognition, interaction and decision; achieve rapid adaptation of heterogeneous robot perception and cognition capabilities in cloud-edge collaboration and scale up the application in typical scenarios.

Evaluation index: The Intelligent Brain Wharf hardware and software system can integrate multi-modal environmental perception software with at least 10 types of multi-modal environmental perception modalities and at least 30 types of rare object recognition categories, with an object recognition accuracy rate of over 90%. The environmental semantics expression software has an accuracy rate of over 90% in environmental semantics expression and a speed of over 200 FPS. A multimodal human-computer interaction system ensures that the success rate of human-computer interaction tasks is greater than 92%, the response time is less than 2 seconds, and the number of human-computer interaction modalities is at least 3. Building an intelligent machine brain platform for real-time decision making, integrating cloud-end collaborative intelligent decision making systems, increasing the cloud-end inference decision making capacity by 30% and the cloud-end inference speed by 5 times; developing multi-modal cloud-end collaborative algorithms, achieving a single cloud-end parallel machine count of more than 20 and a collaborative inference accuracy rate of more than 92%. Achieve rapid adaptation of the new robot's sensory and cognitive capabilities within 8 hours, and apply the Intelligent Brain Wharf to more than 10 types of robots in smart factories, demonstrating over 200 units; apply for no less than 5 invention patents.

Keywords: environmental perception, semantic expression, human-machine interaction, intelligent decision making, cloud edge collaboration

2.6 Key Technologies for Cloud-Edge Collaborative Maintenance of Industrial Robot Clusters (Common Key Technology Category)

Research content: In response to the demand for high reliability and health management of industrial robot clusters, research key technologies such as "cloud-edge-end" collaborative industrial robot cluster distributed data acquisition, industrial robot cluster enhanced intelligent fault diagnosis and traceability, industrial robot cluster performance degradation modelling and self-data-driven terminal matching degradation trend prediction, and control-diagnosis collaborative industrial robot cluster intelligent maintenance decision-making; Establish a "diagnosis-prediction-decision-control" functionally integrated industrial robot maintenance big model; develop an industrial robot cluster "cloud-edge-end" collaborative intelligent maintenance system, and verify its application in key industries to improve the precision of industrial robot maintenance.

Evaluation index: Establish a distributed database for industrial robots of PB level or above, supporting the simultaneous collection of no less than 10 types of monitoring data; establish a case library of the full life cycle degradation of key components of industrial robots, with no less than 20 cases; build the first industrial robot maintenance big model integrating the functions of "diagnosis-prediction-decision-control", with the fault traceability accuracy of no less than 90% and the accuracy of predicting degradation trends of no less than 85%, and the advanced warning time for functional failure of no less than 15 days; Develop an intelligent maintenance system for industrial robots that coordinates "cloud-edge-end", verify it in more than 3 key industries such as new energy vehicles, semiconductor processing and battery manufacturing, and connect no less than 1,000 units (sets) of equipment; the average downtime for fault recovery is reduced by at least 20% compared with the previous system application; file no less than 5 invention patent applications, and submit a draft of a technical standard or group standard for intelligent maintenance of industrial robot clusters.

Keywords: industrial robots, intelligent maintenance, large models

2.7 Key technologies for Verifying the Safety and Effectiveness of Medical-Surgical Robots (Common Key Technology Category)

Research content: Considering the current situation of clinical safety and effectiveness testing methods and evaluation standards for medical surgical robots, this research focuses on the key technologies of dynamic environment modelling of hard tissue typical surgical procedures and key operational behaviours, generation of tissue-instrument interaction motions, multi-source sensing of complex in-body disturbances, and grading of surgical robot autonomy. This research will also investigate methods for assessing the safety of human/force/position interaction, the navigation and positioning capability and effectiveness of robot operation in confined spaces, and the safety of remote teleoperation. Development of a standard for the classification of the autonomy level of medical surgical robots and the detection of operating behavior in disturbed environments. Develop an intelligent multi-dimensional motion simulation platform with a high-fidelity clinical environment for typical surgical procedures. Establish a universal testing and validation platform for the safety and effectiveness of medical surgical robot operating behaviors under dynamic and static environments. Establish a standard system for ethics, safety and performance of medical surgical robots. Conduct evaluation studies on the clinical application effects and effectiveness of medical surgical robots. Develop guidance and normative documents for the technical evaluation of medical surgical robots.

Evaluation index: Develop an intelligent multi-dimensional motion simulation platform for the detection of typical surgical operations in hard tissue medical robotic surgery, achieving performance testing of more than 5 typical operations in dynamic and static environments, such as cutting, drilling, grinding, cutting and puncturing. The number of degrees of freedom in the intelligent multidimensional motion simulation platform should be at least 6, the repeat positioning error should be ≤ 0.2 mm, the force measurement error should be ≤ 0.1 N; the position measurement error should be ≤ 0.2 mm, the attitude measurement error should be ≤ 0.1°, and the operation delay measurement error should be ≤ 100 μs; the braking and slip distance measurement error should be ≤ 0.2 mm, the impact force measurement error should be ≤ 0.1 N, and the maximum impact force measurement should be ≥ 300 N; have the function of remote simulation testing with delay, and formulate a standard for performance testing of medical robotic surgery products in a remote environment; formulate ≥ 3 national or industry standards; formulate a method and standard for detecting the operating behaviour of surgical robots, a standard for testing the usability of surgical robots, a guide for grading the autonomy of surgical robots, two guidelines for technical verification of surgical robots, and a code of ethics for surgical robots; complete product testing of at least 3 types of operating behaviour for 6 surgical robots; complete a report on the economic feasibility of surgical robots based on clinical application data at the level of a metropolitan area. Overall Technological Readiness Level (TRL) shall be ≥ 6 with at least 3 patent applications for inventions.

Note: The application should be submitted by the Medical Devices Technical Review Board or the Medical Devices Inspectorate.

Keywords: Safety and efficacy, test methods, test platforms, medical ethics

3. Industrial Robots

3.1 Autonomous Sewing Robot Technology and Systems (Common Key Technology Category)

Research content: In response to the demand for autonomous sewing technology and equipment in the automated production of the garment manufacturing industry, this research focuses on the key technologies of multi-variety flexible fabric shape detection, layered picking and precise feeding and cutting, real-time collaborative sewing of multi-dimensional space robots, and fabric sewing quality detection and evaluation. It also builds knowledge bases for fabric piecing, bag opening, patching and hemming sewing processes. An intelligent robot sewing process software package will be developed, and autonomous sewing operation equipment and systems will be developed. The research will then be applied and verified in the garment manufacturing industry for jackets and trousers.

Evaluation index: Develop a robotic flexible sewing system with pre-sewing feeding, sewing coordination and post-sewing quality evaluation functions, capable of performing at least 4 types of operations such as automatic layering, wrinkle flattening, material stacking and coordinated sewing; grasping accuracy of grasping ≥95%; separation cycle of each fabric layer ≤ 2s; tracking error of coordinated sewing trajectory ≤ ±0.5 mm, sewing thread error ≤ ±1 mm, minimum sewable fabric thickness ≤ 0.5 mm; establish a sewing quality evaluation system with thread tracking error ≤ ±0.5 mm; develop a sewing process software package that satisfies at least 4 types of processes such as fabric piecing, bag opening, patching and rolled hemming; conduct at least 50 sets of application verification of autonomous sewing operation robot system in typical industries; apply for no less than 5 invention patents/software copyrights.

Note: To be declared by enterprises.

Keywords: manipulation of deformable objects, multi-robot coordination, quality evaluation.

3.2 Autonomous Intelligent Arc Welding Robot Technology and System (Application Demonstration Category)

Research content: In response to the flexible and autonomous welding needs of heavy industry, this research will focus on workpiece identification, localization and feature extraction in an unstructured environment, and the detection and real-time tracking of local features on workpieces using composite vision. It will also develop key technologies such as multi-robot coordination and autonomous path planning, multimodal perception data fusion and real-time welding quality monitoring, and knowledge-based training and generalization of vertical models of welding processes; develop a large vertical model for arc welding applications and implement it in key welding processes of intelligent robots. Finally, it will develop an autonomous intelligent arc welding robot system and scale up its application in industries such as shipbuilding and steel structure manufacturing.

Evaluation index: The welding workpiece detection accuracy should be more than 99%. The visual recognition error of weld geometric dimensions should be ≤ ±0.1 mm, the welding deviation of the workpiece should be ≤ ±0.5mm, and the online detection accuracy of welding quality should be more than 90%; the number of vertical large models in the arc welding application area should be ≥ 16 B, the number of parts in the database should be ≥ 10,000, and support intelligent interaction such as text, image and voice. Realize at least 3 application links in robot welding workpiece recognition, path planning and detection; The welding quality compliance rate of the autonomous intelligent welding robot system should be ≥ 99%, with the promotion and application of more than 500 sets (sets); Apply for no less than 5 invention patents.

Keywords: multimodal perception, multi-robot coordination, vertical arc welding, large model

3.3 High-speed Ultra-precision Hybrid Bonding Robot (Common Key Technology Category)

Research content: In response to the urgent demand for high yield and high capacity in the semiconductor industry's hybrid bonding process, this research focuses on the development of high-speed and high-stability coordinated control between wafer transport robots and bonding platforms, decoupled hinge design of high-stability six-axis nanometer positioning platform, high-precision closed-loop motion control, and dynamic regulation of high-efficiency dual-wafer in-situ alignment. To achieve high-efficiency transfer and ultra-precise alignment of wafers in the hybrid bonding process, a long-range, high-speed, ultra-precision hybrid bonding robot system is being developed, and application verification is being carried out on a wafer-to-wafer production line.

Key performance indicators: Repeated positioning error of wafer transfer manipulator ≤ ±30 μm, angle error ≤ ±35 mrad, highest transfer speed ≥ 2 m/s; Repeated positioning error of terminal actuator active compensation control technology ≤ ±10 μm; Ultra-high alignment precision 6-axis bonding platform compatible with 8-inch and 12-inch standard wafers, bonding platform travel X/Y ≥ ±20μm, bandwidth ≥ 1 kHz, repeated positioning error ≤ ±3 nm, angle error ≤ ±100 mrad; Can achieve ultra-high precision dual wafer in-situ alignment dynamic regulation, displacement control error ≤ ±3 nm; Validate and test the complete bonding process with complete bonding equipment in a wafer-to-wafer hybrid bonding system, core technology modules achieve domestication, wafer-to-wafer hybrid bonding alignment error ≤ ±30 nm, wafer hybrid bonding capacity ≥ 30 pairs/hour; Apply for no less than 10 invention patents, system technology readiness level reaches level 7.

Keywords: Hybrid bonding robot, high speed, ultra-high precision, wafer to wafer

3.4 Mobile high Performance Intelligent Work Robot System (Application Demonstration Category)

Research content: To solve the problem of low efficiency, harsh working environment and high safety risks in manual cleaning of dry bulk cargo holds during unloading at dry bulk terminals, this research studies the key technologies of multi-functional composite optimization design of mobile heavy load arm-extending robots, high-precision self-adaptive disturbance control of electro-hydraulic proportional system, fast modelling of ship holds and autonomous operation planning, and active safety of heavy load arm-extending robot operation. A mobile heavy-load arm-extending robot system for high-altitude operation is developed, which can perform functions such as high-altitude raking, sweeping and stacking of dry bulk cargo. It can also work in coordination with unloading machines and be used for demonstration in ports.

Evaluation index: The robot must have a working height of ≥ 8 m and a load capacity of ≥ 2t; the robot must have an indoor positioning error of ≤ 10 cm; it must be able to perform at least 3 intelligent operations such as collecting, sweeping and stacking scrap at high altitude; it must be able to work in a coordinated manner with unloading machines; it must have an intelligent cleaning operation efficiency of ≥ 500 tonnes per hour; it must be applicable to at least 3 types of cargo; it must be demonstrated in at least 3 dry bulk terminals; and it must have more than 5 units (sets) of promotion and application. Apply for at least 5 invention patents.

Keywords: Mobile heavy duty high altitude operation, fast ship cabin modelling, autonomous work planning

3.5 Key Technologies and Application Demonstration of Robotic Disassembly of New Energy Vehicle Batteries (Application Demonstration Category)

Research content: The project will address the major need for efficient and safe dismantling of new energy end-of-life batteries and will address the key issues of automated separation of multi-stage complex structures of lithium batteries and precise separation and recycling of a single battery component. Development of safe and efficient automatic battery dismantling robots, efficient multi-group separation and comprehensive control of pollutants, and modular and easy-to-interact robot-specific process software packages, as well as research and development of migratory, man-machine interactive battery dismantling robot systems driven by intelligent control. Demonstrate applications for accurate identification and automated disassembly of battery fasteners, conductive connectors, module housings, battery cell separation, and material handling and storage for new energy batteries.

Evaluation index: Development of a new robotic energy battery disassembly system, equipped with a dedicated modular process software system, to achieve the key process steps required for automated disassembly of used batteries. Among them, the battery disassembly system 6-axis robot has a payload capacity ≥ 165 kg, a reach of ≥ 3100 mm, and a repeat positioning accuracy of better than 0.05 mm; the recovery rate of aluminum and copper is ≥95%; the recovery rate of positive and negative electrode powder is ≥98%; compared with traditional methods, the overall energy consumption is reduced by 70% and the carbon dioxide emission is reduced by 80%; it has the capacity to process more than 2000 tons of waste batteries; Lead to the application of 5 new energy battery robot automatic disassembly production lines in leading enterprises in the fields of new energy vehicles, environmental protection, and so on, with at least 10 specialized robots for disassembly, inspection and transportation per production line; apply for no less than 5 invention patents.

Keywords: remanufacturing, battery disassembly, new energy

4. Service Robots

4.1 Development and Application Demonstration of an Operational Nursing Robot System (Application Demonstration Category)

Research content: Based on the care needs of functionally impaired and disabled elderly people, this study aims to explore the modular design method of dual-arm care robots and grasping modules for multitask care; explore key technologies such as obstacle environment perception and care scene understanding, behaviour data-driven care skill imitation learning in the context of multi-scale human-machine-object interactions; develop operational care robots and networked monitoring systems, and carry out typical demonstration applications in community or nursing homes.

Evaluation index: Develop an operational two-armed care robot system capable of rapid gripper change ≥3 times, with gripper change time ≤ 15 seconds; achieve a target recognition and function understanding accuracy rate of ≥95%, identify and understand ≥5 types of care scenarios, and imitate learning of ≥ 10 types of elderly care operation skills (such as item delivery, cooking, and table cleaning) through perceptual understanding; Achieve a target grasping success rate of ≥90% in nursing operations, a success rate of ≥90% in nursing operation tasks, and conduct more than 5 applications of the same type of generalization experiments for each category; Develop a networked monitoring system and realize the demonstration application of operational nursing robots in 10 communities or nursing homes; Apply for no less than 5 invention patents.

Keywords: operational care robots, care scene perception and understanding, care skills imitation learning

4.2 Intelligent Robotic Systems for Brain Function Rehabilitation (Common Key Technology Category)

Research content: To address the problems of the rehabilitation robot system's inability to adapt to the abnormal posture, movement and cognitive function training of patients with brain injury and neurodegenerative diseases, a highly compatible joint self-calibrating embodied morphing system targeting abnormal posture and movement is designed; the temporal-spatial coordinated control of the human-machine dynamic system and the bidirectional mutual learning method between the central nervous system and the peripheral nervous system are studied; establish the "brain-muscle-movement"-machine interface rehabilitation system by integrating EEG, EMG and movement signals; develop a rehabilitation training robot with embodied motor-cognitive coordination; establish an individualized movement-cognitive rehabilitation training mode and a quantitative evaluation system for the whole rehabilitation cycle to achieve brain function remodelling; conduct clinical verification and promotion.

Evaluation index: Develop a rehabilitation robot for movement-cognitive synergy, covering at least two central nervous system diseases such as stroke, Parkinson's disease and dementia; joint movement matching degree ≥85%, total freedom of movement of the robot's lumbar-sacral, spine, knee and ankle ≥15; dynamic system coordination response time of the human-machine system ≤ 240 ms; form ≥4 types of motion-cognitive synergy rehabilitation training modes targeting brain function remodeling, ≥ 6 types of motion-cognitive synergy quantitative evaluation modalities, and a post-evaluation accuracy rate of ≥90% for personalized motion-cognitive rehabilitation methods; Achieve a clinical therapeutic effect of improving the same joint mobility, joint stability, motor function, balance function, cognitive function and activities of daily living by 20% or more compared to traditional rehabilitation robot therapy; have at least 5 clinical application centers and conduct clinical verification on ≥ 100 patients; obtain two medical device product registration certificates; apply for at least 10 invention patents.

Key words: brain function rehabilitation, rehabilitation robot, cooperative rehabilitation, joint self-calibration

4.3 Human-Machine Integrated Cardiopulmonary Assistive Wearable Robot (Common Key Technology Category)

Research content: In response to respiratory impairment problems caused by chronic lung diseases and cardiovascular diseases, this study aims to develop a bipolar phase assistance with variable impedance and anchor point structure design method without joint attachment; explore the key technologies of multimodal fusion breathing intention understanding, human-machine synchronized breathing real-time trigger switching, and in-loop self-adaptive control of neural-muscular-skeletal-airflow temporal conduction; Develop an exoskeleton-based wearable artificial muscle-powered respiratory assistive robot that achieves natural breathing, and conduct clinical verification for typical conditions such as motor neuron injury, chronic obstructive pulmonary disease and cervical spinal cord injury.

Evaluation index: The portable robot supports bipolar support for inhalation and exhalation and combined breathing patterns of chest and abdomen; the driving force of the robot is ≥ 400N, the adjustable stiffness ratio is ≥ 20 times; the trigger delay of the robot's assisted breathing is ≤ 50 ms, the rate of human-robot confrontation is ≤ 5%; the system response time is ≤ 200 ms, the control error is less than 5%; the respiratory tidal volume, movement signal or diaphragm activity level is increased by 10%, the work of breathing is reduced by 20%, the blood oxygen saturation is increased by 5% and the six-minute walk test results are improved by 20%; more than 200 patients have been clinically verified; 2 medical device product registration certificates have been applied for and approved; at least 5 invention patents shall be applied for.

Keywords: Respiratory rehabilitation, wearable robot, variable stiffness mechanism.

4.4 Miniature Flexible Surgical Robot for Paediatric Cranio-Neurological Surgery (Common Key Technology Category)

Research content: To address the challenges of fragile tissues, difficult exposure of anatomical structures and limited surgical field in paediatric head and neck surgery, this study aims to develop a miniature, flexible, dexterous surgical manipulator with integrated structure perception for surgery in delicate tissues and narrow cavities. The key technologies to be studied include target tissue recognition and tumour boundary self-marking, vessel and nerve danger zone warning and intelligent navigation during surgery, as well as human-machine shared safety control that fuses visual and force sensory information. The aim is to develop a paediatric head and neck surgical robot system. Carry out animal and clinical trials to validate the results, and then promote and apply them.

Evaluation index: Development of a paediatric cranio-cervical surgical robot system with a surgical actuator ≥6 degrees of freedom and a diameter of ≤4 mm, an end effector payload of ≥ 3 N, a repeat positioning accuracy of better than 0.25 mm, and the ability to carry ≥ 3 types of end effector tools; an end effector force sensing range of ≥ 5 N, a force sensing accuracy of better than 0. 1 N, and an intelligent navigation display delay of ≤ 300 ms; a tumour boundary self-marking accuracy of ≥ 90%, a vascular and nerve danger area warning deviation of ≤ 1 mm; complete animal testing and clinical trial verification of the entire system, apply for and obtain the third-class medical device product registration certificate; apply for no less than 5 invention patents.

Keywords: minimally invasive surgical robots, paediatric craniofacial surgery, force sensing and feedback

4.5 Artificial Intelligence-Assisted Remote Orthopedic Operations Surgical Robot (Common Key Technology Category)

Research content: In response to the requirements of precise and safe operation for remote hard tissue robotic surgery in high disturbance environments, this research studies the high-precision system modeling of the master control end and mechanism generation with force feedback; it also studies key technologies such as task learning and autonomous generation based on artificial intelligence, task autonomous permission allocation and sharing, temporal and spatial inconsistency-based master-slave motion compensation, and stability control of instrument-bone interaction under large load disturbances. The robotic system for remote orthopaedic surgery will be developed, enabling safe surgery, and experimentally verified.

Evaluation index: Develop an artificial intelligence-assisted remote orthopaedic surgery robotic system with a main end feedback force ≥ 40 N and an off-end operational output force ≥ 400 N, with a force feedback error of ≤ 10%; achieve intelligent segmentation of at least 95% for multiple bone block instances using the Dice coefficient; have an autonomous generation rate of at least 90% for the bone block repositioning task; achieve a tracking error of ≤ 1.2 mm for the movement of bone blocks under dynamic load; achieve a system precision of better than 1 mm; conduct experimental studies in a remote orthopaedic surgery application scenario with high loads, performing at least 10 animal experiments in the scenarios of bone cutting, drilling and repositioning; obtain at least a third class medical device product registration certificate for the system; apply for no less than 5 invention patents.

Keywords: surgical robots, remote orthopaedic surgery, immersive surgery, artificial intelligence.

4.6 Surgical Robotics for Complex Soft Tissue Dissection and Advanced Operations (Common Key Technology Category)

Research content: To solve the problem of lack of minimally invasive surgical channels in deep human tissues such as the posterior orbital cavity, research will be conducted on multi-layer heterogeneous composite continuous body robots that can establish minimally invasive channels and the method of creating flexible support structures to form the surgical operating space. Key technologies such as fine modeling of soft tissues, real-time guidance during surgery, coordinated control of rigid-soft composite structures for position adjustment during surgery and precise operation in confined spaces will be investigated. A prototype of the robotic system will be developed, robotic surgical operation guidelines will be established, animal experiments and efficacy evaluations will be conducted, and technical and functional verification of the complex minimally invasive surgical scenarios in deep human tissues, such as posterior orbital cavity and posterior eyeball tumour resection and cervical lymph node dissection, will be carried out.

Evaluation index: Develop a surgical robotic system for soft tissue manipulation and complex surgery, with an outer diameter of the robot for creating minimally invasive channels of ≤ 10 mm; the diameter of the surgical operating space supported by the soft tissue structure can vary within a range of 10-15 mm, with a pressure sensitivity accuracy of tissue separation of better than 0.1 kPa; the tissue separation accuracy ≥ 92%; the degree of freedom of the actuator end is ≥ 4, with an overall positioning accuracy of better than 1 mm; achieving at least 3 types of surgical scenarios in a typical specialty, completing at least 10 animal studies and 2 clinical studies; the overall technical readiness level is ≥ level 7, and at least 5 invention patents are pending.

Keywords: soft tissue surgical robot, surgical access creation, operating room formation

4.7 Theory and Methods of Drug Delivery Micro-Needle Robots (Common Key Technology Category)

Research content: To address the bottlenecks of low oral absorption rate, poor delivery stability, and difficulty in excretion and degradation of drug-carrying robots, this research will study the structural design and multi-dimensional fabrication methods of digestive tract microneedle drug delivery robots that can break through the barrier of drug delivery; Investigate key technologies such as robot environmental response, group control, dynamic feedback closed-loop drug delivery, drug retention and release, and controlled degradation; develop prototype gastrointestinal microneedle drug delivery robots; conduct live large animal experiments with typical drugs and disease models; and conduct clinical trials.

Evaluation index: Develop at least 2 types of biocompatible and controlled degradable gastrointestinal tract-driven microneedle robots to achieve dynamic feedback closed-loop drug delivery; construct at least 1 type of robot swarm drug delivery model and at least 1 type of mother-and-child drug delivery robot model; possess at least 4 types of macromolecular drug delivery functions across the gastrointestinal tract barrier, with a drug load of more than 6 mg and a drug absorption rate of more than 85%; The number of microneedles penetrating the skin within 10 minutes after drug delivery is greater than 95%, and the retention efficiency of microneedles after drug delivery within 30 minutes is greater than 90%; Complete preclinical large animal efficacy and safety verification, complete Phase I clinical trial; Overall technology readiness level greater than 7; Apply for no less than 5 invention patents.

Keywords: drug delivery, microneedle robot, intestinal propulsion

5. Specialty Robots

5.1 Technologies and Applications of Operational Scientific Research Robots for High-Altitude Environments (Common Key Technology Category)

Research content: In response to the needs of major tasks such as the Second Tibetan Plateau Scientific Expedition and the Antarctic Scientific Expedition, this research will investigate key technologies for the operation of flying robots in extreme environments such as high altitude, low temperature and strong wind, including precise release and recovery, air-ground coordination, real-time three-dimensional modelling of surface structure, automatic drilling mechanism design with surface layer constraints, and remote human-machine hybrid intelligent control. To improve the adaptability, usability and intelligence of the robot in high-altitude scientific exploration, a prototype of a scientific exploration robot with high adaptability and wide-area operation capability will be developed, and field tests will be conducted for typical scientific exploration tasks such as ice core, snowflake, rock and vegetation sampling.

Performance indicators: Develop a range of electric vertical take-off and landing operational robots for extreme environments, capable of operating at altitudes ≥ 6,000 meters and maximum operating altitude ≥ 7,000 meters, with a payload capacity of ≥ 10 kg at 7,000 meters, a flight time of ≥ 1 hour, a working radius of ≥ 20 kilometers, and the ability to withstand winds of ≥ 7 on the Beaufort scale; Develop a detachable and retrievable surface sampling device weighing no more than 25 kg, with a width of no more than 50 cm, a climb angle of at least 30°, and a placement error of ≤ 1 m. Develop a miniaturized high-precision surface modeling charge capable of acquiring data at a rate of ≥ 5 million points per second and having a field of view of better than 360° x 250°. It weighs ≤ 4 kg, has a 3D reconstruction accuracy of better than 5 cm and can output 3D reconstruction results in real time; it is designed for lightweight sample drilling, with a drilling depth of ≥ 65 cm and adaptability to slopes of ≥ 30 degrees. It has automatic and remote control drilling modes; a lightweight surface sample collection manipulator is developed with the ability to operate in the air, with control accuracy of better than 10 cm and a maximum sample weight of ≥ 500 g; the maximum communication distance between cooperative robots is ≥ 1 km, and the radio frequency used should comply with national radio frequency management regulations; to be used in at least 5 types of samples, 20 field tasks in extreme environments such as high altitude and Antarctica, collecting at least 5 types of samples including ice cores, snowflakes, rocks, vegetation, etc.; apply for at least 5 patents for inventions.

Keywords: High altitude scientific expeditions, operational flying robots, air-ground coordination, scientific sampling

5.2 An In-Situ Structural Monitoring System for Aircraft Engine Based on Macro-Micro Intelligent Robots (Common Key Technology Category)

Research content: In response to aircraft engine in-situ inspection needs, this study investigates key technologies such as engine inspection and path planning based on macro-micro intelligent robot technology, macro-micro inspection robot configuration design, multi-heterogeneous robot collaboration, high-precision real-time image acquisition and transmission, critical component damage tolerance assessment and determination, and micro inspection robot positioning, navigation and recovery; an aircraft engine on-wing in-situ inspection device based on macro-micro intelligent robots will be developed and tested.

Evaluation index: Develop a comprehensive on-wing in-situ inspection solution for aircraft engine components based on macro-micro intelligent robots; Develop ≥3 path planning schemes and ≥ 2 control schemes for key components of aircraft engines, with a continuous working time of ≥ 1 hour for the complete robot; Achieve climbing along the blade, inner wall of the casing, and circumferential climbing with an angle of 0-360 degrees, a minimum radius of curvature of ≤ 20 cm, a maximum contour dimension of ≤ 2 cm, a sensing path length of ≥ 4 m, and a climbing speed of ≥ 4 times the length of the robot per second, single duration time ≥ 12 min; Develop two sets of macro-continuum deployment robots, with robot arm diameters of ≤ 3 cm and the ability to carry ≥ 3 micro-robots, macro-continuum robot operating segment lengths of ≥ 1. 5 m and a total number of degrees of freedom ≥ 20, and a minimum bending radius of ≤ 7 cm; develop a micro-image capture and transmission module capable of capturing and transmitting images with a resolution ≥ 1080x720 and video frame rates ≥ 15 frames per second; achieve a positioning error of ≤ one robot length for the micro-robot; develop a software package for damage tolerance assessment of key components and in-line defect detection, capable of detecting minimum crack widths of ≤ 0.7 mm; conduct application verification on at least 4 models of 2 major engine categories with large and small bypass ratios; apply for no less than 5 invention patents.

Keywords: In-situ aero-engine inspection, macro-micro intelligent robots, heterogeneous robot collaboration, micro-robot localization and recovery.

5.3 Amphibious Cross-domain Special Robots for Complex Environment Surveillance (Common Key Technology Category)

Research content: In response to the demand for all-terrain mobility and perception capabilities of robots in complex environments such as maritime rescue and salvage, emergency rescue, and underwater structural inspection, this research will focus on the design of robots with constrained capabilities and stable cross-domain switching, the design of efficient propulsion systems compatible with multiple media in water and air, cross-media detection, sensing and control, multi-source data fusion, and target identification and tracking using magnetic, acoustic, and electromagnetic signals, and the development of integrated platforms for cross-domain operation, cross-media detection, sensing and control; multi-source data fusion and target identification and tracking using magnetic, acoustic, electromagnetic and optical signals; three-dimensional path planning for cross-domain operations; and the development of integrated platforms for magnetic, acoustic, electromagnetic and optical exploration functions and three-dimensional cross-domain specialized robots for complex environment inspection. The research will also include field trials to validate the applications.

Performance indicators: Develop a dedicated robot with three-dimensional cross-domain mobility capabilities, capable of airborne search, surface navigation, underwater submersion and seabed crawling, with autonomous cross-media capability and at least level 2 operational capability in marine conditions; the robot's own weight should not exceed 50 kg and its airborne payload capacity should be ≥10 kg; the flight speed should not be less than 120 km/h; the maximum underwater cruising speed should not be less than 6 knots; the maximum submerged depth should not be less than 20 m; and the underwater payload capacity should not be less than 30 kg; the composite environment comprehensive endurance time should be not less than 8 hours, including at least 30 minutes of air/water endurance time; develop a multi-mode composite detection payload capable of magnetic/acoustic/electromagnetic/optical composite exploration and anti-jamming capability, with a cumulative outdoor visual positioning error of ≤ 1% and a low-light perception feature recognition rate of ≥ 95%; verify the application in two or more typical scenarios; apply for not less than 5 invention patents.

Keywords: amphibious robots, cross-media motion, multi-domain perception in water, land and air, motion planning and control

5.4 Development and Validation of Reconfigurable Underwater Operating Robots (Common Key Technology Category)

Research content: In response to the demand for watertight, all-encompassing, fast and accurate inspection of the inner walls of underwater confined spaces such as water supply pipelines, nuclear power plant cooling water pipelines and pressurized water diversion tunnels, this research investigates key technologies such as rapid reconfiguration of underwater platforms, precise docking and alignment of multiple underwater platforms, and self-adaptive deformation control in the low-information environment, as well as multi-source information fusion navigation and damage detection in confined spaces. A prototype of a reconfigurable wireless autonomous underwater robot for confined space inspection will be developed and its performance will be validated in typical underwater confined space scenarios such as municipal water supply pipelines and pressurized water diversion tunnels.

Evaluation index: Develop a set of reconfigurable untethered autonomous underwater robot prototypes with closed space detection with a maximum operating depth of no less than 700 m and a maximum endurance of no less than 4 hours at a speed of 2 kn. The robot should be able to reconfigure autonomously into not less than 3 functions or configurations and not less than 6 underwater detection units. The untethered robot should be able to safely deploy and retrieve through an opening no larger than 1 meter in diameter. The robot should be able to complete at least 3 bends, a diameter of no more than 10 meters and a length of no less than 2 kilometers of underwater confined space detection tasks. It should be able to achieve autonomous module detection unit underwater autonomous docking, the end-point docking accuracy is better than 10 cm, the docking success rate is not less than 90%. It should be able to achieve reconfigurable underwater robot shape adaptive control, the reconfigurable robot's omnidirectional attitude control accuracy is better than 5 degrees. It can detect more than 3 kinds of typical defects in water-filled confined spaces under pressure with a minimum crack width of 0.5 mm, the defect detection accuracy is not less than 80%, the deformation detection error is not more than 1 cm, and the water-based defect positioning accuracy is better than 0.5 m. It should be applied and validated in no less than 3 underwater confined space engineering projects. No less than 5 invention patents should be applied for.

Keywords: modular reconstruction, adaptive docking, multi-source information fusion, navigation and motion control, damage detection

5.5 Autonomous Inspection and Operation Robots for Permanent Subsea Installations (Demonstration Project)

Research content: In response to the significant need for underwater inspection and maintenance of submarine cables, optical cables and underwater observation networks, this research will focus on the overall design of a mother-daughter submersible consisting of a permanently stationed autonomous underwater vehicle (AUV) and a deformable underwater vehicle, as well as the AUV's autonomous inspection of submarine cables and real-time status assessment method. The research will also explore key technologies such as autonomous docking between AUVs and underwater base stations, wireless power replenishment, near-field wireless communication, and multi-task dexterous operation and deployment/recovery of the deformable underwater vehicle in complex marine environments. The research will also develop a complete suite of permanently deployed AUVs and DPUs and demonstrate their use for autonomous, all-weather inspection and maintenance of subsea assets.

Evaluation index: Develop a set of mother-daughter autonomous underwater vehicle (AUV) and transformable underwater robot (TRU) deep-sea exploration equipment with independent intellectual property rights, capable of autonomous submarine cable burial depth/topography detection, autonomous submarine cable exposure/suspension/external damage identification, autonomous route planning and tracking, autonomous docking and wireless charging with a docking success rate of ≥ 85%; The TRU is capable of delicate operations such as cable marking, tying, and plugging and unplugging underwater equipment; the wireless power transfer base station has a seawater charging capacity of ≥ 10 kW and a charging efficiency of ≥ 90%; the mother-daughter deep-sea exploration equipment has a continuous waterborne stay of ≥ 3 months and a single patrol endurance of ≥ 50 km, with a maximum operating depth of ≥ 300 meters. The radio frequency used should comply with national radio frequency management regulations. Complete at least 3 demonstration applications for different types of tasks with an overall technology readiness level ≥ 7; apply for at least 5 invention patents.

Note: The ratio of support funds for projects to the funds allocated by the state shall not be less than 5:1.

Keywords: mother-daughter deep sea submersible, transformable underwater robot, autonomous inspection, dexterous operation, wireless charging.

5.6 Autonomous Inspection and Evidence Collection Robot with Integrated Vision and Olfactory Sensors (Common Key Technology Category)

Research content: In response to the demand for safety inspection and emergency response technologies in the hazardous chemical industry and public safety, this research will investigate the modeling of multimodal fusion of visual and olfactory sensors for robot-based wide-area hazard source identification, high-sensitivity identification of various hazardous gases, risk factor detection in multispectral stereoscopic visual scenes, olfactory traceback and precise location in time and space, and fine-precision emergency response operations in high-risk scenarios. A robot with autonomous inspection and evidence collection capabilities will be developed and its performance will be evaluated and validated in typical scenarios.

Evaluation index: Development of an autonomous inspection and evidence collection robot system with integrated vision and olfaction, capable of operating in hazardous environments; olfactory navigation success rate ≥ 98%; olfactory sensitivity reaches the PPB level; the number of threat sources identified by multimodal fusion of vision and olfaction ≥ 15; the correct identification rate ≥ 98%, false alarm rate ≤ 5%; the time required to construct a 4D semantic security risk map using physical and olfactory data < 30 seconds, and the future 5-minute risk scenario can be simulated; the time required to collect evidence of suspected hazardous items within a 50 square meter area ≤ 1 minute; the robot can adapt to changes in terrain ≥ 4 types, the maximum climbing angle is not less than 45°, the maximum obstacle clearance height is not less than 20 cm, and the maximum payload is not less than 20 kg; complete application verification in at least 3 typical scenarios such as hazardous gas pits, chemical plant sites, and underground pipelines; apply for no less than 5 invention patents.

Keywords: olfactory navigation, 4D security risk mapping, autonomous inspection and evidence collection, precise hazard mitigation operations

5.7 Development and Demonstration Application of Ultra-large Loading Robots for Open-pit Mines (Application Demonstration Category)

Research content: In response to the problem of low efficiency in manual operation of loading equipment in open pit mines, this research aims to investigate key technologies for large-scale operation of loading robots in complex mining environments, including perception of the working environment, autonomous planning of efficient loading operations, multi-joint coordination and self-adaptive precise operation control, and remote intelligent maintenance of equipment. A super-large loading robot suitable for different operating conditions will be developed and a demonstration application will be carried out in a typical large open-cast mine.

Evaluation index: Development of a 55 m^3 or larger wheel loader robot for open pit mines, capable of autonomous walking, autonomous mining and autonomous loading; the accuracy of target recognition during operation is ≥ 90%; the average cycle time for loading and unloading operations is ≤ 45 seconds and the average energy consumption is reduced by 5%; the control error of bucket position is ≤ 15 cm; the average fault-free rate is ≥ 93%; the maximum digging radius is ≥ 25 m, the maximum digging height is ≥ 18 m and the maximum individual digging weight is ≥ 100 t; the average full bucket rate is ≥ 95%; demonstrate the use of at least 20 sets of loading robot systems, including at least 5 sets of 55 m^3 loading robots, in open pit mines with an annual production of more than 20 million tonnes; the overall technical readiness level shall be ≥ 8; and apply for at least 5 invention patents.

Note: The ratio of support funds for projects to the funds allocated by the state shall not be less than 4:1.

Keywords: open pit mining automation, loading robot, autonomous operation

Declaration Guidelines

for 2023 Key Special Project of “Intelligent Robotics”

In order to implement national science and technology innovation arrangements during the 14th Five-Year Plan, the Intelligent Robots Key Special Project under the national key research and development program has been launched. Following the arrangement of the implementation program for this key special project, we are now releasing the Project Declaration Guidelines for 2023.

The overall objectives of this special key project are: to build an intelligent robot technology system suitable for China's national conditions and promote continuous innovation in technology and products; to realize the advanced industrial chain, high-end products and system applications and promote the high-quality development of China's robotics technology and industry; and to support the independent development of the main fields of the national economy, the country's major needs, people's life and health, and other related industries.

Adhering to the principles of problem orientation, step-by-step implementation and focus, the 2023 guideline deployment focuses on four technical directions, including core components and algorithms, industrial robots, service robots and special robots, and proposes to launch 30 guideline tasks according to the three levels of basic research, common key technologies and application demonstration, and allocates RMB 329 million in government funds. Among them, around the core components and algorithms, service robots and special robots, young scientist projects will be deployed with 2 million yuan for each project. The ratio of support funds for projects in the category of common key technologies to the funds allocated by the state shall not be less than 1.5:1. Application demonstration projects will be led by enterprises for declaration, with the ratio of matching funds to the nationally allocated funds of 2.5:1 at least.

The projects will be uniformly declared according to the research directions under the secondary headings (e.g. 1.1) of the guidelines and, unless otherwise specified, one project is proposed to be supported in each direction, with an implementation cycle of no more than three years. The research content of the submitted projects must include all of the research content and evaluation indicators listed under the secondary headings in the guidelines. The number of topics under the basic research projects shall not exceed 4 and the total number of projects participating units shall not exceed 6; the number of topics under the common key technology and application demonstration projects shall not exceed 5 and the total number of projects participating units shall not exceed 10. There will be a Project Leader for each project and a Topic Leader for each topic in the project.

It is not required that the Young Scientist Project to fully cover the content of the guidelines, and no topic is required under such project. The total number of participating units in the project shall not exceed three. There should be one project leader for the project, and the leader of a young scientist project shall be born after January 1, 1985 for men, and after January 1, 1983 for women. In general, the age requirements for other team members are the same as above.

1. Core components and algorithms

1.1 Online identification of robotic system parameters and dynamics modeling (Basic Research Category, Young Scientist Project)

Research content: Aiming at the problems of low accuracy of robot parameter identification and inaccurate dynamics model, research will be carried out on high-precision offline identification of key parameters of robots, fast and accurate online identification of variable load parameters, and dynamics modeling and numerical computation methods of rigid-flexible coupled systems of robots, so as to establish a parameterized model system. To realize application verification in typical scenes of high-end domestic robots.

Evaluation index: Establish a new method for online identification of robot parameters and dynamics modeling and develop software. Robot system center of mass and inertia identification error: ≤2%; joint friction moment identification error: ≤5%. To realize application validation for as many as 5 types of industrial robots. Overall technology readiness level ≥ 4. At least 5 invention patents shall be accepted or granted.

Note: The number of projects to be supported is 2.

Keywords: parameter identification, dynamics modeling

1.2 Integrated chip for robot joint drive and control (Common Key Technology Category)

Research content: For the demand of robot joints for the underlying servo drive and control of autonomous special chips, research shall be carried out on multi-functional highly integrated chips and complex digital-analog hybrid design, common-mode interference resistance, multi-mode redundancy backup, robot sensor information acquisition and high-precision digital-analog signal SOC integration, internal curing robot servo drive special control algorithms, etc., so as to develop a high-performance modular integrated chip to drive and control robot joints, which can be used in industrial and service robots on a large scale.

Evaluation index: To develop special integrated chip with high safety for robot joint drive and control. Chip main frequency: ≥168MHz; FLASH: ≥512KB; static random access memory (SRAM) cache: ≥128KB; support for 3-phase motor pre-drive, support for FD-CAN and EtherCAT bus, module-internal integrated power management module. The total number of ADC signal lines shall not be less than 6, of which at least 2 lines (each line shall have at least 2 signals) shall be able to achieve ADC synchronous sampling with the non-synchronous error of less than 0.1μs. At least two servo control algorithms, such as vector control, digital proportional-integral-derivative (PID) control, shall be built in the chip with the control frequency of ≥10kHz. It should be able to support at least two types of motors, such as brushless DC motors/permanent magnet synchronous motors. The aim is to realize the large-scale application of the special robot control chip in the industrial robots and service robots. During the implementation of the project, at least 20,000 chips will be sold and used in more than 3,000 robots made in China. Overall technology readiness level ≥ 7. At least 5 invention patents shall be accepted or granted.

Note: To be declared by enterprises.

Keywords: special robot control chip, drive-control integration

1.3 R&D and application of special chips for robot controllers (Common Key Technology Category)

Research content: To meet the demand of real-time closed-loop feedback, low latency, high stability and high integration of robots, research shall be carried out on robot-specific chip architecture integrating Sensing-Computing-Controlling, specialized instruction set, IP modules for planning decisions and multi-axis, multi-channel motion control, hard real-time high-precision closed-loop feedback dedicated circuit, and fusion and integration of kernel interface functions with hard real-time driving algorithms for chips, so as to develop specialized chips for hard real-time motion control of robotic systems and realize the scale application of such chip in a high real-time control system for robots with multi-axis linkage.

Evaluation index: To develop robot-specific control chip and motion control hardware IP algorithm library to realize multi-channel/multi-axis robot motion planning and real-time control; multi-modal sensing module with position sensor, torque sensor and vision sensor with sensing accuracy ≤20bits; jitter deviation of motion control feedback response time ≤0.2μs; servo real-time closed-loop control time ≤20μs; with not less than 4 standard robots 6 + 3 axis motion feedback synchronization control capability, robot control real-time feedback response time ≤200μs; adaptive support for 5 types of motors (brushless DC motors, permanent magnet synchronous motors, asynchronous motors, stepper motors, and reluctance motors), enabling the application of multi-vendor motors; during the implementation of the project, at least 20,000 chips will be sold and used in more than 3,000 robots made in China. Overall technology readiness level ≥ 7, accepted/authorized no less than 5 invention patents.

Note: To be declared by enterprises.

Keywords: kernel chip, hard real-time control

1.4 Robotic hypoid gear reducer (Common Key Technology Category)

Research content: To meet the needs for high stiffness, high precision and lightweight design of robots, research will be carried out on high-precision and high-reduction-ratio hypoid gear meshing theory, tooth profile modification technology, simulation technology of kinematic and dynamic characteristics, and batch manufacturing and assembly process technology, so as to develop hypoid gear reducer, and realize it large-scale application in robots.

Assessment index: To develop 3 types of high-precision, high reduction ratio hypoid gear reducers; torque covering 100N m~600N m, transmission ratio: ≥10; single-joint transmission error: ≤1 arc minute, gear backlash: ≤0.01mm, transmission efficiency: ≥87%, precision life: ≥10,000h; and to apply it in more than 3,000 robots during the implementation of the project. To formulate national, industry or related group standards: ≥1. Overall technology readiness level: ≥7; not less than 5 invention patents shall be accepted/authorized.

Note: To be declared by enterprises.

Keywords: hypoid gears, meshing theory, profile trimming

1.5 Intelligent harmonic reducer for robots (Common Key Technology Category)

Research content: To meet the need for robot intelligent reducer for torque sensing and real-time fault condition monitoring, research will be carried out on in-situ integrated design and fabrication technology of MEMS sensors on gearboxes, reducer dynamic performance parameter identification and dynamic meshing performance optimization technology, real-time multi-dimensional data analysis and state prediction algorithms, so as to formulate specifications for intelligent reducer design, manufacturing and testing, develop intelligent reducer for robots and realize the large-scale application of the reducer.

Evaluation index: To develop intelligent speed reducer products with torque self-awareness and more than 3 functions such as vibration monitoring, temperature sensing and health state prediction; the output load and torque measurement range of the reducer shall be ≥200N m; the transmission accuracy of the reducer shall be ≤40 arc second; torque measurement accuracy≤±0.5%F.S., non-linearity≤±0.5%F.S.; the rated life of the reducer shall be ≥10000h, and the decrease of K1 stiffness during the life shall be ≤50%. During the implementation of the project, the reducer shall be used in at least 2,000 robots made in China. To develop national, industry or related group standards: ≥ 1. Overall technology readiness level ≥ 7. At least 5 invention patents shall be accepted or granted.

Note: To be declared by enterprises.

Keywords: reducer, torque sensing, condition monitoring

1.6 Multi-heterogeneous robot autonomous collaborative detection technology (Common Key Technology Category)

Research content: To solve the problems of satellite signal rejection, limited robot mobility, and difficulty of precision control in the efficient environmental detection of underground unstructured and irregular spaces, research will be carried out on bionic self-organizing network under information denial conditions, autonomous positioning and seamless navigation of robots in unstructured three-dimensional environments, precision motion control and distributed collaborative optimization strategies, three-dimensional space construction based on autonomous collaboration of heterogeneous robots in the air and on the ground, high-dynamic three-dimensional path planning and reconfiguration, and fusion sensing of the surrounding environment of the target to be tested and accurate detection, as well as other key technologies, so as to develop a multi-heterogeneous robot autonomous cooperative detection system applicable to underground unstructured irregular spaces, and carry out validation and application for typical scenarios.

Evaluation index: To form an unstructured three-dimensional environment multi-heterogeneous robot autonomous cooperative detection system; support not less than 3 types of 10 air-ground heterogeneous robot autonomous cooperative operation; absolute robot positioning accuracy under dynamic conditions: ≤5cm; air-ground heterogeneous robot relative positioning accuracy: ≤10cm, and cooperative formation position error: ≤20cm; 100 ㎡ range of environmental mapping accuracy: ≤5cm, cooperative detection time: ≤1min, target recognition rate: ≥95%; and carry out application verification in urban underground pipe corridors and other non-regular space not less than 50,000 ㎡. Overall technology readiness level ≥ 6. At least 5 invention patents shall be accepted or granted.

Keywords: Unstructured three-dimensional environments, air-ground heterogeneous robots, cooperative detection

1.7 Software platform for robotics process knowledge map generation and offline programming (Common Key Technology Category)

Research content: To solve the problem that industrial robots have many kinds of complex processes that hinder agile application, research will be carried out on key technologies such as knowledge extraction and modeling based on process data, knowledge map generation based on process rules, process planning based on knowledge map, robot path planning for complex surfaces of multiple processes, robot parameter optimization based on process constraints and dynamics optimization, and post processing and output to support multiple domestic robot languages, so as to establish a software platform for process knowledge map generation and offline programming, and carry out popularization and application for typical tasks.

Evaluation index: To establish a software platform for robot process knowledge map generation and offline programming, support knowledge map generation and offline programming for no less than 4 processes, such as welding, grinding and polishing, spraying and laser processing with the accuracy of the recommended parameters of the above processes: › 90% and the realizability of the processes: › 80%; the amount of online corrections to the offline programming program: ‹ 10%, and the accuracy of process simulation: › 90%; support for not less than 6 or more robot systems of not less than 4 domestic manufacturers; application by no less than 20 industrial robot systems; and application in not less than 20 industrial robot integrators. Overall technology readiness level ≥ 6. At least 5 invention patents shall be accepted or granted.

Note: To be declared by enterprises.

Keywords: process knowledge graph generation, offline programming, robot dynamics

1.8 Robot human-robot interaction safety and test verification (Common Key Technology Category)

Research content: To deal with the lack of safety testing and evaluation of human-robot interaction of non-medical collaborative and exoskeleton robots, research will be carried out on key technologies such as safety evaluation of robot human-robot interaction and collaboration under biomechanical constraints, safety evaluation of motion following and static-dynamic constraints of robots in close interaction with the human body, and safety guidelines and evaluation models for interaction of robotic systems under complex application scenarios and working conditions, so as to develop a safety test and verification platform for human-robot interaction and carry out application verification.

Assessment index: To establish a safety assessment system for non-medical robot human-robot interaction, form evaluation indexes and evaluation methods, and build a robot human-robot interaction safety test and assessment system; technical indexes of collaborative robot human-robot interaction safety test system: collision force measurement accuracy: ≤0.5N, stopping distance measurement resolution: ≤0.5mm, maximum collision pressure measurement: ≥600N/cm^2 and pressure distribution measurement function; Exoskeleton robot human-machine interaction safety testing system technical specifications: resistance measurement accuracy: ≤0.5N, pressure measurement accuracy: ≤0.5N, motion displacement measurement resolution: ≤0.1mm, so as to formulate two national, industry or related group evaluation specifications. Overall technology readiness level ≥ 6. At least 5 invention patents shall be accepted or granted.

Keywords: safety, test methodology, test platform

2. Industrial robots

2.1 Theory of design of drive-perception integrated soft robots (Basic Research Category)

Research content: Starting from the cutting-edge scientific research on new principles and technologies of soft-body structures, we will study the basic theories of soft-body robots with the ability to adapt to the environment, explore the deformation mechanism of soft-body structures and the mechanism of continuous variable stiffness, and form an integrated design method of deformation adaptation and drive sensing of soft-body structures under extreme environments and complex tasks. We will develop the principle prototype of soft robot adapted to the environment and tasks, and carry out experimental validation according to typical application requirements.

Evaluation index: To develop new principles, technologies and methods related to soft body structures, to develop more than 2 types of functional drive units based on soft body structure, develop a prototype of drive-perception-integrated soft body robot with drive deformation ≥20%, continuous change of stiffness ratio ≥3 times, perception accuracy ≤5%, and complete no less than 2 typical scenarios of operational tasks and verify them in simulated environment. At least two advanced frontier technologies shall be invented first or reach the international advanced level of the same kind of technology, and supporting materials shall be provided. Overall technical readiness level: ≥6; no less than 5 invention patents shall be obtained/authorized.

Keywords: soft robot, drive-sense integration, continuous variable stiffness

2.2 Autonomous intelligence and swarm intelligence emergence in multi-robot co-manufacturing (Basic Research Category)

Research content: At the academic frontier of robot autonomous intelligence and swarm intelligence emergence, we shall explore robot self-perception, self-learning, self-adaptation mechanism, research on autonomous intelligent closed-loop technology that efficiently connects external environment, sensing system, control system, and actuating end; explore multi-machine swarm intelligence emergence and feedback mechanism, research on self-organization and collaborative planning technology; explore multi-machine robot general intelligence interpretation, group collaborative evolution and intelligence and study safe and reliable self-learning evolution operation technology, so as to develop autonomous intelligent robots and swarm wisdom emergence cluster system. We will carry out experimental validation for typical tasks of multi-robot collaborative manufacturing.

Evaluation index: To put forward the theory and method related to autonomous robot intelligence and swarm intelligence emergence, develop no less than 2 kinds of autonomous operation intelligent robot test prototypes, construct more than 2 kinds of swarm intelligence emergence robot cluster systems, and verify the technology in no less than 2 typical scenes of intelligent manufacturing, such as multi-robot collaborative assembly and grinding. The number of robot nodes in each scene is ≥8, the single-task scheduling decision time is ≤1s, and knowledge migration and evolutionary learning of more than 3 types of tasks can be realized; and establish a corresponding evaluation index system with typical scene tasks with the overall technology readiness level of ≥ 4. At least 2 advanced cutting-edge technologies shall be invented or reach the international leading level, and supporting materials shall be provided; and no less than 5 invention patents shall be applied/authorized.

Keywords: autonomous intelligence, swarm intelligence emergence, collaborative manufacturing

2.3 Natural robot interaction and communal collaboration in dynamic unstructured environments (Basic Research Category)

Research content: At the academic frontiers of robot natural interaction and inclusive collaboration, we will reveal the mechanism of human-centered human-machine-object interaction in dynamic unstructured environments, research the technologies of expression/speech/gesture and other visual, auditory, and tactile multi-mode interaction information fusion, human work intention recognition, understanding, and behavioral prediction; break through the technologies of reconfiguration modeling of human-machine shared environments and efficient mutual assistance and behavioral planning; and explore the safety protection mechanism of human-machine inclusive collaboration, so as to construct a human-machine-environment multi-dimensional integration collaborative robot system, and carry out experimental validation in typical scenarios of 3C assembly and other operational tasks.

Evaluation index: To establish the theory and method related to robot natural interaction and inclusive collaboration, develop not less than 3 types of inclusive collaborative robot systems, realize the integrated recognition correct rate of expression/speech/gesture≥95%, dynamic planning frequency≥100Hz, collision force perception ≤0. 5N, and reactive behavior replanning time ≤100ms, carry out technical validation in not less than 3 types of typical scenarios, and establish the corresponding human-machine-object interaction and inclusive collaboration evaluation index system in combination with typical scene tasks; so as to complete the functions of transition cooperation assembly, human-machine collaboration item delivery, dynamic environment active obstacle avoidance and passive compliance; overall technical readiness level ≥4. At least 2 advanced cutting-edge technologies shall be invented or reach the international leading level, and supporting materials shall be provided; and no less than 5 invention patents shall be applied/authorized.

Keywords: collaborative robots, natural interaction, cohesive collaboration, dynamic unstructured environments

2.4 Rapid reconfiguration technology for automated robotic production lines (Common Key Technology Category)

Research content: To meet the need of high-end manufacturing industries, such as consumer electronics, for new manufacturing modes featuring multi-variety, customization, mixed-flow production and fast production changeover, we will research on modularized design methods for plug-and-play robotic machining/inspection/assembly manufacturing cells; make breakthroughs in multi-protocol adaptive interaction and efficient interconnection between robots/equipment/manufacturing execution systems, dynamic configuration and combination optimization of heterogeneous manufacturing units, production line simulation, reconfiguration and rapid line access and other key technologies; develop task-driven methods for rapid configuration, rapid calibration, rapid teaching and low-code programming of industrial robots; develop a multi-process adapted mobile work robot; develop a multi-process adapted mobile work robot; and complete technical verification to meet the manufacturing needs for consumer electronics and other products.

Evaluation index: To a modular, highly stable, high-speed and dexterous robot manufacturing cell to meet the demand for high-end manufacturing such as electronics with the acceleration≥ 2g (gravitational acceleration), running speed ≥ 2m/s, actuator replacement time at the end of different processes ≤2min, and the repeated positioning accuracy after replacement ≤± 0.02mm; develop a plug-and-play multi-process adapted mobile robot with the mobile positioning accuracy ≤±10mm, which can be reconfigured with no less than three types of execution units to adapt to no less than three types of technologies; develop an automated reconfigurable robot production line for the manufacture of consumer electronics such as cellular phones and notebook computers with the robot number of ≥20 sets, production efficiency higher than manual production by ≥30%, and the reuse rate of production line equipment after product changeover of ≥80%. Carry out application validation in domestic consumer electronics and other products manufacturing backbone enterprises. Overall technology readiness level: ≥ 7; not less than 5 invention patents shall be accepted/authorized.

Keywords: reconfigurable, plug-and-play, mobile operations

2.5 Research, development and application of heavy-duty industrial robots (Common Key Technology Category)

Research content: For the technical demand for high precision heavy-duty operation of robots, we will research on joint modeling and integrated co-design of electromechanical control parameters coupling, joint modeling of kinematics and dynamics based on multi-objective optimization, motion control, trajectory planning and real-time compensation of errors under dynamic loading conditions, vibration suppression of high-speed motion and trajectory accuracy maintenance, and other key technologies, and develop 500kg-class domestic heavy-duty industrial robots to conduct process research for the strategic needs of national key industries, and realize application verification.

Evaluation index: To develop tandem multi-joint heavy-duty robots with rated load ≥ 500kg and number of degrees of freedom ≥ 6; the load to weight ratio of the whole machine ≥ 0.2, arm span ≥ 2,800mm; position repeatability ≤ ±0.08mm, trajectory repeatability ≤ ±0.30mm; stabilization time of the robot within 0.4mm ≤ 200ms; average trouble-free time ≥ 60,000h; localization rate of core components such as controller, reducer and servo system ≥ 85%; functional safety in line with ISO10218 standards. Carry out application verification for national key industries such as aviation, aerospace and shipping. Overall technology readiness level: ≥ 7; not less than 5 invention patents shall be accepted/authorized.

Note: To be declared by enterprises.

Keywords: heavy-duty robot, accuracy maintenance, vibration suppression

3. Service robots

3.1 New concept robotics for medical-industrial crossover (Basic Research Category, Young Scientist Project)

Research content: Aiming at the development trend of medical-industrial crossover frontier disciplines, through the crossover integration of multi-disciplines such as materials, machinery, information, medicine and micro-nano with robotics, we will research on new principles, new methods and new forms to enhance the robot's environmental adaptability, task operation ability or intelligent decision-making ability, and realize the innovative design of medical-industrial crossover new concept robotics.

Evaluation index: To form a new concept robot for medical-industrial crossover with original nature, to develop system prototypes, and to demonstrate potential applications in related important fields, with specific task objectives and system assessment indicators designed independently by the declared project team. Compared with the existing technologies in the field, at least 1 single technology shall be of breakthrough innovation in improving the robot's environmental adaptation ability, task operation ability or intelligent decision-making ability. Overall technology readiness level: ≥ 5; not less than 5 invention patents shall be accepted/authorized.

Note: The number of projects to be supported is 3.

Keywords: medical-industrial crossover, new concept robot, micro- and nano-robot

3.2 Theory and methods of behavior enhancement based on brain-computer intelligence integration (Basic Research Category)

Research Content: To meet the demand for behavioral enhancement that integrates robot intelligence and animal intelligence, we will explore the basic theories of highly biocompatible and minimally invasive central nerve signal sensing, advance prediction, control switching of biomechanical systems, hybrid intelligent decision making, and dynamic game of multiple behavioral enhancement groups, and research on the control modes of bi-directional brain control and simultaneous control of the brain and behavioral enhancement of intelligent robots based on direct, fast, and accurate central nerve signal sensing. We will integrate brain-machine intelligence and behavior enhancement robot prototypes and conduct typical application verification.

Evaluation index: To propose the behavioral enhancement technology based on brain-computer intelligence fusion in the bio-machine fusion system, and develop no less than 3 types of minimally invasive self-expanding high-throughput neuroelectrodes, with the ratio of incision area to electrode area ≤0.2, the average precision error of the relative position between electrode sites after self-expanding ≤10μs, and the number of fluxes ≥1024, and the threshold value of the current required for effective electrical stimulation adjustable from 1μA to 1mA; pass a sub-slow toxicity test for not less than 32 weeks; percentage of effective channels for high-throughput neuroelectrode signal acquisition ≥80% at 8 to 12 months of in vivo implantation; conduct experimental validation of information interaction in no less than three brain regions on no less than three model animals such as rodents, large animals, and non-human primates, respectively (of which non-human primates are necessary); the brain-computer interaction model includes real-time perception and closed-loop regulation, control switching, hybrid decision-making of living machines and behavioral enhancement; overall technical readiness level ≥ 6, and validation of the group gaming system framework on at least 1 model animal. At least 2 advanced cutting-edge technologies shall be invented or reach the international leading level and supporting materials shall be provided; and no less than 5 invention patents shall be applied/authorized.

Keywords: bio-intelligence fusion, behavioral enhancement, swarm intelligence gaming

3.3 Drug-targeted delivery field-controlled micro- and nanorobotics and drive-control systems (Basic Research Category)

Research content: To solve the difficult problem of drug target delivery caused by large spatial and temporal highly disturbed in vivo environments of large animals, we will research on the basic theories and realization methods of highly biocompatible micro-nano robots, such as biomimetic design, environment sensing, motion control, and other basic theories and realization methods; explore the mechanism of multi-modal movement and group regulation of micro-nano robots, and break through the key technologies of targeted drug delivery, multi-response composite therapy, and degradation/recovery within the in vivo chamber of large animals; and construct a demonstration and validation platform for micro- and nano-robotics, and carry out large-animal in vivo tests in combination with typical diseases.

Evaluation index: Breakthroughs in cutting-edge key technologies of field-controlled micro-nano robotic systems for in vivo targeted drug delivery to large animals; develop no less than two types of biocompatible micro-nano robots with three-dimensional swimming ability and trajectory tracking accuracy ≤10% of body length, and at least one type of robot with movement speed of 30 times body length per second and trajectory tracking accuracy ≤10% of body length; accuracy of group navigation and localization in body fluid environments is better than 1x the group size; develop for experimental pigs and other large animal disease treatment prototype system, the effective operating space≥20cm×20cm×20cm, field-controlled movement degrees of freedom ≥ 5, actuation frequency ≥ 80Hz, to achieve the digestive tract, joint cavity, intraocular and other typical diseases of large animals in vivo test; overall technical readiness level ≥ 6. At least 2 advanced cutting-edge technologies shall be invented or reach the international leading level, and supporting materials shall be provided; and no less than 5 invention patents shall be applied/authorized.

Keywords: field-controlled micro- and nanorobotics, drug-targeted delivery, large animal in vivo testing

3.4 Flexible robot technology for complex manipulation with variable internal diameter natural cavity (Common Key Technology Category)

Research content: To solve the difficult problem of flexible deformation lumen, such as digestive tract, which has large size change, complex operation and high surgical risk, we will research on the key technologies of flexible robot configuration with large bending curvature adaption and trans-lumen capability, force sensing interaction sensing, modeling and real-time navigation of lumen with variable internal diameter and autonomous control of lumen movement with variable internal diameter, etc., develop prototype of robotic system, establish the operation procedure and specification of the robot, and complete the ethical reporting. We will also conduct animal experiments and effectiveness evaluation, and validate the technology and function in biliary-pancreatic duct intervention surgery and other scenarios.

Evaluation index: To develop a flexible variable internal diameter lumen complex operation robot system and realize intubation, fetching and other complex operations; the outer diameter of the end of the flexible robot is ≤2.8mm, the radius of curvature is ≤15mm, the bending angle is ≥120°, and the degree of freedom meets the corresponding requirements of the art; flexible robot end three-dimensional force sensing accuracy ≤0.05N; comprehensive positioning accuracy≤1.5mm,and navigation error≤5°; overall technical readiness level ≥ 7, completion of not less than 10 cases of large animal experiments of the same species, and submission of third-party evaluation reports; and at least 5 patents for inventions shall be accepted/authorized.

Keywords: interventional surgical robot, force sensing interaction perception, autonomous navigation

3.5 Continuum robotics for injection sampling in confined spaces (Common Key Technology Category)

Research content: To solve the difficult problem of dexterous operation in rigid narrow and curved orifices, we will research on the key technologies of miniature dexterous continuum mechanism creation under multiple constraints, refined three-dimensional modeling of complex orifices, path and attitude planning and precise control of position, endoscopic image enhancement and guidance, and human-robot cooperation and safe operation, etc., and develop prototype of the robotic system, so as to realize the flexible movement and precise operation under multiple constraints in narrow and curved orifices; and we will establish robotic operation procedures and norms, complete ethical reporting, conduct animal experiments and validity evaluation, and carry out technical and functional validation in surgical scenarios such as inner ear injections and sampling through the ear canal via bone rigidity and narrow natural cavities.

Evaluation index: To develop a continuum robotic system under multiple constraints in a narrow space, with functions such as injection and sampling; actuator continuum outer diameter ≤2mm, the number of degrees of freedom≥5, continuum trajectory tracking error ≤0.3mm; end-effector diameter ≤100μm, target point identification accuracy ≥90%, repeatable positioning accuracy ≤0.1mm for puncture operation; overall technical readiness level ≥ 7, no less than 10 cases of homologous animal experiments completed and third-party evaluation reports submitted; not less than 5 patents for inventions accepted/authorized.

Keywords: continuum robot, positional planning, fine surgery

3.6 Heterogeneous tissue debridement and excision robotics (Common Key Technology Category)

Research content: To solve the difficult problems of robot operation and control in narrow space and mixed soft and hard tissue scenes, we will research on the key technologies of multi-instrument collaborative dexterous debridement and resection operation mechanism, precise sensing and identification of heterogeneous tissues based on the fusion of functional and structural images, planning and visual fusion navigation, dynamic task allocation and decision-making, and safe interaction and control of human-robot collaboration, and develop a prototype robot system for debridement and resection of heterogeneous tissues in complex scenes. We will establish robot operation procedures and norms, complete ethical reporting, carry out experimental validation and effectiveness evaluation, and conduct technical and functional validation in scenarios such as intra-articular infection debridement surgery.

Evaluation index: To develop heterogeneous tissue debridement robotic system in complex scenes, with the degree of freedom of the robotic arm meeting the requirements of the corresponding operation, carrying end debridement instruments ≥5, degree of freedom ≥3; heterogeneous tissue boundary recognition rate ≥95%; robot boundary control accuracy under cooperative operation≤1mm; overall technical readiness level ≥7, complete experimental validation of no less than 10 cases of homozygous animals and cadaveric specimens and submit a third-party evaluation report. Not less than 5 invention patents shall be accepted/authorized.

Keywords: debridement and resection robot, heterogeneous tissue recognition, multi-instrument collaboration

3.7 Luminal surgery robot autonomous suture operation technology (Common Key Technology Category)

Research content: To solve the difficult problem of autonomous suturing operation of laparoscopic surgical robots, we will research on the key technologies of vision-based haptic virtual force accurate generation, hand-eye coordinated calibration, real-time accurate localization and navigation, operator's experience data learning and knowledge migration, and the generation of autonomous suturing action based on the set of surgical operation commands, etc., develop the prototype of high-efficiency laparoscopic surgical autonomous suturing robotic system, and establish the operation process and specification of autonomous suturing robots, carry out animal experiments and effectiveness evaluation, and validate the technology and function in laparoscopic surgical scenarios of parenchymal organs, such as kidney.

Evaluation index: To develop a highly efficient laparoscopic surgery autonomous suturing operation robot system to realize autonomous suturing operation on surgical wounds and support different types of surgical access with different numbers of holes ≥2; visual and tactile force conversion rate ≥90%, virtual force conversion precision ≤0.5N; hand-eye calibration precision ≤0.5mm; soft tissue navigation and positioning precision better than 1mm; suturing precision ≤2mm, single-needle suturing time ≤15s; overall technical readiness level ≥7, complete no less than 10 cases of small pig animal experiments and submit third-party evaluation reports; accept/authorize no less than 5 invention patents.

Keywords: laparoscopic surgical robot, autonomous suture manipulation, visual-tactile conversion virtual force

3.8 Highly compatible care and rehabilitation robot technology and system for the disabled elderly (Common Key Technology Category)

Research content: To solve the difficult problems of care and rehabilitation of recoverable disabled elderly, we will research on the design of high-compatibility mechanism of care and rehabilitation robots with multi-position support and multi-rotation centers, intent detection, comprehension and human-machine interaction of disabled elderly, rehabilitation improvement mechanism and safe care method, quantitative assessment and personalized prescription generation, and intelligent care and multimodal rehabilitation intervention, and establish an intelligent information platform for motor ability assessment, care and rehabilitation training, complete ethical reporting and carry out clinical validation.

Evaluation index: To develop a highly compatible care and rehabilitation robot system for recoverable disabled elderly, with functions such as multi-position support, limb movement self-adaptation, weak consciousness detection, multi-mode rehabilitation intervention, etc.; the total number of degrees of freedom of the robot's medulla oblongata, knee and ankle joints is ≥10, and there are ≥ 5 types of care and rehabilitation positions, and the degree of matching of the joint movements is ≥80%; the accuracy of the comprehensive assessment of the locomotor ability is ≥90%, and the accuracy of understanding the weak intention is ≥80%; there are ≥ 5 types of consciousness detection and rehabilitation intervention rehabilitation training modes ≥3; overall technology readiness level ≥7, no less than 10 cases of clinical validation completed; and no less than 5 invention patents accepted/authorized.

Keywords: rehabilitation robot, institutional compatibility, rehabilitation intervention

3.9 Tumor radiation therapy robot system with real-time precise control of position in movable target area (Application Demonstration Category)

Research content: To solve the problems related to the thoracic and abdominal cavity active tumor target area and radiation accurate alignment of radiation therapy operation, we will research on the body surface and in vivo tumor target area associated with motion modeling, and establish the body surface monitoring under the target area motion prediction model, real-time high-precision tracking of micro-motion on the surface of the body, the design of large-load, high-rigidity positioning robot and high-precision dynamic control and other key technologies, to carry out robotic clinical operation specifications and radiotherapy operating room compatibility design and the development of active target-area positional attitude real-time accurate regulation of tumor radiation therapy robot system, so as to complete the research on the robot system operation specifications, clinical diagnosis and treatment specifications, and conduct product registration.

Evaluation index: To develop active target-area positional attitude real-time accurate regulation of tumor radiation therapy robot system, and the whole system obtains NMPA Class III medical device registration certificate; the maximum load of positioning robot≥200kg; positioning accuracy error≤0.5mm, angle deviation≤0.2°; body tracking accuracy≤0.5mm; tumor radiation therapy center deviation ≤3mm, angle deviation ≤1°; the overall technical readiness level ≥8, complete the number of clinical cases stipulated by NMPA; not less than 5 invention patents accepted/authorized.

Note: To be declared by enterprises. At the end of the project, we will provide a complete tumor radiation therapy robot system, complete product testing and clinical trials in accordance with NMPA medical device product registration requirements and obtain a Class III medical device registration certificate.

Keywords: radiation therapy robot, active target area, real-time modulation

3.10 Bone tumor removal robotic system (Application Demonstration Category)

Research content: For bone tumor resection and other abnormal osteotomy surgery operation difficulties, we will research on CT/MR-based multimodal image fusion, feature recognition, segmentation and lesion reconstruction, complex irregular surface resection path planning and enhanced navigation, intelligent perception of interaction and precise control of the robot and other key technologies; develop bone tumor resection robotic system, as well as the supporting power unit and surgical tools, to complete product testing and clinical trials specified in NMPA, carry out research on the operation standard and clinical diagnosis and treatment standard of the robotic system, and complete the registration of the products.

Evaluation index: To develop bone tumor resection robot system with functions of intelligent planning of heterogeneous surfaces and precise tissue resection, and the whole system shall obtain the registration certificate of Class III medical device of NMPA; the robot degree of freedom shall be ≥ 6, the load ≥7kg, the absolute positioning accuracy ≤1.0mm; the system's dynamic trajectory error ≤1.0mm; the accuracy rate of tumor tissue recognition and segmentation ≥90%; the resolution of cutting force recognition ≤0.5N; robot physiological motion compensation delay ≤10ms; overall technology readiness level ≥8; complete the number of clinical cases stipulated by NMPA; and no less than 5 invention patents accepted/authorized.

Note: To be declared by enterprises. At the end of the project, we will provide a complete bone tumor removal robot system, complete product testing and clinical trials in accordance with NMPA medical device product registration requirements and obtain a Class III medical device registration certificate.

Keywords: bone tumor resection robot, irregular surface planning, shaped osteotomy

4. Specialty robots

4.1 Bionic new concept robotics (Basic Research Category, Young Scientist Project)

Research content: Focusing on the national major demand scenarios, based on the cutting-edge theories and advanced technologies of bionics, we will explore new types of drive, new types of mechanism, etc., research new principles, new methods and new forms to enhance the robot's environmental adaptability, task operation ability or intelligent decision-making ability, and realize the innovative design of bionic new concept robots.

Evaluation index: To form a bionic new concept robot, to develop system prototypes, and to demonstrate potential applications in related important fields, with specific task objectives and system assessment indicators designed independently by the declared project team. Compared with the existing technologies in the field, at least one technology shall be a breakthrough innovation in improving the robot's environmental adaptability, task operation ability or intelligent decision-making ability; the overall technical readiness level ≥6, and no less than 5 invention patents shall be accepted/authorized.

Note: The number of projects to be supported is 3.

Keywords: bionic principle, new concept robot, novel drive, novel mechanism

4.2 Principles and technology of micro-nano manipulation for robotic precision assembly (Basic Research Category)

Research content: To meet the demand of precision operation under the tiny scale, we will study the principle of flexible precision transmission, make break through in the nonlinear compensation of ultra-high-precision motion creation, high-resolution displacement control and precise force control under the tiny scale and other key technologies, form the theory and design method of precision power transmission and synchronous drive and control of the macro-micro-nano cross-scale, develop the principle prototype of micro-nano manipulation robot, and carry out experimental validation in conjunction with the typical applications.

Evaluation index: To establish new principles and technologies for micro-nano manipulation of robots for precision assembly; develop a prototype of micro-nano manipulation robots to realize typical micro-nano operations such as positioning, clamping, feeding, rotation, etc., and achieve at least linear displacement ≥100mm in two mutually orthogonal directions, X and Y, with a resolution of ≤2nm and flatness of ≤20nm; range of rotary motion ≥±90°; an angular resolution of ≤0.01°; maximum operating force ≥10N, with a resolution of ≤10mN; maximum operating torque ≥1N mm, with a resolution of ≤1mN mm; overall technical readiness level ≥6. At least 2 advanced cutting-edge technologies shall be invented or reach the international leading level, and supporting materials shall be provided; and no less than 5 invention patents shall be applied/authorized.

Keywords: micro-nano manipulation, flexible precision drive, force-position synchronized drive control

4.3 Dynamic scheduling and optimization of autonomous mobile robot cluster systems (Common Key Technology Category)

Research content: To meet the urgent demand of intelligent warehousing and manufacturing for large-scale cluster operation of autonomous mobile robots, we will research on the technologies of multi-intelligent body high-precision navigation and distributed collaborative sensing under complex dynamic environment, large-scale real-time scheduling of autonomous mobile robot clusters, and optimization of collaborative operation based on data-driven and deep learning, develop the dynamic scheduling and optimization method of autonomous mobile robot cluster system and carry out experimental validation.

Evaluation index: To form dynamic scheduling and optimization methods for autonomous mobile robot cluster systems, with no less than three types of robots, supporting no less than two navigation modes such as two-dimensional code navigation and simultaneous localization and map building (SLAM) navigation with SLAM navigation accuracy of 3. Error under probability ≤±1cm; system scheduling capacity ≥3,000 units; application verification of a total of not less than 20,000 robots in typical scenarios such as pharmaceutical distribution, e-commerce retailing, footwear and apparel, intelligent manufacturing, etc.; overall technical readiness level ≥5, and not less than 5 invention patents accepted/authorized.

Note: To be declared by enterprises.

Keywords: autonomous mobile robots, cluster scheduling

4.4 Robot technology for high-temperature and strong impact load operation of smelting furnace (Common Key Technology Category)

Research content: To meet the needs for robot impact operation technology, we will explore the strong impact load on the robot transmission structure of the mechanical role and failure mechanism, carry out severe working conditions of strong impact class operation robot mechanism design and unloading method, instantaneous high torque high power motors, robot vibration suppression under strong impact load, based on the vision of a servo-force control of large loads of complex operations, and other key technology research; and we will also develop strong impact load operating robots and conduct application verification for typical scenarios.

Evaluation index: To form a strong impact load operation robot design method, develop a strong impact load operation robot system, and carry out application verification for typical scenarios of industrial silicon, calcium carbide and high temperature smelting of silicomanganese, ferrosilicon and so on. The number of degrees of freedom of the impact operation robot ≥ 5; the end of the maximum impact load≥ 80,000N, working temperature ≥ 2000℃; positioning accuracy ≤3cm, maximum impact stroke ≤3.5m, maximum speed ≥1.8m/s; the number of trouble-free impacts ≥10,000 times, to carry out application verification on more than 5 units To develop national, industry or related group standards: ≥ 2. Overall technology readiness level ≥ 7. At least 5 invention patents shall be accepted or granted.

Note: To be declared by enterprises.

Keywords: strong shock environments, robot design methods, unloading methods

4.5 Demonstration of underwater cable-laying robotic systems and applications for offshore new energy power plants (Application Demonstration Category)

Research content: To solve the problem related to the difficulty in the domestic offshore new energy power plant cable laying operation and poor continuous operation ability, we will carry out load analysis of key technologies such as the cable laying operations in different soils under high pressure environments such as mudflats and seabeds, underwater rare soft earth walking and propulsion technology, underwater rare soft earth walking and propulsion technology, and underwater cable detection and localization and automatic rail control technology, so as to develop a submarine cable-laying robotic system adapted to different soil substrates and conduct application validation in typical scenarios.

Evaluation index: To develop submarine cable-laying robotic system applying to different soil substrates. The maximum working depth of the robot≥200m; operation of the applicable seabed substrate for sand, clay, silt, etc., the maximum hardness of the soil≥100kPa; with walking ability with crawler and sleds; underwater cable burial depth detection ability≥9m (cable energizing/joining signal) and≥3m (cable without energizing/joining signal); the maximum diameter of the laying cable≥400mm, cable laying speed≥700m/h, continuous underwater work time≥35 days; laying depth ability≥5m, laying position error≤0.5m. Application demonstration shall be carried out in the scenarios of offshore new energy power generation field cable laying and construction. To develop national, industry or related group standards: ≥ 1. Overall technology readiness level ≥ 8. At least 5 invention patents shall be accepted or granted.

Note: To be declared by enterprises.

Keywords: underwater robot, autonomous underwater localization, submarine cable laying

IFR International Federation of Robotics

A03 Korea

for the Realization of K-Robot Economy

The 4th Basic Plan for Intelligent Robots

(2024~2028)

2024.1.

By Relevant Ministries

Table of Contents

I. Background of Promoting K-Robot Economy

Promoting K-robot economy is a way of catching three birds with one stone by developing a future industry, achieving industrial innovation and responding to the changes in the labor market.

◇ The robotics industry is the key to increasing industrial productivity and promoting economic innovation.

○ Advanced robots are emerging as a **new type of capital goods that increases production efficiency** with the **convergence of new technologies** such as artificial intelligence (AI) and 5G and the expansion of human-robot collaboration across industrial activities.

○ With the **enhanced level of mobility and intelligence** of robots even in the service industry, **new business markets** that bring innovation to logistics, everyday safety, national defense, food manufacturing, etc. are **developing in full swing**.

* The service robotics market is forecast to grow more than 4 times from USD 12.7 billion in 2021 to USD 51.3 billion in 2030 (World Robotics).

◇ Possible to respond to rapid demographic changes and contribute to a safe working environment

○ Robots are a key means to **effectively deal with** the **imbalance in labor supply and demand** caused by the rapid decline of the working-age population and the growth of the elderly population.

* Working-age population aged 15 to 64: projected to decrease by 3.2 million in 2030 compared to 2020 (2022, Ministry of Employment and Labor)

* The number of seniors aged 65 and over in 2022 was about 9.02 million, 17.5% of the total population of Korea (2022, Statistics Korea).

○ Robots can be used in high-risk industries to reduce **occupational injuries and diseases**, thereby meeting the growing **expectations of occupational safety**, and society's perception of dangerous jobs can also be improved.

◇ Advanced robotics is a strategic industry with great potential, and countries around the world are jumping into the global race with related policies.

IFR International Federation of Robotics

○ Advanced robotics has the potential to become a new growth engine and a national strategic industry with significant impacts on the upstream and downstream industries due to the convergence of semiconductors, AI, secondary batteries, and advanced components among others.

○ Recognizing advanced robotics as a future strategic industry and a key sector to enhance industrial competitiveness, major countries have put forth multifaceted support policies.

* (USA) The Biden administration provided USD 1.3 billion in funding to support robotics R&D through the Foundation Research in Robotics (FRR) program (2023) (EU) Plans to invest EUR 2.6 billion by 2027 through the AI, Data and Robotics Association (ADRA) program

NOTE s Industry Promotion Strategies of Major Countries

Country	Description
United States 	❍ Undertaking **NRI** projects centered on **collaborative robots** under the **Advanced Manufacturing Partnership (AMP)** initiative (2011 to 2021) * (National Robotics Initiative) Over USD 250 million in funding for more than 300 projects over the course of 12 years ❍ The Biden administration supported **R&D across robotic systems** through the **National Science Foundation (NSF)'s Foundation Research in Robotics (FRR)** program (2023, USD 1.3 billion). ❍ In **2022**, Boston, Pittsburgh, and Silicon Valley formed the **U.S. Robotics Cluster Alliance (USARC)** to strengthen cross-cluster collaboration, robotics-AI investment, and startup support. * In 2021, the United States accounted for 60% of global investment in robotics (USD 20 billion). ❍ Robotics is included among the **10 core technology areas** of the **CHIPS Act** (USD 500 million in funding in 2023).
Japan 	❍ Established the **New Robotics Strategy** (2015) and invested **JPY 100 billion** (~2020) for robotics business regulatory reform, robot R&D and dissemination, fostering of SI companies, and human resource development. ❍ The Ministry of Economy, Trade and Industry is aiming for the **expansion of robot utilization by small and medium-sized enterprises (SMEs), R&D, and robot infrastructure** through the **Master Plan for the Development of the Robotics Industry (2019)** (2022, USD 900 million) * Manufacturing (USD 77.8 million), healthcare (USD 55 million), robot infrastructure (USD 643.2 million), agriculture (USD 66.2 million), etc. ❍ **Established the Moonshot R&D Program** and **invested USD 4.4 billion** in the robotics field (2020 to 2025) ❍ Included robotics among the **11 critical materials** and **20 critical high-tech technologies** prescribed in the **Economic Security Promotion Act** (2022)
China 	❍ Included robotics as one of the **10 key areas** in Made in China 2025 (2015) and announced the **Robotics Industry Development Plan** (2021 to 2025) - Conducting **R&D projects** (100+) and **pilot and demonstration (testbed) projects** (200+) in 10 key areas* with the aim of **doubling the robot density by 2025**, and establishing experience and verification/validation centers, etc. * Economic (manufacturing, agriculture, construction, energy, commercial logistics) and social and civil (healthcare, caregiving, education, business services, safety and emergency) ** Invested USD 43.5 million in 2022 in the key special projects of "Intelligent Robots" alone ❍ **Announced the Robotics+ Utilization Plan in 2023, presenting R&D and supply plans for service robots in agriculture, logistics, energy, healthcare, etc.**

EU	❍ **Invested EUR 2.8 billion in public-private partnerships (PPPs) through the SPARC Program** (2014 to 2020) * **S**mart **P**erceptive **A**utonomous **R**obots **C**onnected ❍ Invested **EUR 2.6 billion** in AI and robotics through the **ADRA program** in 2021 (2021 to 2027) * (AI, Data and Robotics Association) Development of a robotics-based AI smart manufacturing system

II. Robotics Industry Analysis and Diagnosis

◇ **(Global market) Expected to triple in size from USD 28.2 billion in 2021 to USD 83.1 billion in 2030, with market growth driven mainly by service robots**

◇ **(Domestic market) Ranking No. 1 in the world in terms of robot density in the manufacturing industry, but heavily reliant on foreign-made core parts and others, and the penetration of service robots is lower than expected**

1 Global Market Trends

◇ (Manufacturing Robots) Expected to double in size from USD 15.5 billion in 2021 to USD 31.8 billion in 2030

☐ **(Market) The market size of manufacturing-oriented countries such as China, the United States, Japan, and Germany accounts for about 80% of the total.**

○ **Demand for investment in manufacturing robots is expected to grow due to the increasing automation demand in emerging manufacturing countries** such as China and **supply chain on-shoring policies** in the U.S. and Europe**.**

* In 2022, China's manufacturing robot sales reached USD 7.06 billion, up 3% year-on-year (47% of manufacturing robot sales worldwide).

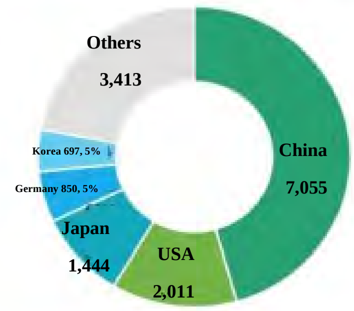
【 Global Manufacturing Robot Market Outlook 】

(Unit: million USD)

Source: Estimated based on data from the IFR

【 Manufacturing Robot Market Share 】

(2021, Unit: million USD, %)



Source: Estimated based on data from the IFR

☐ (Market Players) FANUC, Yaskawa, and Mitsubishi (Japan), ABB (Switzerland), and KUKA (China) together have a **40% share** of the global manufacturing robot market (Market and Market 2021).

○ Technological advancements such as **autonomous operation and AI** have led to the **expanded scope of utilization for manufacturing robots to include atypical processes** and **heated up competition in new markets such as collaborative robots.**

* The collaborative robot market is expected to grow to about USD 10.5 billion in 2027, and major industrial robot companies such as Japan's FANUC, Switzerland's ABB, and Taiwan's Techman are competing for market leadership.

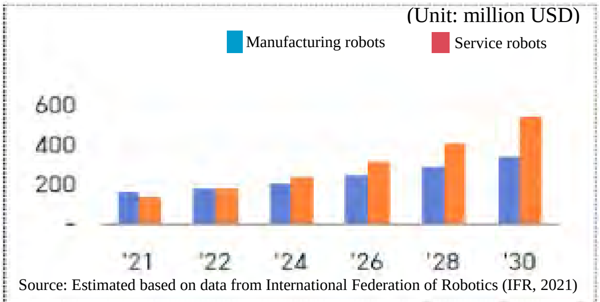
◇ (Service Robots) Expected to quadruple in size from USD 12.7 billion in 2021 to USD 51.3 billion in 2030

□ (Market) There is a heated race in the service robotics market to respond to labor shortages, diversification of service demand, etc. and it is expected to **overtake the manufacturing robotics market after 2025**.

○ The **market for specialized service robots** for the **logistics and healthcare industries** among others is expected to **expand significantly** (120,000 units in 2021 → 450,000 units in 2025, IFR) .

□ (Market Players) **There is yet to be first mover in the market,** so there has been a rapid emergence of **startups developing** service robots with various **differentiated functions.**

【 **Service Robotics Market Outlook** (2021) 】



Source: Estimated based on data from International Federation of Robotics (IFR, 2021)

○ Innovative companies are emerging in fields such as logistics autonomous mobile robots (AMR), food tech robots, and home care robots, and mergers and acquisitions (M&A) are becoming more frequent.

* Amazon plans to utilize robots for 75% of the transportation process for 5 billion parcels per year by developing its own logistics transportation robot (Proteus) and proceeding with an M&A with Kiva (AMR).

◇ (Robotic Parts) Expected to grow six times in size from USD 9.4 billion in 2021 to USD 55.9 billion in 2030

□ (Market) As the competitiveness of high-tech robots **is determined by the level of intelligence, mobility, and precision control, the market for parts** required for intelligence **is expected to grow rapidly.**

* Sensing (lidar, tactile), control (controller), drive (motor, reducer), motion (gripper), etc.

○ In particular, as the autonomous function of robots becomes further strengthened, **robotics software** for controlling cognition, judgment, behavior, etc. is becoming **increasingly more important.**

* The share of software products in robot manufacturing is expected to continue to rise from 23% in 2017 to 53% in 2023.

□ (Market Players) The market for **core parts such as servo motors and reducers** (56% of the cost of manufacturing robots) is dominated by Japanese companies.

Category	Market share
Servo motor	**· FANUC 21%, Yaskawa Electric 20%, Mitsubishi Electric 16%, Siemens 16%, etc.**
Reducer	**· (Harmonic) HDS 73.3%, NIDEC SHIMPO 11.2% / (RV) Nabtesco 60%**

○ American tech companies are offering **cloud-based simulation services, applications, etc.** to preempt the robotics software market.

* Amazon: AWS Robomaker, Google: Cloud Robotics, etc.

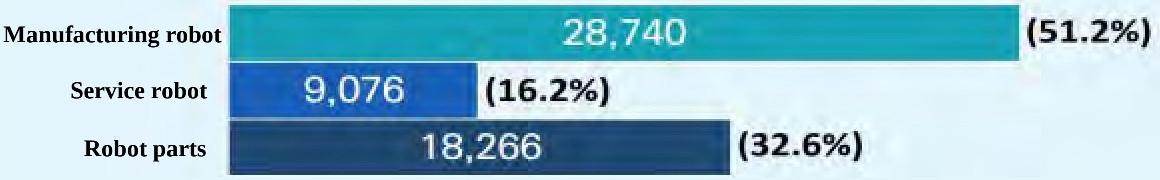
2 Current Status of the Domestic Robot Industry

◇ **The size of the domestic robot industry, as of 2021, is KRW 5.6 trillion, and the localization rate of parts is 44%.**

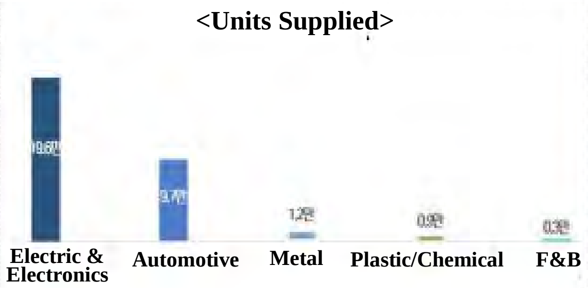
◇ **Manufacturing robots (51.2%) and robot parts (32.6%) account for about 84% of the total market size, while the share of service robots* is still in its infancy.**

* Service robot market share (%): (2018) 11.5 → (2019) 11.9 → (2020) 15.6 → (2021)16.2

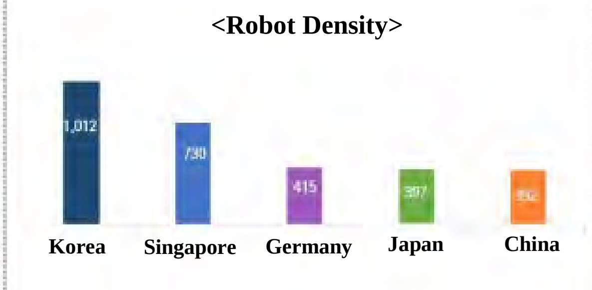
< Domestic Robot Market, as of 2021, KRW 100 million >



Manufacturing robots Concentrated in large industries such as automotive and electric and electronics industries. No. 1 in robot density in the world (IFR, 2021)



Source: IFR, 2022, cumulative



***Number of robots per 10,000 employees in the manufacturing sector**

○ However, the share of domestic companies in the global manufacturing robot market is about 7%*, and manufacturing robots requiring high precision are widely imported.

* Five companies, i.e., FANUC, Yaskawa, Mitsubishi, KUKA, and ABB, account for a 52 to 58% share of the global market (MARKET&MARKET, 2022).

Service robots The service robot market is still only one-third of the size of the manufacturing robot market. Aside from cleaning and food serving robots, logistics and cooking robots are still in the early stages.

* Of the service robot market (KRW 815.7 billion), the cleaning robot market size is estimated to be KRW 300 billion and the serving robot market KRW 270 billion.

○ Serving robots made in China are estimated to account for more than half (53%) the market share (2022).

Robot parts The technological competitiveness of Korea in sensor and software is about two-thirds of that of the leading countries such as Japan and Germany.

* Competitiveness in procurement of parts, software, etc.: Japan 97%, Germany 94.8%, Switzerland 87.2%, US 80.6%, China 73.6%, Korea 67.2%

○ The localization rate of parts is only 44%, which is low overall.
* Localization rate of parts: (2016) 41.1% → (2018) 43.2% → (2021) 44.4% (Korea Electronics Technology Institute)

Market Players About 99% of the 2,500 robotics companies are SMEs, and about 70% are companies with sales of less than KRW 1 billion (13 large companies and 20 medium-sized companies).

○ Large corporations are turning into robot providers through M&A, in-house R&D, etc. and startups are also pioneering the service robot market such as delivery, serving, and caregiving.

* (Samsung Electronics) Acquired a stake in Rainbow Robotics (2023), (Hyundai Motor Company) Acquired Boston Dynamics (2021), etc.

* (ROBOTIS) Operating the indoor autonomous robot “JIP GAEMI”, (Robo Arte) Planning to open a directly operated store in the U.S. called Robert’s Chicken

*

Diagnosis and Implications

◇ **Urgent need to dramatically improve technology, manpower, and corporate competitiveness, which makeup the foundation of the robotics industry**

◇ **Promote the spread of manufacturing and service robots for market expansion and economic innovation in the robot industry**

◇ **Strengthen strategic inter-company, inter-national, and inter-regional cooperation**

◇ **Create a favorable industry environment by redesigning robot-friendly systems and programs**

Technology Imported products are preferred for some of the key parts in the robot manufacturing process.

○ Robot drives and control parts made domestically act as constraints to the application of actual robot products due to lack of reliability and track record.

< Technology Level by Major Robot Parts >

Classification	Current level	Major items	Current situation
Sensing	◕	RGBD, force, torque, and tactile sensors, 2D·3D lidar, etc.	· Localization and mass production of unit sensors underway · Need to gain competitiveness in the AI-incorporated high value-added sensor module market
Control	◕	Single-axis, motion, and remote controller, PLC, etc.	· The level of each control technology is good · Heavy reliance on foreign-made semiconductors such as computation, communication, power, etc. and poor price competitiveness

Drive	◑	Reducer, servomotor, pneumatic drives, grippers, etc.	· Localization and mass production of reducers, motors, etc. underway · Inferior to Japanese products in terms of performance and price competitiveness; China is quickly catching up
Software	○	Gripping, object recognition, autonomous driving software, simulator, etc.	· Low localization rate of software and large technology gap compared to leading countries · Good expertise of software developers, but insufficient number of developers

* Korea Electronics Technology Institute, as of 2021

* Relative gap compared to leading countries for each part: (○) large gap, (◑) intermediate gap, (◕) small gap

Workforce About 35,000 people are employed in the robotics industry (2021), but the demand for workers is expected to increase to 50,000 by 2031 (3.8% annual increase, KIAT, April 2023)

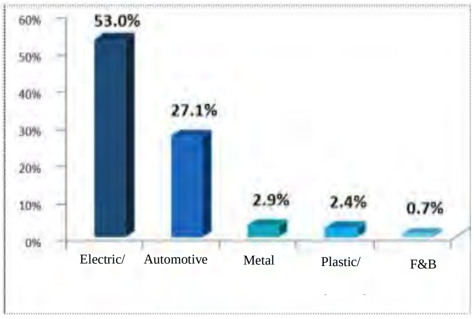
○ Robotics companies want to recruit manpower in various fields including software engineering (63%), mechanical design (44%), and AI (44%) (2022 Robot Industry Manpower Survey).

○ There is a shortage of manpower in the order of master's degree holders (15.3%), high school graduates (5.7%), and bachelor's degree holders (2.8%).

Market The utilization rate of robots among SMEs is still low, and there is still a lack of support for the penetration of intelligent and advanced manufacturing robots.

○ The penetration rate is high in the case of the large device industry.

○ The importance of dissemination of robots across the SMEs given the need to improve productivity and labor shortages is becoming pronounced.



○ For domestic service robots, there is a need to localize core parts and secure price competitiveness.

Business environment There is a need for support for investment funds, R&D, supply chain cooperation, etc.

■ Ranking of difficulties based on the 2021 domestic robot company survey (2,500 companies)
① Low funding (51.6%) > ② R&D support (25.4%) > ③ Cooperation with other companies (6.4%)

○ Support systems have not yet been established for cooperation networks among robotics companies including parts and software companies, regional clusters, international collaboration, and overseas expansion.

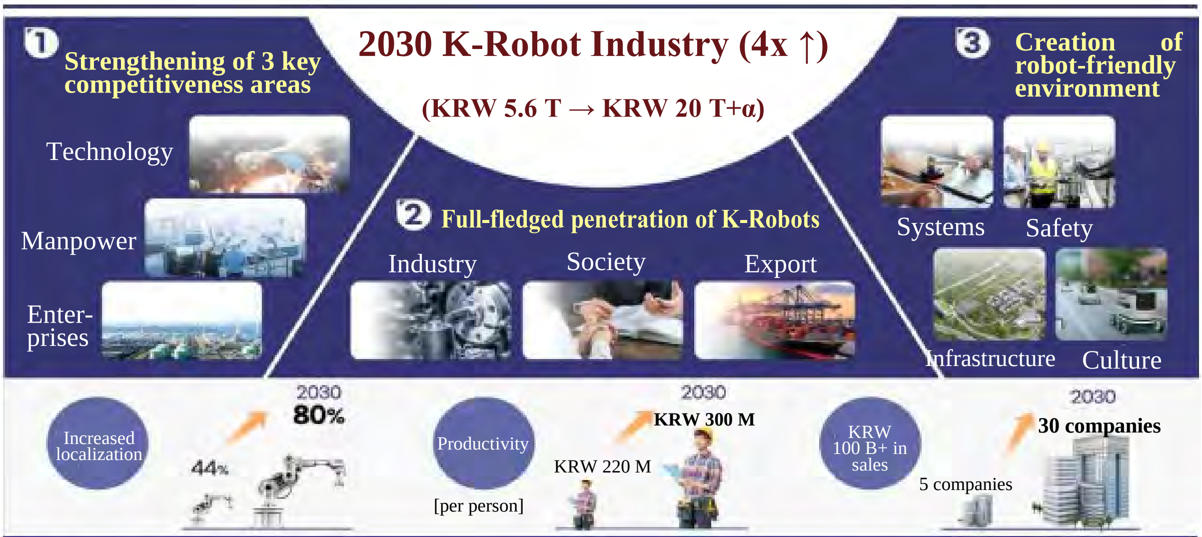
Infrastructure Existing systems designed around people and lack of safety standards are obstacles to entering the robotics market.

* Working toward regulatory improvement of 51 issues identified through the Regulatory Innovation Plan for Advanced Robots (March 2, 2023)

○ With the scope of robot utilization expanding, new issues such as preparedness against safety incidents involving robots and sound robot ethics and culture are being highlighted.

III. Direction of Implementation

Vision | 『K-Robot Economy』 Leading the Global Market



Task

Strong public-private cooperation centered on three major strategies
(KRW 3 trillion + a in public-private joint investment by 2030)

1 Strengthen 3 key areas of competitiveness

① **[Technology] Secure 8 key technologies [5 in hardware & 3 in software]**
② **[Manpower] Train 15,000 professionals in the fields of AI, software, etc.**
③ **[Companies] Nurture 150 robotics companies [Robot Specialty]**

2 Power the global expansion of K-Robots

① **[Domestic market development] Distribute 1 million units in the manufacturing and service industries by 2030**
② **[Overseas market development] Support companies in the areas of overseas certifications, ODA, and international R&D**

3 Build infrastructure tailored to the robotics industry

① **[Framework] Overhaul the Intelligent Robot Act and pursue regulatory reform for market entry**
② **[Safety] Strengthen safety nets by establishing a robot-specific insurance program, etc.**
③ **[Commercialization] Establish testbed facilities for market entry**
④ **[Culture] Promote a social consensus along with the dissemination of robots**

IV. Key Policy Initiatives

Strategy 1 Strengthening three key areas of competitiveness (technology, manpower, and enterprise)

1 Technology Secure 8 key technologies (5 in hardware & 3 in software)

◇ **Gain competitiveness in key parts and software technology** to strengthen the domestic robot supply chain, while **promoting technological collaboration between suppliers and users**

◇ Devise an **R&D roadmap** with concrete initiatives and schedules for technological development for advanced robots over the next decade (first half of 2024) and pursue robot R&D expansion as an inter-ministerial effort (about KRW 180 billion in 2023)

☐ **(Key Parts)** Intensive investment to develop source and application technologies with the goal of improving the technology independence rate of **five key parts in 2030** (44%→80% or greater)

< Technological Development of 5 Key Parts (Proposed) >

Field	Reducer	Servo motor	Gripper	Sensor	Controller
Source technology	· Durable materials · Heat treatment technology	· High power structure · Low speed, high precision	· Operation in dynamic environment · Flexible interaction	· High-definition RGB · Low-cost lidar	· Bin-picking operations · Robotic equipment integration
	↓ **Modularization - Integration**				
Application technology	· High power driver (reducer + servo motor) · Intelligent controller (sensor + controller) · Smart gripper (gripper + controller)			· Robotic hand integrated with tactile sensors (sensor + gripper) · Intelligent driving module (sensor + reducer + servo motor) · Lightweight high-precision robot (integration of all five types of parts)	

○ Reducers, servo motors, etc. are immediately moved to the commercialization phase through collaborative development by public research institutes and user companies (buyers) to ensure uniform quality in mass production and improve output density.

- Prioritize and support technological development projects that are matched by simultaneously surveying the desired technologies of buyers and the development needs of parts companies.

○ Focus on developing robot-specific technologies, such as making sensors smaller and more lightweight, fusing together high-performance computing modules, and adapting to various environmental conditions

○ For controllers, grippers, etc. that require enhanced precision, integrated operation functions, and grasping and control of various shapes, related technologies should be developed and verified using test infrastructure.

* Establish technical support infrastructure for service robot parts (2024~2028, KRW 10 billion), etc.

☐ **(Robotics Software)** Development of essential software technologies that are optimized for robots and enhance mobility, autonomy, and intelligence

○ Development of core software such as intelligent software* related to external environment recognition, context judgment, autonomous operation, etc. and middleware for integrated development, management, and application of robots

* software that expands robot functions by incorporating AI, cloud, big data, etc. into existing robot software

- Also develop software technologies that enhance the level of interaction with humans, such as human voice and behavior recognition and atypical complex cooperative activities

○ Develop software platforms, AI, and other technologies for performing complex operations based on a cloud-edge-device structure*

* Develop core software technology for complex intelligent autonomously behaving entity (Ministry of Science and ICT (MSIT), 2024 to 2027 / KRW 3 billion in 2024)

○ Pursue early commercialization of developed software technologies by drawing participation from buyers in the entire R&D process

< Technological Development of 5 Key Parts (Proposed) >

Autonomous movement software	Autonomous operation software	HRI
· Movement based on a pedestrian map · Spatial cognition based on semantic information · Atypical environment response	· Flexible process response and cognition · Gripping of atypical objects · Human-level task intelligence	· Services utilizing super-sized AI · Operations in reflection of the context of the dialog · Human-friendly task instructions

↓Linking with New Business

· Last mile delivery robots · Indoor and outdoor patrol robots	· Manufacturing robots for atypical assembly process · Household service support robots	· Care robots for seniors living alone · Rehabilitation robots for persons with disabilities

☐ **(Joint Development and Manufacturing)** Creation of a technological ecosystem based on openness and cooperation between buyers and suppliers such as parts and software companies and robot manufacturing companies

○ Formation of an advanced robotics alliance with robotics companies, public research institutes, and universities, modularization of common parts with high industry demand, and joint procurement and logistics

* Modularization of major parts used in key processes (assembly, transportation, processing, etc.) by deriving standardized specifications

→ Reducing the cost of introducing robots for SI companies and enhancing the convenience of maintenance

- Discovery of two models for prioritized support: ❶ Application of domestic parts and software to existing robots and ❷ joint development of domestic parts and software from the planning stage for new robot models

* Approve and support models for cooperation between suppliers and buyers through the Committee for the Competitiveness of Materials, Parts, and Equipment (2024, discover KRW 10 billion worth of cooperation models)

○ Jointly discover the demand for outsourced manufacturing and match with robot manufacturers to reduce manufacturing costs for SMEs and startups

☐ **(Global R&D)** Pursue and support the discovery of joint R&D projects based on specific joint technology needs with leading countries in the field of robotics technology (KRW 7 billion in 2024)
* Operation of consultation channels in each country with the Korea Institute for Advancement of Technology (KIAT) and the Korea Evaluation Institute of Industrial Technology (KEIT) as the supervising agencies

< Examples of Joint R&D >

Country	Field	Participants
United States	Softbot	• US Department of Defense – MOTIE (Example: Softbot Joint Research Working Group)
	Manufacturing, Logistics, Healthcare	• MassRobotics – MOTIE (Joint R&D in key areas of the robotics industry)
Israel	Logistics, Agriculture & Animal Husbandry, and Health	• Israeli Ministry of Economy and Industry – MOTIE (Example: Lighthouse Program)
Germany	Human-Robot Collaboration	• German Federal Ministry of Economics and Technology – MOTIE (Joint R&D in a key area of the robotics industry)
Japan	Social Robots	• Japanese Ministry of Economy, Trade and Industry – MOTIE (Moonshot R&D project, etc.)

☐ **(Technology Roadmap)** Prepared a company-led Advanced Robot R&D Roadmap through industry demand and expert group* reviews and secured more than 30 technologies (2024)
* Launched the Advanced Robot Tech Forum consisting of 30 robotics technology experts from public research institutes, corporate users and suppliers of robots, and universities (August 2023)

○ Derive core technologies in the fields of next-generation manufacturing robots, service robots, robot parts, software, standardization, platforms, etc. in consideration of the future robot market trends

- Jointly plan inter-ministerial R&D projects based on the roadmap, share the progress and achievements,* and redesign the roadmap every 3 years
* Example) (Civil demand) Quadruped robot → (Military sector) Robot capable of removing and detecting explosives

☐ **(Standardization Support)** Active involvement in the development of standards by international standard organizations (ISO/IEC) to keep pace with environmental changes and technological advances (Korea Agency for Technology and Standards (KATS) and National Radio Research Agency (RRA))
※ ISO has 9 divisions incl. industrial and service robot performance and safety, and CISPR has 6 divisions incl. robots for educational and home use

○ Lead the development of international standards for robots by developing joint standards (draft) in collaboration with tech leaders such as the United States and Germany* and preparing a roadmap for international standardization (June 2024) (KATS)
* Propose standards (draft) devised in cooperation with standard-related organizations such as ANSI (United States) and DIN (Germany) to international standard organizations (ISO/IEC)

2 Workforce Train 15,000 professionals in the fields of AI, software, etc.

◇ Focusing on **convergence robotics education in AI and software** in high demand among robotics companies and proactively prepare a **system to supply professional manpower**

☐ **(Robotics Workforce)** Foster human resources with comprehensive expertise in machinery, electronics, software, AI, etc. (4,000 people)

○ (Master's and doctoral degrees) Introduce convergence programs (mechanical, electrical, and electronic engineering, etc.) centered on robotics graduate schools (20) and pursue additional industry-university projects

* Foster human resources specialized in AI robot-based human-machine collaboration technology (2024 to 2028, KRW 10 billion, 800 people)

- Foster AI-software professionals with expertise in AI, XR, big data, motion control, and app design by supporting the MSIT AI convergence and metaverse master's degree program*

* (MSIT) 19 graduate schools of AI and AI convergence and innovation (2023), 5 graduate schools of metaverse convergence (2023) → (2026) 10 graduate schools

○ (Global Exchange) Cultivate global research capabilities in robotics through joint R&D* with global research institutions and universities and youth exchange programs** for science and engineering students

* Conclusion of MOU on the exchange of technology and human resources between KIAT·KEIT (Korea) and MassRobotics (US) (Nov. 2023)

** Special initiative for exchanges of youth in science and technology between Korea and the United States (April 2023), with both countries investing USD 30 million each from 2024 to 2027 for 2,023 exchange students and industrial field trips

☐ **(Professional Manpower)** Help technical manpower in AI, software, etc. hone practical skills in robotics (6,000 people)

○ (Contracting Departments) Include robotics courses in the curriculum of contracting departments related to AI, machinery, electronics, etc. and arrange jobs at robotics companies (Ministry of SMEs and Startups (MSS))

* Of the 79 contracting departments currently supported, 16 are related to machinery (including mechatronics), 5 are related to AI, 2 are related to electronics, etc.

○ ((Software Professionals) Link robotics software education and industry-university projects involving robotics companies with human resources development projects of other industries such as autonomous driving, software, AI, etc. together with software-centered universities*

* Software-centered university project (MSIT, Scale: (2023) 51 universities (KRW 83.8 billion) → (2025) 64 universities)

○ (Educational Cooperation) Strengthen a mutual cooperation system in which robotics education courses are jointly developed and operated among different universities and departments and facilities and equipment are jointly utilized (Ministry of Education (MOE))

* Intelligent Robotics Consortium for Innovative Convergence Universities (2021 to 2026): Hanyang University ERICA (supervising organization), Tech University of Korea, Sangmyung University, Kwangwoon University, Chosun University, Pukyong National University, and Yeungjin University

☐ **(Working-Level Professionals)** Customized training programs tailored to the skill level (5,000 people)

○ (Robotics SI) Expand professional training for robotics system integration (SI: design and engineering, maintenance, and repair) for robotics company employees and beginners by establishing another center in addition to the current Robot Vocational Innovation Center (Gumi)*
* Gumi Robot Vocational Innovation Center (2020 to 2024, KRW 14.4 billion, 2,101 people set to receive training)

○ (Robot Boot Camp) Company-led education and training for employees based on the demand for software manpower among robotics companies

○ (Qualification System) Establishment of an industrial engineer and craftsman qualification system for each field of robotics to upgrade the expertise verification system and actively discover excellent human resources
* Customized job placement support from the Korea Association of Robot Industry (KAR) for people with verified professional qualifications looking for jobs at robotics companies

<As-Is>

Qualification certificate type	Fields
Technician (0)	-
Engineer (3)	Software, hardware, and device development
Industrial engineer (0)	-
Craftsman (0)	-

▶

<To-Be (Example)>

Qualification certificate type	Fields (Proposed)
Technician (3)	Software, hardware, and device development
Engineer (4)	Software, hardware, device, and SI development
Industrial engineer (4)	Production technology, operation, maintenance, quality control
Craftsman (1)	Assembly

3 Companies Nurture 150 robotics companies [Robot Specialty]

◇ Prioritize the **growth of key companies** spearheading the innovation of the domestic robot industry, and create a business ecosystem characterized by **active founding of startups** and **domestic and foreign investment**

☐ **(Specialized Companies)** Discover and support an average of 20 “companies specializing in advanced robotics” in three fields such as manufacturing, service robots, and key parts

○ Intensive cultivation of 30 specialized companies with sales of KRW 100 billion or more that are taking leadership in the expansion of the domestic robot market and overseas market development (~2030)
* Classification of robot companies by sales (2021): 5 companies with more than KRW 100 billion in sales (manufacturing: 5), 15 companies with KRW 50 to 100 billion in sales (manufacturing: 6, service: 3, parts: 6), and 16 companies with KRW 300 to 500 billion in sales (manufacturing: 9, parts: 7)

○ Redesign the “intelligent robot specialty company” designation under the Intelligent Robots Development and Distribution Promotion Act (hereinafter “Intelligent Robot Act”) and introduce additional support measures (Enforcement Decree of the Intelligent Robot Act, 2024)
- Establish a one-stop platform to provide comprehensive support in relation to R&D, financing and sales, manpower supply, commercialization and demonstration, design, regulation and certification (KIAT, 2024)

☐ **(Startups)** Launch the Advanced Robot Startup Boom-Up Program to revitalize new businesses in robotics and create a dynamic industry ecosystem

○ Identify around 10 startups with excellent business models each year and support their commercialization efforts in phases (2024, KRW 1.5 billion)

❶ BM planning and design		❷ Modification, improvement, and verification/validation		❸ Demonstration and dissemination
▸ Planning of demonstration scenarios, safety measures, etc. ▸ Consulting on specifications, standards, and regulatory improvements	→	▸ Product improvement and regulatory sandbox ▸ Support for verification of safety and effectiveness	→	▸ Support for demonstration and supply of robots to users ▸ Proposal of safety standards and regulatory improvement to ministries

○ Support for jointly tackling challenges noted by large and medium-sized companies by matching startups with creative ideas and technologies (2024, KRW 1 billion)

❶ Demand suggested by large and medium-sized companies		❷ Matched with startups		❸ Support for commercialization
▸ Companies providing the resources in their possession including technology, equipment, and spaces	→	▸ Technical capacity, BM, etc. evaluated by an expert committee	→	▸ Support such as planning, design, prototype and mold/die production, technical consulting, etc.

☐ **(Capital for Innovation of Robotics)** Include the robotics industry among the national strategic high-tech industries* and increase liquidity by creating specialized funds and matching startups with investment funds

* Support for location (creation of specialized complexes), manpower (selection of specialized universities and graduate schools), regulatory reform, and R&D exemptions when designated as a national strategic high-tech industry under the National Strategic High-Tech Industry Act

○ (Investment Promotion) Create an equity investment-type robotics fund* in consideration of the high initial cost and risks of the robotics industry (2023, KRW 30 billion)

* A fund for mainly investing in the field of advanced robots within the Industrial Technology Innovation Fund

- Launch a new three-step investment matching program for startups and domestic and foreign investors (2024)

Investment preparation		Field demonstration		IR briefings
Prior networking, consulting, and education for investors	→	Opportunities to demonstrate the technology to investors	→	Regular investment consulting sessions (quarterly)

○ **(Funding)** Discuss policy and financial support for R&D and facility investment in the advanced robotics industry through the Policy and Financial Support Council (Financial Services Commission) (2024)

Strategy 2 Power the global expansion of K-Robots

1 Domestic Market Development Distribute 1 million units in the manufacturing and service industries by 2030

1. Industrial Utilization: Approx. 680,000 units

◇ **Supply robots to industrial fields where it is possible to improve competitiveness** by **enhancing productivity, mitigating labor shortages, and improving the working environment** with high-tech robots with priority

☐ **(① Manufacturing Industry)** Advancement of the production structure with introduction of robots and AI

○ Select core processes in industries with high contribution to the national economy through spillover effects, etc. and implement the Advanced Manufacturing Robot+AI Project* (KRW 4.5 billion in 2024, MOTIE)

* Consortium of suppliers and buyers; R&D support of KRW 1.5 billion for each project

- Maximize productivity such as process optimization, quality assurance, and energy savings by utilizing autonomous mobile robots and collaborative robots incorporated with AI in all processes such as production, transfer, and inspection

○ Increased support for manufacturing companies that need to improve their production environment and deal with labor shortages to adopt robots (KRW 25 billion in 2024, MSS)

* Up to KRW 250 million (50% of the total project cost) in support for around 100 companies in 2024

☐ **(② Agricultural Industry)** Deal with labor shortages faced by farmers and support high-quality food production

○ Development and demonstration of robotics platforms for fruit harvesting and transportation (KRW 2.1 billion in 2024, MOTIE)

○ Establishment of an integrated control system for autonomous and unmanned agricultural machinery and development and demonstration AI farming services in open field environments (MSIT, 2024~)

○ Demonstration and distribution of AI-based agricultural machinery and robots* targeting the main production bases of three product items: apples, onions, and rice (28 farms in 2024) (Rural Development Administration (RDA))

* Autonomous tractors and rice planting machinery, transportation robots, weeding robots, automatic steering devices, drones, etc.

○ Development of intelligent farming robots* for smart greenhouses and establishment of an integrated control system to propagate smart agriculture in response to the declining farming population and population aging (Ministry of Agriculture, Food and Rural Affairs (MAFRA), 2021 to 2027)

* Development of an electrically driven agricultural robotics platform, development of an autonomous driving system based on multi-robot collaboration, etc.

☐ **(③ Logistics Industry)** Provide convenient logistics services for delivery, cargo, industrial sites, etc.

○ Addition of "robots" to the list of transportation vehicles of the courier service business and parcel delivery agency service business under the Last-Mile Logistics Industry Development Act (Ministry of Land, Infrastructure and Transport (MOLIT), 2023)

○ Establishment of smart joint logistics centers at major ports (Port of Incheon by 2025 and Port of Busan by 2027) for cargo stowage using intelligent robots and AI-based inventory management (Ministry of Oceans and Fisheries (MOF))

○ Development of a national standard for warehouse management system (WMS) API for robot interworking with warehouse operators and related associations (KIAT, 2024)

☐ **(④ Small Businesses)** Solving the issue of labor shortages and streamlining services for small business owners

○ Support for the introduction of cooking and serving robots for small businesses (around 500 stores in 2024) (70% of the supply price up to KRW 10 million, MSS)

○ Revision of regulations to clearly reflect the application of robots in the evaluation criteria when determining best practices and sanitation ratings for restaurants utilizing robots (Ministry of Food and Drug Safety (MFDS), 2023)

○ Step-by-step establishment of performance and safety evaluation methods for cooking and serving robots, and institutionalization of integrated safety management pleasures (KIAT, MFDS, 2024~)

☐ **(⑤ Industrial Safety)** Reducing industrial accidents by creating safe workplaces

○ Revision of regulations related to the Marine Environment Management Act to allow the use of underwater cleaning robots for highly dangerous tasks such as cleaning ship surfaces and oil tanks (MOF and Coast Guard, 2025)

○ Establishment of safety verification and registration standards for remote-controlled construction robots, and technology development and demonstration projects for remote inspection of buildings using robots (MOTIE and MOLIT)

○ Development and demonstration of technology to substitute manpower with robots in highly dangerous tasks such as wire inspection at height and medical waste collection (MOTIE and MOLIT)

○ Establishment of Korean Industrial Standard (KS) for safety standards for mobile collaborative robots (KIAT)

2. Social Utilization: About 320,000 units

◇ **Intensive dissemination of advanced robots** in the areas of the public sectors **directly related to quality of life and safety to create results** that people can **experience in their daily lives.**

☐ **(① National Defense)** Responding to the shortage of troops and upgrading security capabilities

- ○ Development and demonstration of cooking robots tailored to the characteristics of military meals, and pilot projects such as military patrol and delivery robots (KRW 1 billion in 2024, MOTIE and Ministry of National Defense (MND))
- ○ Implementation of the project on introducing robots for parts maintenance, which was conducted as a pilot project for the navy (maintenance shop, repair shop, etc.), across the army, navy and air force (KRW 1 billion in 2024, MOTIE)
- ○ Introduction of robots for defense manufacturing processes and parts maintenance (MOTIE, MND, and Defense Acquisition Program Administration (DAPA)) (KRW 1 billion in 2024, MOTIE)
- ○ Development and demonstration of robots capable of undertaking dangerous missions given the defense and security needs related to counter-terrorism, explosive detection and removal, surveillance, vigilance, and reconnaissance (MOTIE, MNDA, DAPA, National Police Agency (KNPA))

☐ **(② Public Safety & Security)** Contribute to the creation of a safe society by suppressing violent crimes and preventing epidemics

- ○ Demonstration of patrol and crime prevention robots by designating “safety zones with robot patrol” around kindergartens as well as elementary, middle and high schools (MOTIE, KNPA, and MOE)
- ○ Development of a system for introducing patrol robots (quadruped, wheeled, etc.) as police equipment and preparation of detailed operation guidelines (MOTIE and KNPA)
- ○ Development of robotics-ICT convergence disease control system (MSIT) and development of performance and safety evaluation criteria for disease control robots (MOTIE)

☐ **(③ Disaster Response)** Strengthen response capabilities to minimize casualties and property damage

- ○ Development of performance evaluation and test methods and detailed operation and management regulations for the introduction and utilization of disaster safety robots as firefighting and rescue equipment (National Fire Agency (NFA) and Coast Guard)
- ○ Development of an autonomous underwater robot system for rapid response to maritime accidents (Coast Guard), and development and demonstration of solutions for search and rescue, fire suppression, and response to chemical terrorism (NFA)

☐ **(④ Healthcare)** Respond to labor shortages and improve the quality of healthcare in areas with poor access to medical services

○ Establishment of a separate national health insurance coverage system for medical treatment using rehabilitation robots with proven clinical effectiveness (Ministry of Health and Welfare (MOHW))

* Seeking to provide coverage for spinal cord injury, Parkinson's, and other diseases besides stroke in case of proving treatment effectiveness

○ Establishment of an AI- and 5G-based integrated control system in large hospitals, and demonstration of multiple robots (KRW 6.3 billion in 2024, MOTIE)

* Demonstration of five types of robots (10 units) including surgical tool transport robots and nursing cart robots at Yongin Severance Hospital

○ Demonstration and supply of surgical and rehabilitation robots by selecting medically vulnerable areas and classes based on local government demand (MOTIE and local governments)

○ Commercialization of micro-medical robot products that can be used in hospitals for surgery, medical checkups, etc.

☐ **(⑤ Welfare)** Eliminate blind spots in welfare services by increasing support for vulnerable groups

○ Distribution of AI pet robots to prevent depression and improve cognition among seniors living alone in collaboration with local governments* (MSIT and local governments)

* (MSIT) Support for demonstration and commercialization of AI pet robots (Local governments) Distribution of AI pet robots (1,100 people in Jeollanam-do Province in 2023)

○ Promote the distribution of AI robots that provide nursery rhymes, storytelling, and dance content to public daycare centers for children's language and emotional development (local governments)

○ Introduction of AI guide robots (25 units in 2023 → 59 units in 2027) in museums and art museums to make it easier for everyone to enjoy cultural and artistic works (Ministry of Culture, Sports, and Tourism (MCST))

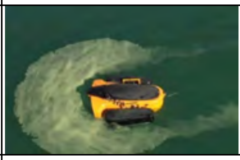
* Provide sign language services and subtitles for the hearing impaired, companion services for the visually impaired, audio guides for children and seniors, and multilingual commentary for foreigners

○ Demonstration of walking route guidance for the visually impaired (MOTIE and MOLIT), and development of a simple boarding robot system to support the mobility of those faced with difficulties walking (KRW 1 billion in 2024, MOTIE)

○ Inclusion of rehabilitation robots and care robots in assistive devices for the elderly to be eligible for public benefits (MOHW)

IFR International Federation of Robotics

Note Examples of robot utilization by major domestic and foreign companies

Field	Company		Details
① Manufacturing	FANUC (Japan)		○ The world's largest industrial robot company that is building a comprehensive automation lineup that includes articulated, collaborative, SCARA and delta robots, as well as CNC, controllers, and motors ○ Leading the controller and industrial robot market by making aggressive R&D investment (8% of sales invested into R&D, about 30% of headquarters employees are R&D personnel, etc.)
② Agriculture	John Deere (USA)		○ The world's largest agricultural machinery company that is commercializing self-driving tractors by integrating robotics and AI technology into agricultural machinery ○ Unveiled a robot fertilizer spray machine, acquired Spark AI, and established a joint venture with GUSS Automation (both in 2023) and using robotics and AI on a wider scope
③ Logistics	Amazon (USA)		○ Acquired Kiva Systems, a logistics robotics company (2012), and utilized 750,000 logistics robots in about 300 facilities, reducing costs by about 20% ○ Developed the collaborative logistics robot Prometheus in 2022 and the picking robot Robin handled about 1 billion items in the first quarter of 2023.
④ Small businesses	LG Electronics		○ Has a diverse lineup of commercial service robots (CLOi series) that can be utilized by small businesses for delivery, serving, cooking, guidance, and sterilization ○ Providing customized solutions to restaurants, hotels, hospitals, etc. and working with various companies such as LG U+, KT, and Woowa Bros.
⑤ Industrial safety	Sheco		○ Developed Sheco Ark, a small oil spill response robot, and Moby-Y, an algae removal robot that is useful for algal blooms and pursuing commercialization by demonstrating them in various environments such as oceans and reservoirs
⑥ National defense	Hanwha Aerospace		○ Developed various defense robots such as explosive detection and removal robots and small-sized reconnaissance robots ○ Developed a multipurpose unmanned search and reconnaissance vehicle integrated with robotics, autonomous driving, and AI technology and demonstrated its performance for the U.S. military (2022)
⑦ Public safety & security	HL Mando		○ Developed patrol robots Goalie, HA Patrol Robot, etc. and pursuing commercialization by testing* them in various demonstration environments* * Siheung Baegot Life Park, Gwanak-gu Villa Neighborhood, Gwacheon Raemian Sur APT, etc. ** Patrolling blind spots and vulnerable areas, cracking down on illegal stopping and parking, traffic guidance, fire monitoring, etc.
⑧ Disaster response	ReSun Tech (China)		○ Established a lineup of eight disaster response robots with heat dissipation, explosion-proof, fire extinguishing, and reconnaissance functions for fire suppression and search and rescue ○ Participated in the 2021 Beijing Petrochemical Comprehensive Practice Drill with four robots

⑨ **Healthcare**	**Intuitive Surgical (USA)**		○ Developed the first FDA-approved surgical robotic system, Da Vinci, and has more than a 90% share of the global surgical robot market *6,730 systems installed in 69 countries around the world, with more than 10 million surgeries performed as of 2021
⑩ **Welfare**	**Robocare**		○ Specializing in caregiving robots for dementia prevention and special needs education with a lineup of various robots such as Silbot and Bomi and education solutions for seniors and children with special needs

2 Overseas Market Development Support companies in the areas of overseas certifications, ODA, and international R&D

☐ **(Partnerships)** Utilize intergovernmental cooperation channels such as the Korea-Saudi Vision 2030, the Korea-U.S. Supply Chain and Commercial Dialogue (SCCD), and the Korea-UAE Investment Platform to discover projects in the field of robotics*

* (Example) With the opportunity created by the US-Korea summit, Doosan Robotics (Korea's No. 1 cobot company) and Rockwell (North America's largest industrial automation company) signed an MOU to cooperate on collaborative robot sales and solution development (April 2023)

○ Promoting inter-national demonstration of R&D outcomes and domestic demonstration achievements, securing empirical data, and pursuing market development (KRW 500 million per year)

* Benchmark testing (BMT): Comparative performance evaluation with overseas parts and products for domestic parts and products to enter the global value chain (GVC)

❶		❷		❸		❹		❺
Discovering demand among domestic robot and parts manufacturers	→	(Stage 1: Screening) Discovering global demand	→	(Stage 2: Verification & Validation) BMT for users	→	Financial assistance for BMT	→	Support for participation in the GVC

☐ **(Entry into the VC)** Promote VC entry of robot manufacturing companies with increasing global demand based on demand analysis* of each robotics field such as logistics and serving robots

* Analyze global business trends, technology level, etc. by robotics field every year and share the results with domestic companies

○ Creation of the K-Robot Directory Book containing key information of domestic companies such as technology level, BM, product specifications, and references (2024 1H) and provide it to potential buyers

○ Establishment of at least five global robot centers* in companies strategically targeted for export such as the US and Middle East and at least two K-Robot training centers in Southeast Asia in connection with ODA projects

* Provide a base to support local sales activities such as robotics testbeds and facilities (office space, service centers, warehouses, showrooms, etc.)

○ Active promotion of domestic robots at major domestic and overseas exhibitions by holding consultation sessions with overseas buyers, live commerce activities (new product introduction), networking parties, etc.

* Hannover Messe in Germany (April 24), Automate in the U.S. (May 2024), Robot World in Korea (October 2024), etc.

☐ **(Overseas Certifications)** Assist in domestic testing and certification processes required for exporting robots in connection with overseas testing institutions* and expand the use of domestic testing and certification bases

* Korea Institute for Robot Industry Advancement (KIRIA) signed MOUs with the European Union (CE), the United States (UL), and China (CCIC) (June 2023)

○ Establishment of dedicated infrastructure and a certification system and provision of technical support, starting with collaborative robots, a field that has high growth potential in the future, to strengthen domestic testing and certification capabilities

* Project for the Foundation Establishment for Safety Certification and Risk Demonstration of Collaborative Robots (2021~2025, KRW 14.9 billion)

Strategy 3 Build infrastructure tailored to the robotics industry

1 Framework Overhaul the Intelligent Robot Act and pursue regulatory reform for market entry

☐ **(Overhaul of the Intelligent Robot Act)** Completely overhaul the framework Intelligent Robot Act to flexibly deal with technological progress and industry changes

○ Drafting of amendments in consideration of the ripple effect on the national economy and industry demands, and solicit feedback from all sectors of society for legislation in 2024

【 Main Details of the Overhaul (Proposed) 】

❶ **(Expanding the Scope of Support)** Include the **entire supply chain**, including parts and software, **in the scope of support**

❷ **(Diversification of Support Policies)** ①**R&D**, ②**Testbed construction**, ③**Promotion of purchases of robots by public institutions**, ④Supply-Demand Establish grounds for **discovering and supporting cooperation models for companies**

❸ **(Nurturing of Related Companies)** Redesign of **robotics specialty companies, international cooperation, database expansion, etc.**

❹ **(Implementation System) Link together ministerial policies, strengthen public-private communication functions**, etc.

☐ **(Regulatory Reform)** Improvements focusing on the Advanced Robot Regulatory Innovation Plan (March 2, 2023): 51 initiatives in four areas (① mobility, ② safety, ③ assistance in collaboration, and ④ robot-friendly environment)

○ Complete 20 initiatives such as allowing outdoor mobile robots to travel on sidewalks and through parks and the use thereof in delivery businesses this year and implement improvement measures for 40 initiatives by 2024

【 Key Improvement Tasks in 2023 】

- Allow outdoor mobile robots to ① **travel on sidewalks and in national gardens and arboretums and** ② **be used in delivery businesses**, and ③ **allow the collection and use of personal information** in relation to the use thereof → MOTIE, MPA, MOLIT, Personal Information Protection Commission, and Korea Forest Service
- Reflected the **evaluation items for determining best practices and sanitation ratings** of F&B establishments utilizing robots → MFDS

- ① **Establishment and demonstration of battery safety certification standards** for mobile electric vehicle charging robots, ② **preparation of a reusable battery safety inspection system** → KATS, and ③ **clarification of whether to install fire prevention facilities** → NFA
- **Establishment of inspection standards for agricultural machinery incorporated with new technologies** such as agricultural robots → MAFRA

○ Convene the Public-Private Council for Robot Industry Regulation Improvement at least once a quarter for implementation checks and continuously discover new tasks reflecting industry demand

☐ **(Improvement of the Subsidy System)** Redesign the subsidy system to strengthen the robotics industry ecosystem by enhancing benefits for the people, improving technological capabilities, promoting investment, creating jobs, etc.

○ Review whether to reorganize the framework such as the robot supply method of the current robot subsidy* project and reflect new evaluation items such as information security (2024)
* (MSS) Serving robots, (MAFRA) Agricultural robots (drones), etc.

2 Safety Strengthen safety nets by establishing a robot-specific insurance program, etc.

☐ **(Enhance Safety)** Establish a safety response system to achieve zero accidents by using robots

○ Development of safety standards through demonstration (regulatory sandbox, etc.) in consideration of the strengthening of the competitiveness of the domestic robot industry and the expansion of new business models at the same time

* Develop safety standards for promising fields with high demand (e.g., disaster safety) and link them with national standards (KS) if necessary (2024~)

○ Establishment of a safety certification system for the movement of outdoor mobile robots such as on sidewalks in consideration of Korea's technology level, driving environment, and consumer safety

* Preparation of the Notice on Operational Safety Certification Procedures and Standards for Outdoor Mobile Robots in November 2023
→ Road Traffic Act allows only "safety-certified robots" to travel on sidewalks

- Establishment of performance standards to verify product technology and safety, such as operating speed, weight, emergency stop, and fall protection functions

* Establishment of on-site inspection standards for the integrated control system operation method, crosswalk traffic method, etc., as well as communication failure response, and preparation of regulations to prohibit uncertified robots from traveling on roads

○ Unification of reporting channels and establishment of an accident history management system by analyzing scenarios and reporting systems for each type of accidents involving robots and utilization thereof for trading used robots

- Make safety education mandatory for robotics manpower training programs, and visit companies and provide consulting on risk assessment on a wider scale (MSS, 70 cases in 2023 → more than 100 cases in 2024)

○ Increased support for robot safety R&D to develop technologies for emergency control such as collision avoidance and operation limitation as well as risk recognition, evaluation, and mitigation (KRW 7.05 billion in 2023 → approx. KRW 10 billion in 2024)

☐ **(Enhancement of Reliability)** Introduce robot insurance (mutual aid) against accidents involving robots

○ Expand the scope of insurance providers to include insurance companies and business organizations, and provide various robot-specific insurance and mutual aid products (2024 1H)

○ Support the development and commercialization of robot-related security software algorithms*, and prepare guidelines for each security threat scenario (KRIRA and Korea Internet & Security Agency (KISA), 2024~)

* Development and demonstration of security technology (communication security, network security, security control, etc.), security inspection, consulting and other types of support

3 Commercialization Establish testbed facilities for market entry

☐ **(National Robotics Test Field)** Establishment of large-scale testbed infrastructure for demonstration of robots' work performance, durability, and safety in actual and virtual environments (2024 to 2028, approx. KRW 200 billion)

< Components of Each Test Field Environment (Proposed) >

Public Convenience	Logistics	Everyday Living	Commerce
Outdoor driving environment, parking lots, etc.	High-tech logistics environment, last-mile delivery, etc.	Office space, home space, etc.	Food courts, hotels, smart hospitals, etc.

○ Spaces near the test field infrastructure for enterprises and research institutes (Robot Business Growth Support Center, 2024 to 2026, KRW 32 billion, Daegu City)

☐ **(Strengthening Regional Infrastructure)** Creation of a "robotics cluster" for channeling the capabilities of the robot industry in the region with local robotics companies, universities, and related organizations playing central roles

* Example) LG Electronics, Intops, DGIST, POSTECH, Korea Institute of Robotics and Technology Convergence, Gumi Electronics and Information Technology Research Institute, etc., have applied for the Gumi Industrial Complex to be designated as a materials, parts, and equipment complex for service robots

○ Joint use of regional robot demonstration centers* established to promote inter-regional collaboration, regional joint projects, etc.

* Safety Robot Demonstration Center (Pohang, Gyeongsangbuk-do Province), Agricultural Robot Demonstration Center (Andong, Gyeongsangbuk-do Province), Underwater Robot Demonstration Center (Busan), Healthcare Robot Demonstration Center (Gwangju), Used Robot Remanufacturing and Refurbishment Center (Gimhae, Gyeongsangnam-do Province), etc.

○ Establishment of the Regional Robot Industry Convergence Project based on cooperation between the central government and local governments (5 : 5 matching, 3 projects worth KRW 1 billion selected every year)

* Formation of a consortium by robotics companies and related organizations in the region, followed by submission of business proposal and evaluation

☐ **(Win-Win Partnerships in SI Field)** Promote cooperation between large companies and SMEs in the field of SI to strengthen the competitiveness of robotic SI for robotic system design and engineering, production, maintenance, and repair

○ Establishment of Robot SI Win-Win Partnership Platform to promote cooperation among small, medium-sized, and large robotic SI companies (MOU signed between SI companies and related government organizations)

○ Matching small, medium-sized, and large robotic SI companies to provide technical support, opportunities to participate in in-house training programs*, etc., transfer know-how, and promote joint participation in projects

* (Samsung Electronics) Win-Win Cooperation Academy, (LG Electronics) Global Operation Center and Production Technology Center, (Hyundai Motor Group) Global Win-Win Partnership Center, (POSCO) Jeseon Win-Win Partnership Center, etc.

4 Culture Promote a social consensus along with the dissemination of robots

☐ **(Robot Ethics)** Preparation of Robot Ethics Guidelines for the coexistence of robots and humans

○ Establishment of Robot Ethics Research Group (tentative name) with experts in humanities, social sciences, and technology (December 2023), and promotion of ethical standards reflecting the development of robot technology and social changes (2024 2H)

* Robot Ethics Conference held (December 2023) to provide a venue for public discussions

- Discussed the desirable direction of robot development and utilization to be observed by each party involved, including the government and public institutions, robot manufacturers, service providers, and users

○ Establishment of the Robot Ethics Charter, etc. to present ethical considerations* necessary for the development and utilization of robot products and services, and share self-check measures, etc.

* Example) Fairness, transparency, privacy, autonomy, convenience, accountability, etc.

☐ **(Raising Awareness)** Strengthen public relations and communication efforts to encourage people to accept robots

○ (Robot Day) Promotion of the designation of Robot Day to raise the level of public understanding of robots and promote the robot industry

* The date will be selected after opinions from companies, experts, and the public are collected by the Korea Association of Robot Industry (KAR), etc.

○ (Communication Platform) Produce popular content that can resonate with people of all ages such as shorts videos, and upload them on KRIRA On Air on YouTube

- Distribution of promotional video "How to Use Robots Correctly" for the digital illiterate such as seniors

○ (Robot Experience) Hold various events related to robots from time to time in collaboration with companies and local governments in order to make it easier for people to experience robots in their daily lives

* Example) National Robot Experience Event at Yongsan Children's Garden (June 2023)

○ (Robot Challenge) Hold the National Robot Challenge with a mission assigned to participants in order to contribute to strengthening national competitiveness and solving social issues (2024~)

* (Target Groups) University (graduate) students from Korea and abroad, the general public, etc., (Mission) Public demand survey, expert proposals, etc., (Support) About 10 teams are selected through a preliminary screening and given free rentals of robots, financial assistance for the development costs, etc.

V. Future Plans

☐ **Implementation System**

○ Strengthening of the function of the Robot Industry Policy Council* to coordinate and link the policies of various industries as a deliberative body for important matters

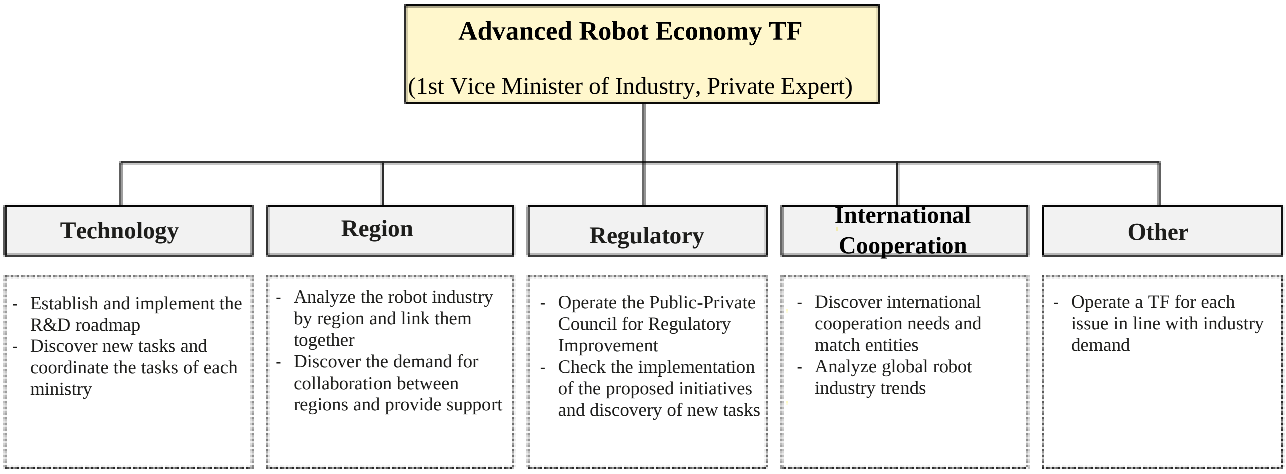
* Chaired by the Minister of MOTIE and composed of members who are at the vice minister level from 19 ministries and agencies (Intelligent Robot Act)

- Review of policy deliberations in advance, promote collaboration between ministries, and discover new businesses through the Robot Policy Working-Level Committee*

* Chaired by the First Vice Minister of MOTIE as the Chairman and composed of high-ranking government officials from 18 ministries and agencies (Level 3 and above) (Article 6 of the Enforcement Decree)

○ Formation of the Advanced Robot Economy Taskforce with industry-university-research institute experts and operation of subcommittees for each topic to discover policies, promote collaboration, and strengthen public-private communication (2024~, quarterly meetings)

* Co-chaired by the First Vice Minister of MOTIE and composed of private experts, and each subcommittee is mainly comprised of experts from the private sector (KRIRA playing the role of secretary)



☐ **Schedule**

○ Announcement of the 4th Master Plan for Intelligent Robots (Jan. 2024)

○ Announcement of the Action Plan for the National Robot Test Field (Jan 2024)

○ Announcement of an R&D roadmap for the development of key technology for advanced robots (first half of 2024)

IFR International Federation of Robotics

2023 Action Plan for Intelligent Robots

2023. 5.

By Relevant Ministries

CONTENTS

I. Background

◈ The **Intelligent Robots Development and Distribution Promotion Act** (hereinafter referred to as the Intelligent Robots Act) **was enacted in 2008 to lay the groundwork for systematic and consistent support for the robot industry.**

☐ Article 5 of the Intelligent Robot Act **stipulates that a master plan must be established every five years** and **an action plan every year** for the promotion of the robot industry.

<Article 5 of the Intelligent Robot Act>
(1) The Government shall establish a master plan every five years (hereinafter referred to as “master plan") in order to achieve the purposes of this Act for the development and distribution of intelligent robots in an efficient manner.
(3))The head of each appropriate central administrative agency shall establish and implement an action plan for the development and distribution of intelligent robots and the establishment of the foundation therefor (hereinafter referred to as “action plan”) within the scope of the affairs under his/her control in conformity with the basic plan per annum.

☐ Accordingly, in order to distribute manufacturing robots on a wider scale, foster the four major types of service robots, and strengthen the robot industry ecosystem, **the 3rd Master Plan (2019~2023) was established** and an action plan was prepared every year.

< Main Details of the 3rd Master Plan for Intelligent Robots >

Vision	**Establish Korea as one of the top four powerhouses in the global robotics industry**	
Objectives	◆ **Expand the market size of the robotics industry (KRW 15 trillion by 2023)** ◆ **Increase the number of companies specializing in robotics valued at over KRW 10 0 billion (at least 20 companies by 2023)** ◆ **Increase the number of manufacturing robots in service (700,000 in cumulative to tal by 2023)**	
Main Initiatives	**1 Increase the penetration of manufacturing robots in the three major manufacturing industries**	• Develop 108 model applications for industries and processes • Provide consulting, conduct demonstration, and distribute each standard model to 10 companies • Train the employees at companies adopting manufacturing robots • Offer robots on a rental/lease basis and transition into a loan model in the private sector
	2 Develop four major types of service robots intensively	• Develop technologies for four types of promising service robots • Distribute and demonstrate four types of service robots → Disseminate them in the private sector • Create new markets in Korea and abroad through regulatory improvements and overseas expansion
	3 Strengthen the foundations of the robotics industry’s ecosystem	• Develop next-generation core technologies for parts and software • Pursue demonstration and distribution of domestically manufactured parts • Create new markets by disseminating convergence robotics technologies to other industries

II. Robotics Industry Trends

☐ **(Global Market)** The size of the **global manufacturing robot market** grew **16% year-on-year to USD 15.4 billion** (about KRW 18 trillion) in 2021, recording an average annual growth of 8% over the past 6 years.

【**Global Manufacturing Robot Market Sales** (Unit: million USD, %) 】

Category	2016	2017	2018	2019	2020	2021	YOY growth	CAGR
Manufacturing robots	10,367	13,624	13,871	13,918	13,381	15,471	16	8

* Source: World Robotics 2022 (Oct. 2022, IFR)

○ **16% year-on-year growth** due to increased production in the **home appliances, electronics,** and machinery industries, which are the main areas of demand, and the **growth of the automotive market** due to the post-COVID economic recovery

* Number of robots installed: (electric & electronic) 110,430 units in 2020 →136,670 units in 2021 (24%↑)
(Automotive) 84,215 units in 2020→ 119,405 units in 2021 (42%↑) <IFR, 2022>

☐ **(Domestic Market)** The size of the domestic robot market was **KRW 5.6 trillion** in 2021 with a **CAGR of 4.1%,** and the growth of the **service robot** market is especially pronounced.

【**Domestic Robot Market Sales** (Unit: Billion Won, %) 】

Category	2016	2017	2018	2019	2020	2021	YOY growth	CAGR
Total	**45,972**	**55,255**	**58,019**	**53,351**	**54,736**	**56,083**	**2.5**	**4.1**
Manufacturing robots	27,009	34,017	34,202	29,443	28,658	28,740	0.3	1.3
Service robots	7,464	6,459	6,650	6,358	8,577	9,076	5.8	4.0
Robot parts	11,499	14,779	17,167	17,550	17,501	18,266	4.4	9.7

* Source: 2021 Robot Industry Survey (Dec. 2022, Korea Institute For Robot Industry Advancement (KRIRA))

○ **(Manufacturing) The size of the domestic manufacturing robot market** was **KRW 2.9 trillion**, **up 0.3% year-on-year** due to increased facility investment* in the **semiconductor and display** industries.

* Equipment investment: (Semiconductors) 27%↑, (Display) 12%↑, (Communication Equipment) 4%↑ <Source: Industrial Statistics Analysis System (ISTANS)>

- The number of **manufacturing robots introduced** in Korea **increased by 2% year-on-year to 31,000 units,** with increased use of robots in the **food and beverage** (70%↑), **plastics and chemicals** (9%↑), **and automotive** (5%↑) industries.

【**Introduction of Manufacturing Robots in Korea in 2021** (Unit: units)】

Category	Automotive	Electric & electronic	Metal	Plastic	F&B	Other manufacturing	Others	Total
# of units	**5,631**	**14,052**	**1,005**	**264**	**623**	**411**	**9,097**	**31,083**
Proportion	26%	64%	5%	1%	3%	2%	29%	**100%**

* Source: IFR 2022, WR Industrial Robots

○ **(Service)** The domestic service robot market is valued at **KRW 0.9 trillion, up 5.8% year-on-year** due to **non-face-to-face services** and **increased demand for home care services** such as care and housework.

* Output: (Healthcare) KRW 85 billion (24.7%↑), (Personal Health Management) KRW 11.2 billion (33.7%↑), (Housework) KRW 238.9 billion (7.3%↑)

○ **(Parts)** The size of the parts market increased by **4.4% year-on-year to KRW 1.8 trillion** as a result of increased production of finished robot products.

【**Status of Companies by Sales Volume** (Unit: companies, %)】

Category	KRW 100 billion or more	KRW 50 billion or more	KRW 10 billion or more	KRW 5 billion or more	Less than KRW 5 billion	Total
Manufacturing	5(0.9)	5(0.9)	28(5.0)	27(4.8)	500(88.5)	565(100.0)
Service	-	3(0.6)	9(1.7)	19(3.7)	485(94.0)	516(100.0)
Parts	-	4(0.3)	24(1.7)	25(1.8)	1,366(96.3)	1,419(100.0)
Total	5(0.2)	12(0.5)	61(2.4)	71(2.8)	2,351(94.0)	2,500(100.0)

* Source: 2021 Robot Industry Survey (Dec. 2022, KRIRA)

□ **(Import & Export)** Exports **increased by 2.3% year-on-year to KRW 1.1 trillion** as a result of increased exports of collaborative robots and medical robots*, while imports **increased by 4.3%** year-on-year to KRW 0.5 trillion due to increased demand for service robots (healthcare, cleaning, etc.)

* 70% of Doosan Robotics (cobots)' overseas sales, entry of Curexo (healthcare) into the Indian market, etc.

□ **(Industry Ecosystem)** As of 2021, there are 2,500 robot companies with 31,387 employees in total in Korea.

○ **(Businesses) 2,500 companies**, up 3% year-on-year, with a CAGR of 3.3% over six years

* Number of businesses by year (rate of increase): (2016) 2,127 → (2019) 2,235 (5%↑) → (2021) 2,500 (12%↑)

- Among the 565 manufacturing robot companies, there are **five companies*** with **KRW 100 billion or more in sales** and **527** small and medium-sized enterprises (SMEs) with **less than KRW 10 billion** in sales, accounting for 93.3%.

  * Hanwha Precision Machinery, Cymechs, Hyundai Robotics, Robostar, Koh Young Technology

- Of the 516 service robot companies, **there are 3 companies* with KRW 50 billion or more in sales, 9 companies** with KRW 10 billion or more in sales,** and **485 SMEs with less than KRW 5 billion in sales**, accounting for 94%.

  * LG Electronics, Samsung Electronics, Everybot ** Yujin Robot, Robotis, EV Soosung, Daeyang, etc.

- Of the 1,419 parts companies, **there are 4 companies* with KRW 50 billion or more in sales, 24 companies** with KRW 10 billion in sales,** and **1,366 SMEs with less than KRW 5 billion sales**, accounting for 96.3%.

  * RS Automation, One ST, etc. ** Autonics, Servostar, Fastech, Higen Motor, Haisung TPC, etc.

IFR International Federation of Robotics

○ **(Employment)** The number of employees in the robotics industry increased by 2% year-on-year with **31,387 employees in total**, with a CAGR of 1.7% over six years.

* Employment by year (rate of increase): (2016) 28,800 → (2019) 30,800 → (2021) 31,300 (+2%)

III. Key Performance Analysis for 2022

1 Increase the penetration of manufacturing robots in the three major manufacturing industries

☐ **(Development of Standard Process Model) Development and dissemination of standard process models** including the three major manufacturing industries (*ppuri*, or “root,” industries in which processing or machining technology such as casting, welding, and surface treatment is applied; textiles; and food and beverages) as well as aviation, shipbuilding, and biochemistry

○ **(Development)** Completed the development of 27 standard process models for the three major manufacturing industries and 9 models for newly added industries such as ships and aviation (2019 to 2022, 109 cumulative)

* Standard process models: (2019~2020) 37 ⇨ (2021) 35 ⇨ **(2022) 37**

【Standard Process Models Developed in 2022】

Industry		process	Standard Model Name
Ppuri (19 models)	Automotive (4 models)	Transport & Loading	① Automotive Parts_Loading/Unloading of Multiple Injection Molding Machines Using Articulated Robots
		Transport & Loading	② Automotive Parts_Insertion of Non-Aligned Metal Materials for Press Machines
		Assembly & Disassembly/Transport & Loading	③ Automotive Parts_High-Speed Fastening of Small Objects and Dynamic Rack Loading
		Testing & Inspection	④ Automotive Parts_Non-Contact High-Speed Inspection of Small Metal Items
	machine (4 models)	Testing & Inspection	⑤ Mechanical Parts of Gas Filters_Product Function Inspection
		Assembly & Disassembly	⑥ Mechanical Parts of HVAC Systems_PCB Bolting and Assembly
		Processing/Machining	⑦ New Parts for Automotive Engines_Machining of Aluminum Castings
		Processing/Machining	⑧ Auto Body and Special Equipment Exterior Parts_Blanking
	Metal & Plastic (6 models)	Transport & Loading	⑨ Metal/Automotive_Loading/Packing of Welded Parts
		Post-Processing/Machining	⑩ Aluminum Casting_Post-Machining (Cutting) Process for Gravity Castings
		Processing/Machining	⑪ Metal Machining_3D Vision-based Multi/Non-Aligned Setting Machine Tending and Precision Machining
		Injection Molding	⑫ Metal Machining_Post-Injection Molding Machining
		Testing & Inspection	⑬ Inspection and Packaging of Painted Products
		Post-Processing/Machining	⑭ Post-Machining of Gantry-Type Large Auto Body Parts
	Electric & Electronic (5 models)	Transport & Loading	⑮ Semiconductor Manufacturing_Parts and Device Transfer
		Processing/Machining	⑯ Semiconductor Manufacturing_Parts/ Device Processing/Machining
		Testing & Inspection	⑰ Semiconductor Manufacturing_Functional Inspection
		Assembly & Disassembly	⑱ Small Electronics Manufacturing_Assembly & Combination
		Transport & Loading	⑲ Small Electronics Manufacturing_Product Packaging and Loading
Textile (4 models)		Assembly & Disassembly	⑳ Footwear & Parts_Display of Coating Work Guide
		Desorption/Detachment	○,21Footwear & Parts_Loading/Unloading of Manufactured Products
		Assembly & Disassembly	○,22 Footwear & Parts_Input of Reinforcement Materials
		Post-Processing/Machining	○,23 Footwear & Parts_Alignment and Packaging of Manufactured Products
F&B (4 models)		Desorption/Detachment	○,24 Franchise F&B_Input in Processing and Post-Processing Process
		Transport & Loading	○,25 Franchise F&B_Transport & Loading
		Assembly & Disassembly	○,26 Franchise F&B_Assembly & Disassembly
		Testing & Inspection	○,27 Franchise F&B_Weighing and Packaging Incasing
New (9 models)	Vessel (3 models)	Transport & Loading and Machining	○,28 Medium-Sized RC Processing Robot Process Model for Vessels
		Processing/Machining	○,29 Vessel Weld Recognition Robot Process Model
		Processing/Machining	○,30 Pipe (Plasma) Cutting Robot Process Model
	Aviation (3 models)	Processing/Machining	○,31 Aircraft Parts Manufacturing_Composite Material Cutting (Side)
		Processing/Machining	○,32 Aircraft Parts Manufacturing_Flat Plate Drilling

		Assembly & Disassembly	○,33Aircraft Parts Manufacturing_Flat Plate Riveting
	Bio & Chemical models)	Transport & Loading	○,34Heavy Cargo Chemicals ((1)Drum, (2)Film Roll) Transport and Loading Processes
		Testing & Inspection	○,35Biomaterial Weighing, Transport, and Loading Processes
		Assembly & Disassembly	○,36 Bio/Medical Device (① Ampoule, ② Dental Porcelain, ③ Suction Tube ④ Wet Wipes Cap) Assembly Process
		Transport & Loading	○,37 Biopharmaceutical Transport and Loading Processes

○ **(Dissemination)** Operation of a database management system (erobot.or.kr) for the dissemination of technology across the private sector by providing process manuals, images and videos, and robot information related to the developed standard process models

□ **(Distribution of Manufacturing Robots) Demonstration and distribution of manufacturing robots** based on the developed standard process models

○ **(Linkage of Standard Process Model)** Using the standard process models (35) developed in 2021, **200 manufacturing robots*** were demonstrated and supplied for 120 processes from 105 companies, and they were disseminated** (MOTIE).

* Demonstration of process standard models for textile, F&B, vessels, etc. (135 units) and improved model tailored to needs (65 units)

** Held manufacturing robot briefing sessions and operated a standard process model PR center (Oct. 2022)

○ **(Supplied to Individual Companies) 318 manufacturing robots* were supplied to 67 companies** to strengthen the manufacturing competitiveness of SMEs with **weak digital foundations (MSS).**

○ **(Safety Certification) Safety certification** support was provided to for **43 companies**, including collaborative robot installation companies (MOTIE), and **70 sessions** of safety inspection **consulting** tailored to each company were held (MSS).

□ **(Employee Training) Training on how to utilize robots** was provided to the employees of companies adopting standard process models and manufacturing robots, and **training centers were operated to nurture experts in robot operation.**

○ **(Linking with Standard Models) Package training** for companies that adopted the standard process models (MOTIE) was **completed by 755 trainees**, and **training on robot utilization** was provided for **1,110 employees** (MOEL).

○ **(Education & Training Center)** Through the **Robot Vocational Innovation Center** (Gumi), **553 professionals capable of using robots** were trained through manufacturing robot operation practice courses.

* Set up seven types of equipment (19 robots, 4 software sets) and developed and operated a new course

□ **(Dissemination in Private Sector) Provided financial and investment services** for the private sector and **promoted robot trading** through **the establishment of a refurbishment center**

○ **(Guarantee & Investment)** Support was provided for commercialization through an agreement and guarantee program and IR events

* Issuance of guarantee certificates for 12 companies (approx. KRW 4.4 billion, guarantee ratio of 95%) and 2 cases of successfully attracting investment (approx. KRW 1.3 billion)

○ **(Purchase & Procurement Support)** Supported the introduction of 86 robots from 80 companies by diversifying robot purchasing methods such as group purchase, short-term rental, and free demo

○ **(Refurb Center)** Launched **Refurb Center** to create a platform to provide performance assurance for used (old) robots and technical support and enable trading (KRW 1.3 billion in 2022)
* Establishment of a used robot remanufacturing refurbishment center (Gimhae, Gyeongsangnam-do Province, 1,907.4 ㎡ (3 floors) in area, 2022 to 2026 (total project cost: KRW 14.3 billion))

2 Develop 4 major types of service robots intensively

□ **(Development of Technology) Development of technology for commercialization** with a **focus on solving pending social issues** such as shortage of caregivers and expansion of non-face-to-face services due to prolonged pandemics/epidemics

○ Development of human-robot interaction (HRI)-based **companion robots** considering the increase in the aging population and single-person households, **indoor and outdoor delivery robot application technology, AI-integrated robotic systems**, etc.

【Major Development of Technology Projects in 2022】

Field	Description	2022 budget
Care	Development of human-following semi-autonomous bed robot for isolated transport of infected patients	KRW 1 B
	Development of a nursing assistant and patient monitoring robot system for isolation wards for infected patients	KRW 1.2 B
	Development of care robot for isolation treatment facilities (MOIS)	KRW 1.3 B
	Translational research on care robots and development of service models robots (MOHW)	KRW 3 B
	(New) Development of companion robots that can communicate emotionally through physical and cognitive interactions with humans	KRW 1.4 B
Wearables	Development of soft sensor-embedded fabric-based actuators and garment-type robotic technology	KRW 700 M
	(New) Wearable robot aiding walking in daily life for in-home healthcare services	KRW 1.2 B
Healthcare	Development of an artificial intelligence-based robotic system for spinal hard tissue surgeries	KRW 1.6 B
	Development of surgical assistant robot to assist in general surgery	KRW 1.2 B
	Development of a lightweight wearable rehabilitation robot for self-rehabilitation of the upper limb	KRW 1.5 B
	Development of robotics- and ICT-integrated disease control and prevention system for pandemic response (MSIT)	KRW 6.1 B
	Development of technology for commercialization of micro medical robots (MOHW)	KRW 9.8 B
	Translational research on rehabilitation robots (MOHW)	KRW 4.5 B
Logistics	Development of parking robots that provide parking convenience and improve spatial efficiency	KRW 1.4 B
	Development of robotic systems for autonomous elevator operations and indoor deliveries	KRW 1.2 B
	Development of robot-enabled unloading system for trunk cargo transport vehicles	KRW 1.6 B

	Development of robot-based loading system technology for cargo loading operation	KRW 600 M
	Development of mobile logistics handling robot technology to streamline Korean warehouse operations	KRW 4 B
	Development of an item management robot that autonomously identifies and manages the inventory of products in stores	KRW 1 B
	(New) Development of multiple robot collaboration planning technology for integrated control of multiple outdoor last-mile delivery robots	KRW 800 M
	(New) Development of service robot technology for retrieving empty dishware after meals	KRW 1.4 B
Integration	Development of robot system for field application to implement the robot utilization service business model	KRW 3 B
	(New) Development of AI-integrated service robot system for user convenience and efficiency improvement	KRW 1 B

☐ **(Development of Technology in 10 Niche Fields)** Development of technology to deal with **social issues** and satisfy the **on-site needs** of individual ministries

【Main Details of Projects by Ministry】

Department	Description	2022 Budget
Ministry of Agriculture, Food and Rural Affairs (MAFRA)	Development of intelligent agricultural robots for smart greenhouses	KRW 2.1 B
	Development of a robot for harvesting horticultural crops based on multi-robot collaboration	KRW 1 B
	Creation of a high-tech unmanned automated agricultural production demonstration complex	KRW 7.5 B
Ministry of Trade, Industry and Energy (MOTIE)	(New) Development of a remote inspection robot system for cableway facilities (wire rope and cutting wheel)	KRW 1 B
	(New) Development of human-robot collaboration technology for dismantling multi-variety EV battery packs that need to be disposed of	KRW 1.1 B
	(New) Safety robot technology capable of detection and response by being operated wirelessly in a small space	KRW 1.2 B
Ministry of Environment (MOE)	Development of non-face-to-face collection and treatment technology for high-risk medical waste	KRW 2.3 B
Ministry of Oceans and Fisheries (MOF)	On-site demonstration and commercialization of underwater construction robots	KRW 2.8 B
Defense Acquisition Program Administration (DAPA)	Development of complex signal-based human-machine high-speed synchronization control technology	KRW 1.8 B
	(New) Development of multi-robot collaboration planning technology	KRW 700 M
National Police Agency (NPA)	Development of gas molecule identification technology for dealing with risk factors for the public	KRW 500 M
National Fire Agency (NFA)	Development of efficient response technology for chemical terrorism such as harmful gases	KRW 1.7 B
Rural Development Administration (RDA)	Robotics technology for hydroponic cultivation, fruit and vegetable cultivation monitoring, fruit-thinning, and harvesting	KRW 1.6 B
	Development of intelligent mowers for apple orchards	KRW 200 M
	Research on the application of robot safety technology for the development of agricultural robots	KRW 100 M
	Development of fruit enlargement and harvest period diagnosis technology for machine harvesting to lower the need for manpower	KRW 100 M
Coast Guard	Development of autonomous underwater vehicles (AUVs) for prompt response in the event of a marine accident	KRW 4.6 B

☐ **(Demonstration & Distribution)** Sought to create a market by conducting **needs-based demonstration projects** and **large-scale demonstration projects** concerning service robots for the general public to feel and experience the benefits and to solve social issues

○ **(By Field)** Demonstration and distribution of 851 units of four major types of service robots (care, wearables, healthcare, and logistics)

> ① (Care robots) 340 companion and dementia prevention robots supplied to welfare centers for persons with disabilities, public health centers, the Korea Veterans Health Service, etc.
> ② (Wearable robots) 256 wearable robots for smart operations in construction and agriculture
> ③ (Healthcare robots) 30 healthcare robots such as artificial joint surgery robots, upper and lower limb rehabilitation robots, etc.
> ④ (Logistics robots) 114 indoor and outdoor logistics and transport robots supplied to hotels, hospitals, warehouses, etc.
> ⑤ (Others) 111 collaborative robots supplied to cafes, restaurants, chicken restaurants, etc.

○ **(Needs-specific Development & Distribution) Customized modification and improvement** of service robot utilization models (22 models) developed in 2021 (Stage 2) and **discovery of 11 new models** (New: Stage 1) based on identified needs

* **(Stage 1) Service model development** → **(Stage 2) Modification, improvement, and verification/validation** → (Stage 3) Demonstration and distribution

【Development of Service Models in 2022】

Category		Sub-field	Model
Modification/ Improvement	Industry (4)	Manufacturing (1)	① Development of an integrated solution for stowage, storage, and picking using a robot shuttle
		Construction (1)	② Development and demonstration of smart work care service using wearable robot solutions
		Agriculture (2)	③ Demonstration and commercialization strategy for mobile collaborative robot platform-based s mart farm robot
			④ Development and distribution of wearable robots suitable for agricultural work
	Commerce (6)	Shipping (4)	⑤ Goods delivery service using self-driving robots at Incheon International Airport
			⑥ Development of cloud-based variable platform multi-service robots using AI technology
			⑦ Promotion of indoor and outdoor self-driving delivery robots in apartment complexes
			⑧ Development of a franchise-specific indoor F&B delivery service robot
		Parking (2)	⑨ Development and demonstration of a high-efficiency parking robot to solve urban parking probl ems
			⑩ Development of an autonomous electric vehicle charging system
	Healthcare (5)	Rehabilitation (1)	⑪ Dissemination of ribless rehabilitation robot remote rehabilitation platform
		Care (4)	⑫ (Improvement of regulations on personal information) Development and distribution of client-t ype multi-purpose home service robot (Developmental disability improvement and care) Development and commercialization of an AI robot for non-face-to-face services
			⑬ Development and commercialization of AI robots for non-face-to-face services for improvemen t and care of developmental disabilities
			⑭ Development and distribution of a multifunctional dementia care and medical assistant robot
			⑮ Verification of the effectiveness and safety of welfare services provided with AI care robots
	Public (4)	Disease control & prevention (2)	⑯ Automation of robots for patrol and nursing assistance processes in isolated wards of hospitals
			⑰ Introduction of multifunctional autonomous driving robots for theme park visitors and establishment of an integrated concierge system
		Safety (2)	⑱ Development of park-specific guidance and patrol robots
			⑲ Autonomous driving and remote control solutions for the use of patrol robots under challenging conditions
	Other (3)	Guide (1)	⑳ Development and distribution of low-cost standard model of "NANA" for assistance to service workers who are burdened by stress from dealing with customers
		Cleaning (2)	○,21 Mid/low-rise building exterior wall cleaning service robot system using an aerial working platform
			○,22 Self-driving outdoor robot vacuum cleaner
New	Industry (1)	Construction (1)	① Development and demonstration of smart work care service using wearable robotics solutions
	Commerce (5)	Parking (1)	② Development and demonstration of automatic electric charging robot for mechanical parking sy stems that combines a variety of sensors and vision
		Delivery (1)	③ Establishment of a robot delivery platform for convenience stores in urban areas through outdoo r self-driving robots
		Food (3)	④ Automated robotic system for the entire process of making Chinese food such as jjamppong (sp icy seafood noodles), jjajangmyeon (noodles in black bean sauce), and tangsuyuk (sweet and so ur pork)
			⑤ Unmanned bakery robot café using a robot manipulator
			⑥ Development of non-face-to-face robot restaurant for home meal replacement store chains
	Healthcare (3)	Care (2)	⑦ Development and demonstration of boarding-type self-driving service robots for people with m obility disabilities
			⑧ Development and service demonstration of nursing assistant robot for nursing hospitals

		Rehabilitation (1)	⑨ Development of a universal surgical assistant Medibot that is compatible with various surgical p rocedures
	Public (1)	Safety (1)	⑩ 5G-based indoor and outdoor robot-integrated security service solution
	Other (1)	Guide (1)	⑪ Development and verification of self-driving robots for information service and luggage transpo rt inside railway stations

○ **(AI/5G-based Large-Scale Demonstration)** Demonstration of a variety of robots in multiple quantities based on integrated control (39 types, 155 units) by type and (stages 1 and 2)

* **(Stage 2, selected in 2021)** 2 projects, 11 types, 26 units, **(Stage 1, selected in 2022)** 7 projects, 28 types, 129 units

【Large-scale Demonstration of Robot Convergence Models】

Addressing social issues		**Benefits and impacts that can be experienced by the general public**	
			
Smart Hospital (Hallym Sacred Heart Hospital) ・Assistance to medical staff and emergency response	**Smart Hospital (Veterans Health Service Medical Center)** ・Increasing the benefits of mobility for people of national merit	**Smart Hotel (Gangwon Land)** ・Non-face-to-face concierge service	**Smart City (COEX~Teheran-ro)** ・Delivery and food serving robots

□ **(Regulatory Improvement)** Implementation of the **Robot Industry Regulatory Roadmap** (Oct. 2020) for proactive regulatory reform and a **regulatory sandbox** and **improvement of the legal framework**

○ **(Regulatory Roadmap)** Out of 33 projects, **9 projects** such as obtaining a permit for underwater robot service and preparation of safety standards **have been improved** (2 projects have been completed earlier than scheduled)

* (Stage 1) ❶Simplify collaborative robot workplace safety certification; ❷Institutionalize safety standards for robot elevator rides; ❸Prepare safety inspection standards for parking robots; ❹ Prepare safety standards for mobile electric vehicle charging robots; ❺Include robots in the product line with excellent growth potential among excellent procurement items; ❻Prepare a plan to designate exemplary restaurants using food tech robots; ❼Obtain permit for the underwater cleaning robot port service business

* (Stage 2) ❽Reflect wearable robot occupational safety and health management expense accounted for items· ❾Provide walking therapy robots for stroke patients

○ **(Regulatory Sandbox) 24 demonstration cases*** of delivery and patrol robots, etc. (7 new cases in 2022)

* 18 cases including indoor and outdoor driving (3 new cases), parking, electric vehicles (new), collaborative robots (new), and remote rehabilitation; 3 cases including regulatory zones for charging robot; and 3 cases such as smart city patrol (new) and delivery (new)

○ **(Amendments to Related Law) Legislation to amend the Intelligent Robots Development and Distribution Promotion Act** to **promote the commercialization of outdoor mobile robots in Korea** (Proposed the amendments to the National Assembly in August 2022)

* Newly added the definition of “outdoor mobile robot,” made it mandatory to subscribe to the operation safety certification system and an insurance policy, etc.

☐ **(Support for Export)** Provide online and offline **assistance tailored to the destination country** and support for acquiring **overseas standard certifications** required by the destination country

○ **(Support for Export Tailored to the Destination Country)** Support the introduction of 52 domestic robots* by matching domestic robot companies with overseas buyers (auto parts manufacturers, golf courses, etc.)

* Injection molding automation robot (2 units, Thailand) and golf caddy robot (50 units, USA)

○ **(Marketing Support for Export)** Support for new market development by holding export consultation meetings in connection with domestic and overseas exhibitions and supporting entry into online e-Commerce markets

* GMV 2022 (May, Seoul), Smart Factory Expo (October, Japan), ICT Expo (November, Japan), etc.

○ (**Testing and Certification Support)** Expanded scope of accreditation areas of the Korea Laboratory Accreditation Scheme (KOLAS)* in the field of software (August) and acquisition of a testing laboratory designated by a German certification body (TÜV Nord)** (October, KRIRA)

* Equivalent to the official reports issued by 105 accreditation bodies in 104 countries

** Acquisition of certifications pertaining to industrial robots, in-home robots, reliability, and electromagnetic compatibility for entry into the EU market

3 Strengthen the foundations of the robotics industry's ecosystem

☐ **(Development of Technology)** Development of technology related to **3 key components and 4 types of software** and support for performance evaluation and certification t

【Major Development of Technology Projects Initiated in 2022】

Field	Project title	2022 budget
Smart gripper	Development of autonomous operation and gripping technology using tactile sensing end-effector-based imitative learning technology	KRW 900 M
	Gripper system technology for production processes of multiple varieties of products such as unspecified objects of various shapes, weights, and strengths	KRW 800 M
	Development of a flexible tactile sensor system that can be applied to the curves of the robot's hand and gripper	KRW 900 M
Robotics software platform	Development of mobile intelligence software for autonomous movement of walking robots in dynamic and atypical environments	KRW 800 M

☐ **(Infrastructure) Promote the commercialization of innovative technologies** and **support the establishment of a safe utilization environment**

○ **(Performance Evaluation of Parts)** Establishment of a performance evaluation and certification support system for upgrading parts and enhancing their reliability (2020-2023, KRW 2.184 billion in 2022)

【Key Highlights in Paving the Foundation for Performance Evaluation and Certification Support for Next-Generation Convergence Parts】

Field	Highlights

Evaluation infrastructure	•A total of 14 types of infrastructure will be built, including 4 types of robot platforms for intelligent controller (2022)
Promotion of commercialization	•Support for commercialization of robot parts (9 cases), prototype production (5 cases), and certification (10 cases)
Registration of standards for robot parts	•Testing and evaluation method for vacuum suction gripper for conveying cotton fabrics and 1 other case

○ **(Safety Certification) Establishment of an international standard-based collaborative robot safety certification system** to ensure the safety of collaborative robots (2021-2025, KRW 1.85 billion in 2022)

【Keyr Highlights in Establishing the Collaborative Robot Safety Certification System】

Field	Highlights
Demonstration environment	•Set up 2 types of equipment, including cobot electrical characteristics test facility and ultra-high-precision position measurement test facility
Certification system	•Development of collaborative robot safety certification test procedure based on ISO 10218-1
Dissemination of technology	•Technical support for cobot process safety improvement and regulatory compliance

○ **(Demonstration & Demand) On-site demonstration support for 35 types of robot parts** to **enhance competitiveness of key parts made in Korea**

* Reducer (10 types), motor drive (8 types), driving control, position sensor, lidar (5 types), servo motor (2 types), drive module (4 types), control board (2 types), gripper, and tool changer (4 types)

□ **(Convergence with Other Industries)** Support for the development and demonstration of next-generation robotics technology **fused with other technologies**

○ **(AI) Establishment of a demonstration test bed** for the realization of **intelligent inspection and transportation (AGV) processes** and support for application of **collaborative intelligent operation technology** to simple and complex processing/machining processes

* Project to boost the competitiveness of collaborative intelligence-based Robot Plus (2020-2024, KRW 4.53 billion in 2022)

【Key Highlights in the Intelligentization of Machinery and Equipment (Collaborative Intelligence-based Robot Pus)】

Field	Highlights
Demonstration environment	•Establishment of simple and complex processing/machining, inspection, and transport (AGV) process testbeds (5 types added, 15 types cumulative) •Development of performance evaluation methods and a pilot authentication scheme for collaborative intelligence modules
Technical support	•Development of collaborative intelligence SDK (software development kit) packaging and utilization examples (10 copyright registrations) •Development of collaborative intelligence-based process automation concept (4 cases) and training (40 people)

○ **(Big Data) Advancement of metal machining data acquisition equipment** and construction of **testbeds to demonstrate robots using big data** for the electric and electronics industry

* Project to build the foundation for developing Meister robots that utilize big data (2021-2025, KRW 8.6 billion in 2022)

【Key Highlights in Meister Robotization Foundation Establishment Project】

Field	Highlights
Demonstration environment	•Establishment of a testbed (Suseo, 11 types of equipment), development of Meister robotization performance evaluation method, and endeavors to register related standards
Technical support	•Discovery of 3 Meister data acquisition support tracks and 3 proof-of-concept (PoC) cases
Human resource development	•Establishment of Learning Management System (LMS) and education and training for employees (118 people)

○ **(5G)** Supporting the demonstration and commercialization of technology by paving the foundation for **5G advanced manufacturing robot demonstration** and dissemination of the technology (2020-2023, KRW 8 billion in 2022)

【Key Highlights in Paving the Foundation for 5G-based Advanced Manufacturing Robot Demonstration】

Field	Highlights
Demonstration environment	•Completion of detailed design, building permit, and groundbreaking ceremony (November) •Commencement of equipment setup (7 types) such as wireless communication verification equipment and a high-tech manufacturing simulation test system
Corporate support	•Corporate support for suppliers and SI companies (7 projects)

○ **(Cloud)** Development of technology for robotics with complex intelligence ('AI brain') that can collect and learn data from multiple different robots in the cloud to augment intelligence (MSIT)
* Intelligent information, robot convergence service (2019~2022, KRW 2 billion in 2022), cloud-based robot complex AI technology development (2020~2023, KRW 7.3 billion in 2022)

□ **(Human Resource Development) Operation of education and training courses centering on convergence with other industries** and **human-robot collaboration** to nurture innovative manpower to perform practical work

○ **(Leading Innovation Based on Robots)** Linking universities and robot companies in each region to **nurture master's and doctoral degree holders** who are capable of integrating robotics with other industries
* Fostering professionals capable of leading innovation based on robotics (2019-2023, KRW 1.95 billion in 2022, 126 people)

○ **(Human-Robot Collaboration)** Operation of degree programs to train experts in high-value intelligent robot-based SI 2.0 who can apply AI
* Fostering experts in AI- and robot-based human-machine collaboration technology (2021-2026, KRW 1.66 billion in 2022, 72 people)

○ **(AI-Robot Employee Training)** Development of education modules tailored to on-site needs and operation of education and training programs that can improve employees' AI convergence capabilities through practices that are applicable in the field
* Nurturing AI convergence talents in the field of intelligent robots (2022-2026, KRW 600 million in 2022, 175 people)

IV. Directions for 2023

◈ Lead industrial innovation through the **intelligentization of manufacturing sites based on robots**

◈ Address social issues using robots and **integrate robot services into people's daily lives**

◈ Pave a foundation for the **creation of innovative fields** such as new technologies and new businesses

1 Intelligentization of manufacturing site by developing and demonstrating models in connection with robotic equipment

○ Development of intelligent AI-based **robot-equipment convergence standard process model** to facilitate advancement to improve productivity in the manufacturing industry

○ Support for the development and distribution of **safety robots for dangerous processes** to prevent industrial accidents and solve the problem of manpower shortage

2 Integrate robot services into people's daily lives based on-site needs

○ Transition to the electric vehicle era, desire to improve the working environment, etc., are driving the **demonstration of robotics convergence based on on-site needs**

○ Development and demonstration of care robots that provide care services for seniors and people with disabilities and support their independence

○ Implementation of laws and systems to further promote the use of daily services such as delivery, customer service, and logistics

3 Establishment of a permanent demonstration system for continuous improvement of regulations and support for commercialization

○ **Efforts to improve on-site regulations** and creation of a smooth commercialization environment for new products through the phased implementation of the Regulatory Innovation Roadmap 2.0

○ Collection of actual and virtual data, development of utilization technology, and **establishment of virtual- and physical-based demonstration infrastructure** to promote robot products and services

V. Action Plans for 2023

1 Increase the penetration of manufacturing robots in the three major manufacturing industries

☐ **(Development of Standard Process Models)** Develop **three major +α fields** and **robot-equipment convergence models**

◯ **(3 units +α)** Support **the development of standard process models** and the **improvement of models** for **industries and processes** (cosmetics, paper manufacturing, etc.) requiring them

* Develop standard models (3 major + α manufacturing) 109 (2019~2022) → 32 (2023)

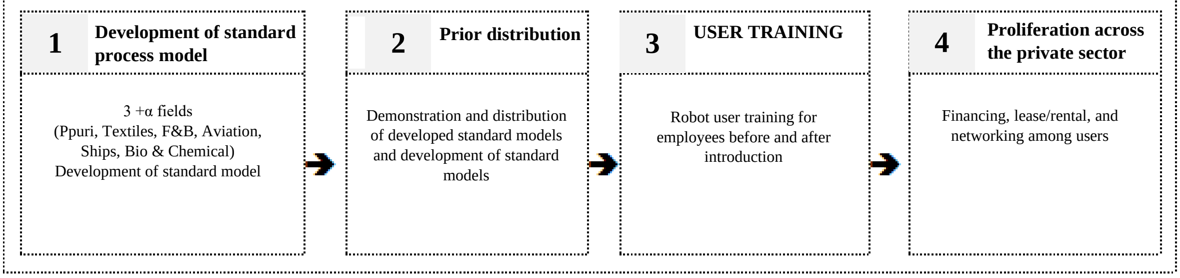
(Improved) 14 (2021-2022) → 3 (2023)

◯ **(Robot-Equipment Convergence Model) Develop AI-based robot-manufacturing equipment integrated process system model** capable of flexible automation of multiple varieties and real-time on-site control (12 models)

* Develop standard models for robot-equipment digital manufacturing package (2022~2025, KRW 4.1 billion in 2023)

☐ **(Supply of Manufacturing Robots) Provide packages that include consulting, prior distribution, user training, etc.** based on n the developed standard process models and the needs of individual companies

<Demonstration of Prior Supply of Manufacturing Robots>



◯ **(Linking with Standard Process Models) Demonstrate and distribute manufacturing robots for the three major +α manufacturing industries b**ased on the standard process models and the upgraded model tailored to the on-site needs

* Operation of Fair Model Promotion Center for the dissemination of standard process model outputs (Oct. 2023)

◯ **(Support for Individual Companies)** Create synergistic effects by combining smart factory and robotics technology to strengthen the manufacturing competitiveness of SMEs (60 companies, MSS)

☐ **(Employee Training)** Provide training packages for the employees of companies adopting standard process models and train robotic SI experts and operators using training centers

○ **(Linking with Standard Models) Conduct step-by-step* training** using standard process models (MOTIE) and **training to improve practical skills** for the employees of companies adopting manufacturing robots (MOEL)
* (Before adoption) Introductory and elementary courses, (After adoption) Practical training and practical course

○ **(Education & Training Center)** Operate the **Robot Vocational Innovation Center** to train **693 professionals** including robot operators (short-term program) and robot SI coordinators (long-term program)
* (Short-term) Operation in the Application Fields of Industrial Robots (20 hours), (Long-term) Palletizing SI, Assembly SI, etc. (100 hours or more)

【Robot Vocational Innovation Center】

		
Robot Vocation Innovation Center (Gumi)	Cobot Lab	Manufacturing Robot Lab

□ **(Dissemination in the Private Sector) Continued operation of financial, investment,** and **purchase support programs** and **support** for **the revitalization of used robot transactions** through the operation of **the Refurb Center**

○ **(Financial & Investment) Agreement guarantee** (95% guarantee ratio, issuance of guarantee), **low loan interest rate program** for 7 major banks, and **IR events held** in connection with domestic and overseas exhibitions

○ **(Refurb Center) Groundbreaking** (Oct. 2023), e**stablishment of a platform for transaction services** (auction, sale, history management, etc.), and support for the development of refurbished parts and substitutes (KRW 2.27 billion in 2023)

【 Refurbishment Center for Used Robot Remanufacturing 】

2 Develop four major types of service robots intensively

☐ **(Development of Technology)** Start **developing new technologies in the field of care and safety** that reflect the needs in the field to address social issues such as demographic changes and industrial accidents

○ **(Care)** Development and demonstration of **work assistance robots** necessary for **vulnerable groups** such as the elderly and persons with disabilities to gain independence and carry out daily activities on their own (2023~2026, KRW 2 billion in 2023)

【Key Projects for the Development of Robotics Technology to Boost the Self-Reliance of Vulnerable Groups】

Field	Project title	Budget 2023
Care	Development of three types of care robots (excretory assistance, mobility assistance, pressure ulcer prevention)	KRW 750 M
Assisted living	Development of mobile living assistance robots that understand people's daily behavior	KRW 700 M
Mobility assistance	Development of a simple riding-type robotic system for the elderly, persons with disabilities, and patients to stand, change posture, and move about indoors	KRW 700 M

○ **(Safety)** Development and on-site demonstration of **safety robot** technology aimed at preventing **disasters (fires) and accidents involving workers in dangerous industries** (2023~2028, KRW 2.2 billion in 2023)

【Key Projects for the Development of Safety Robot Technology for Disaster and Accident Prevention】

Field	Project title	Budget 2023
Fire safety	Development of sensor and robotics technology to search for people at a firefighting site and support fire suppression activities	KRW 100 M
	Development of a quadruped walking robot for firefighting based on human detection and fire suppression solutions and demonstration of firefighting robots and sensors	KRW 2.1 B

○ (**4 Major Fields**) Development of robot technology that can **perform advanced tasks in collaboration with humans** in **hospitals and warehouses**

【Major Technology Development Projects in 2023】

Field	Project title	2023 budget
Care	Development of human-following semi-autonomous bed robot for isolated transport of infected patients	KRW 1.05 B
	Development of a nursing assistant and patient monitoring robot system for isolation wards for infected patients	KRW 1.2 B
	Development of companion robots that can communicate emotionally through physical and cognitive interactions with humans	KRW 900 M
	(New) R&D and demonstration of user-oriented care robot and services (MOHW)	KRW 3.9 B
Wearables	Development of soft sensor-embedded fabric-based actuators and garment-type robotic technology	KRW 700 M
	Wearable robot aiding walking in daily life for in-home healthcare services	KRW 1.6 B
	(New) Development of flexible actuator and soft wearable robot technology for muscle support of care workers	KRW 900 M
Healthcare	Development of stereo X-ray and 3D endoscopic guided spine surgery robotic systems	KRW 1.6 B
	Development of laparoscopic surgery assistant robot for simultaneous multi-instrument control performance	KRW 1.2 B
	Development of a lightweight wearable rehabilitation robot for self-rehabilitation of the upper limb	KRW 1.5 B
	(New) Development of end-effector and pain intervention assistance robot platform technology applicable to three or more types of pain intervention procedures	KRW 750 M

	Development of robotics- and ICT-integrated disease control and prevention system for pandemic response (MSIT)	KRW 4.1 B

Field	Project title	Budget 2023
Logistics	Development of robot-enabled unloading system for trunk cargo transport vehicles	KRW 1.6 B
	Development of robot-based loading system technology for cargo loading operation	KRW 1.2 B
	Development of mobile logistics handling robot technology to streamline Korean warehouse operations	KRW 4 B
	Development of an item management robot that autonomously identifies and manages the inventory of products in stores	KRW 1.05 B
	Development of multiple robot collaboration planning technology for integrated control of multiple outdoor last-mile delivery robots	KRW 1.2 B
	Development of service robot technology for retrieving empty dishware after meals	KRW 1.2 B
	(New) Development of self-driving logistics robot of multi-car towing type for indoor and outdoor transportation of goods	KRW 1.2 B
Integration	Development of robot system for field application to implement the robot utilization service business model	KRW 800 M
	Development of AI-integrated service robot system for user convenience and efficiency improvement	KRW 650 M

☐ **(Demonstration & Distribution)** Pursue **large-scale robot distribution** and **demonstration projects** based on verification of **robotics solutions for solving problems** in the field as well as **data management and integrated control**

○ **(4 Major Fields) Supply of 2,283 service robots mainly from among promising robots**

① (Care robots) Formation of a consortium between local governments and companies to supply 1,600 robots for rehabilitation, companionship, and dementia prevention
② (Wearable robots) Supply 190 wearable robots in the public and private sectors
③ (Healthcare robots) Supply 13 robots following the designation of surgical robots and robot rehabilitation centers (target number met)
④ (Logistics robots) Support the introduction of 400 indoor/outdoor logistics and transport robots in the public and private sectors
⑤ (Others) Support the introduction of 80 units of non-face-to-face service robots and on-site cobots

○ **(Needs-specific Development & Distribution) Development of** new robot services (Stage 1), modification and improvement of newly developed models (11 models) (Stage 2), and demonstration and distribution of modified models (22 models) (Stage 3) (KRW 9.16 billion in 2023)

* **(Stage 1) Service model development** → **(Stage 2) Modification, improvement, and verification/validation** → **(Stage 3) Demonstration and distribution**

【Major Robot Service Models Under Development】

			
EV charging robot	Airport duty-free zone delivery system	Park walkway cleaning robot	Self-driving guide robot for theme parks

○ **(AI/5G-based Convergence Demonstration) Large-scale demonstration of multiple types and number of robots** based on the creation of **integrated control system** and **robot/communication-based data collection infrastructure** (KRW 4.9 billion in 2023)
* (Phase 1) Individual robot demonstration and integrated control system construction (2 new projects), (Phase 2) Multi-robot convergence demonstration and advancement of the integrated control system (Phase 1 in 2022, 7 projects)

☐ **(Regulatory Improvement)** Announce the **Advanced Robot Regulatory Innovation Plan** (March 2023) and amendments to the Intelligent Robot Act (April 2023) with a **focus on improving regulations concerning promising fields of robotics**

○ **(Regulatory Reform) Rediscover regulatory improvement projects and announce implementation strategies** in accordance with changes in social, economic, and institutional environments (agenda of the 3rd Regulatory Reform Strategy Meeting (March))

○ **(Amendments to Related Law) Amend subordinate statutes (enforcement decrees and rules) and preparation of administrative rules** in accordance with **the amendments to related laws such as the Intelligent Robot Act** to **promote the commercialization of outdoor mobile robots**

< Amendment of the Intelligent Robot Act and Its Relationship with Related Statues >

<table>
<tr><td colspan="2">“For outdoor mobile robots that meet the safety criteria,”</td><td>“on the premise of the minimum necessary control,”</td></tr>
<tr><td>(Operational safety certification)</td><td>(Definition newly added)</td><td>(Obligation to subscribe to an insurance policy)</td></tr>
<tr><td colspan="3">“prepare standards to allow travel on sidewalks, park entry, and logistics delivery, as well as data collection and utilization”</td></tr>
<tr><td colspan="3">(❶Road Traffic Act) (❷Enforcement Decree of the Act on Urban Parks, Greenbelts, etc.) (❸ Last-Mile Logistics Industry Development Act) (❹Personal Information Protection Act)</td></tr>
</table>

☐ **(Development of Technology in 10 Niche Fields)** Development of technology to deal with **social issues** and satisfy the **on-site needs** of individual ministries

【Major Projects for 2023 by Ministries】

Field	Project title	2023 budget
MAFRA	Development of intelligent agricultural robots for smart greenhouses	KRW 2.1 B
	Creation of a high-tech unmanned automated agricultural production demonstration complex	KRW 7.5 B
MOTIE	Development of a remote inspection robot system for cableway facilities (wire rope and cutting wheel)	KRW 1.51 B
	Development of human-robot collaboration technology for dismantling multi-variety EV battery packs that need to be disposed of	KRW 1.65 B
	Safety robot technology capable of detection and response by being operated wirelessly in a small space	KRW 1.6 B
	(New) Robotics platform for agricultural work capable of continuous fruit harvesting and multi-transport robot control	KRW 1.5 B
MOE	Development of non-face-to-face collection and treatment technology for high-risk medical waste	KRW 2.3 B
DAPA	Development of complex signal-based human-machine high-speed synchronization control technology	KRW 1.3 B
	Development of complex signal-based human-machine high-speed synchronization control technology	KRW 1.3 B
	(New) Development of garment-type flexible wearable robot technology for optional articulated assistance	KRW 0.4 B
NFA	Development of efficient response technology for chemical terrorism such as harmful gases	KRW 1.9 B
RDA	Robotics technology for hydroponic cultivation, fruit and vegetable cultivation monitoring, fruit-thinning, and harvesting	KRW 1.6 B
	Development of intelligent mowers for apple orchards	KRW 200 M

	Development of fruit enlargement and harvest period diagnosis technology for machine harvesting to lower the need for manpower	KRW 120 M
Coast Guard	Development of autonomous underwater vehicles (AUVs) for prompt response in the event of a marine accident	KRW 7.18 B

☐ **(Support for Export)** Provide **assistance to the destination country** and support for acquiring **overseas standard certifications** required by the destination country

○ **(Export Support Tailored to the Destination Country)** Promote the introduction of domestic robots by **matching each robot product with promising overseas buyers** and **promote dissemination by referring** to the introduction cases

* Example) Educational robots (ASEAN, developing countries), healthcare robots (Central Asia), building cleaning robots (Middle East), etc.

○ **(Export marketing support) Set up a joint PR hall for domestic robotics companies** at **major overseas exhibitions*** and hold **export consultation sessions** to discover new buyers

* Plans to set up a joint robotics hall at IFA 2023 (consumer electronics trade show in Germany) (September)

○ **(Testing & Certification) Work together with new global certification bodies on a wider scale** (MOUs, designated testing laboratories) and **expanded scope of accreditation areas of the Korea Laboratory Accreditation Scheme (KOLAS)** (SGS (Switzerland), TuV Rheinland (Germany), CSA (Canada), etc.)

○ **(Overseas Certification Support)** Carry out **an overseas certification support program** for major countries to deal with **global technology regulations** in the field of robotics (CE Marking (EU), NRTL (North America), CR (China), etc.)

3 Strengthen the foundations of the robotics industry's ecosystem

☐ **(Development of Technology)** Support the technological development and performance certification of **three next-generation key components and 4 types of software**

○ **(Core Components)** Develop technology such as intelligent robot controller using AI and all-weather sensors for the outdoor environment

【New Major Development Projects for 2023】

Field	Project title	2023 budget
Intelligent controller	Development of a reducer that can respond to various system requirements and applies a new tooth type	KRW 750 M
	Development of integrated drive and steering drive modules for autonomous mobile robots (AGVs, AMRs)	KRW 900 M
Self-driving sensor	Development of solid state FMCW LiDAR with a volume of 300cc or less for harsh indoor and outdoor driving environments (snow, smoke, dust, etc.)	KRW 1 B

○ **(Software)** Develop multi-mobile robot autonomous driving technology and robot AI technology for robot-human interaction and upgrading work

【New Major Development Projects for 2023】

Field	Project title	Budget 2023
Robotics software platform	Development of collaborative mapping, environmental awareness, and autonomous driving technology for multiple mobile robots operating in large-scale indoor workspaces	KRW 750 M
	Development of AI source technology for autonomous sharing control and autonomous operational switch for the advancement of atypical operations of ultra-realistic telepresence robots	KRW 900 M

HRI technology	Development of behavior-based service robot HRI auto-generated AI technology for long-term interaction with users	KRW 1 B

☐ **(Infrastructure)** Support testing and certification of high-tech robot and parts to enhance the robot competitiveness for the world stage and **plan to create a testbed based on the actual environment**

○ **(Performance Evaluation of Parts)** Boost product competitiveness by achieving advancement and ensuring reliability through the **performance evaluation and certification of parts** (2020~2023, KRW 1.1 billion in 2023)

【Major plans for Paving the Foundation for Supporting the Performance Evaluation and Certification of Next-Generation Convergence Parts】

Field	Major plans
Evaluation infrastructure	Provide scanning electron microscopes and 1 other type of equipment (2023)
Promotion of commercialization	Support the commercialization of robot parts (5 cases), prototype production (5 cases), and certification (5 cases)
Registration of standards for robot parts	Register standards related to self-driving sensors for robots (1 case)

○ **(Safety Certification)** Establish a collaborative robot safety certification support system by **being accredited by KOLAS** (Korea Testing Laboratory) (2021~2025, KRW 2.14 billion in 2023)

【Major Plans for Paving the Foundation for Safety Certification of Cobots】

Field	Major plans
Establishment of a demonstration environment	Establish a robot test and certification support center (construction is set to be completed in December) and provide environmental conditions and quality test facilities and 3 other types of equipment
Certification system	Acquire KOLAS accreditation for testing, set up a product certification system [K mark + KOLAS + certification report], develop test and evaluation methods, provide accreditation test services, and develop standards
Dissemination of technology	Provide consulting on conformity evaluation and technical support for cobot process safety improvement and regulatory compliance

○ **(Robot Test Field)** Facilitate the **commercialization projects of domestic robot companies** by building **lab/virtual/real-world environment-based infrastructure** for **the demonstration** and **certification** of **robot business models** (BMs)
* National Robot Test Field Project (2024~2028, KRW 299.85 billion, preliminary feasibility study underway)

☐ **(Demonstration & Demand) Verification of reliability** of **the key parts made in Korea** and **on-site demonstration of robot products** equipped with parts and components made in Korea

○ A **demonstration project** for parts with a high cost ratio and **low localization rate** with the participation of robot parts companies, robot manufacturers, and robot demand companies (KRW 1.2 billion in 2023)

☐ **(Convergence with Other Industries)** Support the **development of convergence technology** for the intelligentization and advancement of robots

○ **(Artificial Intelligence)** Implementation of collaborative intelligence of machinery and robots in inspection and transfer (AGV) processes
* Collaborative intelligence-based Robot Plus Competitiveness Support Project (2020-2024, KRW 6.1 billion in 2023)

【Major Plans for Intelligent Machinery and Equipment Project (Collaborative Intelligence-based Robot Plus)】

Field	Major plans
Demonstration environment	Advancement of the testbed, which includes the manufacturing and logistics automation system, contact-type shape inspection system, cell-to-cell mobile robot system, etc., development of performance evaluation methods, and collaborative intelligence-based process demonstration certification
Dissemination of technology	Advancement of collaborative intelligence module SDK for inspection and transport (AGV) processes (1 case), development of SDK application examples (9 cases), discovery of collaborative intelligence PoC (4 cases), construction of datasets, etc.

○ **(Big Data)** Acquire **Meister** (on-site skilled workers) **know-how and data** and develop performance evaluation methods for **robotics technology** to **expand the field application of related technology**

* Project to build the foundation for developing Meister robots that utilize big data (2021-2025, KRW 5.8 billion in 2023)

【Major Plans for Building the Foundation for Developing Meister Robots】

field	Major Plans
Demonstration environment	Establishment of a testbed (Suseo, 5 types of equipment) and equipment setup for an automotive process testbed
Technical support	Discovery of 3 Meister data acquisition support tracks and 3 proof-of-concept (PoC) cases of Meister robotization
Human resource development	Development of 3 teaching materials for the curriculum and training of 200 professionals among current employees

○ **(5G) Built an open demonstration base** and provide **testing and certification** support to foster the 5G-based high-tech manufacturing robot industry and strengthen technological competitiveness (2020-2023, KRW 4.9 billion in 2023)

【Major Plans for Building the Foundation for the Demonstration of 5G High-Tech Manufacturing Robots】

field	Major Plans
Demonstration environment	Setup of 5G-based high-tech manufacturing robot evaluation and certification equipment (15 units, 13 types)
Corporate support	Support for each stage (Suppliers (2021), → Suppliers and SI companies (2022), → Suppliers, SI companies, and user companies (2023~))
Dissemination of technology	Establishment of an official testing and certification system in the field of 5G high-tech manufacturing robots and development and distribution of safety guidelines

○ **(Cloud) Cloud, robotics, and AI brain** technology and **standard framework technology** to expand the level of intelligence by providing personalized services (MSIT)

* Development of cloud- and robotics-integrated AI technology (2020~2023, KRW 7.3 billion in 2023)

☐ **(Human Resource Development) Strengthen the expertise of working-level personnel in the field** and support the cultivation of innovative manpower for practical affairs

○ **(Leading Innovation Based on Robotics)** Operate regular courses in graduate schools in each region to **nurture working-level manpower** capable of incorporating the elements of other industries based on the need for new technology

* Fostering robot-based innovation-leading professionals (2019-2023, 2023: KRW 1.95 billion,

107 people)

○ **(Human-Robot Collaboration)** Operate a degree program to nurture high-value intelligent **robot-based SI experts** who can contribute to the development of smart and automated processes for manufacturing companies
* Nurture experts in AI- and robot-based human-machine collaboration technology (2021-2026, KRW 1.66 billion in 2023, 72 people)

○ **(AI-Robot Training for Employees)** Develop online and offline training courses based on corporate **needs for AI convergence education** and provide **in-depth education and training for employees (with more than 3 years of experience)**
* Cultivate AI convergence talents in the field of intelligent robots (2022-2026, KRW 865 million in 2023, 250 people)

VI. List of Projects

Project		Ministry in charge	Budget (KRW 100 million)	
			2022	2023
1 Increase the penetration of manufacturing robots in the three major manufacturing industries				
	1-1. Develop 108 model applications for industries and processes	MOTIE	407	407
	1-2. Provide consulting, conduct demonstration, and distribute each standard model to 10 companies	MOTIE, MSS	32	57
	1-3. Train the employees at companies adopting manufacturing robots	MOTIE, MOEL	16	24
	1-4. Offer robots on a rental/lease basis and transition into a loan model in the private sector	MOTIE		
	1-5. Shift from government-led subsidy policy to private sector-focused financing model	MOTIE		
	1-6. Hold briefing sessions and promote networking for the dissemination of consumer-oriented robots	MOTIE		
2 Develop four major types of service robots intensively				
	2-1. Support the development and dissemination of technology in 10 niche fields	MOTIE, NPA MAFRA, RDA DAPA, NFA Coast Guard, MOF MOIS, MOE MOTIE, MSIT MOHW, MOIS MOTIE	368	430
	2-2. Develop robots in four major fields → Distribute to vulnerable groups for demonstration → Distribute to the private sector	MOTIE, MSIT MOHW, MOIS	915	679

	2-3. Improve regulations and support package-type overseas expansion to develop domestic and overseas markets	MOTIE	14	20
3 **Strengthen the foundations of the robotics industry's ecosystem**				
	3-1. Achieve self-reliance on advanced key parts and software and perform demonstration of parts	MOTIE	192	195
	3-2. Expand the infrastructure for the dissemination of robotics convergence technology	MOTIE, MSIT	310	286
	3-3. Foster professionals in the field of robotics	MOTIE	36	45
Total			**2,440**	**2,298**

NOTE Action Plans for 2023 by Ministry

Ministry of Science and ICT (MSIT)	**2-2. Develop robots in four major fields → Distribute to vulnerable groups for demonstration → Distribute to the private sector**

▣ Development of robotics- and ICT-integrated disease control and prevention system for pandemic response

1. Background and Purpose

☐ Development of robot-based disease control and prevention technology to reduce the burden on the healthcare system and contribute to efficient infection prevention and containment

○ Establishment of an efficient pandemic response system with minimal human input by strengthening the disease control and prevention capacity using robots and ICT

< Project Overview >

① Areas of support: Establishment of an efficient infectious disease response support system for everyday disease control and prevention (infection prevention, disinfection, automatic diagnosis services, etc.) by minimizing human input and using convergence technology
② Period: 2020 to 2024 (KRW 18.1 billion in total)
③ Details of support: Intensive on-site management of medical institutions with the application of robotics and ICT, provision of treatment facilities, development of convergence solutions necessary for the expansion of around-the-clock disease control and prevention, and on-site demonstration
* Completeness of the technology that can be ultimately applied to hospitals, large-capacity facilities, etc. (innovation & new endeavors)
* Demonstration by using it in actual hospitals, large-capacity facilities, etc. (Collaboration with the MOHW)

2. 2022 Performance Highlights

☐ Enhanced the completeness of the robotics- and ICT-based disease control and prevention solutions for various infectious disease response sites

○ **(Intensive Medical Care Sites)** Achieved the goal of perfecting robotics and ICT convergence services (non-face-to-face automatic nasal sample collection, remote operation of treatment equipment in the intensive care unit, tracking of movement of infected patients) for field support and secured usability evaluation data for the lab environment for the prototype

○ **(Treatment Facilities)** Established a living lab demonstration environment for a non-face-to-face delivery robot system, and achieved the functionality and reliability goals for the robotic system for demonstration

○ **(Everyday Space)** Created disease control and prevention scenarios based on the requirements of medical institutions and related experts and repeated the processes involving prototypes in the living lab

☐ Promoted the dissemination and utilization of robotics- and ICT-based disease control and prevention system

○ Expanded scope of demonstration for actual field application (tracking the movement of infected patients) and strengthened demonstration cooperation with domestic researchers and institutions

○ Conducted comprehensive review and management of certification and standardization strategies for global standardization of the K-disease control and prevention system and enhanced public-private cooperation capabilities

○

3. 2022 Performance Evaluation and Future Direction

☐ Demonstration performance management and verification and promotion of global cooperation and standardization

○ Management of the demonstration and completeness of the convergence disease control and prevention system for each site and efficiency and effectiveness verification based on the calculated empirical data

○ Discovery of companies that will likely use the development outcomes and commercialization, utilization, and dissemination of developed technology

○ Establishment, review, and promotion of in-depth strategies for global standardization of the K-disease control and prevention system that was developed and establishment of a foundation for international standardization through public-private cooperation

4. Action Plan for 2023

☐ Field and living lab demonstration of robotics and ICT convergence solution for disease control and prevention

○ **(Intensive Medical Care Sites)** Obtain empirical data related to the safety and practicality of services incorporated with robotics and ICT at medical institutions, and establish certification and commercialization strategies based on the attainment of system integrity

○ **(Treatment Facilities)** Determine the empirical performance of differentiated core technologies of the non-face-to-face delivery solution for the disease control and prevention situation, verify its applicability to other environments in line with changes in the disease control and prevention situation, and secure commercialized technology

○ **(Everyday Space)** Evaluate the usability of disease control and disinfection solutions using robots for actual users, and ensure field applicability based on systematic analysis of empirical data

5. Schedule

Project	Description (2023 schedule)	2019	2020	2021	2022	2023			
						1Q	2Q	3Q	4Q
Development of robotics- and ICT-integrated disease control and prevention system for pandemic response	Development, operation, and management of the disease control and prevention system								
	Research on the disease control and prevention system for intensive medical care sites								
	Research on the disease control and prevention system for treatment facilities								
	Research on the disease control and prevention system for everyday spaces								

6. Budget

Description		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Pilot Project for the Innovation Challenge Project (Development of robotics- and ICT-integrated disease control and prevention system for pandemic response)	Government	-	24.5	38.75	61	41	165.25
	Private sector	-	-	-	-	-	-
	Subtotal	-	24.5	38.75	61	41	165.25

7. Project Implementation System

☐ The Disease Control and Prevention Robot Project Group is responsible for managing the entire project cycle and National Research Foundation of Korea is responsible for overall project management

MSIT	3-2. Expand the infrastructure for the dissemination of robotics convergence technology

▣ Development of intelligent information, robotics-integrated services, and cloud- and robotics-integrated artificial intelligence technology

1. Background and Purpose

☐ Intelligent information & robotics-integrated services

○ Gain technological competitiveness to apply intelligent information technology to robots and ICT devices to realize an intelligent information society and gain new future growth engines

☐ Development of cloud- and robotics-integrated AI technology

○ Remotely control multiple robots by taking advantage of the "real-time" and "hyper-connected" characteristics of 5G and develop cloud-based robotics-integrated AI technology to achieve advanced intelligence through lifelong learning

2. 2022 Performance Highlights

☐ Intelligent information & robotics-integrated services

○ Developed AI source technology that can guide the robot to the final destination while utilizing information such as inaccurate map-based navigation maps in indoor and outdoor urban living environments

☐ Development of cloud- and robotics-integrated AI technology

○ Pursued the development of an "AI brain" that can learn using data collected on the cloud

- Developed complex intelligence technology to augment and share intelligence with multiple different robots collecting and learning from data via the cloud to overcome the limitations of intelligence at the level of individual robots

○ Developed framework technology for supporting different types of robots and services through standardized communication and optimal role allocation between the cloud and robots

3. 2022 Performance Evaluation and Future Direction

☐ Intelligent information & robotics-integrated services

○ Securing of source technology and creation of new convergence services through continuous pursuit of development of AI and robotics convergence technology

☐ Development of cloud- and robotics-integrated AI technology

○ Enhancement of the level of intelligence by securing cloud, robotics, AI, and brain technology, standard framework, and core technology, and providing personalized services

- (AI Brain) Promotion of autonomous intelligence augmentation technology through lifelong learning of core unit intelligence of robots such as self-evolving continuous learning
- (Framework) Development of context-based response technologies such as driving, operation, interaction, etc., stability based on the cloud connection for robots

○ Continuous support for the development of core technologies for the cloud, robotics, and AI and development of developed technology followed by domain demonstration and commercialization

4. Action Plan for 2023

☐ Intelligent information & robotics-integrated services

○ Final evaluation of ongoing project (1 project, KRW 2 billion) and completed project

☐ Development of cloud- and robotics-integrated AI technology

○ Ongoing execution of ongoing projects (3 projects, KRW 7.3 billion) and final evaluation of the completed projects

5. Schedule

Project	Description (2023 schedule)	2019	2020	2021	2022	2023				2024
						1Q	2Q	3Q	4Q	
Development of innovative ICT-incorporated technology (Intelligent information & robotics-integrated services)	Project execution									
	Mid-term examination of the ongoing project									
	Final evaluation									
Development of cloud- and robotics-integrated AI technology	Project execution									
	Mid-term examination of the ongoing projects									
	Final evaluation									

6. Budget

Description		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Development of innovative ICT-incorporated technology (Intelligent information & robotics-integrated services)	Government	**126**	**134.42**	**120**	**20**	**-**	**400.42**
	Private sector	**6.37**	**7.83**	**7.15**	**4.32**	**-**	**25.67**
	Subtotal	**132.37**	**142.25**	**127.15**	**24.32**	**-**	**426.09**
Development of cloud- and robotics-integrated AI technology	Government	**-**	**55**	**73**	**73**	**73**	**274**
	Private sector	**-**	**2.72**	**3.82**	**3.89**	**3.89**	**14.32**
	Subtotal	**-**	**57.72**	**76.82**	**76.89**	**76.89**	**288.32**

7. Project Implementation System

☐ The Institute for Information and Communication Technology Planning and Evaluation (IITP) is responsible for managing entire project life cycle including planning, announcements, evaluations, and outcomes

Ministry of Agriculture, Food and Rural Affairs (MAFRA)	2-1 Support the development and dissemination of technology in 10 niche fields

1. Background and Purpose

☐ Development of intelligent robots for field farming

○ Development, commercialization, and field application of an intelligent platform (farm bot) that enables agricultural work centered on field farming

☐ Development of intelligent agricultural robots for smart greenhouses

○ Development of agricultural work robots and operation platforms for unmanned agricultural work activities such as transplanting and planting, defoliation, and cleaning in smart greenhouses

☐ Development of a robotic system for harvesting horticultural crops based on multi-robot collaboration

○ Development of a horticultural crop harvesting robotic system based on multi-robot collaboration

☐ Creation of a high-tech unmanned automated agricultural production demonstration complex

○ Creation of an agricultural production system demonstration complex using high-tech agricultural machinery such as unmanned autonomous tractors, agricultural drones, and agricultural robots

2. 2022 Performance Highlights

☐ Development of intelligent robots for field farming

○ Basic mechanism design for the platform, prototype development, self-diagnosis and motion control module development, and final evaluation at the end of the research period (May 2022)

☐ Development of intelligent agricultural robots for smart greenhouses

○ Development of an electric agricultural robotics platform and control system technology

○ Entry into and driving on testbed rail entry, testing of communication systems, etc.

○ Development of robotic planting and transplanting platform manipulator technology with the application of vision technology

○ Designing of a modular system for the autonomous mobile platform and conceptual design of the mechanism

☐ Development of a horticultural crop harvesting robotic system based on multi-robot collaboration

○ Development of loading and harvesting robot and self-driving transport robot prototypes

○ Development of basic technology for recognition of horticultural crops

○ Development of basic technology and monitoring system for multi-robot harvesting collaboration

☐ Creation of a high-tech unmanned automated agricultural production demonstration complex

○ Completion of working design, rezoning work for the construction area of the demonstration complex (50 ha), establishment of an unmanned automated agricultural production control system platform, etc.

3. 2022 Performance Evaluation and Future Direction

☐ Selection of new projects and support for continuation of continuing projects

◯ Final evaluation of the completed project (development of a horticultural crop harvesting robotic system based on multi-robot collaboration) (Feb. 2023)

◯ Continued support for the ongoing project (development of intelligent agricultural robots for smart greenhouses) (2023~) and final evaluation

4. Action Plan for 2023

☐ Development of intelligent agricultural robots for smart greenhouses

◯ Fabrication of an electrically agricultural robot platform based on the results of on-site demonstration

◯ Development and demonstration of multi-variety response technology for implanting and transplanting robotics platform

◯ Development and performance improvement of the cleaning mechanism of the autonomous mobile platform for smart greenhouses

◯ Development of multi-robot collaboration-based self-driving system

☐ Creation of a high-tech unmanned automated agricultural production demonstration complex

◯ Complete the establishment of unmanned and automated agricultural work control systems such as unmanned automated agricultural machinery, automatic irrigation and drainage systems, and unmanned automated agricultural production control system platforms

◯ Complete the construction of management facilities (agricultural machinery warehouse, unmanned nursery and control center, etc.)

5. Schedule

Project	Description (2023 schedule)	2019	2020	2021	2023 1Q	2023 2Q	2023 3Q	2023 4Q	2024
Development of intelligent robots for field farming	• Performance verification and stabilization through testbed and real-world application		■	■					
	• Advancement of platform technology	■	■	■					
	• Commercialization model development and on-site demonstration evaluation			■					
	• Development of lightweight and high-strength work modules (5 types) and optimization thereof	■	■	■					
Development of intelligent agricultural robots for smart greenhouses	• Fabrication of improved electric agricultural robot platform through demonstration			■	■	■	■	■	
	• Development and demonstration of multi-variety response technology of transplanting and implanting robot platform			■	■	■	■	■	
	• Development and performance improvement of the cleaning mechanism of the autonomous mobile platform for smart greenhouses			■	■		■	■	■
	• Development of multi-robot collaboration-based self-driving system			■	■		■	■	■
Development of a horticultural crop harvesting robotic system based on multi-robot collaboration	• Development of a multi-robot collaboration systems for harvesting and transportation		■	■					
	• Development of mobile manipulator with the application of AI for horticultural crop harvesting		■	■					
	• Development of activity monitoring and multi-robot operation systems		■	■					
	• Development of on-site grafting enhancement technology and improvement of functions		■	■					
Creation of a high-tech unmanned automated agricultural production demonstration complex	• Basic and detailed designs		■	■					
	• Creation of a demonstration complex through rezoning		■	■					
	• Establishment of unmanned and automated agricultural work system				■	■	■	■	
	• Construction of an automatic nursery and control center				■	■	■	■	

6. Budget

Description		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Development of intelligent robots for field farming	Government	8.5	8.5	5.1	-	-	22.1
	Private sector	2.9	4.6	-	-	-	7.5
	Subtotal	11.4	13.1	5.1	-	-	29.6
Development of a robot for harvesting horticultural crops based on multi-robot collaboration	Government	-	-	19	21	21	61
	Private sector	-	-	2.34	2.98	3.03	8.35
	Subtotal	-	-	21.34	23.98	24.03	69.35
Development of a horticultural crop harvesting robotic system based on multi-robot collaboration	Government	-	-	7.5	10.0	-	17.5
	Private sector	-	-	0.67	1.0	-	1.67
	Subtotal	-	-	8.17	11	-	19.17
Creation of a high-tech unmanned automated agricultural production demonstration complex	Government	-	6	44	75	75	200
	Municipalities	-	6	44	75	75	200
	Subtotal	-	12	88	150	150	400

7. Project Implementation System

Division	R&R	
Development of robots for field farming, smart greenhouses, and harvesting	MAFRA	(Supervising department) Overall project management incl. project planning, operation, performance evaluation, etc. AND MAJOR POLICY DECISIONS
	Korea Institute of Planning and Evaluation of Technology in Food, Agriculture and Forestry (IPET)	(Specialized Organization) Project planning oversight, budget execution, research group management, project tender, conclusion of agreements, etc.
Creation of a high-tech unmanned automated agricultural production demonstration complex	MAFRA	(Supervising department) Establishment of a plan for the creation of a high-tech unmanned and automated agricultural production demonstration complex, preparation of project implementation guidelines, establishment of a detailed annual action plan, project implementation, analysis of operational performance

	Jeollanam-do Province	(Implementing agency) Project implementation, budget execution, progress check, etc.

Ministry of Health and Welfare (MOHW)	2-2 Develop robots in four major fields → Distribute to vulnerable groups for demonstration → Distribute to the private sector

1 Empirical R&D of consumer-centered care robots and services

1. Background and Purpose

☐ Translational research and service model research for the development of care robots to assist elderly and persons with disabilities in their everyday lives, demonstration of reducing the burden of care, field demonstration-based usability evaluation, and development of a care provider training system

2. 2022 Performance Highlights

☐ Translational research on care robots and R&D of related services (2019 to 2022)

○ Completed four research projects on service model, safety, and data technology for people with severe disabilities and the elderly with reduced mobility (2019~2022)

○ Completed four projects of translational research on care robots such as mobility support, prevention of pressure ulcers, posture change, excretory assistance, and meal assistance (2020~2022)

○ Completed one project on care burden analysis and social value analysis of care robots (2021~2022)

○ Completed demand-based research through the establishment and operation of Care Robot Network Forum and Smart Care Space

3. 2022 Performance Evaluation and Future Direction

○ Translational research on care robots and development of service models, followed by the final evaluation of eight projects (completed in 2022)

○ Selection of projects for new support targets in 2023 and commencement of research

4. Action Plan for 2023

○ Development of care robots for assistance in mobility, bathing, excretion, sleeping, pressure ulcers, eating, and communication

○ Service model, demonstration platform, data standard, and care burden analysis research on care robots

5. Schedule

Project	Description (2023 schedule)	2019	2020	2021	2022	2023			
						1Q	2Q	3Q	4Q

Empirical R&D of consumer-centered care robots and services	Selection of new R&D projects and conclusion of agreements									
	Initiation and conduct of R&D research									

6. Budget

Description*		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Empirical R&D of consumer-centered care robots and services	Government	-	-	-	-	**39**	**39**
	Private sector	-	-	-	-	-	-
	Subtotal	-	-	-	-	**39**	**39**

2 Development of technology for commercialization of micro medical robots

1. Background and Purpose

☐ Support for the development of technology for joint use of micro medical robots in actual hospitals and commercialization of micro medical robots

○ **(Development of common technology for commercialization of micro medical robots)** Companies and medical staff jointly participating in the development of a customized commercialization technology platform for consumers

○ **(Commercialization of micro medical robot products)** High technology readiness level (TRL) to enable early market launch (clinical entry) of the technology once it is commercialized

2. 2022 Performance Highlights

☐ Implemented the project from 2019, supported a total of six projects in the field of medical robots

	Description	Project title	Research Institutions	Total Research Period
1	Development of common technology for commercialization of micro medical robots	Technology center for development of common technology for commercialization of micro medical robots	Korea Institute of Medical Microrobotics (KIMIRO)	2019~2022
2	Commercialization of micro medical robot products	Development of micro medical robot-based guidewire products and systems for peripheral vascular intervention	Seoul National University Bundang Hospital	2019~2023.3. (Phase 1 extended by 3 months)
3		Development of near-infrared fluorescence-guided panoramic endoscope, cancer cell-specific nanorobot, and microrobot for injection to improve the diagnostic accuracy of laparoscopic lymphadenectomy for uterine cancer	Seoul National University Hospital	2019~2023.12. (1-year extension)
4		Development of ultra-small 3D wireless endoscope and AI reading system that can be actively driven based on magnetic field	Dongguk University Industry-University Cooperation Group	2019~ 2023.05. (5-month extension)
5		Development of capsule-type endoscopic robot for upper gastrointestinal examination	Wooyoung Medical	2019~2022
6		Development of micro medical robot system for the treatment of obstructive vascular disease and prevention of embolism and approval of exploratory clinical trials	Hanyang University Industry-University Cooperation Group	2019~ 2023.06. (6-month extension)

3. 2022 Performance Evaluation and Future Direction

○ Continued supporting four extended projects out of the six selected R&D projects (extended due to COVID-19)
* (Budget) KRW 10.1 billion in 2021, KRW 9.8 billion in 2022

4. Project Implementation System

Category	R&R	
Development of common technology for commercialization of micro medical robots	MOHW	(Supervising department) Project oversight incl. project planning, budgeting, etc.
	Korea Health Industry Development Institute	(Specialized Organization) Contribution and project group management, evaluation, budget execution and settlement, etc.
	National Rehabilitation Center	(Supervising Research Institute) Tender, selection, agreement, evaluation, performance management, etc.
Commercialization of micro medical robot products	MOHW	(Project Management) Establishment of annual budget (draft)
	Korea Health Industry Development Institute	(Specialized Organization) Planning, project evaluation & management, outcome utilization, etc.
	Industry, Academia, Research, Disease	(Project Implementation) Project implementation

Ministry of Education (MOE)	2-1 Support the development and dissemination of technology in 10 niche fields

▣ Development of non-face-to-face collection and treatment technology for high-risk medical waste

1. Background and Purpose

□ Need to prepare environmental technologies and policies for the proper disposal of medical waste due to concerns about the frequent occurrence of new infectious diseases since COVID-19

○ Development of non-face-to-face collection and treatment technology using robots to prevent secondary infection caused by medical waste in the event of a surge in infected patients

※ Project for the development of medical waste treatment technology for infectious diseases (2021~2024)

2. 2022 Performance Highlights

□ Development of non-face-to-face collection and treatment technology for high-risk medical waste

○ Structural design of robotic disinfection device for wards/loading and unloading* and prototype production

* Can control the speed, sterilizer spraying time, rotation frequency, repetition frequency, height, etc.

○ Safety testing and certification of the water for self-disinfection (skin irritation, chromosomal abnormalities, phototoxicity, etc.)

○ Development of elevator entry/exit* and automatic door entry and exit functions

* Linked to the freight elevator on each floor in the hospital

○ Development of medical waste loading and unloading assistance device for self-driving robots

3. 2022 Performance Evaluation and Future Direction

□ Development of non-face-to-face collection and treatment technology for high-risk medical waste

○ **(Evaluation)** Attained the development goals according to the established annual R&D plan

○ **(Direction)** Verification and validation of medical waste transport robot prototype and continued development and supplementation

4. Action Plan for 2023

☐ Development of non-face-to-face collection and treatment technology for high-risk medical waste

- ○ Development of interlocking terminal for medical waste loading and unloading units and development of a lock that automatically opens and closes
- ○ Development of a medical waste and robot location tracking system
- ○ Testing of the robot's self-disinfecting water sterilization capacity and verification of inhalation/residual toxicity

5. Schedule

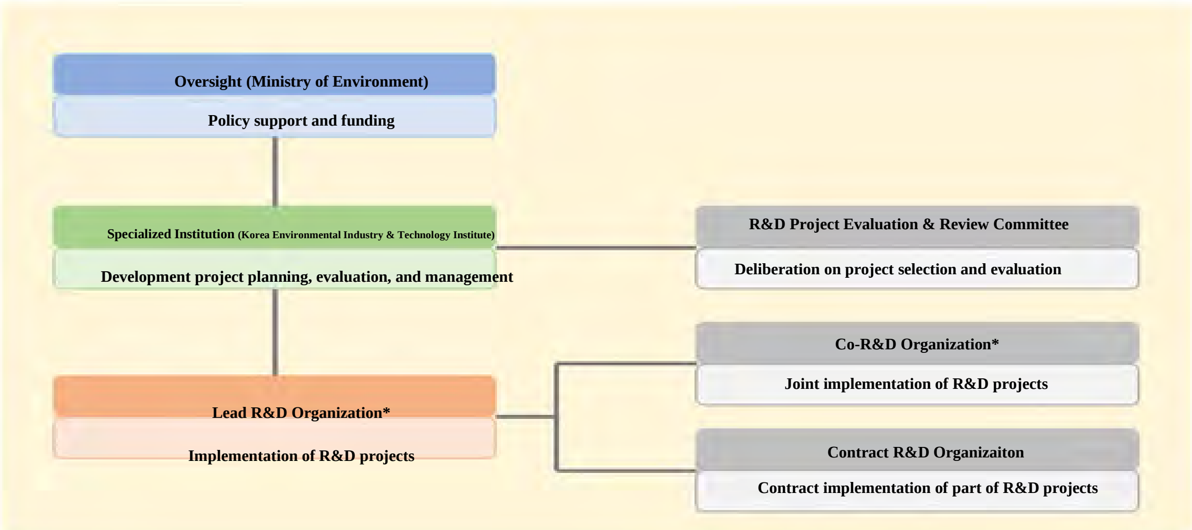
Project	Description (2023 schedule)	2019	2020	2021	2022	2023			
						1Q	2Q	3Q	4Q
Development of non-face-to-face collection and treatment technology for high-risk medical waste	Development of interlocking terminal for medical waste loading and unloading units and development of a lock that automatically opens and closes								
	Location tracking system development and integration								
	Verification and linkage of the robot's self-disinfection device								
	Development of automatic disinfection device for medical waste bins								
	Development of medical waste management and operation system server and administrator program								

6. Budget

Description*		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Development of non-face-to-face collection and treatment technology for high-risk medical waste	Government	-	-	20	23	23	66
	Private sector	-	-	-	-	-	-
	Subtotal	-	-	20	23	23	66

* R&D project for the development medical waste treatment technology

7. Project Implementation System



*** Lead R&D organization (Biodech) and co-R&D organizations (Ajou University Medical Center, LG Electronics, KongTech)**

Ministry of Employment and Labor (MOEL)	1-3 Train the employees at companies adopting manufacturing robots

1. Background and Purpose

○ **(Background)** Collective education and training for employees of relevant companies is necessary to meet the needs for robotics operating personnel and technology arising due to a surge in demand for manufacturing robots

○ **(Purpose)** Provide customized education for SMEs to improve the practical skills of employees of robot(-related) companies and nurture highly skilled experts

2. 2022 Performance Highlights

○ 41 courses such as Automation Control and Robot Operation Programming at 2 joint training centers (Hyundai Robotics and Gyeongnam Robot Land Foundation), and 1,110 people were trained as a result

3. 2022 Performance Evaluation and Future Direction

○ **(Evaluation)** Continued training for SMEs that have signed an agreement by providing training methods using various types of content and recommending to switch from collective training to non-face-to-face remote training

* Contracting companies did not hire many workers due to the prolonged pandemic, so training courses for prospective hires were not opened.

○ **(Future Direction)** Encourage SMEs related to the robotics field to participate in courses on how to utilize robots via social media and YouTube and support the development of curriculum through corporate demand surveys

4. Action Plan for 2023

□ Support for human resource development in the robotics industry

○ **(Discovery of New Institutions)** Support for improving the practical skills of incumbents **and fostering professionals in the robot field,** such as **discovering new institutions** that can train in the robotics field in regions other than Daegu (Hyundai Robotics) and Gyeongnam (Gyeongnam Robot Land Foundation)

○ **(Establishment of Customized Training Courses) Support for the establishment of on-site customized training courses in the field of robotics** based on the job analysis of the contracted SMEs and support for the capacity building required in the field

5. Schedule

Project	Description (2023 schedule)	2019	2020	2021	2022	2023			
						1Q	2Q	3Q	4Q
Education & Training	Education PR and trainee recruitment (website, social media, etc.)								

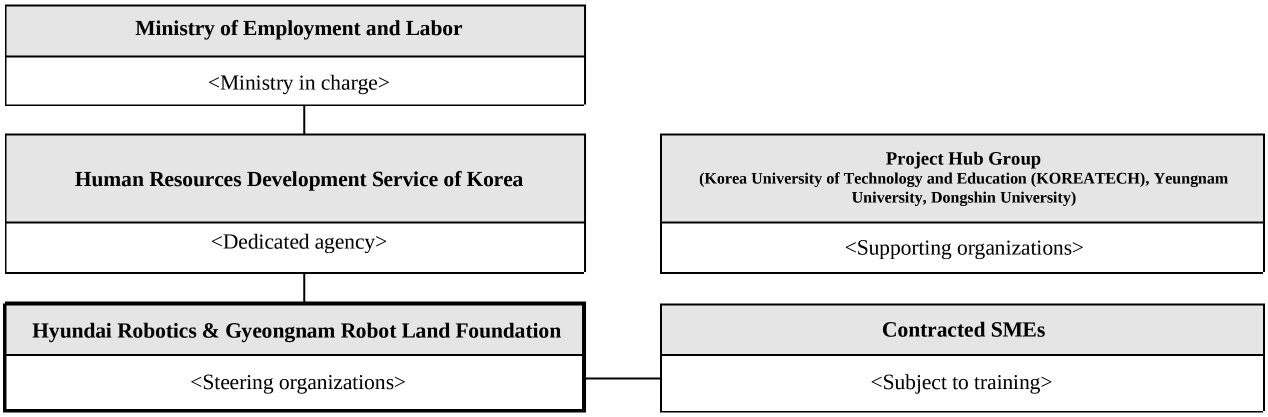
	Operation and feedback (satisfaction survey for each course, etc.)								
Curriculum development	Visit to contracting parties (demand survey, etc.)								
	Course improvement and new course development								
Project management	Steering committee meeting								
	Submission and examination of the project plan for the next business year								

6. Budget

Description*		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Infrastructure subsidy	Government	3	3.6	2.1	2	2	12.7
	Private sector	-	-	-	-	-	-
	Subtotal	3	3.6	2.1	2	2	12.7
Training program operating expenses	Government	2.9	3	0.6	0.6	0.6	7.7
	Private sector	-	-	-	-	-	-
	Subtotal	2.9	3	0.6	0.6	0.6	7.7

* Support for the National Human Resource Development Consortium

7. Project Implementation System



Ministry of Oceans and Fisheries (MOF)	2-1 Support the development and dissemination of technology in 10 niche fields

▣ On-site demonstration and commercialization of underwater construction robots

1. Background and Purpose

○ Gain track records based on field application of three types of underwater construction robots* that have been developed through the on-site demonstration and commercialization project for underwater construction robots

* Light duty (URI-L), heavy duty (URI-T), track-based heavy duty (URI-R)

2. 2022 Performance Highlights

○ (**Underwater Construction Robot**) Upgraded the performance of the equipment and gained additional track records by analyzing the results of a test at sea

- (**Performance Enhancement)** Completed the equipment performance and service upgrades by testing three types of underwater construction robots at sea and analyzing the field application results

* Issued SOC test reports for URI-L, T, and R sea test, field application, and result analysis (Dec. 12, 2022)

 KTC 시 험 결 과 서 한국기계전기전자시험연구원장	 KTC 시 험 결 과 서 한국기계전기전자시험연구원장	 KTC 시 험 결 과 서 한국기계전기전자시험연구원장
URI-L	UIR-T	URI-R

- (**Commercialization of Equipment**) Gained additional track records by consulting with organizations associated with underwater robot construction and winning construction contracts

* URI-T, R: Daejukdo Island cable line burial work in Changwon, Gyeongsangnam-do Province (ordered by Changwon City Hall, KRW 380 million, Sept. 10 to Dec. 31, 2022)

* URI-L: Atlantic Ocean floor survey and biological collection service (ordered by the Ocean Resources Research Center of the Korea Institute of Ocean Science and Technology (KIOST), KRW 800 million, Oct. 31 to Nov. 30, 2022)

* URI-T: Pipe survey work on Yokjido Island of Tongyeong, Gyeongsangnam-do Province (ordered by Tongyeong City Government, exterior survey work of pipes installed in 2020, Dec. 7 to 21, 2022)

3. 2022 Performance Evaluation and Future Direction

○ (**Evaluation**) Enhance the reliability of underwater construction robot equipment by upgrading performance and accumulating track records and achieve commercialization through field application

○ (**Future Direction**) **Not applicable as it was completed in 2022**

4. 2023 Action Plan: Not applicable as it was completed in 2022

5. Schedule: Not applicable as it was completed in 2022

6. Budget

Description		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
On-site demonstration and commercialization of underwater construction robots	Government	19.2	50	62.5	28.2	-	159.9
	Private sector	13	30.3	10.6	2.5	-	56.4
	Subtotal	32.2	80.3	73.1	30.7	-	216.3

7. Project Implementation System

Category	Roles by Department	
On-site demonstration and commercialization of underwater construction robots	MOF	(Project Oversight) Oversight of the overall project
	Korea Institute of Marine Science & Technology Promotion	(Specialized Organization) Project operation
	KIOST	(General Project) Provide support for on-site demonstration and commercialization of underwater construction robots
	Red One Technology	(Project) On-site demonstration and commercialization of light-duty ROV
	Environmental Science & Technology	(Project) On-site demonstration and commercialization of heavy-duty ROV
	KOC	(Project) On-site demonstration and commercialization of track-based heavy-duty ROV

Ministry of SMEs and Startups (MSS)	1-2 Provide consulting, conduct demonstration, and distribute each standard model to 10 companies

1. Background and Purpose

☐ Need to support **manufacturing innovation using robots** in order to boost the **competitiveness of the manufacturing industry,** which is the foundation of our economy

○ **Digital transformation** achieved by **introducing robots in production and manufacturing processes** to improve production efficiency and quality competitiveness and **enhance the competitiveness of small and medium-sized manufacturing companies**

2. 2022 Performance Highlights

☐ **(Distribution) Selected 67 companies** for the construction of robot automation systems **in the field of automotive parts, metal machining, etc.** (support for the introduction of 318 industrial robots, etc.)

☐ **(Consulting) Feasibility review of robot adoption and adoption support** by analyzing the manufacturing process of user companies and designing the processes subject to robot utilization to improve productivity **(61 companies)**

☐ **(Safety) Support for industrial safety inspections such as risk evaluation reports and safety education and training** for companies that have adopted robotic automation systems **(70 companies)**

3. 2022 Performance Evaluation and Future Direction

☐ **(Performance)** Projects such as robot distribution, process consulting, and safety support were carried out without any problems

○ From 2018 to 2021, 155 companies were provided with support to adopt robots, which led to a **60.6% increase in productivity, a 69.6% reduction in defect rates, and a 24% reduction in industrial accidents.**

Category	Process improvement performance				Industrial accident rate reduction
	Increased productivity	Reduction of defect rate	Cost reduction	Rate of increase in delivery compliance	
Result	60.6%	69.6%	45.8%	14.6%	24%

* Result report for each support project, external evaluation service result standard

☐ **(Future Direction)** Create synergy by linking **smart factories and robots**, and **discover mid- to long-term robot demand for high-risk industries, industries with manpower shortages, etc.**

4. Action Plan for 2023

1 Adopting robots for enhanced manufacturing competitiveness

☐ **Strengthen the linkage between smart factories and robotics projects**

○ **Strengthen strategic support** by **selecting and focusing on specific fields** such as **promoted fields** associated with national strategic industries* **and high-risk industries**

* (10 strategic technologies) Semiconductors, displays, secondary batteries, next-generation nuclear power plants, hydrogen, 5G, 6G, biotechnology, space, aviation, AI, mobility, cybersecurity

○ **Relax the priority selection criteria** for excellent smart factory companies even further to expand the scope of **excellent smart factory linkage projects**

○ **Carry out follow-up management** and **practice-oriented training** for companies that have difficulties in using robots based on the results of the survey on the support projects

* Demand for after-sales service due to an increase in applicants ⇨ Smart factory follow-up management, Smart Meister, etc.

☐ **Digitalization support based on support for the introduction of manufacturing robots**

○ Improve the competitiveness of small and medium-sized manufacturing enterprises through digital transformation by **supporting the introduction of robotic automation systems (60 companies)**

○ Improve the productivity of user companies and promoting dissemination of private sector investment **by reviewing the feasibility of introducing robots and supporting the introduction of robots (80 companies) and recruiting robotics experts**

○ **Provide assistance in industrial safety inspections such as risk evaluation reporting and safety education and training** for companies that have introduced robotic automation systems **(70 companies)**

☐ **Discovery of mid- to long-term robot demand**

○ **Discover mid- to long-term robot demand** based on demand surveys by industry and specialty field that requires the use of robots

* Processes with high industrial accidents, decreased employment of foreigners, and industries with unfilled manpower, etc.

○ **Actively discover areas** where robots can be applied to derive results such as increased productivity and reduced industrial accidents* **aside from the manufacturing industry**

* Example) Developed countries such as the U.S. and Japan prevent industrial accidents by using robots to perform dangerous work at construction sites

2 Strengthening public-private partnerships and project management

- **Include private councils and companies** in addition to the supervising departments and related organizations* who have been eligible to attend the regular meetings in order to **actively discover demand**
  * (Supervising departments) KRIRA and Smart Manufacturing Innovation Promotion Group, (Related Organizations) KSS, KITECH, KAR, and Smart Manufacturing Innovation Business Association (SMIBA)
- Conduct online and offline matching consultations on a wider scale to **address the difficulties of forming a consortium of suppliers and adopters**
- **Enhance the substantiality of the project** through fact-finding survey on the completed projects and projects underway, mid-term examination, and technical consulting
  * Introduction of preliminary supervision system, additional confirmation of manufacturing and purchase dates of purchased equipment, etc.
- Networking among suppliers, sharing of success cases, and support for resolving technical difficulties **to strengthen the capabilities of suppliers and establish a stable robot supply ecosystem**

5. Schedule

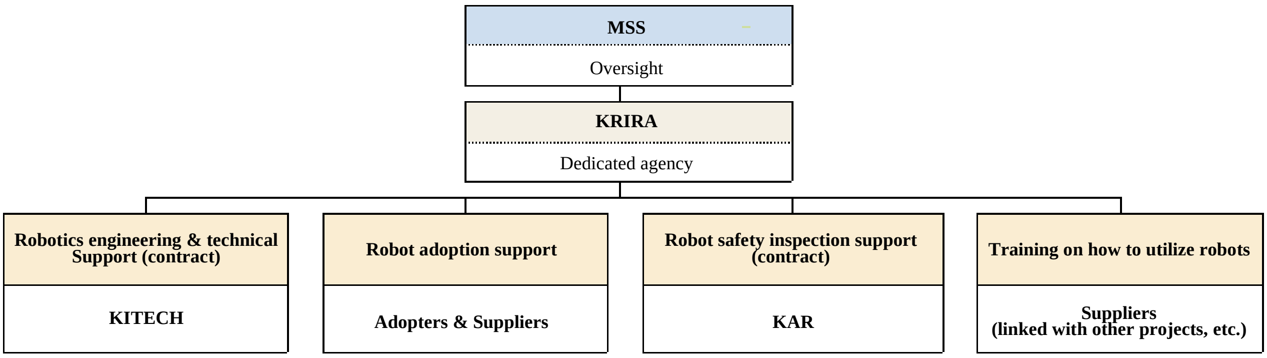
Project	Description (2023 schedule)	2019	2020	2021	2022	2023			
						1Q	2Q	3Q	4Q
Provide consulting, conduct demonstration, and distribute each standard model to 10 companies	Robot adoption support								
	Engineering consulting								
	Safety inspection support								

6. Budget

Description*		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Support for manufacturing innovation using robots	Government	117	105	181	181	181	765
	Private sector	117	105	181	181	181	765
	Subtotal	234	210	362	362	362	1,530

* Private sector budget is based on 5:5 matching

7. Project Implementation System



Defense Acquisition Program Administration (DAPA)	2-1 Support the development and dissemination of technology in 10 niche fields

1. Background and Purpose

☐ **Development of robotics technology in response to environmental changes in the future battlefield**

○ Development of core technologies related to unmanned and robotic systems to undertake missions that are difficult for humans in the battlefield

☐ **Efficient execution of R&D based on inter-departmental cooperation**

○ Discovery and joint planning of robotics R&D fields for joint use by civil and military government departments to prevent redundancies and create synergy

* Joint promotion with the MSIT, MOTIE, and other civilian robot R&D departments from the discovery stage

2. 2022 Performance Highlights

☐ **Development high-speed complex signal-based human-machine synchronization control technology**

○ Close consultation between researchers and participating ministries for interdepartmental cooperation

* 2022.5., 2022.10. DAPA-MOTIE-Ministry of Science and Technology Organizing Organizations Working Meeting

○ Conducted mid-term review of contract research for the establishment of the wearable robot concept (May and Sept. 2022) and final research result review (Dec. 2022)

○ Completed the production of experimental prototype and performance tests (Nov. 2022)

○ Conducted a meeting on the four cases of production and purchases and progress check on research services (Nov. 2022)

○ Interim evaluation of the project (Dec. 15, 2022)

☐ **Development of technology for multi-robot collaboration and autonomous planning**

○ Kick-off meeting (Aug. 2022), analysis of system requirements (2022.09), and allocation of system functions (2022.11)

○ Kick-off meeting of the Ministerial Council for inter-departmental cooperation and working-level consultation on R&D

* Held the 1st R&D Working-Level Meeting with the participation of the Agency for Defense Development (ADD), MOTIE, and supervising department (ATEC T&), kick-off meeting of the Ministerial Council (Aug. 2022), and the 2nd R&D Working-Level Meeting of the Ministerial Council (Dec. 2022)

3. 2022 Performance Evaluation and Future Direction

☐ **Development of high-speed complex signal-based human-machine synchronization control technology**

○ **(Evaluation)** 12 patent applications for securing the rights to the concepts established for each system configuration module (11 in Korea, 1 overseas) and publication of six papers (5 in Korea, 1 overseas)

- Successful completion of experimental prototype design and fabrication and completion of basic performance and gait tests within the planned deadline

○ **(Direction)** Identification of design elements requiring improvement based on a gait test using the experimental prototype and designing and production of the final prototype

- Upgrading of control and intention recognition algorithm based on the gait test

☐ **Development of technology for multi-robot collaboration and autonomous planning**

○ **(Evaluation)** Project commencement, analysis of system requirements, allocation of functions, completion by the deadline, and collection of opinions from the military regarding the operation scenarios (ROK Army Future Innovation Center)

○ **(Direction)** Basic/detailed design, detailed design of core software, and technical cooperation with ministries to satisfy target performance (exchange meetings for each technical field, Ministerial Council, etc.)

4. Action Plan for 2023

☐ **Development of high-speed complex signal-based human-machine synchronization control technology**

○ Encourage close consultation between researchers and participating ministries for interdepartmental cooperation

* Exchanges of technology among ministries through researchers' working-level meetings for discussions of a complex sensor module interface and conference presentations of the results of each R&D project

○ Identify design elements requiring improvement based on a gait test using the experimental prototype and design and fabricate the final prototype

○ Upgrade the control and intention recognition algorithms based on the gait test

☐ **Development of technology for multi-robot collaboration and autonomous planning**

○ Hold R&D working-level meetings continuously to solicit feedback on the technical cooperation fields and cooperation measures for the civilian/military parties and pursue inter-departmental cooperation such as technology exchange in the identified cooperation areas

○ Create basic and detailed designs to satisfy target performance as well as detailed designs of key software

○ Sign a prototype contract using the simulation environment prototype for pre-verification of core algorithm software (2023 Q1) and design results (2023 Q3)

☐ **Development of flexible garment-type wearable robot technology for optional articulated assistance** (new in 2023)

○ Prepare an R&D plan in consideration of the schedule for inter-departmental cooperation and the schedule for linking with existing inter-departmental projects and kick-off the project (Q3 2023)

○ Define the system design concept and analyze the design requirements.

5. Schedule

Project	Description (2023 schedule)	2019	2020	2021	2022	2023			
						1Q	2Q	3Q	4Q
Development of high-speed complex signal-based human-machine synchronization control technology	Performance test for the experimental prototype								
	Designing and fabrication of final prototypes								
	Implementation and improvement of complex sensor signal processing algorithm								
Development of technology for multi-robot collaboration and autonomous planning	Basic design								
	Detailed design								
	Core software design								
Development of flexible garment-type wearable robot technology for optional articulated assistance	Preparation of a plan in consideration of the schedule for inter-departmental cooperation and the schedule for linking with existing inter-departmental projects								
	Project kick-off								
	Establishment of the system design concept and analysis of design requirements								

6. Budget

Description*		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Development of high-speed complex signal-based human-machine synchronization control technology	Government	-	1.0	9.99	18.13	13.16	42.28
	Private sector	-	-	-	-	-	-
	Subtotal						
Development of technology for multi-robot collaboration and autonomous planning	Government				6.90	12.96	19.86
	Private sector				-	-	-
	Subtotal				6.90	12.96	19.86
Development of flexible garment-type wearable robot technology for optional articulated assistance	Government	-	-	-	-	0.4	0.4
	Private sector	-	-	-	-	-	-
	Subtotal						

7. Project Implementation System

Division	Roles by Department	
Development of high-speed complex signal-based human-machine synchronization control technology	DAPA	Development of flexible wearable robot for soldiers
	MOTIE	Development of muscle support robot for workers
	MSIT	Development of a flexible vital signal sensor module
Development of technology for multi-robot collaboration and autonomous planning	DAPA	Collaboration and control system for surveillance and reconnaissance
	MOTIE	Collaboration and control system for logistics and delivery
Development of flexible garment-type wearable robot technology for optional articulated assistance	DAPA	Development of optional articulated flexible wearable robot system for soldiers
	MOTIE	Development of flexible wearable robot system for nursing workers
	MOHW	Development of flexible wearable robot system for persons with disabilities

National Fire Agency (NFA)	2-1 Support the development and dissemination of technology in 10 niche fields

1. Background and Purpose

☐ Establishment of a performance evaluation environment for countering terrorism and development of a field operation plan

○ Establishment of testbeds for inter-departmental counter-terrorism drills* (firefighting, police, etc.)

* Utilization of a robot (equipped with gas sensor and capture device) developed by MOTIE during joint drills

○ Establishment of multi-departmental (NFA, NPA, MOE) drill scenarios and establishment of testbeds for appropriate first response measures for each site and situation such as terrorism, disaster, and crime

2. 2022 Performance Highlights

☐ Validation of counter-terrorism drill scenarios

○ Verification of drill scenarios such as the timing of the deployment of reconnaissance robots before the deployment of police officers and firefighters

☐ Application for approval of the action plan and building permit for the commencement of construction of the testbeds

○ Hire a specialized company for a review of licenses, permits, and certifications

○ Consultation with Gongju City (testbed construction site) for approval of the action plan

3. 2022 Performance Evaluation and Future Direction

☐ Compensation for a delay in the start of construction due to delays in obtaining the site approval and permit for the construction of the testbed

○ Applications have been filed to obtain approval from the authorities to conduct the three projects at the site to which the National Fire Research Institute of Korea has relocated in cooperation with the MOE and Gongju City (licensing & permit).

- The counter-terrorism drill testbed was granted the necessary license/permit (notice issued on Oct. 1, 2022), but delays were caused by another project (realistic drill testbed, notice scheduled to be announced on Jan. 2, 2023) on the same site.
- In order for robot training to proceed according to plan, construction is scheduled to start in early 2021 and be completed by the deadline.

4. Action Plan for 2023

☐ Completion of the counter-terrorism drill testbeds

○ Set to build testbeds for drills equipped with a drill situation simulation system based on the existing design so that drills can be carried out according to the developed scenarios

☐ Pilot operation of joint drills among counter-terrorism departments

○ Training of firefighters, police officers, and reconnaissance robots according to the developed scenarios

5. Schedule

Project	Description (2023 schedule)	2019	2020	2021	2022	2023			
						1Q	2Q	3Q	4Q
Development of efficient response technology for chemical terrorism such as harmful gases	☐ Groundwork for the start of construction of the drill testbeds								
	☐ Groundbreaking of the drill testbeds								
	☐ Installation of a gas discharge system in the testbeds								
	☐ Pilot operation of the testbeds (mobilization of officers and robots)								

6. Budget

Description*		Budget (KRW 100 million)						
		2019	2020	2021	2022	2023	2024	Total
Development of efficient response technology for chemical terrorism such as harmful gases	Government	3.09	8.26	15.52	17.01	19	5.24	68.12
	Private sector	-	-	-	-	-	-	-
	Subtotal	3.09	8.26	15.52	17.01	19	5.24	68.12

※ Including R&D (real-time drill/training status monitoring, equipment construction, etc.) in addition to the cost of building testbeds for drills within the budget

7. Project Implementation System

☐ Supervising organization (National Fire Research Institute of Korea of the NFA)

○ Project oversight, coordination, and management, deliberation and resolution on related matters, and inspection of matters related to project implementation

☐ Integrated specialized organization (National Research Foundation of Korea)

○ R&D project management, contribution payment, settlement

Research oversight Details of the research

☐ Research organizations (Hoseo University, Taesan Electronics)

○ Execution of the research project and discussions with one another

Rural Development Administration (RDA)	2-1 Support the development and dissemination of technology in 10 niche fields

1. Background and Purpose

☐ Growing demand for the use of cutting-edge technology for unmanned agricultural work of Korean-style smart farms

○ Need for quantification (digitalization) of agriculture using the 4th Industrial Revolution technology

○ Need frontier technology to prepare for instability in the agricultural production workforce due to population aging, COVID-19, etc.

* Implementation of data-based farming through interconnection with ICT equipment making up smart farms

☐ The 9th Master Plan for Agricultural Mechanization: Development of smart agricultural machinery (development of agricultural robots, self-driving agricultural machinery, etc.)

* **National Policy Project 71: Industrialization of Agriculture for Future Growth**

○ Development of cutting-edge agricultural machinery that is in line with the Industry 4.0 trends by acquiring and incorporating the cutting-edge technology of the IT, BT, and NT industries for advanced farming through robotization, automation, and smart agriculture

2. 2022 Performance Highlights

☐ **(Growth Measurement)** Development of robots for fruit and vegetable cultivation monitoring, thinning, and harvesting

○ Construction of greenhouses for crop image data acquisition and database creation

* Utilized image data and performed preprocessing for machine learning (10,000 objects per crop)

* Acquired hyperspectral image data to predict crop harvest timing

○ Determination of ripeness (system resilient to external light conditions)

* Developed a step-by-step ripeness reference model using a chrominance meter and CV application technology

○ Development of digital twin technology-based fruit location information technology

* Detect tomatoes based on 2D image for improved processing speed, followed by application of 3D images

* Utilize 3D image acquisition sensors to extract the fruit location information

☐ **(Weeding Robot)** Development of unmanned weeding robot incorporated with self-driving technology

○ Design and manufacture of a secondary starter for weeding robots for orchards

* (Before) One drive (motor) driving both the main mowing blade and the variable mowing blade → (After) Separate motors for the main mowing blade and variable mowing blade (load distribution)

* (Before) In the case of the primary starter, the mowing width is narrow, so it is necessary to mow more than three times→ (After) Changed the mowing width to 2.2 m (from 4 m) to mow just twice

○ Added functions of the weeding robot

* It is possible to use the robot in transporting goods by adding a cargo box to the exterior

☐ **(Self-Driving Robot)** Development of modular steering control system for unmanned farming work

○ Development of an automatic direction adjustment device that can be equipped with high-precision GPS-based handle-type agricultural machinery

* Application: Handle-type agricultural machinery such as tractors, passenger management machines, and planting machines

* Functions: Automatically generates a route based on two points (start (A) and end (B)), drives along this route, collects GPS data, capable of electric handle control, etc.

○ Driving performance: Tolerance ± 7 cm when traveling on the prescribed route * Minimum speed: 0.3km/h

☐ **(Harvesting Robot)** Research on automatic fruit harvesting mechanism using robotic arm control technology

○ Fabrication of a robotic arm-based automatic harvester starter

* Equipped with robotic arm and control device, RGBD camera, control PC, battery, etc.

* RGBD camera: Fixed based on the base and mounted at the tip of the robot (TCP)

○ Utilization of a robotic arm-based automatic harvester simulator

* Moves identically as an actual robotic arm, controllable, and possible to use the control system even in an environment without a robot

○ Establishment of a robotic arm-based automatic harvester control environment

3. 2022 Performance Evaluation and Future Direction

☐ **(Growth Measurement)** Development of robots for fruit and vegetable cultivation monitoring, thinning, and harvesting

○ **(Evaluation)** Acquired data on target crops and created a database

○ **(Direction)** Develop technology to interconnect with the recognition unit of harvesting robots

* Development of technology to provide harvest robots based on the information on the database of crop monitoring robots

☐ **(Weeding Robot)** Development of unmanned weeding robot incorporated with self-driving technology

○ **(Evaluation)** Manufactured a secondary starter (separate motors for the main mowing blade and variable mowing blade)

* It is possible to use the robot in transporting goods by adding a cargo box to the exterior

○ **(Direction)** Conduct a field application test and performance evaluation at various orchards

☐ **(Self-Driving Robot)** Development of modular steering control system for unmanned farming work

○ **(Evaluation)** Developed automatic straight steering system that can be installed with existing handle-type agricultural machinery

* Driving performance: Tolerance ± 7 cm when traveling on the prescribed route

○ **(Direction)** Conducted a pilot distribution project for the new technology after improving performance based on field application

☐ **(Harvesting Robot)** Research on automatic fruit harvesting mechanism using robotic arm control technology

○ **(Evaluation)** Manufacture of an automatic harvester starter equipped with robotic arm, control device, RGBD camera, control PC, battery, etc.

○ **(Direction)** Conduct system integration and linkage with apple location recognition technology

4. Action Plan for 2023

☐ **(Growth Measurement)** Development of robots for fruit and vegetable cultivation monitoring, thinning, and harvesting

○ Development of crop monitoring robot

* Development of technology to interconnect with the recognition unit of harvesting robots
* Development of technology to provide harvest robots based on the information on the database of crop monitoring robots

○ Development of real-time object recognition technology and 3D position extraction technology

* Development of fruit and vegetable growth and harvester quality factor (mechanical properties) evaluation technology
* Development of technology for compatibility between element technologies and technologies applied to thinning and harvesting robots

☐ **(Weeding Robot)** Development of unmanned weeding robot incorporated with self-driving technology

○ Field application test and demonstration on various orchards

* Applicability test according to fruit tree cultivation method (planting spacing, tree type, travel path condition, etc.)
* Analysis of applicability to other fruit trees (pears, peaches, etc.)

○ Performance analysis and evaluation of unmanned weeding robot for orchards

* Analysis of weeding robot performance such as weeding effect, driving performance, and working time (based on 1ha)
* Performance evaluation of existing weeder’s weeding rate, obstacle recognition rate, etc.

☐ **(Harvesting Robot)** Research on automatic fruit harvesting mechanism using robotic arm control technology

○ Development of technology for optimization of robotic arm movement path for automatic harvesting

* Development of robotic arm movement path optimization algorithms for apples and peaches
* Move to the harvest target and move the shipment location after harvesting → Repetition
* Optimization of the automatic harvester system

○ System integration and linkage with apple location recognition technology

* Testing of robotic arm movements according to the work sequence, etc.

5. Schedule

Project	Description (2023 schedule)	2019	2020	2021	2022	2023			
						1Q	2Q	3Q	4Q
Development of robotics technology for hydroponic cultivation monitoring, thinning, and harvesting of fruits and vegetables (21-24)	Development of technology for interconnection with the recognition unit of harvesting robots								
	Development of technology to provide harvest robots based on the information on the database of crop monitoring robots								
	Development of technology for compatibility between element technologies and technologies applied to thinning and harvesting robots								
Development of intelligent mowers for apple orchards (21-23)	Applicability test according to fruit tree cultivation method (planting spacing, tree shape, travel path condition, etc.)								
	Analysis of weeding robot performance such as weeding effect, driving performance, and working time								
Research on the application of robotic safety technology for the development of agricultural robots (20-22)	ISO-based virtual terminal device interface configuration and protocol development								
	VT integration with modular steering control systems								
	Performance evaluation of algorithms based on field application tests								
Development of fruit enlargement and harvester diagnosis technology for labor-saving mechanical harvesting (21-24)	Development of robotic arm movement path optimization algorithms for apples and peaches								
	Testing of robotic arm movements according to the work sequence, etc.								
	Optimization of automatic harvester system								

6. Budget

Description		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Development of robotics technology for hydroponic cultivation monitoring, thinning, and harvesting of fruits and vegetables (21-24)	Government			15	16	16	47
	Private sector						
	Subtotal			15	16	16	47
Development of intelligent mowers for apple orchards (21-23)	Government			2	2	2	6
	Private sector						
	Subtotal			2	2	2	6
Research on the application of robot safety technology for the development of agricultural robots (20-22)	Government		0.88	0.88	0.88		2.64
	Private sector						
	Subtotal		0.88	0.88	0.88		2.64
Development of fruit enlargement and harvester diagnosis technology for labor-saving mechanical harvesting (21-24)	Government			1.2	1.2	1.2	3.6
	Private sector						
	Subtotal			1.2	1.2	1.2	3.6

7. Project Implementation System

☐ Rural Development Administration (supervising department): R&D project oversight incl. project planning and operation, etc.

☐ National Institute of Agricultural Science (implementing department): Integrated system development and field demonstration

☐ Other participating organizations: Collaboration to support the development of element technologies

Korea Coast Guard	2-1 Support the development and dissemination of technology in 10 niche fields

▣ Development of autonomous underwater vehicles (AUVs) for prompt response in the event of a marine accident

1. Background and Purpose

◯ Development of AUVs and their operating systems using cutting-edge technology of the 4th Industrial Revolution for a prompt response in the event of an accident at sea

◯ Contribute to the improvement of public safety through rapid and accurate underwater search using AUVs in the event of a marine accident such as a ship capsizing

2. 2022 Performance Highlights

☐ R&D results in the 2nd year (2022)

◯ Development of AUVs
- Production of one set of AUV equipped with side-scan sonar (SSS)
- Production of one set of AUV equipped with synthetic aperture sonar (SAS)

◯ Development of the operating system
- Manufacture for unmanned surface vehicle hardware and software integration
- Creation of AUV control system and robotic buoy designs

◯ Development of core technology
- Detailed design of underwater and surface water communication networks
- Detailed design of post-processing algorithms

3. 2022 Performance Evaluation and Future Direction

◯ (3rd Year) Development of core technology for AUVs such as robot design, swarm system and control technology development based on basic design such as AUV operating environment and requirements analysis

◯ (4th to 5th Years) Advancement of on-site utilization based on performance verification and performance improvement by testing the system at sea

4. Action Plan for 2023

◯ Development of AUVs
- Production of one set of AUV equipped with side-scan sonar (SSS)
- Basic performance test on the AUV

◯ Development of the operating system
- Manufacture and verification of communication support equipment

- Manufacture of integrated control and post-processing system
- Manufacture and verification of entry/exit and maintenance equipment

○ Development of core technology

- Implementation of core technology for mission sensor data processing

5. Schedule

Project	Description (2023 schedule)	2019	2020	2021	2022	2023			
						1Q	2Q	3Q	4Q
Development of autonomous underwater vehicles (AUVs) for prompt response in the event of a marine accident	Development of AUVs								
	Development of the operating system								
	Development of core technology								

6. Budget

Description		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Development of autonomous underwater vehicles (AUVs) for prompt response in the event of a marine accident	Government	-	-	**20.5**	**46**	**71.8**	**138.3**
	Private sector	-	-	-	-	-	-
	Subtotal	-	-	**20.5**	**46**	**71.8**	**138.3**

7. Project Implementation System

Category	R&R	
Development of autonomous underwater vehicles (AUVs) for prompt response in the event of a marine accident	Korea Research Institute of Ships & Ocean Engineering (KRISO)	Oversight of the design and production and development of procedures according to mission scenarios
	Hanwha Systems	Basic design and functional testing of AUV and USV development
	Korea Institute of Robot Convergence	Development of swarm navigation algorithm and development of USBL stabilization technology
	KATS	Development of synthetic aperture and signal processing technology
	Kyeongin Tech	Detailed design and production of AUV, development of entry/exit equipment, etc.
	Geotech System	Operation of mission sensor post-processing system and at-sea performance test
	BNS Soft	Development of integrated control and data processing analysis support system
	Sonar Tech	Development of SSS system and sonar data processing algorithm
	Safetech Research	Development of AUV simulator
	GigaRF	Development of surface water communication system
	Korea Advanced Institute of Science and Technology	Development of AUV mission planning and replanning algorithms
	Korea Maritime & Ocean University	Development of fault diagnosis and autonomous return algorithm
	Kookmin University	Development of underwater linkage protocol and standardization of communication

E02 Italy


PNR 2021-2027
Programma nazionale
per la ricerca
Ministero dell'Università e della Ricerca

5.4.4 Robotics

Although robots are produced on a large scale, in recent years they have spread across many applications. They are in factories, hospitals, homes, schools, and there are robots-firefighters, robots that create goods and services, and thus saving time and lives: progressively widespread and personalized robots.

As they get modernized, the technologies that get developed by robotics become more and more pervasive and transform the usual devices into intelligent machines as well as create new perspectives, which create new challenges concerning advancing the scientific, technical, and even humanistic knowledge.

Moreover, regarding the effect on the society, Robotics has also gradually assumed more pronounced characteristics of fundamental scientific research, and has established itself as the transdisciplinary center of inter-action technologies (*Inter-Action Technologies*, IAT), which means the methods and techniques that are used in the perception as well as modification of the physical states of the machines and the surrounding environments, pursuant to an artificially implemented intelligent logic. Currently, Robotics illustrates fundamental questions related to the advanced research of the disciplines: Robotics examines natural connections between machines and humans with the help of the sciences of the human mind and neuroscience; it studies the bionic integration between natural and artificial bodies with the sciences of health and rehabilitation; it also develops new systems on micro and nanoscopic scales at the boarders of materials as well as energy sciences; and it studies new mechanisms of artificial learning with the help of mathematical and computational tools in order to derive generalizable models of physical interaction with the real world from empirical data proficiently and rapidly.

Six sectors can be identified through a critical analysis of the original context concerning the whole supply chain, ranging from the fundamental research to the implementation: 1. Robotics in hostile and unstructured environments; 2. Robotics for the industry 4.0; 3. Robotics for infrastructure inspection as well as maintenance; 4. Robotics for the agrifood sector; 5. Robotics concerning health; 6. Robotics for mobility and autonomous vehicles. The above mentioned priority sectors need to develop an appropriate robot autonomy as well as dexterity capabilities that affect the potency of crucial applications and exceed the state of the art at the present time. Due to the COVID-19 pandemic, the health emergency strongly fosters the first sector. Consistent with the priorities, identified in the *clusters* of Horizon Europe's *Pillar II*, in which robotic technologies are profoundly enabling, are the other five sectors: *cluster 1 Health*, *cluster 3 Civil Security for Society*, *cluster 4 Digital, Industry, and Space*, *cluster 5 Climate, Energy and Mobility*, *cluster 6 Food, Bioeconomy, Natural Resources, Agriculture and Environment*. In addition, concerning *cluster 2 Culture, Creativity and Inclusive Society Societ*, robotics's ethical, legal, social, and economic (ELSE) implications represent an integral component of a research project. At the beginning of all discussions, Italian Robotics was the origin of the implications with the meetings on Roboethics in the year of 2004. As a result, a strong awareness that the capabilities of autonomous robots will have a substantial impact, and as a consequence of that clear ethical and legal principles have to control such a development in order to be inclusive and not to create different social divisions, was established.

The National Robotics Community (academies, research centers, companies, start-ups) summoned to the Institute of robotics, and intelligent machines (I-RIM), stands for the Italian industrial and research expertise. A national sector investment plan (project finalized Robotics CNR 1989-1994) has invested 56.4 billion lire and has enabled the financing of over 200 projects in FP7 and H2020 (with a share surplus of 3.5%) and 15 *ERC grant* for a total of 120 billion euros, in addition to an impact that is difficult to quantify, but which also strongly impacts this industry. Moreover, with the help of strategic investments performed in the current phase, and characterized by a far-reaching production conversion based on new market needs, security, and new technologies, such a factor is a breakthrough and will gain more significance in the future. The "robotic" implementation sector in the NRP will have, as anticipated, a strong impact on the significant national sectors of research and innovation, including digitalization, critical infrastructures, and clean energy.

Sector 1. Robotics in Hostile and Unstructured Environments

The COVID-19 pandemic and its health emergency show the urgent need for the capacity to carry out work safely, especially in environments that are previously known to have suddenly become potentially risky. The need was pronounced in the first place for hospitals and nursing homes, where health personnel were exposed to a potential patient contagion, but in the later stages, also in the production, logistics, and trade of material goods. Therefore, the incisive response is to extend the *smart working* paradigm to the uses which take into account physical action on people and the environment during the growing need for safety and distancing.

In Italy, using robotic technologies in a risky environment has powerful motivations as well as potential that goes further than the prevention of contagion. The dismantling of nuclear power plants as well as delivery of hazardous materials and contaminated waste (from hospitals, industries, and research laboratories) in the building of the national depot that is supposed to replace existing deposits (at the 30-year project limit) and to secure large quantities of radioactive material is a binding commitment that the world assumes by making considerable investments in robotic technologies to avoid human radiation exposure.

Responses to frequent disasters that are also of significant social impact as well as natural catastrophes, unfortunately, are fields of robotics application, in particular Italian recent research that has been successful, and have successfully shown the possibility of a practical implementation through developing operational robotics systems concerning rescue for the relief as well as support of the activities of the National Fire Brigade. Such requirements can also be found in defense and security operations (approach and inspection of suspicious persons, materials, and vehicles, management of terrorist threats) and rescue, and handling of dangerous substances, as the pharmaceutical chemistry. On the contrary, there is a high number (1,218 in 2018, increasing in 2019) of deaths at work, the continuously strong prevalence of musculoskeletal disorders (MSD) among Italian employees despite legislation and prevention measures being followed, as well as domestic accidents (4.5 million per year, of which 8,000 are fatal), which clearly shows that the concept of the hostile environment has to be extended further than just concepts that are conventional. The prevalent characteristic of these applications is the urgency to separate the robot operator from the place where the robot is operating physically. It outlines the actual condition for activities in hardly accessible environments, such as space or the bottom of the oceans and the subsoil, ship holds, and large tanks. Environments like these have also great communication difficulties that the autonomous functions of a robot can resolve.

When robots will be sent for to help people in their individual or family life in the near future, the home environment will also become a part of the unstructured and potentially critical environment. The research of the next decade is intended to protect the people from exposure to these environments, so that they can enhance their personality as well as professional matters and perform actual *physical smart working.* There will be collaborative robots and robotic avatars, and semi-autonomous intelligent machines that can be sent to remote and dangerous environments to carry out high-dexterity tasks, and that will have to take over the skills of specialized operators, avoiding dangers and psychophysical fatigue in critical scenarios. At the same time, it contributes to equalizing tasks and potential between humans, which have different physical structures. Looking at the long-term perspective, it could lead to a real bionic synergy between a human and a robot, who will work shoulder to shoulder to achieve a new accomplishment which neither a human nor a robot would be able to do alone. For the society in which humans and robots would co-live, this would mean a realistic step forwards.

Sector 2. Robotics for Industry 4.0

Robots are a preferred tool for flexible automation systems, where the production needs to change according to changing market needs because robots are versatile, reliable, and capable of performing various tasks with absolute precision. The robot has become irreplaceable for primarily repetitive operations: loading/unloading of machines, welding, painting, and all tasks in which the speed of the execution spikes a factory's productivity, decreases cycle times and relieves the human from performing these tasks in uncomfortable conditions. In Italy, the sales figures for industrial robots in are extraordinary, with 11,100 units sold in 2019, increasing 13% compared to the previous year, in contrast to the shrinking world market in 2019. The robotics market in Italy is the sixth in the world and the second in Europe, after Germany. The robot density in Italy, calculated as the number of robots per 10,000 employees, is 212, against a worldwide average of 113[92].

There are many reasons for the success of industrial robotics in the world and Italy: *a)* industrial robots adjust well to the ever-rising customization of products what requires small batches with a high production mix; *b)* rising competitiveness in the global market requires productivity gains, defect elimination and reduction, sustainable production solutions; *c)* robots today are not the prerogative of a large industry alone any more but are increasingly used by medium-small companies (SMEs), especially in a version of collaborative robots that are able to operate in close contact with humans and are destined to have an increasing relevance even in non-industrial application matters. The diffusion of the production paradigms of sector 4.0 has renewed the importance of using robots as machines that are highly digitized. Side by side with traditional industrial manipulators, mobile robots (AGV, AMR, LGV) are becoming more and more important for industrial logistics and also for the material flow and transport applications, in general. The research is directed towards the management of fleets of mobile robots, of mobile robots with manipulators on board, the thrust and intelligent integration with the MES (*Manufacturing Execution System*), and the development of lightweight mobile robots for last-mile logistics.

A progressive introduction of robotics in industrial sectors other than those traditionally interested in robotization is expected concerning such scenario (*automotive* and electrical/electronics industry). Of particular importance are the applications of robotics in the aerospace sector (drilling, riveting, positioning of parts), in which the requirements of high precision as well as reliability constitute challenges of great interest for research.

Especially with modern technologies based on AI and big data, the robot will become important in the new intelligent factory with the help of integration with the rest of the factory automation. That may result in an increasing fusion of the physical and digital aspects of the machine itself, which will turn into a cyber-physical system inextricably linked to its digital representation that may be used for predictive maintenance, advanced perception, production monitoring, and also performance optimization. Furthermore, Robotics is going to benefit from the evolution of other production technologies, especially *additive manufacturing*, which will increase the scenario interest. In order to improve productivity, the manipulator robot is equipped with a material deposition tool or is integrated with 3D printers.

In accordance with analysts, collaborative robotics is set for solid growth in the following years. That growth will have to be assisted by research and technology transfer activities to meet the needs of operating safely in joint human-robot environments. Still only partially explored by research are the aspects of ergonomics and aid to the operator in limiting the exposure to the risk of the musculoskeletal system. In addition, collaborative robotics are going to give new life to craftsmanship, that is working against the phenomenon that specialized professionals are aging, and such will be pervasive as well as reach new sectors (for example, fashion, the flagship Made In Italy sector) and will favor *reshoring* of productions delocalized abroad in the years prior.

[92] International Federation of Robotics (IFR) (2020), https://ifr.org/, accessed on 15/11/2020.

Sector 3. Robotics for Infrastructure Inspection and Maintenance

Regarding the petrochemical and energy sectors, in the modern era, industries face an unprecedented digitalization. Thus, initiatives to utilize robotic technologies for automatic or autonomous inspection and remote maintenance become progressively widespread, and that currently accounts for about 3% of the robot market sold worldwide. Innovative robotic solutions for inspection of tanks, heat exchangers, refining towers, turbines, offshore platforms (in 2018 the market was worth $ 7.19 billion), complex environments *nearshore* often associated with disaster or natural calamities, *pipe-racks*, underwater pipelines (in 2014 the ROV market was worth $ 1.2 billion) and surface pipelines are among the main targets of research and development centers of large enterprises in the sector today. Correspondingly, the inspection of turbines will benefit profoundly from the solutions connected with so-called *soft* robotics, both plants in the field of energy conversion and propulsion in the aeronautical sector, which will be able to conquer the limits of the current boroscopic technology. Another example of possible applications of mobile, marine, and aerial robotic technologies is the inspection of power lines, aqueducts, dams, and wind generation systems. New studies illustrate that aerial robotics alone will minimize offshore platform inspection costs by up to 90%, storage tank inspection costs by up to 70%, and wind tower inspection costs by up to 50%.

The civil sector should also be considered next to the industrial sector. They both relate to complex shipbuilding activities that are carried out more efficiently and with a reduction in time and costs by using robotic solutions, as well as for the rising urgent need to carry out surveys and inspections of civil works in an objective, repeatable and certified way, and that with cost reduction as well as improvement of quality, reliability, and timeliness of measures. Viaducts, roads, bridges, tunnels, subways, trains and rail networks, trams and tram networks, aircraft and airports, ships, cultural heritage, and historic buildings are other sectors for which the development of semi-autonomous robotic solutions with a high level of specialization would determine a paradigm shift compared to statically programmed inspection plans that may be found at the present time. Using robots for the inspection and maintenance of railway infrastructure and trains is significant. The high standards and safety requirements of the present rail transport may profoundly benefit from a maintenance-on-condition Program, which requires the availability of robotic systems that are capable of performing the preventive diagnosis of possible faults and/or malfunctions through computer vision and automatic measurement systems.

In addition, a steady monitoring of critical infrastructures may be implemented, supplemented by distributed IoT sensors for the long-term use. Safety takes an essential stand for such scenarios that usually are considered risky and/or wear and tear for the operators. In this sector, robotic technologies may help to create circular and clean industries. For example, robots may be used to inspect tanks or pipelines in the petrochemical or water treatment sector, thus avoiding reclamation or interruption of the primary services. Investment in research may result in two benefits, that is strengthening Italy's industrial leadership, reducing costs as well as improving plant efficiency, and creating new markets for service companies and innovative start-ups, which would have the opportunity to develop products with high added value, and are, therefore, regarding short-term factors, not attackable by emerging countries.

Sector 4. Robotics for the Agrifood Sector

The agrifood sector, contributing 11% to GDP and 9% to exports (Smart AgriFood Observatory), is one of the sectors that is undergoing a profound transformation in terms of automation and connectivity regarding industry 4.0 and the IoT at the present time, which may be seen in all the stages of production, in general. In order to reach the end user, an agrifood product has to go through outdoor and indoor cultivation phases: storage and conservation, transformation, transport, and sale. At all these stages, robotics may profoundly contribute to achieving high standards, that is, to sowing, irrigation, weeding, monitoring, harvesting, transportation, quality assurance, processing raw materials into high-quality products, refilling shelves, or processing customer orders through the collection of goods.

Typical challenges that the agrifood sector is facing are the increase in the human population and with that, the continuously growing need for agrifood products, climate change, the fight against plant diseases, high labor, and energy costs, the demand of society for environmentally friendly and self-sustainable production, reducing manual low-paid and harmful tasks or increasing human capacities with mechatronic aid, along with the effects of COVID-19 and the consequent reduction of the workforce, and also the increase in the demand for zero-km products. These challenges may be overcome solely with a high level of automation and digitization that may be found in precision agriculture technologies. The industrial leadership in critical technologies, such as robotics, which allows artificial intelligence to be given a physical body capable of interacting with the environment, will become crucial to achieving a clean, climate-neutral, sustainable and responsible agrifood production. According to the Smart Agrifood Observatory, 11% of international start-ups that are operating in the sector are Italian, which makes Italy essential in this field. The Ministry of Agriculture, Food and Forestry has approved the guidelines for developing precision agriculture in Italy with the ministerial decree of December 22, 2017, n. 33671. The sector's importance has also been recognized at the European level and gets reflected in rural development policies, such as the *Agricultural European Innovation Partnership* that launched in 2012 [1].

Articulation 5. Robotics for Health

Published in 2015 were the most recent data on the medical devices sector in Italy. According to this information, there are 4,368 companies in the surveyed sector, most of which are SMEs. 52% are operating in production, 44% in commercial activities, and the remaining 4% in services. The total number of employees employed in the sector is about 70,000, 8% of which are employed in research and innovation, for a total production value of 9,750 million euros, of which more than 70% gets generated by public demand. Cross-referencing data on public health demand as well as supply, it shows that the sector would benefit significantly from targeted investments involving savings from the National Health Service (NHS) and strengthening a productive sector which only partially responds to the national demand.

The sectors in which public spending gets divided (health care and rehabilitation, pharmaceuticals and therapeutic apparatus, *long-term care*, auxiliary services, disease prevention, and administration) reflect the path followed by the patients: prevention, diagnosis, therapy, convalescence, rehabilitation, and assistance. Therefore, we may consider targeted actions in those sectors which allow the Italian medical companies to penetrate these sectors that are not covered by large foreign multinationals yet and that and gain significant market space.

Observing the prevention – diagnosis – cure - convalescence path, one may see how robotic technologies can significantly contribute to the improvement of the quality of care and to economies regarding public health costs, which the following examples are exemplifying. For example, preventive measures may be improved by using telepresence devices that also may be used in the hospital, which allow remote communication, psychological support for the patients, and the assistance without the direct implementation of medical personnel. Also, diagnostics can be improved by introducing more accurate as well as extensive patient local and remote screening systems, e.g., robotic biopsies and satellite centers for tele-ultrasound. Moreover, robotic surgery systems are widespread in the operating room at this point already, however, the cost for those is too high for most hospitals. Consequently, solutions have to be sought that can drastically reduce the cost while maintaining the quality of robotic implementation. The relevant problem is regarding domestic care for medical considerations and in the activities of daily life. Robotic instruments may help to maintain the independence and active life of the elderly and allow early diagnosis of diseases, the care of patients at home during convalescence after surgery, the supervision of the use of drugs, and the implementation of continuous rehabilitation therapies, for example. The domestic robotic system would avoid the misuse of drugs, which means very high cost for the NHS regarding both patient health and the direct cost of drugs, which is impacting society. That very same system could perform rehabilitation and home monitoring functions that allow patients extended therapy cycles (at the 24/7 limit) without going to hospitals, reducing traffic and pollution, and ensuring prompt intervention in the event of accidents or illnesses, especially,

[1] *https://ec.europa.eu/eip/agriculture/en, accessed on 19/11/2020.*

wearable robotic systems may be considered, such as exoskeletons that are useful not only for rehabilitation but also for the care of patients with disorders or limitations of the movement of the limbs, upper or lower, which resulted from spinal injuries or pathologies, such as well as for the reduction of fatigue in daily activities. If integrated with appropriate sensor networks, they can be used in remote diagnostics.

The hospital organization was revealed due to the COVID-19 emergency: the lack of medical personnel, the need to offer health services, and also performing functions at a safe distance from the patient or the environment. In response to the absence of personnel, industrial collaborative robotics technologies can be transferred to the medical field and provide, for example, support services to the operating room, the movement of patients, assistance in the ward, the distribution of drugs, the disinfection of spaces, and the connection with remote family members. Functions like these are to include logistics services for healthcare (cleaning, sanitizing, sorting, medicines, etc.). Especially robotic sanitation will have to be spread to non-sanitary environments to ensure the safety of environments with a large amount of people, for example, shopping centers, airports, and trade fairs. Furthermore, to maintain a safe distance between the health worker and a contagious patient or a dangerous environment, for example drug preparation, remote control technologies, tele-operation, and autonomous robots will be used, which will allow putting a physical barrier between the health worker and the patient or dangerous drugs, thus risks of contagion or intoxication may be avoided.

Sector 6. Robotics for Mobility and Autonomous Vehicles

Mainly satisfied by privately owned fossil fuel and human-driven cars until the present time, personal mobility will experience an actual revolution in the upcoming decades. The transition to autonomous driving will be the catalyst for this revolution, which will enhance a distribution of the electric car, a transition from a private car to a shared car, and also the reduction of the average size of circulating vehicles that will permit the user at every opportunity to be able to choose the minimum size vehicle with which their needs are met.

The *robo-taxi*, a fully autonomous vehicle may be used as well as released on request and may be reinforced by recent analyzes drawn from telematics data concerning the plausibility of the paradigm, which show that not more than 10% of the present fleet circulating in Italy is never used simultaneously. Such a shift to full vehicle automation is revolutionary and would be progressive but also brisk and is assumed to be completed within 20-30 years at most.

Considering the technological side, the way more expensive and sophisticated aspect of the *robo-taxi* would be in the automation (or robotization) package, which would contain a number of interconnected technological layers: smart actuators (brakes, steering, motors, etc.), sensors (inertial units, GNSS systems, but above all EGO sensors of distance from obstacles, for example, video cameras, LIDAR, radar and acoustic sensors), the vehicle dynamics control system (*motion control*) and the navigation control system (trajectory and speed profile planning). The aspect of intelligence for this technological package (i.e., the control and signal processing algorithms) would become the most essential as well as characterizing component and would be developed from automation, *machine learning,* and signal processing (especially images) on. Such technological package could be considered a complex and articulated form of artificial intelligence in its declination which focuses on physical interaction with the exterior world parts mediated by actuators as well as sensors: that makes it exquisitely be robotics.

Such a vast, significant, and adequately adapted technological package for the robotization of the vehicle will be applied to all land vehicles on the road that may be classified as follows: *a)* vehicles for the mobility of people on the road (cars, buses, minibusses); *b)* vehicles for the mobility of goods by road (trucks, commercial vehicles); c) *off-highway* vehicles (vehicles for agriculture, construction, earthmoving, groomers, etc.); *d)* vehicles without people on board (*unmanned*) (ground drones, for the mobility of goods – *last-mile delivery* in urban and metropolitan centers or for agriculture, complemented and supplemented by manipulative robotics systems in order to perform processing operations).

All in all, humans are looking towards decades of development where mobility technologies are of enormous strategic importance and that are going to define new industrial sector balances. Therefore, the role of Technological Research in this field in Italy can and has to be of utmost importance: Italy is one of the world's leading forces in the field of vehicles, from bicycles to motorcycles, from trucks to tractors, clearly passing through the car. Italy has always been in a top position and is still ranking so high with some of the most important and prestigious worldwide leading brands. Simultaneously, Italy is a global excellence in automation, control systems, as well as robotics and may thus seize the unique opportunity to be the leader in the technological development of autonomous vehicles.

Enabling Technologies

The enabling technologies research needs to include the focus on: *a)* technologies for continuous learning and the integration of perception and implementation with natural and artificial intelligence, which allow the operators to take advantage of the capabilities augmented by machines without being dispossessed of their essential cognitive and operational skills; *b)* technologies to improve the intuitiveness, usability and ergonomics of human-robot interfaces, allowing the effective use of robots by humans without specific training; *c)* technologies to facilitate the physical and social interaction of robots with the environment and with the surrounding people, using new materials, *smart* sensors and actuators, control architectures to ensure stability and security; *d)* technologies for the realization of new traditional and typical mechatronic devices of *soft* robotics for correct handling and locomotion in aerial, aquatic environments, under the ground and on soils of different and rugged nature*; e)* technologies for autonomous navigation, situation recognition and dynamic vehicle control to achieve sustainable mobility of self-driving vehicles in urban areas and intelligent traffic control in urban areas; *f)* technologies for improving energy autonomy as well as resilience to imperfect communications and the ability to communicate at high speed with reduced latency times in realistically encountered situations in application scenarios; *g)* technologies in order to reduce the ecological trace of robotic systems with the help of the development of new forms of energy derived from the environment as well as environmentally friendly materials. Such development of such technologies will improve or simplify the work of humans (hostile environments, industrial and civil environments, medicine, agrifood, and mobility), and save or increase jobs (artisans, new production companies, with robots and intelligent machines in Italy instead of abroad). As a result, the impact on the entire work process will be immediate and positive, not only because significant technological innovations have always resulted in an increased number of jobs, but because robotics allows to increase productivity and perform economic activities on national soil that would otherwise remain relocated.

The **Department for Digital Transformation of the Presidency of the Council of Ministers** has contributed to defining the joints of this sphere of implementation.

The **Ministry of Infrastructure and Transport** has contributed to the definition of sector 3 of this sphere of implementation.