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IFR International Federation of Robotics

INFORMATION PAPER

WORLD ROBOTICS R&D PROGRAMS

IFR International Federation of Robotics

Contents

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 up-to-date materials including updated and new information mostly during 2022.*

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. Several big programs in one country can be separately summarized, for instance, space robotics, NRI program 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**: November 1, 2022*

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

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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	
	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	-
	E08	Benelux	
	E09	Austria	
	E10	Denmark	
	E11	Switzerland	Updated
	E12	Czech Republic	
	E13	Poland	
	E14	Russia	
America	U01	USA	Updated
	U02	Canada	Executive Summary only
	U03	Mexico	

Executive summary

Basically, every country plans and allots specified budgets for each program, but some ambiguity exists in terms of the different program periods of each country, and there are some external restriction policies.

Main changes

- China: The Chinese government provided funding of 43.5 million USD (315 million CNY) for 'the Key Special Program on Intelligent Robots in 2022'. The other programs have not been included yet, primarily due to difficulty in accessing governmental materials.
- Japan:
    - A budget of 440 million USD (50 billion JPY) was allocated to robotics-related projects in the Moonshot Research and Development Program over a period of 5 years from 2020 to 2025.
    - More than 930.5 million USD (105.7 billion JPY) in support has been provided by the Japanese government in 2022.
- Korea:
    - The Korean government allocated 172.23 million USD (244 billion KRW) in funding for the '2022 Implementation Plan for the Intelligent Robot'.
    - The Korean government is planning to budget 7.41 million USD (10.5 billion KRW) from 2022 to 2024 for the 'Project for Full-Scale Test Platform Project for Special-Purpose Manned or Unmanned Aerial Vehicles'.
- European Union: The European Commission is expected to provide total funding of 198.5 million USD (201.0 million EUR) for the robotics-related work program 2021-2022 in Cluster 4 under Horizon Europe.
- Germany: The German government will provide around 69.1 million USD (70 million EUR) annually until 2026 (total budget: 345.6 million USD (350 million EUR) for five years).
- United Kingdom: In the UK, over the past five years (2017-2022), more than 129 million USD (112 million GBP) have been invested in the "Robot for a Safer World" program to support over 153 projects and 212 organizations.
- United States of America:
    - (NASA) For the Artemis lunar program, the US government is planning to allocate a budget of 35 billion USD from 2020 to 2024. In 2020, NASA funded the Artemis I mission to the amount of 1.6 billion USD.
    - (DOD) The DoD defense budget invested of 7.54 billion USD in the fiscal year (FY) 2021 (approximately 1.07 percent of the total DoD budget) for unmanned systems across all agencies. It can be seen that the funding for unmanned systems and robotics in the last three years has been decreased, with funding in FY2021 reduced by 9% (from FY 2020) and 21% (from FY 2019). 8.2 billion USD funding is planned for unmanned systems in FY 2022
    - (NRI) The US government supported the NRI-3.0 fund to the sum of 14 million USD in 2021.

China

China, which began conducting research on industrial robots in 1972, promoted R&D on industrial robots with such applications as spraying, spot-welding, arc-welding, and transport robots from the era of the 7th Five-Year Plan (1986-1990). In March 1986, it announced the 863 program, a high-tech R&D program. This was a scheme of massive government support for robot-related R&D, and constituted a key source of funding for China's research into industrial and intelligent robots.

In the 1990s, R&D of welding robots was prioritized, and investment made in nine robot industrialization hubs and seven R&D hubs. At this time, China's leading robot manufacturers such as Shenyang Siasun, Harbin Boshi Automation, and Beijing Research Institute of Automation for Machinery Industry first appeared.

The 10th Five-Year Plan (2001-2005), which began in 2001, included hazardous assignment robots, counterterrorism ordnance disposal robots, and human-like and bionic robots. In addition, the 11th Five-Year Plan (2006-2010), which began in 2006, included key technologies for intelligent controls and human-robot interaction, and it emphasized robotics and automation technologies for industries including integrated circuits, ships, automobiles, light fabrics, household electrical appliances, and foodstuffs.

The 12th FYP (2011-2015) was labeled “for intelligent manufacturing,” and demanded that Chinese manufacturing firms use (automate) more robots and integrate information technology.

The Guideline on Promoting the Development of the Industrial Robot Industry, announced in 2013, sets out the goals that China should achieve by 2020. These include: 1) developing three to five globally competitive robot manufacturers; 2) creating eight to ten industrial clusters for the industry; 3) achieving 45% of domestic market share for China’s high-end robots and; 4) increasing the robot penetration rate to 100 per 10,000 people.

Also announced in May 2015, ‘Made in China 2025’ aimed to innovate the three-stage manufacturing industry for the next 30 years and included advanced numerically controlled machine tools and robots among the top 10 core industries.

In the 13th FYP (13th Five Year National Economic and Social Development Plan, 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. It designated 10 product and five core components. The 10 products were: 1) welding robots; 2) cleaning robots; 3) intelligent industrial robots; 4) human-machine cooperation robots; 5) two-armed robots; 6) heavy loads AGV; 7) fire-fighting rescue robots; 8) surgical robots; 9) intelligent public service robots and; 10) intelligent nursing robots. The five core components were: 1) high precision reducers; 2) high performance motors for robots; 3) high performance controllers; 4) sensors and; 5) terminal actuators.

In order to implement the "National Medium- and Long-Term Science and Technology Development Plan Outline (2006-2020)", "Made in China 2025", and other plans, and to promote the rapid development of intelligent robot technology and industry, "Intelligent Robots" key special projects are being deployed in accordance with the requirements of the "Innovation Chain" and implemented in six directions, focusing on the basic cutting-edge technologies of intelligent robots, new-generation robots, key common technologies, industrial robots, service robots, and special robots. The special implementation period is 5 years (2017-2021).

The Ministry of Science and Technology of China released its 4th Guidelines on the “2020 Intelligent Robots Key Special Program” on March 23, 2020 with allocated funding of approximately 9.13 million USD (about 66 million CNY).

In 2021, the 14th 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, and the robot industry was included in 8 key industries for the next 5 years. In order to implement national science and technology innovation arrangements during the “14th Five-Year Plan”, the “Intelligent Robots” Key Special Program was launched under the National Key R&D Plan on April 23, 2022 with funding of 43.5 million USD (315 million CNY).

Japan

In **Japan**, the national R&D program for 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 Japan’s Economic Revitalization), based on the revised 2014 Japan Revitalization Strategy, as a key policy of the Abenomics Growth Strategy. After announcing this strategy, the robot-related budget for FY2016 stood at 258.7 million USD (29.4 billion JPY), an increase of 83% over the previous fiscal year. The budget for FY2019 is 332.6 million USD (37.8 billion JPY). The New Robot Strategy presented action plans in five sectors to pursue over the following five years (2016-2020), which were: Manufacturing; Service; Nursing and Medical; Infrastructure, Disaster Response, and Construction and; Agriculture, Forestry, Fishery, and Food Industry. The Robot Revolution & Industrial IoT Initiative (RRI) was established in May 2015, to execute these action plans. The government and the RRI provide a plan for sectoral robot-related R&D projects as well as cross-sectoral activities such as global standardization, regulatory reform, and robot awards and competitions. The robot-related R&D projects are planned in three stages: introduction and substantiation; development of technology applicable to market and; development of next-generation technology.

The Council for Science, Technology, and Innovation, under the leadership of the Prime Minister of Japan and the Minister of State for Science and Technology Policy, has promoted planning and coordination for comprehensive basic science, technology, and innovation policies, taking a bird's-eye view of Japan's entire science and technology landscape. In these circumstances, the council proposed three new policies: (1) strategic formulation of overall governmental science and technology budget; (2) the cross-ministerial Strategic Innovation Promotion Program (SIP); and (3) Impulsing Paradigm Change through Disruptive Technologies (ImPACT). ImPACT is the R&D program to promote high-risk and high-impact R&D that could result in disruptive change to industry and society. ImPACT was implemented from 2014 to 2018 and provided funds of 484 million USD (55 billion JPY). SIP is a program aimed at accomplishing a leading role in science, technology, and innovation beyond the framework of government ministries and traditional disciplines. SIP has identified R&D themes that will address the most important social problems. Each R&D theme is led by a program director who is responsible for guiding the projects from basic research through to practical application and commercialization, and then ultimately towards a clear exit strategy. The first period was carried out from 2014 to 2018 at a cost of 440 million USD (50 billion JPY), and the second period was started in 2018 with funding of 573.7 million USD (65.2 billion JPY) until 2022.

Such R&D programs will be showcased in the name of World Robot Summit to accelerate R&D and to introduce and diffuse in the Japanese society in 2021 (originally planned for 2020). World Robot Summit features World Robot Challenge where robots will be compete with one another and World Robot Expo where the latest robot technologies will be exhibited. There are 4 categories in both events, industrial, service, disaster robotics and junior.

In July 2019, Council for Promoting Social change Taking Advantage of Robots announced a report titled by Changes in the Environment Surrounding Robots and Direction of Future Policy. This report analyzes the market trends of industrial robots, the expanded participation of new runners, the appearance of new businesses utilizing robots, and the direction of each country's robot policy. Then, based on the analysis, the report presents the direction of future robot policy. As of 2020, follow-up measures are in progress. Additional funding of 17.6 million USD (2 billion JPY) for the year 2019 (up from 0.88 billion USD (100 billion JPY) for the year 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 both the physical and mental limitations of the human body and AI robots that evolve alongside humans.

In 2021, the national research and development agency, the New Energy and Industrial Technology Development Organization (NEDO), launched projects related to robotics and AI technology to cope with the explosive spread of COVID-19, which has widely affected global social and economic activities and brought about unprecedented change to everyday lives. These projects focus on developing new industrial robots and self-driving robots to strengthen supply chains and maintain logistics services with funding of 79.81 million USD (9.07 billion JPY) for the year 2021 and 67.48 million USD (7.68 billion JPY) for the year 2022.

Korea

Since welding robots in car manufacturing was first introduced to **Korea** in 1978, an industry-academia collaboration began conducting independent robot-related R&D without government support. Subsequently, in 1987, the government started supporting the 'Common Core Technology Development Project' in the field of manufacturing robots and followed this up with an active R&D support policy. However, due to the IMF crisis, which began in 1997, government support and R&D almost stopped completely. Intelligent robots appeared in 2002, and the Ministry of Trade, Industry, and Energy (MOTIE), Ministry of Information and Communication, Ministry of Science and ICT (MSIT) and various ministries and agencies began to provide support for the robot business, meaning government support was scaled up and organized. In August 2003, the robot industry was selected as one of the top 10 'next generation growth engine industries'. During the six years from 2002 to 2007, the government led the development of technology and market creation by investing a total of 343.4 million USD (486.5 billion KRW), 296.6 million USD (420.2 billion KRW) in R&D, 6.7 million USD (9.5 billion KRW) in demand creation, and 52.8 million USD (74.8 billion KRW) in foundation) for 1,259 projects. It then enacted a 'special robot law' in November 2007.

In March 2008, the 'Intelligent Robot Development and Supply Promotion Act' was enacted, and in accordance with Article 5 of the Act, the statutory plan, 'The First 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). In the meantime, policy investments totaling 536.9 million USD (760.7 billion KRW) (R&D 362.6 million USD (513.7 billion KRW), 72.7%) were made, and the robot industry is assessed to have achieved substantial results in corporate sales growth while securing some key source technologies via continuous improvement-oriented R&D development that avoided simply emulating the past. In 2011, the robot team at the Ministry of Knowledge Economy was expanded to become the 'Robot Industry Division' and the robot market exceeded 1.4 billion USD (2 trillion KRW) by production standards that year.

'The Second 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 and services (Logistics Robots (AGV), Emotion Robots (Human Robot Interaction), which were relatively weak compared to technologies and products. The second plan did not limit the scope of robot industry to robot products, establishing 'Seven Robot Convergence Business Strategy Roadmap', in order to expand other manufacturing and service sectors of robot technology. It also plans to strategically utilize the robot supply business to create a new market for large-scale robots and strengthen global cooperation with countries possessing advanced robot technology and others. The seven key areas are: 1) manufacturing; 2) automobiles; 3) medical and rehabilitation; 4) culture; 5) defense; 6) education and; 7) marine. During the five-year period, the government's R&D-related budget was 77.2, 87.9, 90.8, 121.6 and 119.8 million USD (109.45, 124.6, 128.6, 172.2 and 169.7 billion KRW) from 2014 to 2018 respectively.

With the vision of leaping into the world's top four robot industry by 2023, 'The 3rd Basic Plan for Intelligent Robots (2019 ~ 2023)' was announced in 2019. While the 1st and 2nd basic plans are centered primarily on the government-led support system, support areas, and growth foundation for the growth of the robot industry, The 3rd basic plan promotes systematic dissemination and diffusion through the selection and concentration of promising sectors as well as role assignment for the government and the private sector. The main tasks are as follows.

(1) Expanded dissemination for manufacturing robots with focus on the three largest

manufacturing businesses – To supply 700,000 units manufacturing robots (accumulated) by 2023, develop standard models of robot utilization are to be developed for 108 processes by 2023, while first develop standard models for the three largest business types such as root, textile, food and beverage, etc.

(2) Concentrated cultivation of four largest service robot areas – such as care, wearable, medical care, logistics, etc. were selected. Technology development and dissemination are supported with leading by the concerned departments such as Ministry of Defense, Ministry of Agriculture, etc. for the ten largest niche market-type areas such as drone-bot, agriculture/exploration robot, etc. to develop robots in many different areas; National defense area (unmanned surface vehicles, wearable muscular strength-enhancing robots), agriculture area (smart farm robots for facility gardening, unmanned tractor, agricultural robot capable of control, harvesting operations), underwater/exploration area (underwater robot system capable of monitoring environmental changes, safety robots for the marine accidents, and underwater construction robots), and evacuation/safety area (search robots for a narrow space, remote mobile measuring device with sensors and detection device for drugs), etc.

(3) Reinforcement of Robot Industry Ecosystem - Support independence of the three key next-generation components (Intelligent controller, Autonomous mobile sensor, Smart gripper) and the 4 key software components (Robot SW platform, Gripping technology SW, Image information-processing SW, Human-robot interaction). Reinforce the support focus on demonstration and dissemination of decelerator, motor, motion controller, etc.

In April 2022, the ‘Project for Full-scale Test Platform of Special-purpose Manned or Unmanned Aerial Vehicles (2022-2024)’ was released from the Ministry of Trade, Industry, and Energy (MOTIE). The purpose of the project is as follows:

(1) Establishment of an industrial ecosystem for special-purpose manned or unmanned aerial vehicles.

(2) Establishment of a full-scale testing infrastructure for development of special-purpose manned or unmanned aerial vehicles.

(3) Support for full-scale field experiments of special-purpose manned or unmanned aerial vehicles and utilization of extant infrastructures.

The work program has been providing total funding of 7.41 million USD (10.5 billion KRW) for the project period (2022-2024).

Australia

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

On November 17 2021, the government announced 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-added in critical technologies for industry, academia, and the nation’s international partners. Of the 63 critical technologies, 4 are related to robotics, of which the first 3 also belong to the list of critical technologies of initial focus: advanced robotics, autonomous systems operating technology, drones, swarming and collaborative robotics, and nanoscale robotics.

In January 2022, the Robotics and Automation on Earth and in Space Roadmap 2021-2030 was announced, which is a key priority area under the Australian Civil Space Strategy 2019-2028. It is the third in a series of technical roadmaps to be delivered by the Australian Space Agency. The roadmap is considered an important milestone on the road to achieving 20,000 new jobs and tripling the size of

Australia's civil space sector to 7.68 billion USD (12 billion AUD) by 2030.

Most recently, in August 2022, the government announced investment of 0.64 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.

European Union

The Framework Programs (FPs) – abbreviated FP1 to FP7 with "FP8" named "Horizon 2020" and FP9 referred to as "Horizon Europe" – are the **European Union**'s main instrument for funding research and development activities. These multi-annual programs have been implemented since 1984. The framework programs up until Framework Program 6 (FP6) covered five-year periods. From Framework Program 7 (FP7) on, programs run for seven years.

In FP6 and FP7, carried out from 2002 to 2013, the robotics-related work program was still focused on technological research, but Horizon 2020 places emphasis on innovation and transfer of technology to the marketplace.

FP7 is the seventh Framework Program for Research and technological development scheme, which was carried out from 2007 to 2013. The European Commission (EC) financial contribution in FP7 was estimated to be around 49.4 billion USD (50 billion EUR) over seven years.

The robotics-related sections in FP7 focused on research related to the perception, understanding, action-cognitive, and intelligent enabling technologies. Upon completion, FP7 directly funded some 130 robotics-based projects involving around 500 organizations, with total grants of 529.3 million USD (536 million EUR). Other funding with elements related to robotics amounted to 167.9 million USD (170 million EUR).

Horizon 2020 is the eighth EU Framework Program, running from 2014 to 2020. The work programs in Horizon 2020 are set out in multi-annual programs, namely Work Program 2014-2015, Work Program 2016-2017 and Work Program 2018-2020. The Robotics Work Programs in Horizon 2020 are established based on the outcomes of the consultation and discussions in the SPARC program. In addition, the robotics projects funded by Horizon 2020 represent a wide variety of research and innovation themes from Information and Communication Technologies (ICT), Future and Emerging Technologies (FET), and Societal Challenges. Through this program, EC provides an estimated 691.2 million USD (700 million EUR) worth of funding for robotics research and innovation. The summary section covers the Horizon 2020 ICT Robotics Work Program related to manufacturing, commercial, healthcare, consumer, transportation, civil and agri-food, inspection, search and rescue robotics.

Under ICT Work Program 2014-2015, the Research Development and Innovation (R&D&I) projects aim to advance current robot capabilities in terms of robustness, flexibility, and autonomy, while operating in real-world environments for manufacturing, commercial, civil, and agriculture. The work programs have been providing total funding of 155 million USD (157 million EUR) for 36 projects.

The R&D&I projects in ICT Work Program 2016-2017, with estimated funding of 119.5 million USD (121 million EUR), focus on a wide variety of robotics and autonomous systems and capabilities, such as navigation, human-robot interaction, recognition, cognition, and handling to move research results into the marketplace.

ICT Work Program 2018-2020 is the final work program under Horizon 2020. Its main topics are related to digitization of industry through robotics, robotics applications in promising new areas, and robotics core technologies such as AI and cognition, cognitive mechatronics, socially cooperative human-robot interaction, and model-based design and configuration tools. For this program, a total of 154 million USD (156 million EUR) has been budgeted.

Horizon Europe, the new European Framework Program on research and innovation over the period of 2021 to 2027, has been launched. Building on the achievements and success of Horizon 2020, Horizon Europe will support top researchers, innovators, and general citizens to develop the knowledge and solutions needed to ensure a green, digital, and healthy future. Specifically, the Strategic Research, Innovation and Development Agenda (SRIDA) of the new European Public Private Partnership (PPP) “Artificial Intelligence (AI), Data and Robotics Partnership” aims at strengthening the AI, Data and Robotics infrastructure and ecosystem. The SRIDA defines the vision, overall goals, main technical and non-technical priorities, investment areas and a research, innovation and deployment roadmap under the Horizon Europe Program. The robotics-related work program is embedded in Cluster 4: Digital, Industry, and Space under Horizon Europe. The Work Program 2021-2022: Cluster 4: Digital, Industry, and Space was announced in 28 Oct 2021. Robotics-related R&D&I projects will focus on the digital transition of the manufacturing and construction sectors, autonomous solutions to support workers, enhanced cognition, and human-robot collaboration based on research into digitization, AI, data sharing, advanced robotics, and modularity. The robotics-related work program 2021-2022 in Cluster 4 will provide total funding of 198.5 million USD (201.0 million EUR).

Germany

In **Germany** in 2006, the High-Tech Strategy (HTS) was formulated to move the country forward on its way to becoming a worldwide innovation leader. The goal is for good ideas to be translated quickly into innovative products and services. Most of the framework of the High-Tech Strategy promotes partnership between companies, universities, and research institutions in order to bring together institutional research and entrepreneurial expertise.

The Industry 4.0 initiative, in which robot-related R&D plays an important role, is one part of the High-Tech Strategy of the German government to maintain Germany’s status as a leading supplier of products and production location for digital equipment, processes, and products. As such, the German government launched a series of technology-centered research programs related to robot R&D.

Between 2009 and 2014, the “AUTONOMIK” program provided funding for robot-related R&D projects in the fields of manufacturing, logistics, and assembly. The technology program of AUTONOMIK focused on forward-looking approaches to advance the development and proof testing of smart tools and autonomous systems. Through this program, the German government has provided a total of 43.4 million USD (44 million EUR) in funding for 14 projects involving around 90 partners from industry and academia.

The outcomes of the AUTONOMIK program formed an important basis for the program entitled “AUTONOMIK für Industrie 4.0” that was designed to merge information and communication technologies with industrial production technologies. From 2013 to 2017, 16 projects qualified for support from the Federal Ministry, which backed the projects with funding in the order of 43.4 million USD (44 million EUR). These funded projects tried to address a range of technologically important issues including human-robot interaction, 3D technologies in industrial application, and cognitive features that enable systems to act independently.

Since 2016, the 49.4 million USD (50 million EUR) funded “PAiCE” program has been continuing the work as a follow-up program related to AUTONOMIK and “AUTONOMIK für Industrie 4.0” for the next five years. The technology program of “PAiCE” emphasizes the development of digital industry platforms as well as collaboration between companies using these platforms. In particular, the robotics-oriented projects are focusing on the creation of platforms for service robotics solutions in the various relevant application areas including service, logistics, and manufacturing fields.

The High-Tech Strategy 2025 is the fourth edition of German R&D and innovation activity in this area and was adopted in September 2018. It has been set the target of 3.5 percent of GDP per annum investment in R&D by 2025. In several program lines of the mission “Shaping Technology for the People”, the robotics-related program “Together Through Innovation” was launched in 2020. With this research program line, the Federal Ministry of Education and Research (BMBF) will provide around 69.1 million USD (70 million EUR) annually until 2026.

Italy

The **Italian** government contributes to research funds that are managed by the EC, and Italian researchers successfully 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 was extended through public consultation to public and private stakeholders and interests and to civil society. The National Research Program (PNR), provided for by Legislative Decree 204/1998, is the document that guides research policies in Italy, the realization of which State administrations contribute to through the coordination of the Ministry of University and Research. And robotics is one of the primary areas of research and innovation in the PNR 2021-2027, and the relevant content is indicated below:

1. Robots more and more pervasive and personal

2. 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

Other robot-related programs were launched in Italy include the following:

1. Innova per l'Italia: technology, research, and innovation to counter the COVID 19 crisis, 23 March 2020: For reasons of speed, the call is addressed to entities that already have platforms, or can easily adapt them, algorithms of analysis and artificial intelligence, robots, drones, and other technologies for monitoring, preventing, and controlling Covid-19

2. Competence Centers: In June 2020, the highly specialized Competence Center on advanced robotics and artificial intelligence Artes 4.0 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

3. MISE innovation projects:

- Complex and high value-added ships

- Robotics for radiotherapy and surgery

4. Robotics Olympics 2020 to encourage and support the educational potential of robotics, with reference to STEM

United Kingdom

Witnessing rapid developments in microelectronics, data processing, and robotics technologies over the last 10 years, government, academia, and many industries in the **UK** are recognizing robotics technology to be a game changer in the way people live and work. The increased utilization of robotics technology is seen as one way to significantly increase productivity and consequent growth in the UK economy. Robotic systems are now starting to be able to sense their environments in real time and process information to deliver a goal and not just a task i.e. they can act with a degree of autonomy. This has resulted in significant amounts of funding becoming available from UK Research and Innovation (UKRI)-related organizations to support the research, development, and commercialization of RAI technologies.

Analysis by the National Nuclear Laboratory shows that 20% of the cost of complex decommissioning (approximately 13.8 billion USD (12 billion GBP)) will be spent on Robotics and Autonomous Systems (RAS) technology.

In the UK, Accenture estimates that automation and robotics could provide significant economic benefits over the next 10 years.

- 211.14 billion USD (183.6 billion GBP) of value to UK industry
- 17.25 billion USD (15 billion GBP) of cost savings passed on to consumers
- 127,000 workplace injuries avoided

From 2017 to 2020, the challenge of robotics offers more than 109.365 million USD (95.1 million GBP) in a 4-year program that will develop robots and AI to take people out of dangerous work environments and into areas that lie beyond human limits. Currently, the

ISCF RAI in Extreme Environments program has 3 delivery streams to provide funding to various projects around the UK. These fall under:

- Collaborative research and development
- Demonstration competitions
- Hubs

Until 2021, 109.365 million USD (95.1 million GBP) in a 4-year program and an additional 17.25 million USD (15 million GBP) have been committed through these delivery streams, complemented by around 92 million USD (80 million GBP) of industry-matched funding. The projects receiving this funding demonstrate the cross-cutting nature of RAI, with a broad range of activities that the ISCF is supporting to ensure that the UK remains at the forefront of this growing industry. These funded activities can be broken down into five environments:

- Offshore (wind, underwater, ice)
- Nuclear
- Space
- Mining
- Cross-cutting – projects that cover different technological developments or could be applied across many industries

An additional 8.05 million USD (7 million GBP) funding in 2021 for the “remote offshore rescue service” was granted. In March 2022, the challenge ended with over 129 million USD (112 million GBP) having been invested into 153 projects and 212 organizations, complemented by over 575 million USD (500 million GBP) of industrial matched funding.

Sweden

In **Sweden**, Robotdalen – a Swedish robotics initiative with the goal of creating regional growth in Mälardalen and Sweden as a whole by building an innovation system in robotics and automation – commenced its operations in 2003 as a VINNVÄXT winner. From 2003 to 2019, VINNOVA (a Swedish governmental R&D agency) had supported Robotdalen. It was one of Europe’s leading robotics centers, where researchers, developers, manufacturers, and academics work together in the field of robotics with a commercial focus. Robodalen had a particular emphasis on industrial, logistics, service, and healthcare robotics. There were five representative projects: robot suit HAL, FIREM (FIre REscue in Mines), STRADA for interactive remote rehabilitation for stroke patients, the cognitive retinal generator for assisting ophthalmic surgery, and the world’s first hygiene robot, Poseidon. As VINNVÄXT funding was being phased out in 2019, Robotdalen was restructured into Robotdalen AB, enabling its commercial revenues to be managed and switched up.

Aside from Robotdalen, the Swedish Foundation for Strategic Research (SSF) funds science, engineering, and medicine via grants of up to 54.6 million USD (600 million SEK) annually. From 2016 until 2021, there was a robotic related research theme “Smart Systems 2015” including ICT, robotics, and AI with a budget 27 million USD (300 million SEK). The goal of framework grants for research on smart systems is to improve the designs and functionalities of existing kinds of technological systems or to create entirely novel types. Smart systems may offer adaptive, predictive, and robust behaviors and capabilities even under hostile conditions. They could also provide compensation for uncertainty or variability in a range of contexts. Safety and security can be features of a target system, while flexibility and upgradeability are normal parts of the specification. The major research areas are Cyber Physical Systems, Integrated Systems, Systems of Systems, Automation, Autonomous Systems and Robots, and Artificial Intelligence-Based Information Systems.

Switzerland

To enhance the scientific competitiveness of **Switzerland**, the Swiss National Science Foundation (SNSF) has so far launched four series (2001, 2005, 2010, 2014) comprising 36 NCCRs (NCCR: National Center of Competence in Research) in total. In 2010, NCCR Robotics was launched, and EPFL and ETH Zurich are home institutions. With total funding of 20 million USD (20,629,608 CHF) from 2018 to 2021, NCCR Robotics promotes three main strands of research:

- Wearable robotics: Regait++, Third Arm
- Mobile robots for rescue operations: Flying robots, legged robot, collaboration, learning and tests

- Educational robotics: teaching resources (Thymio), Cellulo

United States

US robot R&D programs managed by the US government in 2020 were mainly reviewed on the key categories with “Space Robotics”, “Military Autonomous vehicle & System”, and “Ubiquitous Collaborative Robots”. As a space robot R&D program, National Aeronautics and Space Administration (NASA) has been promoting Mars Exploration Program (MEP). MEP is a long-term mission in order to explore the planet Mars, funded by NASA. Since it was formed in 1993. MEP has been applying diverse orbital spacecraft, landers, and Mars rovers to discovery the clues about the possibilities of life on Mars, as well as the planet's climate and natural resources. At the beginning of the 21th century, the MEP missions were concentrated on the “Follow the Water” goal, including the Mars Odyssey (2001), Mars Exploration Rovers (2003), Mars Reconnaissance Orbiter (2005), and Mars Phoenix Lander (2007). Since then, MEP has transitioned from the “Follow the Water” goal to a combination of characterizing the climate and geology of Mars with the Mars Science Laboratory’s Curiosity rover (2011) and Mars Atmosphere and Volatile Evolution (2013). Currently, the MEP missions are pursuing more emphasis on seeking signs of life as well as preparing for human exploration of the planet by conducting the programs of InSight Lander (2018), Mars Rover (2020).

Since NASA announced the Mars rover program named as “Mars 2020” on 4 December 2012, the rovers have taken a journey toward Mars with specific goals. In September 2013, NASA launched Opportunity rover for scientists/researches to propose and develop the instruments, including the Sample Caching System for storing Martian soil. The science instruments for the mission were selected in July 2014 after an open competition based on the scientific objectives set one year earlier. Mars 2020 has been in progress by MEP with a planned launch on 17 July 2020, and touch down in Jezero crater on Mars on 18 February 2021. The rover in the Mars 2020 program is based on the design of Curiosity rover but key scientific instruments are embedded in the rover to explore a site likely to have been habitable. The budget of MEP in 2017 was supported with about 647 million USD by the US government and separately, NASA funded 408 million USD for Mars Rover 2020 and 239 million USD for other missions & data analysis, respectively. In 2019, MEP have funded approximate 604.5 million USD and NASA is supporting 348 million USD for Mars 2020 and 253.5 million USD for Other missions & data analysis, respectively.

Following the Mars exploration program, National Aeronautics and Space Administration (NASA) launched a lunar program named “Artemis” in May, 2019. The purpose of the Artemis lunar program is to return astronauts to the lunar surface by 2024 and to construct promising capabilities for Mars missions after 2024. The Artemis program has close relevance to Mars exploration programs such as Mars 2020, in that the Artemis program pursues the goal of building capabilities as an outpost for Mars. The Artemis lunar program is a newly crewed spaceflight program by NASA, the US commercial aerospace institution, and international partners including the ESA (comprising 22 countries), Canada, Japan, and Russia. The missions of the Artemis lunar program can be divided into two phases; Phase 1 from 2020 until 2024 and Phase 2 from 2025 to 2029 (expected). Phase 1 focuses on getting systems in place to support the first human lunar surface landing in more than half a century. It will proceed in a sequence of 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, then down to the lunar surface). Phase 1 also includes lunar science research with the goal to study polar volatiles, the geology of the South Pole-Aitken Basin, and to land at a lunar swirl feature to perform the first direct magnetic measurement. Meanwhile, Phase 2 comprises the capabilities necessary to establish a sustainable human presence on and around the Moon. For the Artemis lunar program, the US government is planning a budget of 35 billion USD from 2020 to 2024. In 2020, NASA provided 1.6 billion USD in funding for the mission of Artemis I.

For a military autonomous system R&D, Department of Defense (DOD) has been managing lots of programs related to develop unmanned military systems and robotic vehicles. Since RDE Focus of the US Secretary of Defense was released in 2010, "Autonomy" has become Science & Technology (S&T) priority of DOD. Annually, DOD has announced progress reports and plans associated with development of military autonomous vehicles and integration of the vehicles/systems of each department such as Army, Navy, Air Force, etc. The development topics of autonomy technology can be classified into 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). In the topics, seven core technologies have been identified: sensors/payloads, navigation/control, weapons, comms/data management, autonomy, propulsion/energy, mobility. The largest investment has been made in the integrated sensors and payloads followed by navigation and control systems. Annual budget to develop autonomy systems of DOD was funded with 9.6 billion USD for 2019 into three main services (Navy, Army, Air Force) and the other agencies (DBDP, DARPA, DLA, DTIC, DTRA, MDA, OSD, SOCOM, TJS, WHS) in the DoD for developing unmanned systems and robotics.

The United States Department of Defense (DoD) remains the largest customer for unmanned systems technologies, with 8.3 billion USD and 7.3 billion USD budget projected in 2020 and 2021, respectively. Over 1,000 unique projects with funding ranging from the sub-$1 million range to over 100 million USD are associated with 17 different departments and agencies that are seeking to develop and deploy UxS in support of U.S. troops.

In FY 2021, 7.54 billion USD of the DoD budget was invested in unmanned systems, with 3.327 billion USD for procurement and 4.213 billion USD for RDT&E of autonomous systems. This year's investment (approximately 1.07% of total DoD budget) observes the decrease in funding of unmanned systems and robotics in the last three years by 9% and 21% in comparison with FY 2020 and FY2019, respectively. In addition, the FY 2022 budget includes 8.2 billion USD to support the RDT&E and procurement of unmanned systems.

For a fundamental robot R&D, National Robotics Initiative (NRI) was launched in 2011 and NRI has been advanced from NRI-1.0 to NRI-2.0, supported by the US Government. At the beginning, the goal of NRI-1.0 is to accelerate the development and use of robots in the United States as 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 main goals of NRI have focused on seeking research on the fundamental science, technologies, and integrated systems needed to achieve the vision of ubiquitous collaborative robots and to assist humans in every aspect of life with "Ubiquity: Seamless integration of co-robots". Moreover, in NRI-2.0, collaboration between academic, industry, non-profit, and other organizations is encouraged in order to accomplish better connections between fundamental science/ engineering/ technology development, deployment, and use. Annual budget of NRI-2.0 in 2019, was funded with 35 million USD as the projects of Foundation (FND) and Integrative (INT) in multiple agencies of the federal government, including the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), the National Institutes of Health (NIH), the U.S. Department of Agriculture (USDA), Department of Energy (DOE) and the U.S. Department of Defense (DOD). From 2020, NASA and NSDA/NIFA only considered projects within its stated budget limits. Moreover, the DOE and the DOD were removed as partner organizations, and the National Institute for Occupational Safety and Health (NIOSH) added as one. The US government supported NRI-2.0 to the amount of 32 million USD in 2020.

In 2020, the Unites States released the 2020 US National Robotics Roadmap that pursues implementation of robots for purposes of economic growth, improved quality of life, and empowerment of people.[1] Based on the robotics 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 increasingly autonomous systems. The IRAS strategic priorities and associated key programs are intended to promote safe, efficient human-robot teaming, improve validation and verification of robotic and autonomous systems, and advance intelligent physical systems. The IRAS budget accounts for 4% of the overall FY 2021 budget of 6.5 billion USD that the president requested for federal agencies' Networking and Information Technology Research and Development (NITRD)-related R&D. As part of the IRAS programs, NRI-3.0 was released in 2021 to support fundamental research in the United States that will advance the science of robot integration. NIR-3.0 supports research that promotes integration of robots for the benefit of humans in terms of human safety and human 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 ecosystems for innovation, and moreover, to promote new integrated approaches to the challenges of accountability, interoperability, ethical operation, and trust which will be engendered by integrated functional ubiquitous robots.

The annual budget of NRI-3.0 in 2021 was 14 million USD for Foundation (FND) and Integrative (INT) projects in multiple agencies of the federal government, including the National Science Foundation (NSF), Department of Transportation (DOT), National Aeronautics and Space Administration (NASA), National Institutes of Health (NIH), National Institute for Occupational Safety and Health (NIOSH), and U.S. Department of Agriculture (USDA). From NRI-3.0, NASA, NIFA, and NIOSH have been only considered projects within their stated cost limits. Moreover, the DOT and NIH have been added as partner organizations.

Canada

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

The only Canadian government-led large robot R&D program is Canadarm*, Canada's best-known contribution to robotics. A manipulator able to withstand the harsh radiation of space, it was first used by the crew of the NASA Space Shuttle Columbia in 1981. On subsequent missions, Canadarm2 and Dextre were used to construct and maintain the International Space Station. On February 28, 2019, the government promised 1.4 billion USD (2.05 billion CAD) in funding for this "third generation" Canadarm over 24 years.

The first Canadarm's technical name was The Shuttle Remote Manipulator System (SRMS). The project was launched in 1974. Spar, CAE, and DSMA Atcon formed the industrial team, with what was formerly the National Research Council of Canada (NRC) and currently the Canadian Space Agency (CSA) overseeing the project. The Government of Canada invested 78 million USD (108 million CAD) in designing, building, and testing the first Canadarm flight hardware, which was given to NASA for the orbiter Columbia. It was deployed in 1981 and returned to earth in 2011.

The second Canadarm's technical name was The Space Station Remote Manipulator System. It was designed, built, and tested from 1986 to 2001 by MDA in Brampton, Ontario. On April 21, 1988, Canada announced a 1.2 billion Canadian dollar commitment over 15 years for the realization of the Mobile Service System (MSS) under the name of the Canadian Space Station Program. It included the Space Station Remote Manipulator System (SSRMS,

[1] *Reference : 2020 US National Robotics Roadmap, NITRD Supplement to the President's FY 2021 Budget,* *https://svrobo.org/svr-reports-publications/*

Canadarm2), mounted on a Mobile Base System (MBS) and designed to handle large loads onboard the ISS, and the Special Purpose Dextrous Manipulator (SPDM, Dextre), a second robot designed to perform more delicate tasks. Canadarm2 was deployed on April 19, 2001 and MBS was deployed on June 5, 2002. A total of 1 billion USD (1.4 billion CAD) were invested in this up to 2002. The third and last component of MSS, Dextre, was developed from 2003 to 2007 and deployed on March 11, 2008 and 84 million USD (116 million CAD) were invested.

The third Canadarm's letter of interest, "Lunar Gateway Robotics_Canadarm3" was announced on July 26, 2019. 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 artificial intelligence-enabled robotic system to the United States-led Lunar Gateway, the government announced 152 million USD (209 million CAD) in funding from 2019 to 2024 to develop Canadarm3 under a policy entitled "Canada Reaches for the Moon and Beyond" in the 2019 Canadian Budget. CSA announced a request for a proposal to develop XLA, XDA "Gateway External Robotics Interfaces (GERI) Large and Dexterous Arms Interfaces_Phase A" on April 26, 2019. It states that 1,990,710 USD (2,727,000 CAD) for XLA and 2,780,935 USD (3,809,500 CAD) for XDA will be allocated, and its expected completion date is on or before August 31, 2020.

Canadian Robots Canadarm2 and Dexter have led to the development of many technologies, such as neuroArm and IGAR. Now, with the improved Canadarm incorporating advanced artificial intelligence (AI) technologies, Canadarm3 is expected to open the door for new robotics technologies.

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

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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 system with high real-time function, high reliability, multi-processor parallel working capacity or multi-core processor shall to 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 integrator 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, warehousing and logistics, intelligent	◦ Development and promotion of new robot products for high-end application market and intelligent manufacturing.

	home, education, and entertainment.	
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 advantages.

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 supports 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 2022"**
Region	China
Issued by	Ministry of Science and Technology of the People's Republic of China
Announcement	April 27, 2022
Term of validity	2022
Budget	about 43.5 million USD (about 315 million CNY)
Key words	Basic frontier technologies, Common key technologies, Industrial robots, Service robots and special robots
Related website	https://service.most.gov.cn/kjjh_tztg_all/20220427/4894.html
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 2022 is released.
Goal	◦ Development of an intelligent robotics system suitable for China's national conditions; 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 latest R&D project	-
The key targets of the latest R&D project	◦ Basic frontier technologies ◦ Common key technologies ◦ Industrial robots ◦ Service robots and special robots

Contents

1. Basic frontier technologies

1.1 Theory on integrated design of robot structure-function-performance

Research content	Evaluation criteria
◦ Research on the comprehensive design of motion and force analysis theory in the integrated design of structure-function-performance for complex environment robots to reveal the inner mechanism of robot function generation, multi-structure conversion and dynamic performance evolution.	◦ Development of a robot principle prototype to verify the environmental adaptability and motion operation function under more than 4 types of working conditions through active/passive regulation of single structure/structure configuration. ◦ Pioneering at least two state-of-the-art techn

◦ Development of a collaborative method of robot design, manufacturing and drive control O&M theory in the whole process of design – mechanics – materials – manufacturing - operation. ◦ Development of a principle prototype of the robot, which can change its structure independently according to the external environment through mechanism reconstruction to realize the operation in different environments.	ology or reaching the highest international standards; with at least 5 patents for invention applied/gained.

1.2. Controllable cross-media bio-mechanical fusion robot

Research content	Evaluation criteria
◦ Study of the basic theories and implementation methods of controllable cross-media fusion robot to explore the mechanism and model theory of bio-neural feedback and motion control. ◦ Development of bio-mechanical cross-media integration bi-directional interface technology based on neural signal transmission mode. ◦ Study of embedded multi-mode motion information sensing and online detection method. ◦ Establishment of cross-media bio-mechanical system and experimental platform of neuromuscular-mechanical fusion.	◦ Development of controllable cross-media fusion robot system with biological neural response mechanism with the accuracy rate of ≥70% and a shape variable detection error of≤ 5% based on embedded sensing in more than three scenarios. ◦ Pioneering at least two state-of-the-art technology or reaching the highest international standards; with at least 5 patents for invention applied/gained.

1.3 Interactive control and behavioral integration of bio-mechanical systems

Research content	Evaluation criteria
◦ Research on the method of simultaneous measurement and multimodal fusion of physiological information on myoelectricity, myoacoustic, blood flow and blood oxygen with physical information on forces and postures. ◦ Exploration of the feedback mechanism of mixed ultrasound and electrical stimulation affecting human movement and sensation. ◦ Development of a multifunctional integrated flexible bi-directional neuromuscular interface device. ◦ Establishment of an experimental platform for interactive control of bio-mechanical systems with human-machine co-motor function. ◦ Achievement of accurate intent recognition understanding and motion behavior fusion of human in the loop.	◦ Development of a flexible bi-directional muscle interface device with synchronized detection function for physical and physiological signals and the in situ synchronous measurement and ultrasound stimulation function. ◦ Achievement of three-dimensional forces, temperature, myoacoustic and myoelectric at an ultrasound stimulation spatial resolution of ≤ 8 mm; human-computer interaction intention recognition rate shall be ≥ 90%. ◦ Establishment of a bio-mechatronics system interaction control experimental platform with the walking speed of ≥ 1.6m/s, and realize the typical application of human-machine integration in more than three scenarios. ◦ Pioneering at least two state-of-the-art technology or reaching the highest international standards; with at least 5 patents for invention applied/gained.

1.4 Multi-robot collaborative universe sensing technology

Research content	Evaluation criteria

◦ Research on the universe scene perception and model representation methods of fusion of information about robot, environment, geography and social activities, the emergence and feedback mechanisms of multi-robot swarm intelligence, the cross-domain matching and cross-fusion of multiple types of information, the multi-robot navigation and localization, the target detection and tracking, and the interactive decision-making and other key technologies supported by universe perception. ◦ Development of a multi-robot collaborative universe perception and intelligent decision-making system and conduct typical application verification.	◦ Development of the universe sensing and intelligent decision-making system for multi-robot clusters. ◦ Realization of the sensing fusion of more than 3 types of cross-domain information. ◦ Verification of the application in more than 2 typical scenarios with more than 10 sets of 5 types of robots for each scenario. ◦ Pioneering at least two state-of-the-art technology or reaching the highest international standards; with at least 5 patents for invention applied/gained.

1.5 Robot skill learning and intelligence development

Research content	Evaluation criteria
◦ Research on dexterous manipulation arm-hand design, modeling planning and precise control, complex scene object multimode perception and operation, complex operational skill knowledge expression and learning, operational skill recurrence optimization, cumulative generalization, migration application, and other key technologies. ◦ Development of robot skill learning and development system and platform on dexterous manipulator.	◦ Development of the dexterous manipulator with various sensing abilities for forces, positions/touching. ◦ Establishment of the robot skill learning and development and platform with HMI skill transfer and independent development to realize the learning of more than 5 complex operation skills and the understanding and independent use of tool functions. ◦ Verification of more than 3 scenarios in the same category with no object without reprogramming to show the generalized application capacity. ◦ Pioneering at least two state-of-the-art technology or reaching the highest international standards; with at least 5 patents for invention applied/gained.

1.6 Highly mobile wheel-foot bionic robot for complex plateau environment

Research content	Evaluation criteria
◦ Research on the integrated design of wheel-foot composite functional structure, multi-sensor fusion. perception, agile gait and stability control and wheel-foot composite behavior planning and decision making methods. ◦ Breakthroughs in key technologies related to high-speed modeling of complex environment and autonomous climbing/agile jumping/omnidirectional movement behavior control and autonomous generation and switching of combined motion modes. ◦ Development of a highly mobile wheel-foot bionic robot prototype. ◦ Realization of wheel-foot composite agile motion in typical environment of highland mountainous areas.	◦ Development of highly mobile wheel-foot bionic robot with the ability to adapt to highland mountainous environments. ◦ Implementation of at least 3 movement modes with wheel, foot and wheel-foot. ◦ Achievement of more than four kinds of behavior combinations with crossing trenches, steps, vertical obstacles, mud lands and long-distance slopes. ◦ Requirement of the robot specification: self-weight: ≤ 350kg, loading capacity: ≥ 200kg; wheel-mode speed: ≥ 30km/h, slope climbing degree: ≥ 45 °; foot-mode movement over vertical obstacle: ≥ 1m, jump distance: ≥ 2m. ◦ Pioneering at least two state-of-the-art technology or reaching the highest international standards; with at least 5 patents for invention applied/gained.

1.7 New concept robot system creation

Research content	Evaluation criteria
◦ Research on the new principles, methods and forms to enhance the environmental adaptation capability, task operation capability or intelligent decision-making capability of robots to conduct innovative design and create new concept robot system.	◦ Development of prototypes of new concept robotic systems with originality. ◦ Determination of the specific task objectives and system evaluation criteria under the declared project. ◦ Pioneering at least one state-of-the-art technology or reaching the highest international standards in improving the robot's environmental adaptation capability, task operation capability or intelligent decision-making capability; with at least 5 patents for invention applied/gained

2. Common key technologies

2.1 Performance improvement and application of core robot parts

Research content	Evaluation criteria
◦ Research on the technologies of designing and optimizing the retention and reliability of precision reducer of robots. ◦ Research on the design of robot controller performance and scalability; ◦ Research on high quality high power density drive and servo motor performance optimization design ◦ Development, promotion, and application of core components of robots leading among the similar products in the world.	◦ Establishment of the index system for benchmarking with similar foreign products. ◦ Leading in the world among similar products for the performance and consistency of controllers, servo motors, drives and reducers. ◦ Realization of 9-axis interpolation and multi-machine cooperative interpolation and 16-axis linkage in total with additional axes. ◦ Achievement of more than 10 patents for invention applied/gained and more than 20,000 sets of ontology packages.

2.2 Overall performance optimization and application of multi-articulated industrial robots

Research content	Evaluation criteria
◦ Research on the lightweight design of robots, the high speed, high load and high precision dynamics design and control of complete robots and the off-line programming and no-demonstration deployment. ◦ Breakthroughs in key technologies such as electromechanical coupling parameter calibration, attitude error compensation and variable inertia high-speed vibration suppression. ◦ Improvement of the accuracy, static and dynamic performance and ease of use of domestic industrial robots, and the 6 degree of freedom articulated industrial robot with typical loading capacity.	◦ Establishment of a robot system for benchmarking with similar foreign products. ◦ Reaching the leading level among the similar foreign products in the key industrial robot enterprises in at least 5 countries for the performance index of the 6 degree-of-freedom industrial robots with typical loading capacity. ◦ Achieved sales of over 20,000 robots. ◦ Achievement of more than 10 patents for invention applied/gained.

2.3 Integrated development platform for process applications of industrial robots

Research content	Evaluation criteria
◦ Research on processes and technologies for real-time arc tracking in welding, laser seam positioning and tracking, force control and compensation in contact applications such as assembly, drilling, grinding and polishing, precise control of spray flow and path planning. ◦ Breakthroughs in key technologies such as intelligent learning and optimization of process	◦ Development of an integrated development platform for process applications of industrial robots, including intelligent process planning, data center and virtual simulation platform. ◦ Implementation of more than six typical processes, including welding, painting, grinding, polishing and assembly; with an accuracy rate of more than 95% for simulation and emulation

rules and parameters, intelligent process data center and virtual simulation. ◦ Development of an integrated development platform for process applications of industrial robots.	. ◦ Use of the platform in more than 5 key enterprises in at least three high-end industries; with the sales of more than 500 sets. ◦ Achievement of more than 10 patents for invention applied/gained.

2.4 Intelligent operating system of industrial robots

Research content	Evaluation criteria
◦ Research on open and distributed network control system architecture design, robot universal configuration motion control and dynamic trajectory planning, and self-learning. ◦ Breakthroughs in system multi-task parallel real-time processing, high reliability network control and information security transmission, system multi-awareness fusion and robot control security and other key technologies.	◦ Development of a general-purpose industrial robot intelligent operating system with at least one real-time task interface within 2ms. ◦ Realization of Integration of system with application algorithm library; with the average algorithm time of < 50ms. ◦ Verification of system application in more than 2 typical scenarios. ◦ Use of more than 2000 sets of system in robots made in China. ◦ Achievement of more than 10 patents for invention applied/gained.

3. Industrial robots

3.1 Automation line and application demonstration of full-process robots for painting high-speed train bodies in white

Research content	Evaluation criteria
◦ Research on automatic body positioning and measurement technology, automatic sandblasting, automatic robot spraying of primer/putty/intermediate paint/finish and putty/paint robot adaptive polishing process. ◦ Breakthroughs in key technologies such as high precision and efficient calibration and measurement, spraying operation planning, adaptive force control and automatic identification of defects of weak characteristic coating. ◦ Establishment of an automated production line for painting robots for rail vehicles.	◦ Development of high precision and efficient visual measurement system for vehicle bodies with the measurement resolution of 0.05mm (depth direction) and the measurement efficiency of ≥ 4.7m²/min. ◦ Realization of the coverage of automated operation for surface putty and paint (>95%). ◦ Improvement of operation efficiency by 20% over manual operation. ◦ Achievement of more than 10 patents for invention applied/gained. ◦ Establishment of more than two enterprise standards..

3.2 Flexible integrated manufacturing system and application demonstration for power battery pack multi-robot

Research content	Evaluation criteria
◦ Research on key technologies such as automatic welding of battery modules, automatic gluing of cases, collaborative human-machine operation of fasteners and agile production of mixed rows of multiple species. ◦ Establishment of a flexible manufacturing system for collaborative operation of multi-category power battery pack robots.	◦ Development of a multi-robot flexible integrated manufacturing system for power battery packs, including robotic flexible work cell workstations for assembly, welding, gluing, fastening and testing. ◦ Realization of robot demonstration on more than 3 production lines. ◦ Use of more than 50 sets of robots applied to each line in 3 categories. ◦ Achievement of more than 10 patents for invention applied/gained. ◦ Establishment of more than two enterprise standards.

3.3 Automated production line and application demonstration of robots for woven material industry

Research content	Evaluation criteria
◦ Research on the key technologies such as ro botized yarn management, finding yarn head s, yarn hanging, yarn threading etc. ◦ Breakthroughs in key technologies such as a daptive end-effector design for weaving robot s, large-load weaving axis transfer and dexte rous operation in restricted spaces, and fabri c defect detection and real-time disposal. ◦ Development of a series of special robots for weaving material operation and robot automa ted production system for complex productio n process of weaving materials.	◦ Development of domestic robot automated pr oduction line for the weaving material industr y, with quality inspection, fault detection, proc ess information, data traceability and other fu nctions. ◦ Realization of more than 3 application demon strations of domestic robot automation produ ction line; with more than 10 robot application s (including the textile-specific robots to be d eveloped under the project). ◦ Achievement of more than 10 patents for inv ention applied/gained.

4. Service robots

4.1 R&D of robotic system for assisting spinal laminectomy surgery

Research content	Evaluation criteria
◦ Research on key technologies such as auton omous planning, human-machine collaborati on, safe and effective local autonomous oper ation of the vertebral plate decompression su rgery robot. ◦ Research on robot clinical operation specifica tion and operating room compatibility design.	◦ Obtaining a Class III medical device license f or a complete robotic system for assisted spi nal laminectomy. ◦ Realization of automatic robotic planning and local autonomous operation. ◦ Verification of robotic system on more than 6 0 clinical demonstration applications in more t han 5 hospitals with the product technology m aturity of ≥ level 8. ◦ Achievement of more than 5 patents for inve ntion applied/gained.

4.2 R&D of robotic system for soft tissue puncture surgeries such as lungs

Research content	Evaluation criteria
◦ Research on the ease of use, stability and cli nical adaptability of the puncture treatment s urgery robot to improve the clinical surgical c apability of the product. ◦ Breakthrough in high reliability and high safet y guarantee technology for surgical robots to realize the reliability design of the whole mac hine. ◦ Research on the clinical operation specificati on and operating room compatibility design f or thoracoabdominal puncture oriented to lun g, liver or kidney to improve clinical adaptabil ity.	◦ Obtaining a Class III medical device license f or the lung puncture surgery robot system. ◦ Verification of robotic system on more than 6 0 clinical demonstration applications in more t han 5 hospitals with the product technology m aturity of ≥ level 8. ◦ Preparation and submission of clinical trial ca ses and clinical trial reports. ◦ Achievement of more than 5 patents for inve ntion applied/gained.

4.3 Brain neurointerventional nuclear magnetic image guidance (NMR) compatible puncture robot technologies and systems

Research content	Evaluation criteria
◦ Research on NMR-compatible cerebral neuro interventional robot system design, NMR ima ge processing and real-time navigation, cere bral neurointerventional surgery design and 3 D path planning of puncture needle, precision control, and safety assurance technology. ◦ Development of a prototype NMR-compatible	◦ Achievement of Cerebral neurointerventional puncture robotic system compatible with 3T M RI scanner. ◦ Verification of robotic system on 10 live anim als and 5 human specimens under NMR navi gation with the product technology maturity o f ≥ level 7.

puncture robot system for neurological interventions in the brain of animal and human specimens.	◦ Achievement of more than 5 patents for invention applied/gained.

4.4 Fundus microinjection surgery robot technologies and systems

Research content	Evaluation criteria
◦ Research on microinjection robot mechanism in the confined space of the closed eye to achieve precise and flexible operation under minimally invasive conditions; Optical Coherence Tomography (OCT) and microscopic image fusion technology for precise targeting; Complex soft tissue robotic precision microinjection technology to achieve microscopic precision injection in the fundus.	◦ Development of a robotic system for fundus microinjection surgery. ◦ Verification of robotic system on more than 10 live animals with a success rate of ≥ 90%; with the product technology maturity of ≥ level 7. ◦ Achievement of more than 5 patents for invention applied/gained.

4.5 Percutaneous spinal endoscopic surgery robot technologies and systems

Research content	Evaluation criteria
◦ Research on key technologies such as rigid-flexible coupling robot mechanism adapted to the needs of spinal endoscopic surgery, multi-source information perception and image fusion in narrow water environment, vision-enhanced guidance and human-machine cooperative safety control. ◦ Development of a robotic system for spinal endoscopic operation in confined spaces to realize surgical operation functions such as peeling, probing, clamping, cautery and cutting under spinal endoscopy.	◦ Realization of dexterous and delicate operations such as endoscopic stripping, probing, clamping, cautery and cutting. ◦ Verification of robotic system on 10 live animals and 5 human specimens with a success rate of ≥ 90%; with the product technology maturity of ≥ level 7. ◦ Achievement of more than 5 patents for invention applied/gained.

4.6 Intelligent Traditional Chinese Medicine (TCM) acupuncture robot technologies and systems

Research content	Evaluation criteria
◦ Research on the key technologies such as robot dexterity mechanism, state perception and fine control of robotic humanoid acupuncture operation, digital modeling and automatic identification of acupuncture points under image guidance, automatic positioning planning of acupuncture points. ◦ Development of an intelligent TCM acupuncture robot system to realize animal and human application verification.	◦ Development of an autonomous acupuncture robot system for indications including nerve injury, urinary incontinence, and pain treatment. ◦ Verification of acupuncture robot system on more than 10 cases of animal and 20 cases of human; with the product technology maturity of ≥ level 7. ◦ Achievement of more than 5 patents for invention applied/gained.

4.7 Acquired debilitating rehabilitation robot technologies and systems for critical illnesses

Research content	Evaluation criteria
◦ Research on the interaction technology of multimodal information fusion of vision, haptics, electrophysiology and ultrasound to achieve patient cognitive state recognition, behavioral intention understanding and human-computer interaction control; Assisted respiratory rehabilitation assessment and treatment technology, muscle function recovery method with precise electrical stimulation, variable configuratio	◦ Development of wearable system for collecting physiological and morphological information such as EEG, EM, and ultrasound; cognitive state and intention recognition categories (≥ 20); correct recognition rate (≥ 90%). ◦ Development of robotic platform for assisting patients to complete the autonomous conversion of sitting, standing positions, and self-balancing walking with the active drive degrees

n robot creation method.	of freedom of ≥ 12. ◦ Verification of robot system on 5 cases of clin ical trials; with the product technology maturit y of ≥ level 7. ◦ Achievement of more than 5 patents for inve ntion applied/gained.

4.8 Urination and defecation ability enhancement training and cleaning robot system for bed-ridden elderly people

Research content	Evaluation criteria
◦ Research on a robot for defecation ability en hancement training with functions of autonom ous diagnosis and assessment, personalized rehabilitation prescription generation, rehabili tation training and effect assessment. ◦ Breakthrough in key technologies such as de fecation intention monitoring, human position recognition and positioning, human-machine contact force control, hip cleaning robot contr ol, system comfort and safety design.	◦ Development of the defecation ability training module; with more than 3 training modes; wit h improved the defecation and urination abilit y (~20%). ◦ Verification of robot system on more than 30 cases; with the accuracy rate of urination and defecation monitoring and early warning (>95 %); with the product technology maturity of ≥ level 7. ◦ Achievement of more than 5 patents for inve ntion applied/gained.

4.9 Single-port cardiac surgery robot technologies and systems

Research content	Evaluation criteria
◦ Research on robot mechanism configuration and end-effector design in confined spaces t o meet surgical operation requirements; High -precision multidimensional force sensing tec hnology to achieve precise force feedback fo r surgical operations; Precise recognition of s urgical targets based on image information to achieve real-time dynamic tracking control of the operative area; ◦ Development of a prototype single-hole cardi ac surgery robot system to realize typical car diac surgery operations such as internal mam mary artery acquisition and mitral valve surge ry.	◦ Development of a single-hole cardiac surgery robotic system with a flexible end surgical act uator with the single-hole channel diameter (≤ 30 mm), three multifunctional instruments, more than six surgical actuator end degrees o f freedom, surgical actuator positioning accur acy (≤ 1mm), surgical actuator end effective o peration force (≥ 3 N), and force sensing acc uracy (< 0.1 N). ◦ Verification of robotic system on 10 live anim als; with the product technology maturity of ≥ level 7. ◦ Achievement of more than 5 patents for inve ntion applied/gained.

5. Special robots

5.1 Large hydropower dam underwater intelligent defect detection robot system

Research content	Evaluation criteria
◦ Research on key technologies such as lightw eight structure design of underwater inspecti on robots, inertial autonomous positioning an d navigation technology, dam defect measur ement and identification, underwater anti-dist urbance motion control, underwater power su pply and communication, remote operation a nd local autonomous fusion. ◦ Research on robot clinical operation specifica tion and operating room compatibility design.	◦ Development of large hydropower dam under water intelligent defect detection robot with th e maximum working depth of ≥ 300m, the dir ectional positioning accuracy of < 1°, the dist ance positioning accuracy of < 0.5% slope di stance, the depth positioning accuracy of < 0 .05%, and the speed estimation accuracy of < 0.5%. ◦ Verification of robot performance in large da m based on the defect measurement area err or of ≤ 5%, the volume error of ≤ 10% and th e defect positioning error of < 0.5 m; with the product technology maturity of ≥ level 7. ◦ Achievement of more than 10 patents for inv ention applied/gained.

5.2 Key technology and application demonstration of high-speed robot for Mini LED mega-volume transfer

Research content	Evaluation criteria
◦ Research on one-time, high-speed, precise and stable giant transfer methods for Mini LEDs. ◦ Research on key technologies such as lightweight design of intermittent motion transfer robots with ultra-high speed, high precision and high frequency, multi-source error transfer and compensation, fatigue life design under alternating load, and system vibration suppression under high frequency excitation.	◦ Development of High-speed robot system for Mini LED mega-transfer with X, Y axis positioning accuracy (≤ 5μm), maximum transfer target area (≥ 1450mm × 850mm), minimum transfer chip (≤ 125μm × 75μm), transfer speed (≥ 180,000pcs/hour), and chip transfer accuracy (15@3σ). ◦ Verification of robot system performance in at least 15 application demonstrations. ◦ Achievement of more than 5 patents for invention applied/gained.

IFR International Federation of Robotics

A02 Japan

<table>
<tr><td>Title</td><td colspan="2">New Robot Strategy – Japan’s Robot Strategy</td></tr>
<tr><td>Region</td><td colspan="2">Japan</td></tr>
<tr><td>Issued by</td><td colspan="2">The Headquarters for Japan’s Economic Revitalization</td></tr>
<tr><td>Announcement</td><td colspan="2">January 23, 2015</td></tr>
<tr><td>Term of validity</td><td colspan="2">2016 – 2020</td></tr>
<tr><td>Budget</td><td colspan="2">842 million USD (95.7 billion JPY) for 2022</td></tr>
<tr><td>Keywords</td><td colspan="2">Robot Revolution Initiative, New Robot Strategy, Connected Industry, Society 5.0</td></tr>
<tr><td rowspan="4">Related website</td><td>New Robot Strategy</td><td>https://www.meti.go.jp/committee/kenkyukai/seizou/robot_competition/pdf/001_se02_00.pdf</td></tr>
<tr><td>Robot Revolution Initiative</td><td>https://www.jmfrri.gr.jp/english/outline/</td></tr>
<tr><td>Fukushima Robot Test Field</td><td>https://www.fipo.or.jp/robot/</td></tr>
<tr><td>World Robot Summit</td><td>https://worldrobotsummit.org/en/</td></tr>
<tr><td>Background</td><td colspan="2">◦ Research and development of humanoid robots in Japan began in the 1970s, centered on universities and companies, and accelerated with the development of IT technology in the 1990s.
◦ In 1995, the Japanese government began supporting the research and development of humanoid robots.
◦ With ASIMO and HRP, Japan was recognized as being the world leader in humanoid 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 the 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 is investing in the development of intelligent robots with AI and IoT as part of the New Robot Strategy.</td></tr>
<tr><td>Goal</td><td colspan="2">◦ 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 and of autonomous accumulation and utilization of data by such robots
◦ To globally standardize Japan’s robot technologies</td></tr>
<tr><td>The latest R&D project</td><td colspan="2"></td></tr>
<tr><td>The key targets of the latest R&D project</td><td colspan="2"></td></tr>
</table>

Contents

1. Definition of Robot Revolution.

- Turning what used not to be positioned as 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 reinforcement 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. Robot Revolution & Industrial IoT Initiative (RRI)

◦ Established in May 2015, its goal is to promote the New Robot Strategy in a cross-cutting way with the participation of a diversity of relevant trade associations, enterprises, academic communities, and research institutions and in coordination with relevant government agencies. It has 3 working group: (1) Manufacturing Business Revolution through IoT; (2) Promotion of Robot Utilization in Society; (3) Robot Innovation.

3.2. Fukushima Robot Test Field

◦ In Minamisoma city & Namie Town, this test field opened partially in July 2018 and fully in March 2020. Test facilities such as Airfield safety net, disaster-affected city, water tank, road with debris, etc. are equipped to research and test for robots and drones (disaster response, structural inspection, delivery, etc.)
◦ As of October 2020, 21 universities, research institutes, and companies related to drones, robots, mobility, non-destructive inspection, etc. have moved into the research building, and full-scale demonstration tests have begun.

3.3. World Robot Summit

◦ WRS 2020 was postponed by FY2021 due to COVID 19, and the specific date is not determined yet. Even after the postponement, the title "World Robot Summit 2020" will be continued to use.
◦ WRS 2020 originally was scheduled to be taken a place in Aichi International Exhibition Center and Robot Test Field located in Fukushima Prefecture in October 2020. Two themes are introduced: (1) World Robot Challenge: Industrial Robotics, service Robotics, disaster robotics, etc. (2) World Robot Expo: Exhibition of the latest robot technology.

4. Robotics R&D projects budgets FY2022 by sectors

Sector	Project	Budget (M USD)	Budget (B JPY)	Ministry
Manufacturing & Service (77.88 M USD)	Project for the realization of an energy-saving society in which robots and drones play an active role (Website: https://www.nedo.go.jp/activities/ZZJP2_100080.html)	1.681	0.191	METI
	Development of integrated technologies that will be the core of next-generation artificial intelligence and robots (Website: https://www.nedo.go.jp/activities/ZZJP_100138.html)	12.32	1.4	METI
	Strategic Innovation Creation Program (SIP) Phase 2/Automated driving (Website:	21.639	2.459	METI

		https://www.nedo.go.jp/activities/ZZJP_100159.html)			
		Realization of Advanced Air Mobility Project: ReAMo Project (Website: https://www.nedo.go.jp/activities/ZZJP2_100181.html)	25.784	2.93	METI
		Innovative Robot R&D Platform Construction Project (Website: https://www.meti.go.jp/main/yosangaisan/fy2022/pr/ip/sangi_10.pdf)	16.456	1.87	METI
	Nursing & Medical (55.08 M USD)	Advanced R&D and development system resilience project for medical equipment (Website: https://www.meti.go.jp/main/yosangaisan/fy2022/pr/ip/sangi_16.pdf)	46.376	5.27	METI
		Nursing care robot development acceleration project (Website: https://www.mhlw.go.jp/wp/yosan/yosan/22syokan/dl/01-02.pdf)	8.712	0.99	NHLW
	Infrastructure, Disaster Response, Construction (643.28 M USD)	Fukushima Robot test field (Website: https://www.meti.go.jp/main/yosan/yosan_fy2022/pr/fu/fukko_03.pdf)	92.4	10.5	METI
		Project to promote practical development of regional reconstruction (Website: https://www.meti.go.jp/main/yosangaisan/fy2022/pr/fu/fukko_02.pdf)	550.88	62.6	METI
	Agriculture, Forestry, Fishery (66.25 M USD)	Smart Agriculture Acceleration Demonstration Project (Website: https://www.affrc.maff.go.jp/docs/smart_agri_pro/kanren/yosan/R4Tousho-1.pdf)	3.335	0.379	MAFF
		Demonstration of smart agricultural production area model (Website: https://www.affrc.maff.go.jp/docs/smart_agri_pro/kanren/yosan/R4Tousho-2.pdf)	3.08	0.35	MAFF
		Development and demonstration of smart agricultural technology (Website: https://www.affrc.maff.go.jp/docs/smart_agri_pro/kanren/yosan/smt-agri-PR-R4hosei.pdf)	38.72	4.4	MAFF
		Improving the productivity of livestock farming entities using ICT (Website: https://www.maff.go.jp/j/budget/r4kettei.html https://www.maff.go.jp/j/budget/pdf/r4kettei_juten.pdf)	8.8	1.0	MAFF
		Comprehensive promotion measures for smart agriculture (Website: https://www.maff.go.jp/j/budget/pdf/r4kettei_juten.pdf)	12.32	1.4	MAFF

Title	**Projects in the Robotics and Artificial Intelligence Fields**
Region	Japan
Issued by	New Energy and Industrial Technology Development Organization
Announcement	September 2022
Term of validity	
Budget	Robotics-related projects for 2022: 67.48 million USD (7.68 billion JPY)

Keywords	Projects in the Robotics and Artificial Intelligence Fields, Moonshot program	
Related website	Projects in the Robotics and Artificial Intelligence Fields 2022	https://www.nedo.go.jp/content/100885591.pdf
	Moonshot program	https://www8.cao.go.jp/cstp/english/moonshot/top.html https://www8.cao.go.jp/cstp/english/moonshot1.pdf
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2. Development of UAV Traffic Management System and collision avoidance technologies (completed in FY2021)
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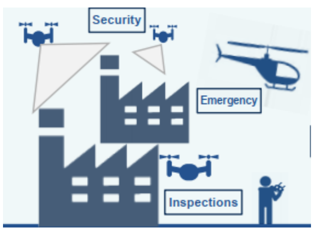
<td>
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1. Development and evaluation of automated driving systems (FOTs: Field Operational Tests)
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2. Moonshot Research and Development Program

- Period: 2020-2025 (up to 10 years if it is decided to continue after 5 years)
- 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.
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- Goal #5: Creation of the industry that enables sustainable global food supply by exploiting unused biological resources by 2050.
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- 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.

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:

Project title	Overview
The Realization of an Avatar-Symbiotic Society where Everyone can Perform Active Roles without Constraint	◦ This project aims to realize an avatar-symbiotic society in which cybernetic avatars allow everyone to perform active social roles without constraint. ◦ Through the teleoperation of multiple CAs that can fully transmit the user's actions, intentions, and reactions in scenarios which feature hospitality-rich dialogue, the user will be able to take part in various social activities (work, education, medical care, daily life, etc.)
Liberation from Biological Limitations via Physical, Cognitive and Perceptual Augmentation	◦ This project aims to develop cybernetic avatars that can be controlled via intention. ◦ This intention will be estimated from brain activities and information observed on the surface of the human body and through interactions
Cybernetic Avatar Technology and Social System Design for Harmonious Co-experience and Collective Ability	◦ This project aims to develop cybernetic avatar technologies that allow people to take full advantage of their abilities and share their variety of skills and experiences with many other people. ◦ Taking into account the social and ethical issues involved in the mutual utilization of physical skills and experiences, a system that fits well with humans and society will be designed.

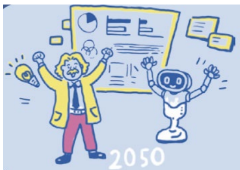
◦ Website: https://www8.cao.go.jp/cstp/english/moonshot/sub1_en.html

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.
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◦ R&D projects:

Project title	Overview
Smart Robot that is Close to One Person for a Lifetime	◦ This project aims to establish robot evolution technology that combines flexible machine hardware and unique AI that can understand many kinds of tasks ◦ The final goal is to build a human-robot symbiotic society by introducing a general-purpose AI robot that can work with people not only in housework and customer service but also in welfare and medical fields where human resources will be in short supply by 2050
Innovation in Construction of Infrastructure with Cooperative AI and Multi-Robots Adapting to Various Environments	◦ This project aims to develop collaborative AI robots that respond to various situations flexibly and perform given tasks in challenging environments such as disaster sites or the moon ◦ By 2050 these collaborative AI robots will, on behalf of humans, conduct emergency response missions following natural disasters and construct lunar bases
Co-evolution of Human and AI-Robots to Expand Science Frontiers	◦ This project aims to develop AI-robots that conduct scientific experiments in challenging environments (e.g. in a hazardous atmosphere, or in a micro-scale setup), while interacting with scientists as their peers. ◦ A system that fits well with humans and society will be designed.
Adaptable AI-enabled Robots to Create a Vibrant Society	◦ This project aims to create a collective of adaptable AI-enabled robots available at a variety of places. Each robot will be usable by anyone at any time, and will adjust its form and functions according to the individual user to provide optimal assistance and services

◦ Website: https://www8.cao.go.jp/cstp/english/moonshot/sub3_en.html

Title	**Projects in the Robotics and Artificial Intelligence Fields**
Region	Japan
Issued by	New Energy and Industrial Technology Development Organization
Announcement	September 2022
Term of validity	
Budget	Robotics-related projects for 2022: 67.48 million USD (7.68 billion JPY)
Keywords	Projects in the Robotics and Artificial Intelligence Fields, Moonshot program
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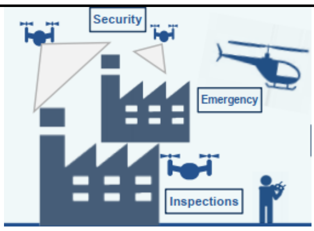
<td>

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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
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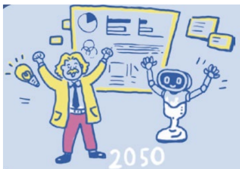
	◦ Development of AI robots that humans feel comfortable with, have physical abilities equivalent to or greater than humans, and grow in harmony with human life, by 2050. ◦ Development of AI robots that behave well with humans under certain conditions and allow over 90% of people to feel comfortable with 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:

Project title	Overview
Smart Robot that is Close to One Person for a Lifetime	◦ This project aims to establish robot evolution technology that combines flexible machine hardware and unique AI that can understand many kinds of tasks ◦ The final goal is to build a human-robot symbiotic society by introducing a general-purpose AI robot that can work with people not only in housework and customer service but also in welfare and medical fields where human resources will be in short supply by 2050
Innovation in Construction of Infrastructure with Cooperative AI and Multi-Robots Adapting to Various Environments	◦ This project aims to develop collaborative AI robots that respond to various situations flexibly and perform given tasks in challenging environments such as disaster sites or the moon ◦ By 2050 these collaborative AI robots will, on behalf of humans, conduct emergency response missions following natural disasters and construct lunar bases
Co-evolution of Human and AI-Robots to Expand Science Frontiers	◦ This project aims to develop AI-robots that conduct scientific experiments in challenging environments (e.g. in a hazardous atmosphere, or in a micro-scale setup), while interacting with

	scientists as their peers. ◦ A system that fits well with humans and society will be designed.
Adaptable AI-enabled Robots to Create a Vibrant Society	◦ This project aims to create a collective of adaptable AI-enabled robots available at a variety of places. Each robot will be usable by anyone at any time, and will adjust its form and functions according to the individual user to provide optimal assistance and services

◦ Website: https://www8.cao.go.jp/cstp/english/moonshot/sub3_en.html

A03 Korea

Title	The 3rd Basic Plan on Intelligent Robots
Region	Korea
Issued by	Ministry of Trade, Industry and Energy, Related Departments Jointly
Announcement	August 29, 2019
Term of validity	2019 - 2023
Budget	126 million USD (151,590,000,000 KRW) for 2020
Key words	◦ 3 Manufacturing businesses: Root, Textile, Food and Beverage etc. ◦ 4 Service robot areas: Care, Wearable, Medical Care, Logistics ◦ Next-generation key components and SW: Driver, Sensor, Controller, SW ◦ 3 Key components: Intelligent controller, Autonomous Mobile Sensor, Smart Gripper ◦ 4 Key SW: Robot SW Platform, Gripping Technology SW, Image Information-Processing SW, HRI Technology
Related website	http://www.motie.go.kr/motie/ne/announce2/bbs/bbsView.do?bbs_cd_n=6&biz_anc_yn_c=Y&bbs_seq_n=65584
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 in Korea

Manufacturing robot	◦ Market emergence of cooperation robots ◦ The cooperation robot market is emerging
Service Robot	◦ Growth primarily with cleaning robots ◦ Now at the early formative stages of the next-generation market(logistics, medical robots, etc.)
Component/SW	◦ Key components dependent on imports ◦ Rapid growth of the robot software market

2. Promotion Status and Evaluation

2.1. Technology development

- While the level of technology has been improved, market-leading products and technologies are lacking.
- Compared with the manufacturing robot area, more than 3 times more has been invested in the new service robot areas.

< Support Status for Development of Robot Technology (Unit: 1 M USD)>

	'10	'11	'12	'13	'14	'15	'16	'17	'18	Total	Ratio
Manufacturing	8.1	4.9	10.8	10.4	8.1	6.9	4.5	6.1	5.9	65.6	12.4%
Service	14.1	22.4	16.7	23.6	24.4	27.2	25.3	31.1	32.3	217.1	41.1%
Component/SW	25.7	29.3	27.7	21.5	22.8	23.6	28.1	33.7	33.1	245.4	46.5%
Total	47.9	56.6	55.2	55.5	55.2	57.7	57.9	70.9	71.3	528.2	100%

2.2. Infrastructure

- While the foundation for commercialization of new technologies has been prepared, its utilization is poor.
- The regulation sandbox system has been recently incorporated (January 2019)

< Robot as subject of review for regulation sandbox >

Robot	Outdoor delivery Robot	Underwater robot	Home rehabilitation robot	Agricultural robot
Picture				
Difficulty	Mobile road standard missing	Overall precision diagnosis for marine structures not allowed	Remote rehabilitation with home rehabilitation robot not allowed	Test and approval standards absent Government support not allowed

3. Differences from the 1st and 2nd Basic Plans

- (1st, 2nd Plan) Construction of government-led support system, support areas and growth foundation for growth of robot industry.
- (3rd Plan) Implementation of systematic dissemination and diffusion through choice and concentration for promising areas as well as role assignment for government and civilians

< Differences from the 1st and 2nd Basic Plans >

	1st and 2nd Plan	3rd Plan
Support system	◦ Establishment and implementation of policies led by the government ◦ KRW 628.8 billion incorporated in robot technology R&D for 10 years with improvement of technology level	◦ (Government) Development of standard models → Leading of dissemination → Education of users ◦ (Civilian) Diffusion of autonomy through support of rental/lease service, etc.
Support area	◦ Wide support of areas including formation of existing market (manufacturing, education and cleaning robots) and having prospect of growth (agriculture and exploration robot, construction and dismantling robot, etc.)	◦ Support of promising areas through choice and concentration - Expanded dissemination with focus on three largest manufacturing businesses - Concentrated cultivation of four largest service robot areas - Independence of three largest key components and four greatest software technologies

Growth foundation	◦ Focus on construction of system and support institutions	◦ Focus on excavation and improvement of regulations, etc

4. Implementation Tasks

4.1. Expanded Dissemination of Manufacturing Robots with a Focus on the 3 Manufacturing Businesses

4.2. Intensive fostering of 4 service robots

< Reasons for Selecting the 4 Service Robot Areas >

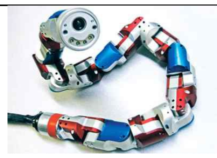
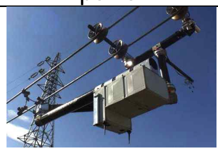
<table>
<tr><th colspan="2">Classification</th><th>Detailed Area</th><th>Reason for selection</th></tr>
<tr><td rowspan="2">Publicly-led

(Government 50%, Local government 50%)</td><td>Care</td><td>· Entry-level meal-assisting robot
· Two arm-type transfer lifting robot
· Excretion care (Bidet) robot</td><td>· Most closely related to our actual life
· Maximum globally-sold quantity
· High domestic industry competence</td></tr>
<tr><td>Wearable</td><td>· Work-supporting robot
· Elderly, disabled-assisting robot</td><td>· Most promising based on long term
· Currently most unexplored area</td></tr>
<tr><td rowspan="2">Civilian-led

(Government 50%, Civilian 50%)</td><td>Medical care</td><td>· AI-based smart operation robot
· Operating robot arm</td><td>· Area with high technology barrier
· High-risk, high-profit area</td></tr>
<tr><td>Logistics</td><td>· Smart logistics-handling robot
· Multiple robot for indoor/outdoor delivery</td><td>· Area with highest growth rate
· Promising utilization such as logistics center, hospital, etc.
· Area with high domestic industry competence</td></tr>
</table>

◦ For the then largest niche market-type areas such as drone-bot, agriculture/exploration robot, etc., technology development and dissemination is supported with leading by the concerned departments such as Ministry of Defense, Ministry of Agriculture, etc.

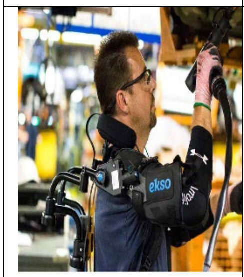
<Collaboration between Ministry of Industry and related departments>

<table>
<tr><th></th><th>National Defense Robot</th><th>Agriculture / Exploration Robot</th><th>Safety Robot</th><th>Inspection maintenance robot</th></tr>
<tr><td>Representative application area</td><td>National defense</td><td>Agriculture and livestock industry, exploration</td><td>Disaster, evacuation</td><td>Energy area, etc.</td></tr>
<tr><td rowspan="4">Robot Product</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mine-removing robot</td><td>Facility-gardening robot</td><td>Exploration robot for disaster area</td><td>Maintenance/repair robot for photovoltaic panel</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>Runway manufacturing robot</td><td>Extreme place robot</td><td>Evacuation robot for disaster area</td><td>Maintenance/repair robot for power cable</td></tr>
<tr><td>Related department</td><td>Ministry of Defense, Defense Acquisition</td><td>Ministry of Agriculture and Forestry, Ministry of Oceans and Fisheries, Ministry of Land, Infrastructure</td><td>National Fire Agency, National Police Agency,</td><td>Ministry of Industry, etc.</td></tr>
</table>

	Program Administration	and Transport, Rural Development Administration, etc.		

* Development of guide robot and entertainment robot is being led by the private sector.

◦ Development of robots in four largest areas → Dissemination and demonstration for socially underprivileged, etc. → Civilian diffusion

Care Robots				
Meal-assisting Robot	Transfer/lifting Robot	Excretion-supporting Robot	Hand Rehabilitation Robot	Dementia Prevention Robot
				
Wearable	Medical Care Robot		Logistics Robot	
Work support	Operation robot	Rehabilitation robot	Indoors	Outdoors
				

◦ Creation of domestic/overseas markets through support for areas such as regulations improvement, overseas entry, etc.

4.3. Reinforcement of Basic Stamina for Robot Industry Ecosystem

◦ Selection of next-generation key components and software for reinforcement of competitiveness of the back industry

(Technology development/performance evaluation) Support independence of the three key next-generation components among 13 hardware components and the four key software components among 7 software components
(Demonstration and dissemination) Support decelerator, motor, motion controller, etc. with high existing support level with focus on demonstration and dissemination

◦ Items of Technology development/performance evaluation, demonstration and dissemination

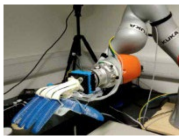
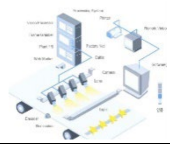
13 H/W Components		next-generation 3 key components
Driver	1. Smart gripper 2. Decelerator 3. Motor 4. Driving module 5. Power transmission device	1. Decelerator 2. Motor
Sensor	6. Autonomous mobile sensor 7. Visual sensor 8. Tactile force sensor 9. Motion sensor 10. Other sensor	

	Controller	11. Intelligent controller 12. Motion controller 13. PC-type controller	3. Motion controller
	7 S/W Components		4 key components
	S/W	1. Robot SW platform 2. Gripping technology SW 3. Image processing 4. HRI SW 5. Simulator 6. Development tool 7. OS for robot	1. Robot SW platform 2. Gripping technology SW 3. Image processing 4. HRI SW

◦ Independence of 3 key next-generation components

Technology	Intelligent controller	Autonomous mobile sensor	Smart gripper
Utilization area	High-performance manufacturing, wearable robot	Manufacturing, logistics, life-supporting robot	High-performance manufacturing, logistics robot
			

◦ Independence 4 key software controlling service competitiveness

Technology	Robot SW platform		Gripping technology SW	Image information-processing SW	HRI technology
Utilization area	Common		Life-supporting, logistics robot	Operation robot	Life-supporting robot
		+			

◦ Promotion of demonstration/dissemination for domestically produced components
◦ Creation of new market by diffusion of robot convergence technology to other industries

< Robotization effects for machines >

Autonomous, active control	Flexibility, customization	Energy reduction·optimization
		
· Smart monitoring · Autonomous, active control	· Modularization of equipment, system · Expansion of robot application · Production of variety, mixed types	· Energy reduction/management · Optimization of manufacturing process

5. Future Implementation Plans

Implementation Task		Period	Remarks
1. Expanded dissemination of manufacturing robots with focus on three key manufacturing businesses			
	Preceding development of 108 robot utilization models per business type and per process	2019-	Collaboration with Ministry of SMEs and Startups
	Consulting and demonstration/dissemination for 10 enterprises per standard model	2019-2023	Collaboration with Ministry of SMEs and Startups
	Robot utilization education for workers with a focus on the enterprises supporting incorporation of manufacturing robots	2019-2023	Collaboration of Ministry of Employment and Ministry of SMEs and Startups
	Induction of autonomous diffusion through purchase support such as rental/lease services, etc.	2020-	
	Conversion from government-led subsidy policy to civilian-centered loan model	2019-	
	Activation of briefings and networks for diffusion of consumer-oriented dissemination/diffusion of robots	2019-	
2. Concentrated cultivation of four key service robot areas			
	Selection of the four key service robot areas with the highest growth potential	Completed	
	Support of technology development/dissemination in the 10 key areas of niche market type	2019-2023	Collaboration of related departments
	Development of the 4 key robots→ Dissemination/demonstration for socially underprivileged, etc.→ Civilian diffusion	2019-2023	Collaboration of related departments
	Creation of domestic/overseas markets through regulations improvement, overseas entry of package type	2019-2023	
3. Reinforcement of basic stamina for robot industry ecosystem			
	Selection of next-generation key components and S/W for reinforcement of competitiveness of rear industry	Completed	
	Independence of three key next-generation components and 4 key software areas	2020-2023	
	Promotion of demonstration/dissemination for domestically-produced components	2020-2023	
	Creation of new markets by diffusion of convergence technology to other industries	2019-2023	Collaboration with Ministry of Science and ICT

Title	**2021 Implementation Plan for the Intelligent Robot**
Region	Republic of Korea
Issued by	Ministry of Trade, Industry and Energy, Related departments Jointly
Announcement	4 May, 2021
Term of validity	
Budget	153 million USD (217 billion KRW)
Key words	Intelligent robot, manufacturing robot, service robot, robot parts
Related website	http://www.motie.go.kr/motie/ms/nt/announce2/bbs/bbsView.do?bbs_seq_n=66748&bbs_cd_n=6
Background	The implementation plan of 2021 for the 3rd basic plan (2019-2023)
Goal	◦ Expand the size of the robotics industry (to KRW 15 trillion by 2023) ◦ Increase the number of robotics companies valued at over KRW 100 billion (20 companies by 2023) ◦ Expand penetration of manufacturing robots (700,000 in cumulative total by 2023)
The latest R&D project	

The key targets of the latest R&D project	
Contents	

1. Analysis of Key Performance in 2020

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

◦ Development of standard robot models

- Additional development of standard process models for using robots in the top three manufacturing industries (root, textile, food and beverage)

Industry type		Process	Title of the standard model
Root (15)	Automotive (4)	Processing	Automotive Parts_Thermoforming Process for the Friction Materials of Brake Pads
		Testing & Inspection	Automotive Parts_Mobile Inspection Process for Brake Pads
		Post Processing	Automotive Parts_Grinding Process for the Backplates of Brake Pads
		Post Processing	Automotive Parts_Washing Process for the Backplates of Automotive Brake Pads
	Machinery (4)	Assembly & Disassembly	Mechanical Parts of Gas Filters_Boling Assembly Process
		Detachment	Mechanical Parts of Air Condition Systems_Input Process for the Electronics
		Detachment	Automotive Engine Parts and Components_Aluminum Die Casting, Ejection and Trimming Process
		Feeding & Loading	Vehicle Body and Automotive Parts of Special Vehicles_Press Feeding Process for Sheet Materials
	Metal & Plastic (4)	Processing	Metal and Special-Purpose Machinery_Arc Welding Process
		Processing	Metal and Automotive Parts_Machine Tending Inspection and Measurement Process
		Processing	Metal Castings_Finishing Process After Casting
		Post Processing	Metal and Plastic Products_Painting Process
	Electric & Electronic (3)	Detachment	Electronic Parts_Printed Circuit Board_Automatic Insertion and Withdrawal: Optical and X-ray Inspection Equipment Process
		Detachment	Electronic Parts_Printed Circuit Board_Operation of Insertion Handle for Surface Treatment Using Chemicals
		Post Processing	Electronic Parts_Printed Circuit Board_Automated and Unmanned Packaging Process (Complex Process)
Textile (4)		Feeding & Loading	Textile & Weaving_Feeding and Loading Processes for Bobbins
		Post Processing	Textile Product Dyeing and Finishing_Solution Supply and Injection Processes
		Feeding & Loading	Other Textile Products_Pickup and Transport Processes
		Post Processing	Other Textile Products_Packaging Process
Food & Beverage (4)		Feeding & Loading	Kimchi_Loading, Unloading and Input Processes
		Detachment	Kimchi_Detachment Core Removal and Cutting Processes
		Assembly & Disassembly	Kimchi_Assembly & Disassembly and Seasoning Mixing Process
		Testing & Inspection	Kimchi_Palletizing Process After Testing and Inspection

1.2. Intensively Nurturing Four Service Robotics Areas

◦ Technical development and distribution in four fields

- Initiatives in 2020 related to the top four service robotics fields, i.e. Care, Wearables, Healthcare, Logistics.

Field	Description	2020 budget
Care	Development of four types of care robots (assistance in transport, excretion, and bedsore prevention)	2.8 million USD (4 billion KRW)
	Translational research on care robots and development of service models (Ministry of Health and Welfare, MOHW)	1.5 million USD (2.2 billion KRW)
Wearables	Development of an exoskeleton robot for paraplegics	0.98 million USD (1.4 billion KRW)
	Development of an upper limb exoskeleton with excellent muscle assistance and wearability for construction workers	0.5 million USD (0.8 billion KRW)
	Development of a robotic suit that can travel 100 m in 7 seconds	0.92 million USD (1.3 billion KRW)
	(New) Development of a cloth-type actuator and clothing type robotics with built-in soft sensors	0.28 million USD (0.4 billion KRW)
Healthcare	Development of a navigation system of a micro robot for brain diseases	0.77 million USD (1.1 billion KRW)
	Development of a dental surgical robot enabling high-precision implant procedures	0.7 million USD (1 billion KRW)
	(New) Development of an AI surgical robotic system for operating on soft tissue in the spine	0.7 million USD (1 billion KRW)
	(New) Development of a robot for assisting in general surgery	0.56 million USD (0.8 billion KRW)
	Technological development for commercialization of micro healthcare robotics (MOHW)	6.1 million USD (8.7 billion KRW)
	Translational research on robotics for rehabilitation (MOHW)	2.6 million USD (3.7 billion KRW)
	(New) Development of a disease control and prevention system incorporated with robotics and ICT to respond to pandemics	1.76 million USD (2.5 billion KRW)
Logistics	Development of an indoor/ outdoor self-driving delivery robot that can move capable of agile maneuvering amid a crowd	1.69 million USD (2.4 billion KRW)
	Development of an Autonomous Mobile Robot (AMR) that can follow humans in the industry and daily life	0.8 million USD (1.2 billion KRW)
	(New) Development of a parking robot for parking convenience and efficient use of parking lots	0.7 million USD (1.0 billion KRW)
	(New) Development of a robot capable of autonomously getting on and off elevators and indoor delivering	0.56 million USD (0.8 billion KRW)
	(New) Development of a system for unloading cargo from transportation vehicles using a robot	0.77 million USD (1.1 billion KRW)

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

- Two new projects for an inspection robot for hazardous materials storage tanks (MOTIE) and high-speed human-machinery synchronization technology (DAPA)

Government department	Description	2020 budget
Ministry of Trade, Industry and Energy (MOTIE)	Development of robot technologies for exploring narrow spaces for search and rescue of people buried in collapsed buildings, etc.	0.63 million USD (0.9 billion KRW)
	Unmanned automation robot capable of monitoring horticultural facilities, harvesting and transporting crops, and controlling disease and pest	0.91 million USD (1.3 billion KRW)
	Smart underwater robots and underwater environment monitoring systems	0.91 million USD (1.3 billion KRW)
	Fault diagnosis and cleaning robot for maintenance of solar	0.98 million USD

	power plants	(1.4 billion KRW)
	(New) Development of a robot system for non-destructive examination of hazardous materials storage tanks	0.56 million USD (0.8 billion KRW)
National Policy Agency (NPA)	Development of a mobile robot for collection and identification of hazardous gases (with the cooperation of MOTIE)	1.06 million USD (1.5 billion KRW)
Ministry of Agriculture, Food and Rural Affairs (MAFRA)	Design of basic mechanisms for an agricultural robot platform for vegetable farms and development of a prototype robot	0.63 million USD (0.9 billion KRW)
Rural Development Administration (RDA)	Improvement of the accuracy of deep learning-based analysis technology of crop growth information	0.85 million USD (1.2 billion KRW)
	Unmanned tractor steering control and autonomous driving technology based on image information analysis of the farming environment	0.35 million USD (0.5 billion KRW)
	Recognition of existence of trees and their shape by applying radar sensors to pest control robots	0.14 million USD (0.2 billion KRW)
Defense Acquisition Program Administration (DAPA)	Performance test and pilot operation of powered exoskeleton	2.7 million USD (3.9 billion KRW)
	(New) Development of high-speed human-machine synchronization control technology	0.07 million USD (0.1 billion KRW)
National Fire Agency (NFA)	Establishment of training test bed to develop robots against chemical terrorism including toxic gases	0.56 million USD (0.8 billion KRW)
Ministry of Oceans and Fisheries (MOF)	Development and field test of a shipboard support system for underwater construction robots	3.5 million USD (5 billion KRW)
Ministry of the Interior and Safety (MOIS)	Creation of a disaster robot simulator and a mobile robot system	0.56 million USD (0.8 billion KRW)
Ministry of Environment (MOE)	Field test and reliability assessment on high-precision probe robotics	1.2 million USD (1.7 billion KRW)

1.3. Bolstering the Ecosystem of the Robotics Industry

◦ New investment (5 billion KRW) in three key components* and four key software fields**

* Intelligent controller, autonomous driving sensor, and smart gripper

** Robotic software platform, grabbing technology software, image information processing software, and HRI technology

Field	Description	2021 budget
Intelligent controller	Development of a general-purposedevice for direct demonstration of hard assembly work	0.77 million USD (1.1 billion KRW)
Smart gripper	Soft morphing robot technology (soft gripper) for assisting workers	0.35 million USD (0.5 billion KRW)
	Development of a multi-purpose soft gripper for automation of agricultural process	0.35 million USD (0.5 billion KRW)
	Development of recognition, gripping, and manipulation technology for flexible cable wiring	0.77 million USD (1.1 billion KRW)
Gripping technology	Development of robotics-based palletizing technology for efficient and safe loading of various types of boxes	0.77 million USD (1.1 billion KRW)
Human-Robotics	Development of shared work framework technology to intelligently respond to atypical work environments	0.49 million USD (0.7 billion KRW)

◦ Infrastructure:
To provide support for performance assessment and certification of next-generation convergence parts and to establish an infrastructure to share facilities for the development of robots
◦ Demonstration and matching:
To provide support for demonstration of ten robotic components for seven robots by matching manufacturers and parts supplies
◦ Industrial convergence:
Development, demonstration, and commercialization of core next-generation robotic technologies fused with artificial intelligence and 5G technology

2. Direction of Implementation in 2021

Objectives	◦ To meet social needs (population reduction, improvement of quality of life, etc.) by disseminating robots that collaborate with humans ◦ To help sharpen the transformation to contactless workplaces and digital transformation of all industries by utilizing robots ◦ To create an environment for utilization of robots by pre-emptive support and expansion of an infrastructure for demonstration

3. Implementation Plan in 2021

3.1. Plan to Expand Penetration of Manufacturing Robots in the Three Key Manufacturing Areas
◦ To sharpen the competitive of robot part industry and to improve its foundation

Development of Standard Models	Pre-emptive distribution	User training	Proliferation of private autonomous activities
Development of standard process models for three key fields and new fields (shipbuilding, aviation, chemical, bio, etc.)	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

3.2. Plan to Intensively Nurture Four Service Robotics Areas
◦ New investment (10.7 billion KRW) in four key service fields centered on resolution of social problems, such as spread of infectious diseases and the surge of transportation volume

Field	Description	2021 budget
Care	Development of semi-autonomous human-following bed robot for quarantine transport of infected patients	0.56 million USD (0.8 billion KRW)
	Development a robotic system to nurse and monitor patients in isolation rooms for infectious disease	0.63 million USD (0.9 billion KRW)
	Development of care robots for facilities of isolation treatment (MOIS)	0.7 million USD (1 billion KRW)
Healthcare	Development of a lightweight wearable rehabilitation robot capable of self-rehabilitation of the upper limbs	0.77 million USD (1.1 billion KRW)
Logistics	Development of a robot-based cargo system for loading and unloading cargo	0.63 million USD (0.9 billion KRW)
	Development of mobile cargo robot technology for efficient operation of korean warehouses	2.1 million USD (3 billion KRW)
Integrated	Development of a field-applicable robot system for creation of Business models (BM) of robot utilization services	2.1 million USD (3 billion KRW)

◦ Development of technologies in key ten fields for niche markets
- New investment (14.5 billion KRW) in nine projects: robots exploring polar regions (MOTIE), intelligent agricultural robots, etc.

Department	Description	2021 budget
MOTIE	Development of a robotics system and an operation system applicable into the polar (Antarctic) environment	0.85 million USD (1.2 billion KRW)
MAFRA	Development of an intelligent agricultural robot for a smart greenhouse	1.3 million USD (1.9 billion KRW)
	Development of harvest robots in the horticultural industry based on collaborative robots	0.56 million USD (0.8 billion KRW)
RDA	Development of robots to determine the ripeness of fruits and to measure the yield by utilizing imaging data	0.98 million USD (1.4 billion KRW)
	Development of smart pest control robots for orchards and research to verify effectiveness and apply it in the field	0.21 million USD (0.3 billion KRW)
	Research on intelligent weed trimmers for apple orchards	0.14 million USD (0.2 billion KRW)
	Research on operation mechanism based on robotics-arms for autonomous harvest	0.07 million USD (0.1 billion KRW)
Korea Coast Guard	Development of an autonomous underwater robotic system for swarming search and rescue in maritime accidents	1.48 million USD (2.1 billion KRW)
MOE	Development of technology for contactless collection and disposal of medical waste	4.5 million USD (6.5 billion KRW)

3.3. Plan to Bolster the Ecosystem of the Robotics Industry
◦ New investment (2.2 billion KRW) in two projects to develop key technologies for intelligent controllers and smart grippers

Field	Description	2021 budget
Gripper	Development of recognition technologies and grippers capable of grasping objects with various shapes and materials	0.85 (1.2 billion KRW)
Controller	Development of 5kHz or higher general-purpose intelligent robotic controllers taking account of operators' safety	0.7 (1 billion 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

4. List of Projects

Category	Project		Supervising gov. dept.	Budget million USD (100 million KRW)	
				2020	2021
1. Plan to	1-1	Develop 108 robot utilization models	MOTIE, MSS	4.5	7.7

Expand Penetration of Manufacturing Robots in the Three Key Manufacturing Areas		for each industry and process		(65)	(109)
	1-2	Provide consulting, perform demonstration, and distribute to 10 enterprises for each standard model	MOTIE, MSS	16.7 (237)	28.7 (407)
	1-3	Train the employees of enterprises adopting manufacturing robots	MOTIE, MOEL	1.7 (25)	2.2 (32)
	1-4	Provide support for buyers through rental/lease service and induce dissemination in the private sector	MOTIE	0.07 (1)	0.07 (1)
	1-5	Transition to civil loan models from national subsidy policies	MOTIE	-	-
	1-6	Strengthen briefing sessions and networks for proliferation of robots centered on users	MOTIE	-	-
2. Plan to Intensively Nurture Four Service Robotics Areas	2-1	Select four service robotics areas with high growth potential	Inter-departmental collaboration	-	-
	2-2	Provide support for the development and proliferation of technologies in ten key field in niche markets	MOTIE, NPA, MAFRA, RDA, DAPA, NFA, NCG, MOF, MOIS, MOE	15.7 (223)	22.5 (319)
	2-3	Develop robots in four fields → Distribute to the socially disadvantaged and minority and field assessment→ Proliferation in the private sector	MOTIE, MIST, MOHW, MOIS	34 (482)	52 (738)
	2-4	Create domestic and international markets by supporting deregulation and package-type overseas expansion	MOTIE	0.98 (14)	0.98 (14)
3. Plan to Bolster the Ecosystem of the Robotics Industry	3-1	Select key next-generation parts and software to sharpen the competitiveness of rear industries	MOTIE	-	-
	3-2	Promote self-support in the three next-generation key parts and four key software technologies	MOTIE	4.9 (70)	7.9 (113)
	3-3	Promote field assessment and proliferation of domestically produced parts	MOTIE	2.1 (31)	2.7 (39)
	3-4	Create new markets by proliferating robot convergence technologies across other industries	MOTIE, MIST	18.1 (257)	28.1 (398)
Total				99.2 (1,405)	153.2 (2,170)

Title	**2022 Implementation Plan for the Intelligent Robot**
Region	Korea
Issued by	Ministry of Trade, Industry and Energy, Related Departments Jointly
Announcement	7 March, 2022
Term of validity	
Budget	172.23 million USD (244 billion KRW)

Key words	Intelligent robots, Manufacturing and service industry innovation through robots
Related website	http://www.motie.go.kr/motie/ms/nt/announce3/bbs/bbsView.do?bbs_cd_n=6&bbs_seq_n=67423
Background	The implementation plan of 2022 for the 3rd basic plan (2020-2023)
Goal	◦ Expansion of the market size of the robotics industry (KRW 15 trillion by 2023) ◦ Increase of the number of companies specializing in robotics valued at over KRW 100 billion (at least 20 companies by 2023) ◦ Expansion of the manufacturing robot number (cumulative 700,000 units by '23)
The latest R&D project	Project for Full-scale Test Platform of Special-purpose Manned or Unmanned Aerial Vehicles (announced on 19 April, 2022)
The key targets of the latest R&D project	◦ To establish an infrastructure for full-scale tests of special-purpose manned or unmanned aerial vehicles ◦ To establish a network and a technical support system ◦ To nurture technical manpower and support industry education

Contents

1. Analysis of Key Performance in 2021

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

◦ Development of standard robot models

- Prior development of standard models focused on the three major manufacturing industries (fundamental, fiber, food and beverage)

◦ Additional development

- 26 standard process models in major manufacturing areas (fundamental, fiber, food and beverage) and 9 for new industries (shipping and aviation).

* Development of standard process models: 14 in 2019 ⇨ 23 in 2020 ⇨ 35 in 2021

Industry type		Process	Title of the standard model
Funda-mental (18)	Automotive (5 models)	Post-processing	Contaminant removal process
		Assembly/ Disassembly	Application process
		Processing	Projection and inspection process
		Testing/Inspection	Missing product detection process
		Testing/Inspection	Riveting and operation inspection process
	Machinery (4 models)	Assembly/ Disassembly	Gas Filter Mechanical Parts: Bolting assembly process
		Post-processing	Air Condition System Mechanical Parts: Packaging process for electronics manufacturing tray
		Post-processing	Automotive Parts for New Engines: Deburring Process
		Processing	Vehicle Body and Special Vehicle Exterior Panel Parts: Discharge and riveting process for semi-products
	Metal/Plastic (6 models)	Post-treatment	Metal/Automotive Parts: Casting post-treatment process
		Detachment/Inspection	Loading/unloading and inspection processes of injection-molded plastic parts
		Detachment	Welding quality inspection process on arc welding for special-purpose machinery
		Processing	Metal/Automotive Parts: Welding quality inspection process on resistance welding process
		Processing	Metal/Automotive Parts: Re-processing process associated with machine tending
		Processing	Metal/Plastic Parts: Plating rack loading/unloading process
	Electrical & Electronic (3 models)	Transport/loading process	Non-standard parts mounting process
		Testing/Inspection	Assembled PCB inspection process
		Post-processing	PCB coating agent application process
Textile		Post-processing	Dyeing and Finishing: Shrink packaging process

(4)		Transport/loading process	Dyeing and Finishing: Cart loading process
		Detachment	Other textile products: Fabric/roll mounting process
		Transport/loading process	Other textile products: Transporting/loading sheets
Food & beverage (4)		Transport/loading process	Meal replacement: Transporting/loading process
		Detachment	Meal replacement: Detachment process
		Assembly/Disassembly	Meal replacement: Assembly/disassembly process
		Testing/Inspection	Meal replacement: Testing & inspection process (encasing)
New (9)	Shipping (3 models)	Processing	Mobile welding process to replace hand-welding
		Post-processing	Small plate round cutting (RC) process
		Testing/Inspection	Automatic recognition inspection process for round cutting (RC)
	Aviation (3 models)	Post-processing	Shaping process after hardening: Trimming
		Post-processing	Lightweight structure polishing process: Deburring
		Processing	Machining process after composite lamination: Cutting
	Bio/ Chemistry (3 models)	Transport/loading process	Bio/Pharmaceutical Products: Packaging process (transport and loading)
		Transport/loading process	Bio/Medical Device: Packaging/inspection process
		Transport/loading process	Chemical Container/Plastic: Packaging process (transport and loading)

1.2. Intensive Promotion of Four Service Robotics Areas

◦ Technical development and distribution in four fields

- Developed technologies related to the top four service robotics fields, i.e. logistics, healthcare, caregiving, and wearables
- Development of new robots for infectious disease response and logistics

Field	Description	2021 budget
Caregiving	(New) Development of a human-following semi-autonomous robotic bed for the isolation of infected patients	0.6 million USD (0.9 billion KRW)
	(New) Development of nursing assistance and patient monitoring robotic systems for infection isolation wards	0.6 million USD (0.8 billion KRW)
	(New) Development of caregiving robots for isolation treatment facilities (MIS)	705 million USD (1 billion KRW)
Wearables	Development of soft sensor-embedded fabric-based actuators and garment-type robotic technology	494 million USD (0.7 billion KRW)
Healthcare	Development of an artificial intelligence-based robotic system for spinal hard tissue surgeries	1.1 million USD (1.6 billion KRW)
	Development of surgical assistant robots for general operations	0.8 million USD (1.2 billion KRW)
	Development of pandemic response robots and ICT convergence-based disease prevention & control system(MSIT)	2.7 million USD (3.9 billion KRW)
	(New) Development of a lightweight wearable rehabilitation robot for self-rehabilitation of arms	0.8 million USD (1.1 billion KRW)
Logistics	Development of parking robots that provide parking convenience and improve spatial efficiency	1.3 million USD (1.8 billion KRW)
	Development of robotic systems for autonomous elevator operations and indoor deliveries	0.8 million USD (1.2 billion KRW)
	Development of robot-enabled unloading system for trunk cargo transport vehicles	1.1 million USD (1.6 billion KRW)
	(New) Development of technology for a robot-based cargo loading system	0.3 million USD (0.5 billion KRW)

	(New) Development of mobile logistics handling robotic tech. to streamline operations at Korean-style logistics warehouses	2.1 million USD (3 billion KRW)
Integrated	(New) Development of field-applied robotic systems for implementing business models for robotics services	2 million USD (2.9 billion KRW)

◦ Technical Development in 10 Fields as "Niche Markets"
- Development of technologies in response to the demands of the government departments
- 9 new projects such as robots for polar environments (MOTIE), agricultural robots (MAFRA), and swarm search robots (KCG)

Government department	Description	2021 budget
Ministry of Trade, Industry & Energy (MOTIE)	Development of robotic systems and operational technologies that can be used in polar (Antarctic) environments	0.8 million USD (1.2 billion KRW)
Ministry of Agriculture, Food and Rural Affairs (MAFRA)	Development of intelligent farming robots for smart greenhouses	1.3 million USD (1.9 billion KRW)
	Development of robots for harvesting horticultural crops based on the collaboration of multiple robots	0.6 million USD (0.8 billion KRW)
Rural Development Administration (RDA)	Robotics technologies for hydroponic cultivation, monitoring of fruit growing, fruit thinning and harvesting	1.06 million USD (1.5 billion KRW)
	Development of intelligent weeder for apple orchards	0.14 million USD (0.2 billion KRW)
	Research on the application of robot safety technology for agricultural robot development	0.07 million USD (0.1 billion KRW)
	Fruit enlargement and harvester diagnosis technology for labor-reducing mechanical harvesting	0.07 million USD (0.1 billion KRW)
Korea Coast Guard (KCG)	Development of an autonomous underwater robotic system for swarm search on marine accidents	1.5 million USD (2.1 billion KRW)
Ministry of Environment (MOE)	Development of contactless collection and treatment technology for medical waste	4.6 million USD (6.5 billion KRW)

1.3. Strengthening the Basic Capacity of the Robotic Industry Ecosystem
◦ Technology Development
- 2 new projects for core parts technology.

Field	Description	2021 budget
Smart Gripper	Development of multi-variety, random piece-picking recognition technology and gripper	0.8 million USD (1.1 billion KRW)
Intelligent Controller	Development of 5kHz or higher universal intelligent robotic controller for worker safety	0.7 million USD (1 billion KRW)

◦ Infrastructure
- Establishment of infrastructure for joint use of robot development equipment owned by institutions.
- Support for performance evaluation and certification of next-generation fusion parts
◦ Industry convergence
- Development, demonstration, and commercialization of next-generation core robotics technologies converged with artificial intelligence (AI) and 5G technologies

2. Direction of Implementation in 2022

Objectives	◦ Accelerating smart manufacturing and service market growth through robot-based industrial innovations ◦ Creating an environment that applies robotics to improve people's convenience and awareness ◦ Establishing a foundation for creating innovative fields with new technologies and businesses

2.1. Establishing the basis for the overall industrial adaptation of robots through the discovery and development of robotics application models
◦ Development of robotics application models in aviation, shipbuilding, and chemical industries
◦ Support for the discovery of new business models customized for contactless demands, such as serving, cooking, and education
◦ Development and support of private-oriented financial support models such as robot-specific insurance, lease, and rental

2.2. Early popularization of robots through diversifying demonstrations
◦ Demonstration of large-scale robotics convergence services with national recognition centered on close facilities for everyday life to help solve social issues, such as an aging society and low birthrate
◦ Distribution of lifestyle robots such as in-home healthcare robots and emotional companion robots

2.3. Fostering innovative growth fields through pre-emptive regulatory improvement and high-tech demonstrations
◦ Continuous pre-emptive on-site regulatory improvement efforts through the step-by-step implementation of the regulatory innovation roadmap
◦ Establishing a demonstration infrastructure and technological support system to promote the commercialization of high-tech robot products with 5G, AI, and big data

3. Implementation Plan in 2020
3.1. Plan to Expand Penetration of Manufacturing Robots in the Three Key Manufacturing Area

Development of Standard Models	Pre-emptive distribution	User training	Proliferation of private autonomous activities
3 major fields + new fields such as shipping and aviation + improvement of existing models	Distribution and demonstration of standard models that have been developed	Robot user training before and after the introduction to current employees	Vitalization of finance, lease/rental support and demand networks

3.2. Intensive Promotion of Four Service Robotics Areas
◦ Technology development focused on solving social problems such as the lack of caregiving professionals and a stay-at-home era due to prolonged infectious disease conditions
◦ New development of human-robot interaction (HRI)-based companion robots for the aging society, increased single-person households, and integrated control of multiple outdoor delivery robots

Field	Description	2022 budget
Caregiving	Development of a human-following semi-autonomous robotic bed for the isolation of infected patients	0.7 million USD (1 billion KRW)
	Development of nursing assistance and patient monitoring robotic systems for infection isolation wards	0.8 million USD (1.2 billion KRW)
	Development of caregiving robots for isolation treatment facilities (MOIS)	0.9 million USD (1.3 billion KRW)
	Translational research for caregiving robots and development of service models (MOHW)	2.1 million USD (3 billion KRW)
	(New) Development of a companion robot that can communicate emotionally through physical and cognitive interaction between humans and robots	0.9 million USD (1.4 billion KRW)
Wearable	Development of soft sensor-embedded fabric-based actuators and garment-type robotic technology	0.5 million USD (0.7 billion KRW)
	(New) Wearable walking aid robot for everyday use for healthcare at home	0.8 million USD (1.2 billion KRW)
Healthcare	Development of an artificial intelligence-based robotic system for spinal hard tissue surgeries	1.1 million USD (1.6 billion KRW)

	Development of surgical assistant robots for general operations	0.8 million USD (1.2 billion KRW)
	Development of a lightweight wearable rehabilitation robot for self-rehabilitation of arms	1.1 million USD (1.5 billion KRW)
	Development of pandemic response robots and ICT convergence-based disease prevention and control system (MSIT)	4.3 million USD (6.1 billion KRW)
	Development of technology for commercialization of micro-medical robots (MOHW)	7.1 million USD (10.1 billion KRW)
	Translational research for rehabilitation robots (MOHW)	3.2 million USD (4.5 billion KRW)
Logistics	Development of parking robots that provide parking convenience and improve spatial efficiency	0.9 million USD (1.4 billion KRW)
	Development of robotic systems for autonomous elevator operations and indoor deliveries	0.8 million USD (1.2 billion KRW)
	Development of robot-enabled unloading system for trunk cargo transport vehicles	1.1 million USD (1.6 billion KRW)
	Development of technology for a robot-based cargo loading system	0.4 million USD (0.6 billion KRW)
	Development of mobile logistics handling robotic technology to streamline operations at Korean-style logistics warehouses	2.8 million USD (4 billion KRW)
	Development of goods management robots that autonomously identify and manage inventory of goods in retail stores	0.7 million USD (1 billion KRW)
	(New) Development of collaborative autonomous planning technology to control multiple outdoor terminal delivery robots in an integrated manner	0.5 million USD (0.8 billion KRW)
	(New) Development of service robot technology for post-meal empty dish collection	0.9 million USD (1.4 billion KRW)
Integrated	Development of field-applied robotic systems for implementing business models for robotics services	2.1 million USD (3 billion KRW)
	(New) Development of AI convergence service robot system to improve user convenience and efficiency	0.7 million USD (1 billion KRW)

◦ Development of technologies in key ten fields for niche markets
- Technology development in response to social issues and the demand of individual government department from the field

Government department	Description	2022 budget (million USD)
MOTIE	(New) Development of remote inspection robot system for cableway facilities (wire rope and pulley devices)	0.7 million USD (1 billion KRW)
	(New) Development of human-robot collaboration technology for dismantling various EV waste battery packs	0.75 million USD (1.1 billion KRW)
	(New) Safety robotic technology that can be detected and responded wirelessly in small spaces	0.8 million USD (1.2 billion KRW)
MAFRA	Development of intelligent farming robots for smart greenhouses	1.5 million USD (2.1 billion KRW)
	Development of robots for harvesting horticultural crops based on the collaboration of multiple robots	0.7 million USD (1 billion KRW)
RDA	Hydroponic cultivation, monitoring of fruit growth, excess fruit thinning, and harvesting robot technology	1.1 million USD (1.6 billion KRW)
	Development of intelligent mower for apple orchards	0.14 million USD (0.2 billion KRW)
	Research on the application of robot safety technology for agricultural robot development	0.07 million USD (0.1 billion KRW)
	Fruit enlargement and harvester diagnosis technology for labor-reducing mechanical harvest	0.07 million USD (0.1 billion KRW)
DAPA	Development of complex signal-based human body-machine high-speed synchronization control technology	1.1 million USD (1.6 billion KRW)

	(New) Development of autonomous planning technology for multi-robot collaboration	0.14 million USD (0.5 billion KRW)
NPA	Development of gas molecule identification technology that can respond to harmful factors	0.35 million USD (0.5 billion KRW)
NFA	Development of efficient response technology for hazardous gases at chemical terrorism sites	1.2 million USD (1.7 billion KRW)
MOF	Field demonstration and commercialization of underwater construction robots	1.9 million USD (2.8 billion KRW)
MOE	Development of contactless collection and treatment technology for medical waste	5.3 million USD (7.6 billion KRW)

3.3. Strengthening the Basic Capacity of the Robotic Industry Ecosystem
◦ Technology development, performance evaluation, and certification of 3 core parts and 4 softwares

Field	Description	2022 budget (million USD)
Smart Gripper	Development of autonomous operation and object grasping technology using imitation learning technology based on the tactile sensing end effector	0.63 million USD (0.9 billion KRW)
	Gripper system technology for various production processes, including unspecified objects of various shapes, weights, and strengths	0.56 million USD (0.8 billion KRW)
	Development of a flexible tactile sensor system that accommodates the curves of the hand and gripper of the robot	0.63 million USD (0.8 billion KRW)
Robotic SW platform	Development of mobile intelligence SW for autonomous movement of walking robots in dynamic and atypical environments	0.56 million USD (0.8 billion KRW)

◦ Infrastructure
- Promotion of innovative technology development and support
- Support for the establishment of a safe utilization environment
◦ Industry convergence
- Support for the development of core convergence technologies to overcome the limitations of robotics

4. List of Projects

Category	Project		Supervising gov. dept.	Budget (million USD) (100 million KRW)	
				2021	2022
1. Plan to expand penetration of manufacturing robots in the three key manufacturing areas	1-1	To develop 108 robot utilization models for each industry and process in advance	MOTIE, MSS	0.07 (109)	0.1 (150)
	1-2	To provide consultation and demonstration to 10 enterprises for each standard model	MOTIE, MSS	0.28 (407)	0.28 (407)
	1-3	To provide training on using robots for employees centered on companies that support the introduction of manufacturing robots	MOTIE, MEL	0.22 (32)	0.22 (32)
	1-4	To induce autonomous dissemination in the private sector through purchase support for rental/lease services	MOTIE	0.007 (1)	0.01 (16)
	1-5	To convert a government-led subsidy policy to a private-oriented financing model	MOTIE	-	-
	1-6	Host briefing sessions and vitalize networks to spread demand-driven robot dissemination	MOTIE	-	-

2. Plan to intensively nurture four service robotics areas	2-1	To support 10 niche market-type technology development and distribution	MOTIE,NPA, MAFRA, RDA,DAPA, NFA,KCG, MOF,MOIS, MOE	0.22 (319)	0.26 (368)
	2-2	To develop robots in 4 major areas → To distribute and demonstrate robots to the underprivileged → To spread them to the private sector	MOTIE, MSIT, MOHW, MOIS	0.52 (738)	0.64 (915)
	2-3	To create new markets in Korea and abroad by easing regulatory restrictions and supporting package-type overseas expansion	MOTIE	0.01 (14)	0.01 (14)
3. Plan to strengthen the basic capacity of the robotic industry ecosystem	3-1	To promote self-sufficiency in the next-generation core parts/software and parts demonstration	MOTIE	0.1 (152)	0.13 (192)
	3-2	To expand infrastructure for the penetration of robot convergence technology	MOTIE, MSIT	0.28 (398)	0.22 (310)
	3-3	To nurture professional workforce in the robotics field	MOTIE	0.02 (36)	0.02 (36)
Total				1.56 (2,206)	1.72 (2,440)

5. Project for Full-scale Test Platform of Special-purpose Manned or Unmanned Aerial Vehicles

5.1. Introduction

◦ Establishment of a test and evaluation basis for medium and large-scale special purpose manned and unmanned aerial vehicles to create an industrial ecosystem for special purpose manned and unmanned drones exceeding 150 kg in weight excluding fuel

◦ Pressing needs of an infrastructure for research, development, and assessments of aerial vehicles including the operating environments to establish an industrial ecosystem for special-purpose manned or unmanned aerial vehicles

Project purpose	Project period	Project budget
◦ To create an industrial ecosystem for special-purpose manned or unmanned aerial vehicles	3 years (2022-2024)	Total project cost 7.41 million USD (10.5 billion KRW)
◦ To establish a full-scale testing infrastructure for development of special-purpose manned or unmanned aerial vehicles		
◦ To provide support for full-scale field experiments of special-purpose manned or unmanned aerial vehicles and utilization of extant infrastructures		

5.2. Main contents

◦ To establish an infrastructure for full-scale tests of special-purpose manned or unmanned aerial vehicles

(1) To build a facility for full-scale tests of special-purpose manned or unmanned aerial vehicles
(2) To install apparatus for full-scale tests of special-purpose manned or unmanned aerial vehicles
(3) To create an assessment process for special-purpose manned or unmanned aerial vehicles
(4) To establish and implement a plan for certification of internationally certified testing institute

◦ To establish a network and a technical support system.

(1) To establish a cooperative network with certified testing institutes
(2) To establish a support system for integrate tests and assessment
(3) To establish a support system for research and development

◦ To nurture technical manpower and support industry education

(1) To foster experts for testing and certification of special-purpose manned or unmanned aerial vehicles
(2) To provide support for the education of testing and certification methods for special-purpose manned or unmanned aerial vehicles

IFR International Federation of Robotics

A11 Australia

<table>
<tr><td>Title</td><td colspan="2">Australian Governmental Key Actions Related to Robotics</td></tr>
<tr><td>Region</td><td colspan="2">Australia</td></tr>
<tr><td>Issued by</td><td>The Blueprint and Action Plan for Critical Technologies</td><td>Department of Industry, Science and Resources</td></tr>
<tr><td>Announcement</td><td colspan="2">November 17, 2021 (The Blueprint and Action Plan for Critical Technologies)</td></tr>
<tr><td>Term of validity</td><td colspan="2"></td></tr>
<tr><td>Budget</td><td colspan="2"></td></tr>
<tr><td>Key words</td><td colspan="2">Advanced robotics; Autonomous systems operation technology; Drones, swarming and collaborative robots; Nanoscale robotics</td></tr>
<tr><td rowspan="2">Related websites</td><td>The Blueprint for Critical Technologies</td><td>https://www.industry.gov.au/sites/default/files/2022-08/ctpco-blueprint-critical-technology.pdf</td></tr>
<tr><td>The Action Plan for Critical Technologies</td><td>https://www.industry.gov.au/sites/default/files/2022-08/ctpco-action-plan-critical-technology.pdf</td></tr>
<tr><td>Background</td><td colspan="2">◦ 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.
◦ Of the 63 critical technologies, four are related to robotics, of which the first three also belong to the list of critical technologies of initial focus*, as follows:
– Advanced robotics
– Autonomous systems operating technology
– Drones, swarming and collaborative robotics
– Nanoscale robotics
◦ 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 0.64 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.
* the list of critical technologies of initial focus : 24 technologies in 9 categories</td></tr>
<tr><td>Goal</td><td colspan="2">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</td></tr>
<tr><td colspan="3">Contents</td></tr>
<tr><td colspan="3">1. “The Action Plan for Critical Technologies”
1.1. Critical technologies in the national interest
1.1.1. Overview: 7 Categories, 63 technologies on the list, in order to assist with the identification of critical technologies in the national interest. Many technologies on the list have implications for defence and security.
1.1.2. List of 7 Categories
✓ Advanced materials and manufacturing
✓ AI, computing and communications
✓ Biotechnology, gene technology and vaccines
✓ Energy and environment</td></tr>
</table>

✓ Biotechnology, gene technology and vaccines
✓ Energy and environment
✓ Transportation, robotics, and space

1.2. List of critical technologies of initial focus (9 categories, 23 technologies)
✓ Critical minerals extraction and processing
✓ Advanced Communications (including 5G and 6G)
✓ Artificial intelligence
✓ Cyber security technologies
✓ Genomic and genetic engineering
✓ Novel antibiotics, antivirals and vaccines
✓ Low emission alternative fuels
✓ Quantum technologies
✓ Autonomous vehicles, drones, swarming and collaborative robotics

1.3. Critical technologies related to robotics

Technologies	Implications	Applications
Advanced robotics	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. Applications for advanced robotics include industry and manufacturing, defence and public safety, and healthcare and household tasks	Industry and manufacturing, defence and public safety, and healthcare and household tasks
Autonomous systems operating technology	Self-governing machines that can independently perform tasks under limited direction or guidance by a human operator. Applications include passenger and freight transport, un-crewed underwater vehicles, industrial robots, public safety and defence	Passenger and freight transport, un-crewed underwater vehicles, industrial robots, public safety and defence
Drones, swarming and collaborative robotics	Uncrewed air, ground, surface and underwater vehicles and robots that can achieve goals with limited or no human direction, or collaborate to achieve common goals in a self-organising swarm. Applications for drones, swarming and collaborative robots include public safety, environmental monitoring, agriculture, logistics, and defence	Public safety, environmental monitoring, agriculture, logistics, and defence
Nanoscale robotics	Nanoscale machines made from components like DNA. Application for nanoscale robotics include targeted drug delivery, identifying cancer cells and moving molecules to assemble drugs or other nanoscale robots	Targeted drug delivery, identifying cancer cells and moving molecules to assemble drugs or other nanoscale robots

1.4. Key Australian Government Actions

Initiatives	Period	Budget *	Related technologies
National Collaborative Research Infrastructure Strategy:	2018 - 2029	2.52 billion USD (4 billion AUD)	Advanced robotics, Autonomous systems operating technology, Drones, swarming and collaborative robotics
Advancing Space: Australian Civil Space Strategy	2019 - 2028	1.51 billion USD (2.4 billion AUD)	
Next Generation Technologies Fund	2015 - 2026	459 million USD (730 million AUD)	
Defence CRC for Trusted Autonomous Systems	2019 – 2025	31 million USD (50 million AUD)	
Robotics and Autonomous Systems Group - Commonwealth Scientific and Industrial Research Organisation (CSIRO)	2021 - 2023	289 million USD (459 million AUD)	

The Medical Research Future Fund	2022/23-2031/32 (2nd 10-year investment)	12 billion USD (3.9 billion for 2nd 10-year investment) 20 billion AUD (6.3 billion AUD for 2nd 10-year investment)	Nanoscale robotics

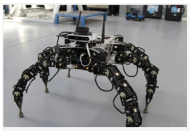
** The budget is for the whole program, not only for robotics*

2. Other Key projects related to robotics in Australia

2.1. Key projects related to Advancing Space: Australian Civil Space Strategy 2019-2028

Project title	Summary
RSOC: The Responsive Space Operations Centre	◦ Application: The project will develop a secure business model with a user-centric approach to action satellite tasks from the public and traditional Australian markets, such as agriculture, mining and banking. ◦ Funding: 4.22 million USD (6.597 million AUD) ◦ Period of duration: 2020-2022 ◦ Funding scheme: The Space Research Fund ◦ Website:https://www.grants.gov.au/Ga/Show/f50adb36-b3e5-7178-b9b3-7e450c608b39
Australian Space Automation, AI and Robotics Control Complex (SpAARC)	◦ Application: SpAARC will incorporate three integrated facilities: a connected and secure control centre supporting multiple teams; a development and test centre supporting hardware and software simulation testing; and a training facility for qualification in terrestrial and space robotic operations. ◦ Funding: 3.168 million USD (4.95 million AUD) ◦ Period of duration: 2020-2022 ◦ Funding scheme: The Space Research Fund ◦ Website:https://www.grants.gov.au/Ga/Show/f819d0d9-9d3a-9507-e596-04d3f287dbb9

2.2. Key projects related to CSIRO Robotics and Autonomous Systems Group

Project title	Summary
Legged Robots 	◦ These systems are well suited to navigating environments that are too dangerous or dirty for safe human work, such as a chemical spill in a plant or the ceiling beam in a factory. ◦ Typical robots: Gizmo, Zee, Weaver, MaX (Multi-legged autonomous explorer), Magnapod.
Science Rover 	◦ In prototype stage, the ultimate goal is to have the rover operate alone, with scientists from all over the world able to retrieve data from it and control it remotely in real-time. ◦Website:https://research.csiro.au/robotics/autonomous-science-rover/

2.3. Key projects related R&D projects supported by ARC

Project title	Summary
Re-Evolving Nature's Best Positioning Systems for People and	◦ Application: The aim is to develop next-generation positioning capabilities to reduce Australia's risky strategic reliance on vulnerable GPS satellites by other countries, and to transform through enhanced automation and robotics. ◦ Funding: 1.738 million USD (2.716 million AUD) ◦ Period of duration: 2022-2027

Their Machines	◦ Related scheme: Australian Laureate Fellowships ◦ Website: https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/FL210100156
Synthetic leukocytes: bio-inspired DNA nanorobots powered by flow	◦ Application: This project will contribute new methods for synthetic particle motion in flow and provide new insights into biomolecule interactions ◦ Funding: 370,034 USD (578,178 AUD) ◦ Period of duration: 2022-2024 ◦ Funding scheme: Discovery Projects ◦ Website:https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DP220101528
Interactive learning for robots in human environments	◦ Application: The outcomes are expected to include new validated methods and frameworks to enable robots by non-experts and to be quickly deployed in a variety of settings. And also to provide transformative benefits, improving safety in the workspace, and enabling improved quality of life in the home. ◦ Funding: 673,573 USD (1,052,549 AUD) ◦ Period of duration: 2021-2025 ◦ Related scheme: ARC Future Fellowships ◦ Website:https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/FT200100761
Robust and Scalable Autonomous Landing for Drones	◦ Application: The aim of this project is to develop a transformative robust and scalable autonomous landing system for drones. ◦ Funding: 294,139 USD (459,593 AUD) ◦ Period of duration: 2022-2024 ◦ Related scheme: Linkage Projects ◦ Website:https://www.grants.gov.au/Ga/Show/807daf9c-ba78-4aa8-8f5b-afd90d9c489e
Multisensory perception in active observers	◦ Application: The project will establish the mechanisms underlying the perception/action link and reveal how perceptual stability is achieved. It will generate useful knowledge for virtual, remote and robotic applications. ◦ Funding: 321,920 USD (503,000 AUD) ◦ Period of duration: 2021-2023 ◦ Related scheme: Discovery Projects ◦ Website:https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DP210101691
Non-invasive and safe human-machine interface (HMI) systems	◦ Application: Expected outcomes are a novel human-machine interface methodology, and function and application-specific machine learning methods ◦ Funding: 213,795 USD (334,055 AUD) ◦ Period of duration:2021-2024 ◦ Related scheme: Discovery Projects ◦ Website: https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DP210102911
Robotic Perception with Unconventional Sensors	◦ Application: The outcomes of this research have the potential to improve the effectiveness of critical civil infrastructure maintenance technology. ◦ Funding: 241,809 USD (377,827 AUD) ◦ Period of duration: 2021-2024 ◦ Related scheme: Discovery Projects ◦ Website:https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DP210101336

Brain Robot Interface for Physical Human Robot Collaboration	◦ Application: This project aims to discover new knowledge of cognitive conflict and develop models and algorithms that enable intuitive physical human-robot collaboration to jointly conduct laborious tasks in unstructured environments. ◦ Funding: 289,112 USD (451,737 AUD) ◦ Period of duration: 2021-2023 ◦ Related scheme: Discovery Projects ◦ Website:https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DP210101093
Force-mediated dynamic chemistry in hydrogels	◦ Application: Expected outcomes include novel hydrogel materials along with design criteria for force-activated molecule immobilization and for biomedical applications, additive manufacturing, soft robotics and flexible electronics. ◦ Funding: 247,505 USD (428,914 AUD) ◦ Period of duration: 2021-2023 ◦ Related scheme: Discovery Projects ◦ Website:https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DP210103654
Learning deep resilient behaviour for uncertainty-aware autonomy	◦ Application: It aims to propose a novel framework for developing uncertainty-aware autonomous systems using deep learning. ◦ Funding: 289,920 USD (453,000 AUD) ◦ Period of duration: 2021-2023 ◦ Related scheme: Discovery Projects ◦ Website:https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DP210100879
Stretchable Organic Transistors for Wearable Electronics and Robotics	◦ Application: It focuses on challenges of fabricating stretchable organic transistors for applications in robotics through semiconducting polymers with stretchability and integrating into stretchable organic transistor configurations. ◦ Funding: 230,400 USD (360,000 AUD) ◦ Period of duration: 2022-2025 ◦ Related scheme: Discovery Projects ◦ Website:https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DP210103006
Optimisation of piezoelectric metamaterials: Towards robotic stress sensors	◦ Application: Expected outcomes include manufactured proof-of-concept sensors that enable measurement of local stress fields. ◦ Funding: 240,000 USD (375,000 AUD) ◦ Period of duration: 2022-2024 ◦ Related scheme: Discovery Projects ◦ Website:https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DP220102759
Learning Robotic Navigation and Interaction from Object-based Semantic Maps	◦ Application: The outcome would be robots capable of using human instructions to efficiently learn complex interaction and navigation behaviours that transfer to unseen environments. ◦ Funding: 329,600 USD (515,000 AUD) ◦ Period of duration: 2022-2025 ◦ Related scheme: Discovery Projects ◦ Website:https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DP220102398

Bioinspired hierarchically Intelligent Hydrogels for Soft Machines	◦ Application: Expectations include new macromolecular design concepts to achieve intelligent hydrogels for artificial muscles and soft robotics. ◦ Funding: 286,127 USD (447,074 AUD) ◦ Period of duration: 2022-2024 ◦ Related scheme: Discovery Early Career Researcher Award ◦ Website: https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DE220101102
Blast Resistant Interlocking Brick Walls Using Engineered Waste Materials	◦ Application: This project aims to develop a next-generation building system integrated with robotic construction, using intelligent interlocking block units with hazard resistance, and sustainable engineered recycled plastic waste. ◦ Funding: 272,496 USD (425,775 AUD) ◦ Period of duration: 2021-2024 ◦ Related scheme: Discovery Early Career Researcher Award ◦ Website:https://dataportal.arc.gov.au/NCGP/Web/Grant/Grant/DE210100986

2.4. 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: 3.2 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:3.187 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

E00 EU

Title	**Horizon Europe Work Programme 2021-2022 (7. Digital, Industry and Space)**	
Region	European Union	
Issued by	European Commission	
Announcement	Work Program 2021-2022: 28 Oct 2021 (Final ver.)	
Term of validity	First call: Work Program 2021-2022 (Horizon Europe: 2021-2027)	
Budget	Robotics-related Work Program 2021-2022: 198.5 million USD (201.0 million EUR)	
Key words	Strategic Research, Innovation and Deployment Agenda (SRIDA), Horizon Europe, Work Program 2021-2022, Cluster 4: Digital, industry and space	
Related website	Strategic Research, Innovation and Deployment Agenda (SRIDA)	https://ai-data-robotics-partnership.eu/wp-content/uploads/2020/09/AI-Data-Robotics-Partnership-SRIDA-V3.0.pdf
	Horizon Europe	https://ec.europa.eu/info/horizon-europe_en
	Cluster 4: Digital, industry and space	https://ec.europa.eu/info/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 94.30 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 were announced in 28 Oct 2021.	
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 2021-2022: Digital, Industry and Space (28 Oct 2021 - 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) of the AI, Data and Robotics Partnership (PPP)

◦ A new SRIDA has been issued by the EU's new Public Private Partnership (PPP) "AI, Data and Robotics Partnership" to strengthen the AI, Data and Robotics infrastructure and ecosystem. This builds on the work of the five organizations, with ADRA (AI, Data and Robotics Association) being the partner from the private side:
- 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):
- Mobilizing 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 prioritized 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	◦ **Clusters** **- Health** **- Culture, Creativity & Inclusive Society**	◦ European Innovation Council ◦ European Innovation

◦ Research Infrastructures	**- Civil Security for Society** **- Digital, Industry & Space** **- Climate, Energy & Mobility** **- Food, Bioeconomy, Natural Resources, Agriculture & Environment** **- Non-nuclear direct actions of the Joint Research Centre**	Ecosystems ◦ 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 2021-2022: Cluster 4. Digital, Industry and Space

◦ The robotics-related work programs have been drafted by the commission and the final version were announced in 28 Oct 2021.

3.1. HORIZON-CL4-2021-TWIN-TRANSITION-01-01: AI enhanced robotics systems for smart manufacturing (IA)

◦ **Scope:**

- Development of robust, easy to use, explainable and compliant AI tools for manufacturing environments that require minimal learning and can be configured without highly skilled personnel;
- Implementation and integration of the latest research findings on technologies such as sensors, actuators, control, edge computing, haptic technologies, mechatronics, robotics and autonomous systems to enhance collaborative robotics systems in order to develop advanced smart manufacturing human-machine collaborative systems ensuring safe physical and social interactions and efficient collaboration with human workers;
- Demonstration of complex, safe and efficient collaboration between multiple agents simultaneously, e.g. humans, autonomous agents, industrial machinery, AGVs and collaborative robots;
- Demonstrate results in at least three large-scale industrial use-cases, targeting sectors and tasks typically difficult to automate

◦ **Expected Outcomes:**

- Provide safe, highly flexible, reconfigurable and modular solutions, allowing fast response to repurposing changes in production requirements, reducing considerably programming effort and configuration time for new products;
- Demonstrate significant improvements towards a meaningful and seamless social collaboration in teams of human workers, autonomous agents and robots by exploiting the latest advancements in AI, robotics and Social Sciences and Humanities (SSH);
- Create a network of open-access pilots to allow new users, especially students, start-ups, representatives from the makers' community and SMEs, to experiment new technologies and to enable data and knowledge sharing through the European industrial ecosystems.

◦ **Specific conditions:**

Specific conditions	Features
Indicative budget	◦ The total indicative budget for the topic is 27.65 million USD (28 million EUR).
Type of Action	◦ Innovation Actions
Technology Readiness Level	◦ Activities are expected to start at TRL 5 and achieve TRL 7 by the end of the project

3.2. HORIZON-CL4-2021-DGITAL-EMERGING-01-09: AI, DATA and Robotics for the Green DEAL (IA)

◦ **Scope:**

- Integrated and optimized AI, data and robotics solutions in order to demonstrate, by addressing use-cases scenarios in actual or highly realistic operating environments, how they can directly contribute to the Green Deal.

◦ **Expected Outcomes:**

- Innovative AI, data and robotics solutions for resource optimization and minimization of waste in any type of sector (from agri-food, to energy, utilities, transport, production, etc.), reduction of energy consumption and greenhouse gas emission including exploitation of all data and information sources contributing to optimizing applications for a greener planet.
- Optimized AI, data and robotics (including modular and adaptive solutions) to maximize contribution to the Green Deal in various applications such as environmental and waste management, including for instance waste clean-up (e.g. plastic collection, sorting), or in the circular economy value chain.
- Advanced physical intelligence and physical performance of robotics solutions in diverse harsh environments serving the Green Deal

◦ **Specific conditions:**

Specific conditions	Features
Indicative budget	◦ The total indicative budget for the topic is 26.66 million USD (27.00 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-CL4-2021-DGITAL-EMERGING-01-10: AI, DATA and Robotics at work (IA)

◦ **Scope:**

- AI, data, robotics, and automation solutions to support workers in their daily tasks, improving working conditions (both physical and social) and work performance/efficiency, while considering safety, security and resilience, as appropriate.

◦ **Expected Outcomes:**

- A new human-centered paradigm to keep people away from unsafe and unhealthy jobs via collaborative embodied (physical) AI, engaging and empowering end-users and workers, regardless of their gender, age or background.
- Human-centric AI supporting professionals in trustworthy hybrid decision-making, and optimizing their tasks

◦ **Specific conditions:**

Specific conditions	Features
Indicative budget	◦ The total indicative budget for the topic is 21.72 million USD (22.00 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

3.4. HORIZON-CL4-2021-DGITAL-EMERGING-01-11: Pushing the limit of robotics cognition (RIA)

◦ **Scope:**

- Development of technologies and systems that significantly enhance the cognitive ability of robots from the current state of the art to achieve greater levels of interaction and autonomy

◦ **Expected Outcomes:**

- New generation of AI-Powered Robotics: Enabling robots to have more profound impacts than they currently have, in powering them with a deeper kind of AI, endowing them with better perception and understanding of the world (up to semantic, and explainable representations)
- Smarter robots with improved capabilities, functionalities (including complex functionalities such as manipulation of delicate, irregular, dynamic or deformable objects, navigation in uncontrolled and variable or challenging and harsh environments, and continuous human physical interactions)
- An increased level of autonomy over the current state of the art, necessary to address real-world problems, while ensuring safety and reliability
- Smooth and trustworthy (including safety and reliability) human-robot collaboration through advanced reactivity and mutual understanding, and human-centric automated adaptation of robots in human-robot interactions

◦ **Specific conditions:**

Specific conditions	Features
Indicative budget	◦ The total indicative budget for the topic is 43.94 million USD (44.50 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

3.5. HORIZON-CL4-2021-DGITAL-EMERGING-01-12: European Network of Excellence Centres in Robotics (RIA)

◦ **Scope:**

- Scale-up existing research capacities and reach a critical mass through tighter networks of European robotics excellence centers

◦ **Expected Outcomes:**

- Scientific and technology advances in the major robotics challenges hampering its deployment
- A strong and tightly networked European research community in robotics, making it a world-class powerhouse for robotics excellence

◦ **Specific conditions:**

Specific conditions	Features
Indicative budget	◦ The total indicative budget for the topic is 11.36 million USD (11.50 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

3.6. HORIZON-CL4-2022-DGITAL-EMERGING-01-05: AI, Data and Robotics for Industry optimization (including production and services) (IA)

◦ **Scope:**

- Integration and optimization AI, data and robotics solutions in order to demonstrate, by addressing use-cases scenarios in actual or highly realistic operating environments, how they optimize production and service use cases

◦ **Expected Outcomes:**

- Advancing AI, data and robotics, and automation for the optimization of production and services value-chains, optimization of products, services, processes, to increase competitiveness, working conditions, and environmental sustainability, and supporting the European Economy using AI, data and robotics technologies
- AI or learning systems (including, but not limited to self-learning, continuous and transfer learning, self-configuring systems) adapting production or services workflows to changing environments, dynamic and unpredictable resource constraints and to the capabilities and restrictions of humans and transferring results from one domain to another

◦ **Specific conditions:**

Specific conditions	Features
Indicative budget	◦ The total indicative budget for the topic is 18.76 million USD (19.00 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

3.7. HORIZON-CL4-2022-DGITAL-EMERGING-01-07: Increased robotics capabilities demonstrated in key sectors (IA)

◦ **Scope:**

- Integration of novel robotics technologies into solutions that are capable of autonomously taking over dangerous, dull and dirty jobs, or that are capable of achieving tasks beyond human capabilities

◦ **Expected Outcomes:**
- Demonstrators able to show the added value of robotics and their performances in addressing challenges in major application sectors, or in dangerous, dull, dirty tasks or those strenuous for humans or in extreme environments
- Systems able to demonstrate beyond human performance in complex tasks, with high impact in key sectors, that show extended levels of adaptation and flexibility
- Systems able to show high levels of reactivity and responsiveness and intelligibility when performing human-robot and robot-robot interactions in major application sectors

◦ **Specific conditions:**

Specific conditions	Features
Indicative budget	◦ The total indicative budget for the topic is 35.55 million USD (36.00 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

3.8. HORIZON-CL4-2021-HUMA1-02: European coordination, awareness, standardization & adoption of trustworthy European AI, Data and Robotics (CSA)

◦ **Scope:**
- Support to the PPP on AI, Data and Robotics to develop a strong and inclusive network bringing, academia, industry, and public and industry users, including the major industrial European sectors and all relevant stakeholders
- Widespread educations and outreach programs including public awareness and addressing acceptability and trustworthiness
- Investigation and promotion of the potential contribution of AI, data and robotics to social welfare and sustainability
- Promotion of the adoption of trustworthy AI, data and robotics in procurement both public and private (B2B, B2C, B2G, etc.)
- Support to standardization in view of boosting AI, data and robotics industry, helping to create, and guarantee trustworthy and ethical AI, data and robotics, and in support of the EC regulatory framework

◦ **Expected Outcomes:**
- Efficient AI, Data and Robotics Public-Private Partnership supporting the community and the implementation of the SRIDA
- Reinforced links among initiatives in AI, Data and Robotics in H2020, Horizon Europe, Digital Europe Program, and other programs (Networks of excellence centers, DIHs, pilots, data platforms, and other projects)
- Widespread educational and outreach programs
- Increased adoption of AI technologies in all Member States and Associated Countries, towards elimination of gaps between Member States and Associated Countries
- Increased adoption of trustworthy AI, data and robotics in procurement both public and private (B2B, B2C, B2G, etc.)
- Standardization methods for trustworthy and ethical AI to foster AI, data and robotics industry, and in support of the EC regulatory framework
- Efficient support to the research community via the AI-on-demand-platform, a public community resource

◦ **Specific conditions:**

Specific conditions	Features
Indicative budget	◦ The total indicative budget for the topic is 12.84 million USD (13.00 million EUR).
Type of Action	◦ Coordination and Support Actions

E01 Germany

Title	High-Tech Strategy 2025	
Region	Germany	
Issued by	Federal Ministry of Education and Research	
Announcement	December 07, 2020	
Term of validity	2021-2026	
Budget	Total 345.6 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 government as a comprehensive national strategy that defines the objectives and milestones of the Federal Government's research and innovation (R&I) policy. ◦ 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' was 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 of 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.	
The latest R&D project	Together through Innovation (announced on December 07,2020)	
The key targets of the latest R&D project	Interactive technologies for healthcare and nursing 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.

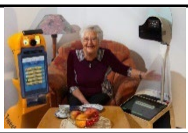
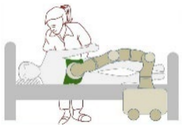
1.1. Program line of the mission 'Shaping technology for the people'
◦ Safety and health in the digital world of work: safety and health in the digitalized world of work
◦ Future of Work - Innovations for Tomorrow's Work, in particular through the establishment of 'Regional Competence Centers for Labor 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/

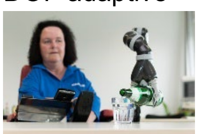
2.1. Robotics related project notice 1: Robot system for care
◦ The aim is to promote innovative research and development projects in human-technology interaction, which strengthen the independence and well-being of those in need of care, relieve nurses and care.
◦ Application-oriented joint projects are funded in two areas: (1) development and (2) testing of innovative robotic systems.
- Focus 1: Robot technologies for new nursing solutions
- Focus 2: Better nursing practice through robotic solutions
◦ Related website: https://www.interaktive-technologien.de/foerderung/bekanntmachungen/robotik-pflege
◦ Application-oriented joint projects
- The aim of the accompanying project is to develop the theoretical and practical basics for evaluating the use of robotic systems in nursing.

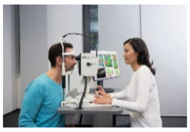
Project title	Summary
AdaMekoR 	◦ Application: Adaptive robotic system for diagnosis, prevention and rehabilitation of knee problems ◦ Funding: 1.86 million USD (1.88 million EUR) ◦ Period of duration: 03/2020 - 03/2023 ◦ Website: http://adamekor.de/
ArNe 	◦ Application: Assistant robot for care use in people with neuromuscular diseases ◦ Funding: 2.35 million USD (2.38 million EUR) ◦ Period of duration: 02/2020 - 01/2023
HoLLiECares 	◦ Application: Multifunctional service robot to support professional care in hospitals ◦ Funding: 2.55 million USD (2.58 million EUR) ◦ Period of duration: 02/2020 - 01/2023
MobiStaR 	◦ Application: Mobilization robot in intensive care recipients ◦ Funding: 1.97 million USD (2.00 million EUR) ◦ Period of duration: 02/2020 - 01/2023 ◦ Website: https://www.forschungsprojekt-mobistar.de/forschungsprojekt-mobistar
MORPHIA	◦ Application: Mobile assistant robot for care and security in home care ◦ Funding: 2.33 million USD (2.36 million EUR)

	◦ Period of duration: 02/2020 - 01/2023
PeTRA 	◦ Application: Multifunctional robotic support solution for patient transfer system ◦ Funding: 2.68 million USD (2.71 million EUR) ◦ Period of duration: 02/2020 - 01/2023
PfleKoRo 	◦ Application: Cooperative robot to support typical care activities such as moving a person ◦ Funding: 2.02 million USD (2.05 million EUR) ◦ Period of duration: 02/2020 - 01/2023
REsPonSe 	◦ Application: Service robot to relieve and support caregivers ◦ Funding: 2.13 million USD (2.16 million EUR) ◦ Period of duration: 02/2020 - 01/2023 ◦ Website: https://www.forschungsprojekt-response.de/forschungsprojekt-response
RoMi 	◦ Application: Robot support for routine tasks to strengthen cooperation in care facilities ◦ Funding: 1.47 million USD (1.49 million EUR) ◦ Period of duration: 03/2020 - 02/2023 ◦ Website: https://www.romi-projekt.de/
RUBY dementia 	◦ Application: Personalized human-robot interaction technology to support for home care support for dementia patients ◦ Funding: 2.51 million USD (2.54 million EUR) ◦ Period of duration: 03/2020 - 02/2023

2.2. Robotics related project notice 2: Adaptive technologies for society - intelligent interaction between humans and AI

◦ The goal is to promote innovative research and development projects in human-technology interaction that use artificial intelligence (AI) methods to optimally assist people in solving problems.
◦ Related website: https://www.interaktive-technologien.de/foerderung/bekanntmachungen/meki
◦ Robotics-related projects

Project title	Summary
DOF adaptive 	◦ Application: Assistive robotic arms through the use of deep neural networks. ◦ Funding: 1.31 million USD (1.33 million EUR) ◦ Period of duration: 02/2021 - 01/2024
MINIMAKI 	◦ Application: AI-based simulator in minimally invasive heart valve surgery ◦ Funding: 2.07 million USD (2.10 million EUR) ◦ Period of duration: 03/2021 - 03/2024

Ophthalmo-AI 	◦ Application: Intelligent, cooperative diagnosis and therapy support in ophthalmology ◦ Funding: 2.81 million USD (2.85 million EUR) ◦ Period of duration: 03/2021 - 03/2024
KIPos 	◦ Application: AI-controlled post-operative care for cardiac surgery patients ◦ Funding: 1.93 million USD (1.95 million EUR) ◦ Period of duration: 02/2021 - 01/2024

4.3. Robotics related project notice 3: 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 two research fields such as 'Digitally supported health and care' and 'Living spaces: smart, sustainable and innovative' of the research program 'Together through innovation'.
◦ Related website: https://www.interaktive-technologien.de/foerderung/bekanntmachungen/kmu-innovativ
◦ Robotics-related projects

Project title	Summary
VRnano 	◦ Application: VR-based system using the interaction possibilities of humans-senses and musculoskeletal system ◦ Funding: 1.15 million USD (1.16 million EUR) ◦ Period of duration: 01/2021 - 12/2023
Dynamic HIPS 	◦ Application: VR-based surgical training simulator with haptic feedback ◦ Funding: 2.04 million USD (2.07 million EUR) ◦ Period of duration: 05/2020 - 10/2022
RobDIP 	◦ Application: Adaptive robotic system for diagnosis, prevention and rehabilitation of knee problems ◦ Funding: 1.31 million USD (1.33 million EUR) ◦ Period of duration: 05/2020 - 04/2023
MRiLS 	◦ Application: Simulation model for interactive training using mixed reality technology ◦ Funding: 1.80 million USD (1.83 million EUR) ◦ Period of duration: 02/2020 - 01/2023
SAMMIE 	◦ Application: Human-machine interface for effective collision avoidance of unmanned aerial vehicles ◦ Funding: 1.07 million USD (1.09 million EUR) ◦ Period of duration: 04/2021 - 03/2024
Textile Muscle 	◦ Application: The musculoskeletal system to support finger strength with textile actuators ◦ Funding: 1.02 million USD (1.03 million EUR) ◦ Period of duration: 05/2021 - 10/2023

2.4. 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
RimA 	◦ Application: Create the technological and economic basis for innovative robotic components, services and applications for new robotic solutions in everyday life ◦ Funding: 2.64 million USD (2.67 million EUR) ◦ Period of duration: 08/2021 - 04/2025

IFR International Federation of Robotics

E02 Italy

<table>
<tr><td>Title</td><td colspan="2">Governmental Robotics R&D Programs</td></tr>
<tr><td>Region</td><td colspan="2">Italy</td></tr>
<tr><td rowspan="2">Issued by</td><td>National Research Program 2021-2027</td><td>Ministry of University and Research</td></tr>
<tr><td>Governmental Robotics R&D Programs</td><td>Summarized by Prof. Rezia Molfino of the University of Genova, Vice-President of SIRI</td></tr>
<tr><td>Announcement</td><td colspan="2">December 15, 2020</td></tr>
<tr><td>Term of validity</td><td colspan="2">2021-2027</td></tr>
<tr><td>Budget</td><td colspan="2"></td></tr>
<tr><td>Keywords</td><td colspan="2">Robotics, National Research Program 2021-2027, Innova per l'Italia, Competence centers, MISE innovation projects, Robotics Olympics 2020</td></tr>
<tr><td rowspan="4">Related website</td><td>National Research Program 2021-2027</td><td>https://www.mur.gov.it/sites/default/files/2021-01/Pnr2021-27.pdf</td></tr>
<tr><td>4. Extended Annex “Digital, Industry, Aerospace” of PNR 2021-2027</td><td>https://www.mur.gov.it/sites/default/files/2021-08/4.AllegatoEsteso_Digitale.pdf</td></tr>
<tr><td>Artes 4.0</td><td>https://www.artes4.it/</td></tr>
<tr><td>Robotics Olympics 2020</td><td>https://www.miur.gov.it/olimpiadi-di-robotica</td></tr>
<tr><td>Background</td><td colspan="2">◦ 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)</td></tr>
<tr><td>Goal</td><td colspan="2">◦ 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</td></tr>
<tr><td colspan="3">Contents</td></tr>
</table>

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

◦ Robotics is one of the large areas of research and innovation in the PNR 2021-2027, the contents is indicated below.

1.1 Robots more and more pervasive and personal: Although robots originated in large-scale manufacturing, in recent years they have been spreading in an increasing number of application scenarios. We find them in factories, hospitals, homes, in schools, robots that put out fires, create goods and services that buy time and that they save lives

1.2 Six priority areas for the entire supply chain, from fundamental research to application: 1. Robotics in hostile and unstructured environments, 2. Robotics for Industry 4.0, 3. Robotics for infrastructure inspection as well as maintenance, 4. Robotics for the agrifood, 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: 11,100 units were sold in 2019, with a growth of 13% compared to the previous year. ◦ The Italian robotics market is the sixth worldwide and the second in Europe, behind the Germany. ◦ The density of robot in Italy is 212, against a worldwide average of 113.	◦ 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 ability based on analysis of the data collected in the production systems (artificial intelligence will increasingly have to combine with industrial robotics) ◦ Mobile robots (AGV, AMR, LGV) are of increasing importance in industrial logistics alongside traditional industrial manipulators. ◦ 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 infrastructure inspection as well as maintenance	◦ 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 ◦ Undergoing a significant transformation in terms of automation and connectivity in the sense of Industry 4.0 and IoT	◦ Robotic solutions including robotic systems capable of carrying out dexterous and soft manipulations as well as locomotion 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, 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	◦ Personal mobility will undergo a real revolution in the upcoming decades with the transition to autonomous driving ◦ This revolution will increase the distribution of the electric car, a transition from a private car to a shared car, and the reduction of the average size of circulating vehicles	◦ Robo-tax: a fully autonomous vehicle is now a trending personal mobility model, which can be called, used, and released on request to make a certain journey, within the ‘in service” model of use. ◦ Technological package, hardware and software, for the robotization of the vehicle will be applied to all land vehicles on the road that may be classified as follows: ✓ Vehicles for the mobility of people on the road (cars, buses, minibusses) ✓ Vehicles for the mobility of goods by road (trucks, commercial vehicles) ✓ Off-highway vehicles (vehicles for agriculture, construction, earthmoving, groomers, etc.) ✓ Vehicles without people on board (ground drones for the mobility of goods – last-mile delivery in urban and metropolitan centers or for agriculture).

1.3. Enabling Technologies: Enabling technologies research in robotics needs to focus on the following:

a) 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.
b) Intuitiveness and usability of human-robot interfaces, which enable the effective use of robots by people without specific training.
c) Ability of robots to physically interact with the environment and with surrounding people with stability and safety.
d) Development of physical tools for accurate handling and locomotion in airborne, aquatic environments, and on soils of a different and uneven nature.
e) Autonomous navigation, event identification, and dynamic vehicle control for self-driving car sustainability and intelligent traffic management in cities.
f) Energy autonomy and resilience to imperfect communications in realistically situations encountered in field applications.
g) Development of new forms of energy derived from the environment and environmentally friendly materials to reduce the ecological trace of robotic systems.

- The development of these technologies will strengthen/simplify people's work (hostile environments, industrial and civil environments, medicine, agrifood and mobility) and save or increase the jobs (artisans, new production companies, with robots and intelligent machines in Italy instead of abroad). The impact on the entire work process 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. Innova per l'Italia: technology, research and innovation against the COVID emergency, 23 March 2020

- The project is a joint initiative of the Minister for Technological Innovation and Digitization, the Minister of Economic Development and the Minister of University and Research together with Invitalia and in support of the structure of the Extraordinary Commissioner for the Coronavirus Emergency.
- For reasons of speed, the call is addressed to entities that already have platforms, or can easily adapt them, algorithms of analysis and **artificial intelligence, robots,** drones, and other technologies for monitoring, preventing, and controlling Covid-19, which can be used to support patients or by the Civil Protection and other interested bodies, in compliance with the principles of privacy, security and ethics.

3. Competence centers

- In June 2020, the highly specialized Competence Center on **advanced robotics and artificial intelligence** Artes 4.0 and the Digital Innovation Hub of Confindustria Sicilia formalized the collaboration to push the companies of this region towards new innovative and development dimensions with 4.0 technologies.
- Artes 4.0 is an association with national coverage and international projection that links university partners (including the Sant'Anna School of Pisa) 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 between large, small, medium, and micro companies able to provide innovative, rapid solutions at the right quality / price to business customers.

4. MISE innovation projects

- In January 2020, Innovation Projects by MISE (Ministero dello Sviluppo Economico), including the Fincantieri project, were lauched to innovate the manufacturing processes of **complex and high value-added ships** and which will see the production sites of Monfalcone and Trieste as protagonists. The overall costs of the project amount to approximately 11.37 million USD (11.51 million euros).

- The G.Giglio Biomedical and Clinical Research Institute of Cefalù in collaboration with Gesan Com won with a project on **robotics for radiotherapy and surgery**. They aim to develop a platform, based on innovative technologies, for minimally invasive treatments in radiotherapy and minimally invasive robotic surgery. The platform will be installed on the sites of the Sicilian Region. The overall costs of the project amount to approximately 27.27 million USD (27.61 million euros).

5. Robotics Olympics 2020

- Miur (Ministry of Education, University and Research), in collaboration with School of Robotics, in 2019/2020 launched the sixth edition of the **Robotics Olympics**. The free competition was dedicated to selected students from upper secondary schools aiming to promote, encourage and support the educational potential of robotics with reference to STEM subjects. The main theme of the 2019/20 edition was the environment and the projects presented proposed solutions for improving environmental conditions. Student teams created robots operating in aquatic, land, or air environments.

E04 UK

Title	Industrial Strategy Challenge Fund (Robots for a Safer World)
Region	UK
Issued by	◦ Innovate UK ◦ Department for Business, Energy & Industrial Strategy ◦ UK Research and Innovation
Announcement	8 May 2017 (revised March 2022)
Term of validity	2017 ~ 2022
Budget	129 million USD (112 million GBP)
Key words	Robotics and AI, Research Hub, marine sensors, Collaborative R&D, feasibility studies
Related website	Robots for a safer world: ISCF — Robots for a safer world: Industrial Strategy Challenge Fund - GOV.UK (www.gov.uk) RAI in extreme environments funded through ISCF — https://ktn-uk.org/news/robotics-for-a-safer-world-learn-more-about-iscf-funded-robotics-ai-projects/ Additional funding in 2021 for Robots for a safer world — https://www.ukri.org/news/remote-offshore-rescue-service-among-robotics-backed-by-government/ https://www.ukri.org/news/robotics-contest-winners-help-improve-uk-offshore-sustainability/
Background	Industrial Strategy Challenge Fund ◦ In 2017, UK introduced ‘Industrial Strategy’ to boost productivity ◦ It is part of government’s 5.4 billion USD (4.7 billion GBP) investment in R&D over 4 years ◦ The fund is delivered by UK Research and Innovation. ◦ It identified the biggest opportunities in the 4 grand challenge areas (Artificial Intelligence and data, ageing society, clean growth, future of mobility) ◦ It has 16 challenge funds and robot related challenge is “Robots for a Safer World”
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	Innovate UK Smart Grants: January 2022, APC 20: Developing automotive technologies and growing capability towards net zero
The key targets of the latest R&D project	◦ Sensing and actuation ◦ On-board electronics ◦ Radio frequency electronics ◦ Power supplies ◦ Control systems ◦ Task-oriented payloads
Contents	

1. More than 111.6 million USD (97 million GBP) plan made in 2017, 17.25 million USD (15 million GBP) additional funding in 2020, and 8.05 million USD (7 million GBP) funding in 2021 for Robots for a Safer World challenge

Funding	Contents	Managed by	Note
51.2 million USD (44.5 million GBP)	Four research hubs for robotics	Engineering and Physical Sciences Research Council (EPSRC)	Plan made in 2017 (RAI in extreme environments: As of February 2020, over 109.365 million USD (over 95.1 million
4.945 million USD (4.3 million GBP)	Five research projects to develop marine sensors	Natural Environment	

		Research Council (NERC)	GBP) has been invested)
35.65 million USD (31 million GBP)	Collaborative R&D competition	Innovate UK	
20.7 million USD (18 million GBP)	Demonstrator feasibility studies following a separate competition	Innovate UK	
17.25 million USD (15 million GBP)	Robotic solutions to solve problems arising from pandemic and hazardous industries	Innovate UK	Additional funding in September, 2020
8.05 million USD (7 million GBP)	Remote offshore rescue service	Innovate UK	Funding in May, 2021

The RAI in extreme environments funding is broken down into five extreme environments in different regional areas as follows

Environments	Invested funding	Contents
Offshore	48.07 million USD (41.8 million GBP)	The projects in offshore energy include one Innovation Hub, 9 Phase 1 Demonstrator projects, 7 of which proceeded to a second phase Demonstrator, and 20 CR&D projects. These projects address sensing, control, actuators, mapping and navigation, and vehicle design, with many of them addressing UAVs, USVs and UUVs; cases with crawler and climbing robots also exist.
Nuclear	39.27 million USD (34.15 million GBP)	16 projects addressing RAI capabilities and systems have been funded; these include 2 Innovation Hubs, 6 Demonstrator and 7 CR&D projects which are addressing overall system and system integration related issues, with two them working on Unmanned Under-water Vehicles (UUVs)
Space	14.49 million USD (12.6 million GBP)	Including one Innovation Hub, one phase 1 Demonstrator that continued into a second phase, two further Demonstrators and three CR&D projects. The projects address mostly operational aspects, covering system level issues to go along with components and subsystems (e.g. FPGA and photonics)
Cross-cutting	13.2 million USD (11.5 million GBP)	Comprising two Phase 1 Demonstrators, one of which progressed to a second Phase, 6 further Demonstrator projects and 11 CR&D projects. The projects cover a broad spectrum of robotics aspects & capabilities, including sensing, navigation, SLAM, control, sub-system and system integration related issues, the majority of them working with UxVs (i.e. UAV, UGV, USV, UUV) as the core platform for inspection & operation
Mining	2.07 million USD (1.8 million GBP)	There is one project coming from the Innovation Lab competition, which includes the use of UAV enhanced sensing capabilities, and another one from the Electronics, Sensors and Photonics in Extreme Environments competition, addressing on-board electronics and integration of existing and COTS components for autonomous surveying.

2.

3. Four research hubs

2.1. National Center for Nuclear Robotics

◦ Led by: Professor Rustam Stolkin, University of Birmingham

◦ ISCF funding: 12.9 million USD (11.24 million GBP)

◦ Project partners: Universities of Bristol, Edinburgh, Essex, Lincoln, West of England, Lancaster University, Queen Mary University of London.

◦ Relevant website: https://www.ncnr.org.uk/

2.2. The Robotics and Artificial Intelligence in Nuclear (RAIN)

◦ Led by: Professor Barry Lennox, University of Manchester

◦ ISCF funding: 13.6 million USD (11.84 million GBP)

◦ Project partners: Universities of Oxford, Liverpool, Sheffield, Nottingham, Lancaster, Bristol and the UKAEA's RACE center.

◦ Relevant website: https://rainhub.org.uk/

2.3. Offshore Robotics for Certification of Assets (ORCA)

◦ Led by: Professor Yvan Petillot, Heriot-Watt University

◦ ISCF funding: 16.36 million USD (14.23 million GBP)

◦ Project partners: Universities of Edinburgh, Oxford and Liverpool, Imperial College London

Relevant website: https://orcahub.org/

2.4. Future AI and Robotics for SPACE (FAIR-SPACE)

◦ Led by: Professor Martin Sweeting, University of Surrey

◦ ISCF funding: 7.67 million USD (6.67 million GBP)

◦ Project partners: Imperial College London, Universities of Edinburgh, Liverpool, Salford, and Warwick

◦ Relevant website: https://www.fairspacehub.org/

3. Challenge also addressed new need arising through one-year extension:

Resilient future: includes 38 projects in the agriculture, health, logistics, construction and infrastructure sectors among others.

COVID-19 fast start: the program funded 16 projects from the Innovative UL organized “Bussiness-led innovation in response to global disruption” competition.

3.1 Winners of the UK Research and innovation’s robots for a safer world challenge

The winners were announced in 2021 Robotics and Artificial Intelligence Industrial Showcase (May 2021). The following project winners will be backed by 7 million GBP of government support.

Project title	Lead organization	Content
Offshore Survival Systems	Quaybridge	Development of semi-autonomous unmanned rescue vessel (URVs to search and save live of offshore wind workers
Automated drone	Digital & Future technologies	An automated drone system which able to deliver vital healthcare equipment to hospital, load and unload its cargo without human assistance.

Access Control Lab	Mobitix, University of Liverpool	Development of an automated “back-up lab” which can be operated remotely
Smart drone pad control centre	Motion Robotics	The control centre will coordinate drone flights between hospitals and suppliers/lab.
Bulk grain-monitoring robot	Crover Ltd	Development of s a small robot that can ‘swim’ through grains stored in bulk for highlighting their condition and identifying grain spoilage
Wall-climbing robot	HausBots Limited	The small and medium-sized robots can climb vertical surfaces and be used for tasks such as building and infrastructure inspection, cleaning, painting and maintenance.

3.2 The Robot for a safer world competition

The competition was opened in October 2020 aim to develop the next generation of subsea autonomous systems which able to gather data, maintain windfarms and map the sea floor more efficiently and cost-effectively

Date	Start on after April 2021 End by 31 March 2022
New technologies requirement	- Energy harvesting and low power AI computing - Fleets of autonomous robots - Developing a subaquatic equivalent of Google Maps.
Funding	Three project winners will receive a share of 5.18 million USD (4.5 million GBP) from UL research and Innovation’s Industrial Strategy Challenge Fund, supported by: - Net Zero Technology Centre - Ministry of Defense - Royal Navy.
Progress	In total, there were 129 first round competition applications, which were whittled down to a final 16 organizations with three winning projects.
Projects	- Subsea enhanced autonomous mapping (SEAMless) project With aim to create subaquatic equivalent of Google Maps, that will provide more accurate positioning data than GPS. SEAMless will operate in open water and near infrastructure, to carry out targeted surveys and inspections for offshore renewables and oil and gas decommissioning. The system will be able to map an entire offshore windfarm, creating a digital model, enabling underwater robots to position themselves and navigate safely due to increased autonomous awareness. - Demeter project With aims to shift the way conducting undersea monitoring from manual, expensive, and low-frequency data retrieval to automated, inexpensive, high frequency and on-demand intelligence retrieval using the autonomous subsea robots to continuously collect and analyze data without the need for expensive, high-maintenance, energy intensive infrastructure. - Squads of Adaptive Robots (SoAR) project Deliver fleets of autonomous underwater vehicles (AUV) and un-crewed surface vehicles overseen by an AI fleet capable of adaptive

	mission planning. This will provide a cost-effective way for offshore wind power operators to: Observe the environment Respond to incidents Monitor operational, decommissioned and abandoned structures.
Relevant website	https://www.ukri.org/news/robotics-contest-winners-help-improve-uk-offshore-sustainability/

4.The latest Collaborative R&D project

Title	APC 20: Developing automotive technologies and growing capability towards net zero	
Total Funding	28.84 million USD (25 million GBP)	
Managed by	Innovate UK	
Goal	◦ It aims to support the UK's transition towards net zero product manufacturing and supply chain in the UK automotive sector.	
Research categories	Project must advance technologies in one or more of the following areas: - Battery cell components or systems - Fuel cell and associated balance of plant - Electric machines and power electronics - Fossil-free fuel internal combustion - Hydrogen storage and management systems - Recycling or recovering materials from any of the above - Digitalisation leveraged during the development, production or in-service phases	
Project size	◦ Project's total eligible costs must be between £5 million and £40 million. Your project must be a minimum of 50% match funded, with a suggested maximum number of 6 partners.	
Date	◦ Competition opens date: 12 January 2022 ◦ Competition closes date: 2 March 2022	
Relevant website	Funding Competition	https://apply-for-innovation-funding.service.gov.uk/competition/1076/overview#summary
Title	Innovate UK Smart Grants: January 2022	
Total Funding	28.84 million USD (25 million GBP)	
Managed by	Innovate UK	
Goal	◦ To deliver game-changing and commercially viable R&D innovation that can significantly impact the UK economy.	
Research categories	Funding innovative research and development (R&D) projects across a variety of technologies, markets and research categories, including: - Feasibility projects - Industrial research projects - Experimental development projects	
Project size	◦ Projects of 6 - 18 months must have total eligible project costs between 115,380 USD and 576,890 USD (100,000 GBP and 500,000 GBP) and can be single or collaborative. ◦ Projects of 19 - 36 months must have total eligible project costs between 115,380 USD and 2.31 million USD (100,000 GBP and 2 million GBP) must be collaborative	
Date	◦ Project start date: 01 Oct. 2022 ◦ Project end date: 30 Sep. 2025	
Relevant website	Funding Competition	https://apply-for-innovation-funding.service.gov.uk/competition/1087/overview#summary

E07 Sweden

<table>
<tr><td>Title</td><td colspan="2">Robotdalen</td></tr>
<tr><td>Region</td><td colspan="2">Sweden</td></tr>
<tr><td>Issued by</td><td colspan="2">VINNOVA(Swedish governmental innovation agency)</td></tr>
<tr><td>Announcement</td><td colspan="2">2003</td></tr>
<tr><td>Term of validity</td><td colspan="2"></td></tr>
<tr><td>Budget</td><td colspan="2"></td></tr>
<tr><td>Keywords</td><td colspan="2">Robotdalen, Industrial robot, Logistics, Service robot, Healthcare robot</td></tr>
<tr><td rowspan="5">Related website</td><td>Robotdalen</td><td>http://www.robotdalen.se/</td></tr>
<tr><td>EC, ERDF</td><td>https://ec.europa.eu/regional_policy/en/projects/sweden/smart-helpers-for-humans</td></tr>
<tr><td>VINNOVA</td><td>https://www.vinnova.se/p/robotdalen-2013-2019/
https://www.vinnova.se/p/robotdalen-2.0/</td></tr>
<tr><td>OECD</td><td>http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/ICCP/IE%282012%296&docLanguage=En</td></tr>
<tr><td>SSF</td><td>https://strategiska.se/en/research/</td></tr>
<tr><td>Background</td><td colspan="2">◦ The Robotdalen started in 2003 as an initiative with the goal of creating regional growth in Mälardalen and Sweden by building an innovation system in robotics and automation
◦ VINNOVA(Swedish governmental innovation agency) has been financing Robotdalen since 2003 as a part of the national VINNVÄXT-program*

* 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="2">◦ To be an internationally established innovation environment to help new businesses establish themselves on the market and successfully commercialize their robot solutions</td></tr>
<tr><td>The latest R&D project</td><td colspan="2"></td></tr>
<tr><td>The key targets of the latest R&D project</td><td colspan="2"></td></tr>
<tr><td colspan="3">Contents</td></tr>
<tr><td colspan="3">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

2. Organizer
Mälardalen University, Västerås

3. Funding
◦ <u>2003-2013:</u> 0.9 million USD (10 million SEK) per year from VINNOVA, VINNVÄXT-program
◦ <u>2007-2013:</u> Substantial funding (25% of its total funding), European Regional Development Fund
◦ <u>2013-2017:</u> 2.18 million USD (24 million SEK) from VINNOVA
◦ <u>2017-2019:</u> 0.5 million USD (6 million SEK) from VINNOVA</td></tr>
</table>

4. Program

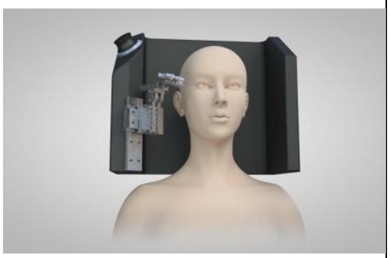
Business solutions, R&D, testbeds, award (Robotdalen Innovation Award)

5. Focus

Industrial robotics, Logistics, Service robotics, Healthcare robotics

6. Contents

- Productivity-enhancing feasibility studies in the manufacturing industry
- R&D assignments (private sector)
- Implementation assignments (public sector)
- Innovation project (startups)
- International work that strengthens the brand

Repre-sentative ongoing projects	- Robot suit HAL (Hybrid Assistive Limb)	
		◦ In 2012, The Japanese company Cyberdyne set up business in Sweden for the clinical test to get CE marking for the European market ◦ The Robotdalen initiated clinical tests together with the Karolinska institutet and Rehabiliteringsmedicinska Universitetskliniken ◦ With positive results, Robotdalen is providing business solutions now
	- FIREM (Fire Rescue in Mines)	
		◦ The FIREM project investigates the possibility of equipping and existing, remote-controlled wheel loader in the mining environment with fire-fighting technology ◦ Behind the project are Robotdalen and Mälardalen University, together with Boliden Mineral AB, Cold Cut Systems AB, Luleå University of Technology, Volvo Construction Equipment AB and Örebro University
	- STRADA	
		◦ In a cooperation between Robotdalen/ Mälardalen University, SICS Swedish ICT, Danderyd Hospital, Alkit Communications and IUS Innovation this project has developed interactive remote rehabilitation for stroke patients
	- Cognitive Retinal Generator (CRG system)	
		◦ A medical tool for eye doctors, aimed at assisting ophthalmic surgery ◦ CRG has been created by by Dr.-Ing. Mohammad Ali Nasseri at Technische Universität München, with support from e.g. Robotdalen ◦ It was appointed as one of the winners of the Robotdalen Innovation Award 2015

	- Poseidon	
		◦ The world's first hygiene robot from Robotics Care AB ◦ The project has, in addition to Robotdalen, since its inception in 2013 received support from, among others, Almi, the Research and Development Council of Västmanland, Vinnova, the County Administrative Board of Västmanland and Swedish Institute of Assistive Technology
Products in 3 core areas	Health care	◦ Bestic: An eating aid for people that have difficulty eating on their own ◦ Giraff: Giving elderly the ability of distance communication with health care staff and family members ◦ JustoCat: A robotic soft toy animal, in the form of a cat, which helps soothe people with dementia ◦ Mollii: Tailored rehabilitation in the form of a garment with electrotherapy programmed according to the individual's requirements ◦ Racefox: An app for elite training where smartphones' sensors monitor the individual's movement patterns ◦ RobCab: A fully autonomous logistics system for indoor hospital transports ◦ Safebase: Sensor system for cost effective care planning and increased safety in home care and elderly care ◦ Zoom Uphill: An all-terrain four-wheeler that gives people with difficulty to walk access to the forest and open country ◦ SEM™Glove: A glove improves grip strength and reduces muscle strain ◦ 1080 Quantum: For optimized training and allows for quick and easy evaluation of muscular function ◦ Tek RMD (Robotic Mobilization Device) ◦ Solutions for tomorrow – True X-ray mobility
	Industry	◦ Automated masking: Robotized masking process before welding ◦ Compogrip: A specially designed light weight gripper ◦ Fixyz: A component for the light weight gripper Compogrip
	Service	◦ Furhat: A robot head, which can communicate with one or more persons at once ◦ Groundbot: A spherical robot equipped with sensors, for surveillance of large areas ◦ IBA 2009: Robotized ice-blasting for cleaning of containers ◦ OpiFlex: Mobile robot platform for increased productivity for short run manufacturing ◦ Scooptram Automation System: A sensor system for autonomous mine loaders that load, haul and dump material in mines ◦ Robotvision: A vision based system for picking of unsorted goods ◦ Rosio: Welding robot for friction stir welding using a rotating tool ◦ YourFlow: A software tool for value stream mapping for the industry

Title	**Framework Grants for Research on Smart Systems**
Region	Sweden
Issued by	SSF(Swedish Foundation for Strategic Research)
Announcement	Every year
Term of validity	2016 ~ 2021
Budget	27 million USD (300 million SEK)
Keywords	SSF, Smart systems, Cyber Physical Systems, Robot, Automation, AI-based Information Systems
Related website	https://strategiska.se/app/uploads/sites/2/rit15_en.pdf https://strategiska.se/en/research/ongoing-research/smart-systems-2015/project/
Background	◦ SSF provided funding of around 54.6 million USD (600 million SEK) per annum and has a capital of approximately 91 million USD (1 billion SEK) as a basis for its activities. Funds are given to a large number of research projects at universities and technical institutes, many in collaboration with industry and also awards grants to leading researchers, with an emphasis on young coming stars. ◦ Priority areas: ✓ Biotechnology, medical technology and other Life Science Technologies ✓ Materials Sciences & Technologies ✓ Information, Communication & Systems Technologies(ICT)
Goal	◦ The Swedish Foundation for Strategic Research, SSF, supports research in science, engineering and medicine for the purpose of strengthening Sweden´s future competitiveness.

Contents

Currently there are 32 ongoing research group projects supported. Among them just 1 research group project belongs to robotics research category as followings :

● Framework Grants for Research on Smart Systems

◦ Background

The massive introduction of information and communications technology (ICT) greatly improves our handling of complexity in everything from genome research to effective manufacturing. Yet, needs and ambitions tend to grow at a higher pace than the system engineering abilities, and the spectre of complexity remains a moving target. ICT offers possibilities to develop functions that go far beyond human abilities, e. g. in memory, text search, computations, endurance, etc. Recently, it has also mounted a serious challenge to the previous human supremacy in object recognition and related areas.

◦ Goal

ICT's abilities to improve the designs and functionalities of existing kinds of technological system or to create entirely novel types. Smart systems may offer adaptive, predictive, and robust behaviours and capabilities even under hostile conditions. They could also provide compensation for uncertainty or variability in contexts. Safety and security can be features of a target system, while flexibility and upgradeability are normal parts of the specification.

◦ Research areas

✓ Cyber Physical Systems
✓ Integrated Systems
✓ Systems of Systems
✓ Automation
✓ Autonomous Systems and Robots
✓ Artificial Intelligence-Based Information Sysetms

◦ Projects in Smart Systems

Project title	Summary	Organization, Duration	Budget
Automation of system-specific model-based learning	To develop a new probabilistic modeling language, with new modeling techniques and machine learning algorithms. The end result is an automated solution for application specific	Uppsala Univ. '16.07 - '21.06	2.6 million USD (29 million SEK)

	model-based machine learning. End-users : Autoliv, Greenely, Karolinska, and ABB		
Smart assembly 4.0	To realize the idea of autonomous, self-optimizing robotized assembly factory maximizing quality and throughput, maintaining flexibility and reducing cost. The result is the system S/W for sorting and self-adjusting equipment to improve quality without tightening tolerances.	Chalmers U.T. '16.09 - '21.08	2.9 million USD (32.1 million SEK)
Semantic mapping & visual navigation for smart robots	To develop smart systems capable of integrating the different aspects of vision in a collaborative manner. Expertise from computer vision, machine learning, automatic control and optimization with goal of establishing integrated framework is gathered.	Chalmers U.T. '16.07 - '21.06	2.8 million USD (31.1 million SEK)
Smart Implicit Interaction	In smart environment, our activities drive and change the smart objects around us at the same time as they continuously adapt to us - creating for a new interface paradigm. This smart implicit interactions stay in background, thriving on data analysis of speech, movements, and other contextual data.	KTH - Royal Institute of Tech '16.07 - '21.06	3 million USD (33.1 million SEK)
Time-critical cloud services	The key missing property from today's cloud infrastructure is the ability to execute data transactions within a delay bound. The concept will be proven by performing data transactions in less than 250 ms within Sweden.	KTH - Royal Institute of Tech '16.07 - '21.06	2.4 million USD (27 million SEK)
SoPhy: Large-scale cyber-physical transport systems	To develop novel mathematical and computational tools for fundamental understanding and engineering design of emerging cyber-physical transport networks..	KTH - Royal Institute of Tech '16.07 - '21.06	2.9 million USD (32 million SEK)
Robot-assisted rapidly formed knowledge networks	The main objectives are to investigate and develop both the science and systems aspects of an enhanced version of HFNs that we call Hastily Formed Knowledge Networks (HFKN). The project targets the automation of many of the interaction practices required for teams of emergency responders to operate efficiently.	Linköping Univ. '16.07 - '21.06	2.4 million USD (27 million SEK)
EACare: Physical agent to support the mental well-being of the elderly	To develop an embodied agent - a robot head with communicative skills - capable of interacting with elderly people, analyzing their mental and psychological status via powerful audiovisual sensing and assessing their mental abilities to identify subjects in high risk.	KTH - Royal Institute of Tech '16.07 - '21.06	2 million USD (22 million SEK)
Smart Intra-body network	To develop a smart system platform consisting of an intra-body network of sensors and bio-electronic actuators, all connected by body-coupled communication (BCC).	Linköping Univ. '16.08 - '21.07	3.1 million USD (34.8 million SEK)
Mutual adaptation in systems for human-robot interaction	To develop a systematic bi-directional adaptive framework that yields safe, effective, socially acceptable and efficient robot behaviors and human-robot interactions.	KTH - Royal Institute of Tech '16.07 - '21.06	2.9 million USD (32 million SEK)

E11 Switzerland

Title	**NCCR Robotics (NCCR: Swiss National Center of Competence in Research)**	
Region	Switzerland	
Issued by		
Announcement	1st December, 2010	
Term of validity		
Budget	20 million USD (20,629,608 CHF)(2018 ~ 2021)	
Key words	Wearable robots, Mobile rescue robots, Educational 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/
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), - Scuola universitaria professionale della Svizzera italiana (SUPSI)	
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.	
The latest R&D project		
The key targets of the latest R&D project	◦	

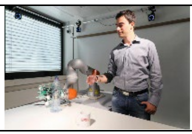
Contents

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

1.1. Wearable robotics

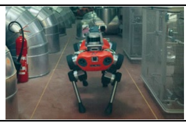
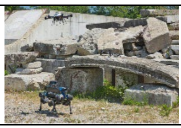
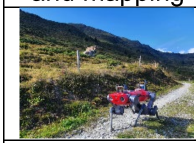
- Goal: To develop a novel generation of wearable robotic systems, which will be more comfortable for patients and more extensively usable in a clinical environment
- Main research

Project	Detailed task	Content
Regait++	 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

	 EES	A computational infrastructure combining real-time monitoring of neural signals associated to walking and control algorithms, with the ultimate goal of restoring walking through epidural electrical spinal cord stimulation
Third Arm		A robotic limb to allow subjects to control an additional robotic limb in combination with the natural arms and hands, while performing activities of daily living

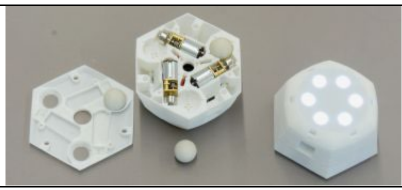
1.2. Rescue Robotics

- Goal: To create robust and agile robots that can walk, fly and swim into unstructured environments and assist rescuers
- Main research

Project	Detailed task	Content
Flying Robots	 Foldable Drone	A drone inspired by birds that fold their wings in mid-air to cross narrow passages
	 Packdrone	A quadcopter surrounded by a foldable cage that provides an all-round protective structure that physically separates the propellers from the environment, ensuring the safety of people in the vicinity
	 Manipulation with drones	A drone equipped with robot arm, enabling physical interaction with their environment, and manipulation operations from the air.
Legged Robot	 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
	 KROCK-2	A quadrupedal robot which can both surpass obstacles twice as high as the robot itself (15 cm) and move under narrow passages of the same height, can be replaced easily on the field as the construction of the robot is modular
Collabo-ration, learning and tests	 Collective localisation and mapping	A project to give walking and flying robots the ability to share visual information during a search-and-rescue mission and build collectively a map of the environment, at the same time determining each robot's position into it.
	 Machine learning for rescue robots	A project to give rescue robots the ability to walk unknown terrains using Machine Learning (ML)

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
- Two products were developed; the Thymio robot - a mobile robot increasingly used to teach robotics and programming, and Cellulo - a small, inexpensive and robust robot that kids can move with their hands and use in groups.

Teaching Resources (Thymio)		Cellulo
		

2. Funding

- Financing 2010-2021

Time-frame		
Funding source	2014 - 2017	2018 - 2021
SNSF grant*	15.2 million USD (15,295,000 CHF)	11.1 million USD (11,150,000 CHF)
Funds of EPFL*	6.7 million USD (6,727,000 CHF)	6.3 million USD (6,350,000 CHF)
Funds of ETH Zurich*	4.6 million USD (4,600,000 CHF)	1.8 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	31.6 million USD (31,611,707 CHF)	20.6 million USD (20,629,608 CHF)

* contractually agreed funding

U01 USA

Title	**National Robotics Initiative 3.0: Innovations in Integration of Robotics (NRI-3.0)**
Region	United States of America
Issued by	National Science Foundation (including USDA, NASA, DOT, NIH, NIOSH)
Announcement	February, 2021
Term of validity	2021 ~ , annual revision
Budget	12 to 14 million USD, FY2021
Key words	National Robotics Initiative, Ubiquitous Robots, Integration of Robots
Related website	NRI 3.0: Innovations in Integration of Robotics A Roadmap for US Robotics Supplement to the President's FY2021 Budget
Background	The National Robotics Initiative 3.0: Innovations in Integration of Robotics (NRI-3.0) program builds upon the preceding National Robotics Initiative (NRI) programs to support fundamental research in the United States that will advance the science of robot integration. The program supports research that promotes integration of robots to the benefit of humans including human safety and human independence.
Goal	◦ To strengthen the robotics research community, fostering innovation and workforce development, accelerating progress, demonstrating novel capabilities, and building ecosystems for innovation. ◦ To promote new integrated approaches to the challenges of accountability, interoperability, ethical operation and trust which will be engendered by integrated functional ubiquitous robots.

Contents

1. The Introduction of NRI-3.0

- The NRI-3.0 program seeks research on integrated robot systems and builds upon the previous NRI programs to focus on **innovative integration of robotics technologies**.
- An NRI proposal should convince the reader that the proposed system will enable **new functionality** or significantly improve upon **the state of the art of integrated robotics**.
- Building upon the successes of earlier versions of NRI, the goal of the NRI-3.0 program is to support fundamental research that will accelerate **the development and use of integrated robot systems** in the United States

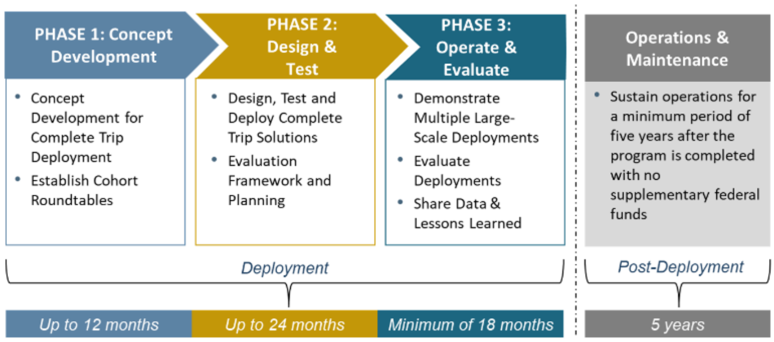
1.1. From NRI-2.0 to NRI-3.0

	NRI-2.0 FY2020 (NSF 20-522)	**NRI-3.0** FY2021 (NSF 21-559)
Summary of Significant Changes	◦ The deadlines have been revised; a single class of projects exists for all proposals for NRI 3.0. The NRI program now focuses on research in the innovative integration of robotic technologies. ◦ The NRI program has expanded to include robotic research that does not necessarily emphasize collaboration. ◦ The NRI 2.0 theme requirements have been largely eliminated. ◦ NASA will only consider projects that are within its stated cost limits. ◦ NIFA will only consider projects that are within its stated cost limits. ◦ NIOSH will only consider projects that are within its stated cost limits. ◦ DOT and NIH have been added as partner organizations.	
Funding	◦ Annually 22 to 32 million USD	◦ Annually 12 to 14 million USD

2. NRI-3.0 Program Description

- The NRI-3.0 program encourages cross-disciplinary projects.
- Collaboration among academic, industry, government, non-profit, and other organizations is encouraged to establish better linkages between fundamental science and engineering and technology development and use, through partnerships among researchers, applications developers, users, and industry.
- International collaborations that enhance and add significant value to the proposed research and education activities will also be considered.
- Fundamental research in integration of robotics is the focus of the NRI-3.0 program.

2.1. Sponsoring agency mission-specific research

<table>
<tr><td rowspan="3">DOT FHWA</td><td colspan="2">Interest in robotic research and development that provides improved safety and mobility for the U.S. highway system. In particular, FHWA is interested in fundamental advances that solve important public needs and can scale for national use.</td></tr>
<tr><td>ITS4US Deployment</td><td>◦ ITS4US Deployment Program is a $40 million multimodal effort, led by the ITS JPO and supported by OST, FHWA, and FTA to identify ways to provide more efficient, affordable, and accessible transportation options for underserved communities that often face greater challenges in accessing essential services.
◦ The program aims to solve mobility challenges for all travelers with a specific focus on underserved communities, including people with disabilities, older adults, low-income individuals, rural residents, veterans, and limited English proficiency travelers.
◦ The program, to be executed in three phases, has procured and awarded multiple large scale, replicable, real world deployments of integrated innovative technologies to address the challenges of planning and executing complete trips:
- **Phase 1**: Deployment Concept
- **Phase 2**: Design and Test (Current Phase)
- **Phase 3**: Operate and Evaluate
- **Post-Deployment Operations & Maintenance**
</td></tr>
<tr><td>Pedestrian Safety Summit</td><td>◦ **Purpose**: Provide virtual platform for dialogue to discuss pedestrian safety issues and determine initiatives and actions to improve pedestrian safety. The objectives are to:
- **Inform**: Raise awareness of U.S. DOT and stakeholder initiatives and resources available for pedestrian safety.
- **Listen**: Gather detailed input from a diverse group of stakeholders regarding opportunities and challenges facing pedestrian safety, as well as successes and lessons learned.
- **Engage**: Get feedback on draft Current and Future Federal Actions to Enhance Pedestrian Safety.</td></tr>
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<tr>
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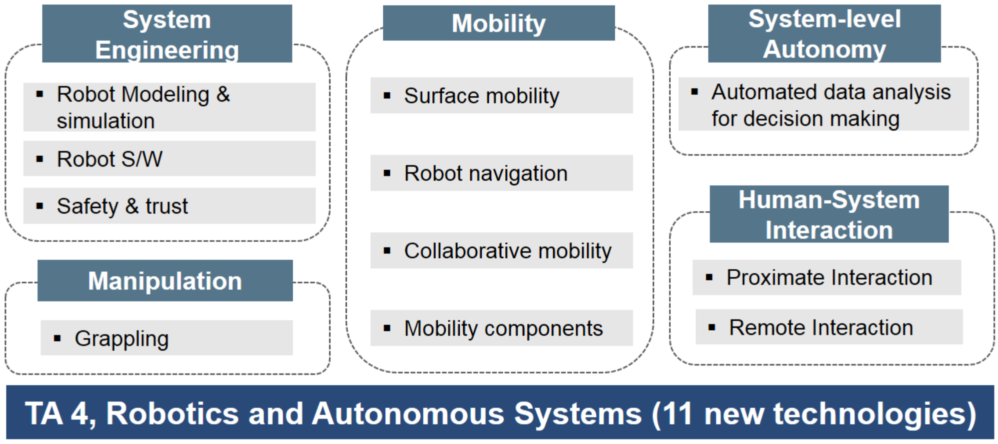
<tr>
<td>Accessible Transportation Technologies Research Initiative (ATTRI)</td>
<td>◦ The ATTRI Program is leading efforts to develop and implement transformative applications to improve mobility options for all travelers, particularly those with disabilities.
◦ ATTRI research focuses on removing barriers to transportation for people with visual, hearing, cognitive, and mobility disabilities.
◦ Complete Trip
- Using ATTRI's pre-trip concierge, wayfinding and navigation, robotics and automation, and safe intersection crossing applications, someone can travel with confidence throughout his/her trip in an unfamiliar part of town.

</td>
</tr>
<tr>
<td rowspan="2">NASA</td>
<td colspan="2">Focus on "Moon to Mars" highlights objectives to establish a long-term presence in the vicinity of and on the Moon, and to invest in technologies needed for the exploration of Mars and other deep-space destinations.</td>
</tr>
<tr>
<td colspan="2">◦ NASA seeks research and technology development that will significantly increase the performance of robots to collaboratively support deep space human exploration and science missions.
◦ Research and technology development should focus on being customizable to both the human and robot, preventing single-system or "one-off" solutions.
◦ Robotic systems will be of varying archetypes and modalities – it is expected that many of these systems will be mobile and include manipulation capabilities.
◦ Some systems may operate with rich data (from sensors, models, etc.), while others may operate with minimal data derived from limited on-board sensors.
◦ NASA's 2015 technology roadmap and 2020 technology taxonomy cite critical technologies needed to enable and advance Human-Systems Interaction, which includes human-robot teams. In addition, some example research and technology areas include, but are not limited to, the following:
- Strategies to decrease data needed between human and robot while not impacting team performance
- Remote operator interfaces that increase situational awareness and robotic intent understanding, and that optimize operator workload
- Autonomous performance monitoring
- Autonomous command planning and sequencing
* It is desired that research and technology development include testing to assess human-robot team performance.</td>
</tr>
</table>

<table>
<tr><td></td><td colspan="2">* Critical technologies needed to enable & advance Human-System Interaction from NASA Space Technology Roadmaps and Priorities Revisited:
</td></tr>
<tr><td rowspan="2">NIH</td><td colspan="2">Interest in targeting to support the development and integration of assistive robotic technology to achieve functional independence in humans; improve quality of life; assist with behavioral therapy and personalized care; and promote wellness/health.</td></tr>
<tr><td colspan="2">◦ NIH encourages robotics research and technology development to enhance health, lengthen life and reduce illness and disability. The NIH also supports non-hypothesis driven applications, which includes technology-driven and problem-driven applications.
◦ The most significant challenges will be in addressing safety issues, especially for applications to be used in home-based and long-term care settings where integration of complex systems will be required. Additionally, these assistive robots need to quickly adapt to changes of the user and the environment. Human assistive devices should be designed to assist healthcare providers as well as the individuals needing care.
◦ In the future, assistive robotics will enable people to engage in all aspects of human life with endurance and dignity.
- Home care and long-term personalized care robots;
- Robotic wellness/health promotion and maintenance;
- Robotic behavioral, geriatric, and rehabilitative therapy;
- Robotic aids for mobility, manipulation, human communication and cognition, vi sion for non-sighted persons;
- Assistive robotics to eliminate health disparities across populations; and Infectio us disease monitoring and assessments.</td></tr>
<tr><td rowspan="2">NIOSH</td><td colspan="2">Focus on identified research priorities in the areas of basic cause-and-effect research and intervention to address knowledge gaps related to integration of robotics technologies and worker safety and health.</td></tr>
<tr><td>Basic/etiologic research</td><td>- Risk factors involving human worker’s cognitive, physical, physiological, and emotional capability and limitations when working with robots and robotics technologies;
- Refinement and development of science-based human pain and injury thresholds for collaborative robots, wearable robots, and new robotics technologies;
- Robotics technologies and engineering features for safe, intuitive, and useful collaborative and co-existing robot systems;
- Risk factors involving human-robot interface and safety communication;
- Task-related and environmental risk factors that are specific to each industrial sector, particularly for the industries in which integrated robotics technology has high potential for improving workplace safety;</td></tr>
</table>

		- Risk factors associated with adaptability of robots in dynamically changing work environments or situations outside normal operating conditions.
	Intervention research	- Evaluation of integrated robotics technologies as potential interventions to reduce or prevent existing hazards and resulting injuries and illnesses to workers; - Evaluation of training that helps human workers acquire skills, knowledge, and abilities needed to work with integrated robotics systems safely in complex and dynamic industrial environments; - Innovative workplace interventions including engineering controls and administrative controls. Research may address costs of the intervention and impacts on productivity.
USDA/ NIFA	Focus on robotics research, applications, and education to enhance agricultural production, processing, and distribution systems that address the following goals of the USDA science blueprint; sustainable agricultural intensification, climate adaptation in agriculture, value added innovation in agricultural systems, and translation of food and nutritional information technological advances in food industry	
	Scalable Robotic Technologies - Automated and mechanized intelligent systems that focus on labor-intensive tasks in production and distribution of crops; - Automated systems for planting, scouting, spraying, culturing, irrigating, and harvesting plant crops (including forests) to decrease costs, improve efficiency, or reduce inputs of water, fertilizer, or chemicals; - Improved robotics for inspection, monitoring, culturing, sorting, and handling of plants and flowers in controlled environment facilities and nurseries, or for managing or studying (e.g., monitoring, inspecting, sorting, vaccinating, deworming) large numbers of live animals, either domestic or wild; - Automated systems for inspection, sorting, processing, or handling of animal or plant products (including forest products) in post-harvest, processing, or meat Processing, or product distribution environments; - Multi-modal and rapid sensing systems for detecting defects, ripeness, physical damage, microbial contamination, size, shape, and other quality attributes of plant or animal products (including forest products), or for monitoring air or water quality. **Configurable Multi-Agent Teams** - High-level task planning, execution, and control systems for spatially distributed autonomous or semi-autonomous robots that operate in concert with co-workers, either human, robotic, or other devices/systems; - Innovative use of intelligently coupled robot drones and unmanned ground vehicles (UGVs) to improve crop and animal management; - Communication protocols and standards for inter-agent coordination (including natural language) and for unsupervised collaboration; - Distributed intelligence, fault tolerance, and "failure with grace" that will allow high-level task completion despite failure of one or more agents (or teams) or temporary loss of human attention.	

2.2. Robotic Projects for K-16 Education

- To promote further exploration of the linkages of research on Integrated robots to one or more levels of K-16 education, NSF's Directorate for Education and Human Resources will provide funding at the lower end of the funding range.
- Successful projects will advance the vision of integrating technologies to make robots more capable by developing and testing innovative strategies for either:

a) Engaging students or teachers in the study of robotics in the context of science, technology, engineering, or mathematics (STEM) education; or

b) Designing, developing, optimizing or using robotics to enhance teaching and learning in formal or informal STEM education settings.

▪ Due to limited funds and the multi-agency nature of this solicitation, **education-focused proposals are discouraged at the higher end of the funding range**.

Title	**US DoD Budget For Unmanned System**
Region	United States of America
Issued by	United States Department of Defense (DoD)
Announcement	May 2021 (revised May 2022)
Term of validity	Annual revision
Budget	7.5 B USD invested for 2021, and 8.2 B USD planned for 2022
Key words	Unmanned system, Robotics, Research, Development, Test & Evaluation (RDT&E)
Related website	https://www.defense.gov/ https://comptroller.defense.gov/Budget-Materials/Budget2022/
Background	Current United States national security and defense strategies involve responding to growing international competition and threats from terrorists, 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 autonomy

The DoD defense budget invested of 7.54 billion USD in fiscal year (FY) 2021 (approximately 1.07 percent of total DoD budget) for unmanned system across all agencies observing the decrease in funding of unmanned system and robotics in last three year by 9% (compare to FY 2020) and 21% (compare to FY 2019). The FY 2021 budget resources are invested in following areas

Fiscal Year	Funding	Contents
2021	7.54 billion USD	3.327 billion USD for procurement of autonomy system
		4.213 billion USD for RDT&E of autonomy system
2022	8.2 billion USD	Detail amount of procurement and RDT&E is not announced

1.1. The DoD FY 2021 enacted budget and FY 2022 request budget built upon three priorities

Priorities	Contents
Defend the Nation	• Defeat COVID-19 – The Department will continue to act boldly and quickly to support Federal Government efforts to defeat the disease, defend the force against it, and work with our domestic and international partners to protect our Nation from potential novel and deadly viruses of the future. • Prioritize China as the Pacing Threat – The Department will prioritize China as our number one pacing challenge and develop the right operational concepts, capabilities, and plans to bolster deterrence and maintain our competitive advantage. • Address Advanced and Persistent Threats – We will ensure that we remain fully ready to respond to and effectively deter nation-state threats emanating from Russia, Iran, and North Korea, and disrupt transnational and non-state actor threats from violent extremist organizations, such as those operating in the Middle East, Africa, and South and Central Asia. • Innovate and Modernize – The Department will innovate at a speed and scale that matches a dynamic threat landscape. This will require advances in our joint warfighting concepts and a commitment to rapid experimentation and fielding of capabilities. Where necessary, we will divest of legacy systems and programs that no longer meet our security needs, while investing smartly for the future.

Defend the Nation	• Tackle the Climate Crisis – We will elevate climate as a national security priority, integrating climate considerations into the Department's policies, strategies, and partner engagements
Take care of our people	• Grow our Talent – We will build opportunities for growth and development in the Department, invest in training and education, and create new opportunities for advancement that drive promotion and retention for our total workforce - civilian and military. • Build Resilience and Readiness – The Department will maintain and enhance force readiness and protect the safety, health, and welfare of service members and their families, as well as our civilian employees. The Department will lead with our values, building diversity, equity, and inclusion into all aspects of our work to drive innovative solutions across the enterprise. • Ensure Accountable Leadership – DoD leaders at every level will be responsible for building a safe environment for our people and guaranteeing that we show swift and clear accountability to anyone who does not act within the highest standards of the Department.
Succeed through teamwork	• Join Forces with our Allies and Partners – We will consult with our allies and partners and, when appropriate, we will act together. • Work in Partnership with Our Nation – We will redouble our commitment to a cooperative, whole-of-nation approach to national security that builds consensus, drives creative solutions to crises, and guarantees that we lead from a position of strength -fielding a credible force, ready to back up the hard work of our diplomats around the world and our national partners here at home. • Build Unity within DoD – We will continue to build unity of effort and mission across components, commands, services, and theaters, and we will demonstrate teamwork at the highest levels of the Department and expect it across every level, knowing that working collaboratively together will ensure the greatest success in protecting and defending our Nation.

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: Operating safely and efficiently	▪ Air collision avoidance ▪ Ground mobility ▪ Naval mobility ▪ Work-centered Processing, Exploitation, and Dissemi nation (PED) cell
Near-term (2021 – 2024): Machined-assisted operations	▪ Threat identification and COA recommendation ▪ Cueing analysts from fused sensor data ▪ Extending human range ▪ Logistical operation
Mid-term (2025 – 2028+): Man-Unmanned teams	▪ Heterogeneous swarms ▪ Man-unmanned teaming
Long term Fully autonomous	

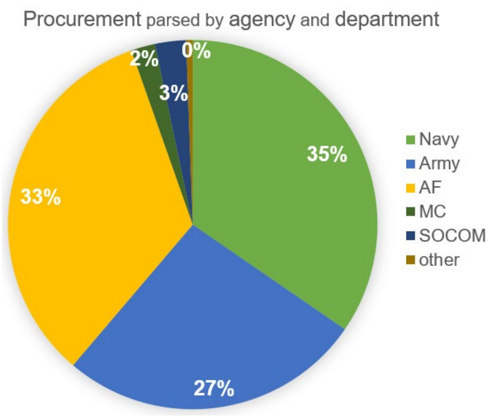
2. DoD Programs

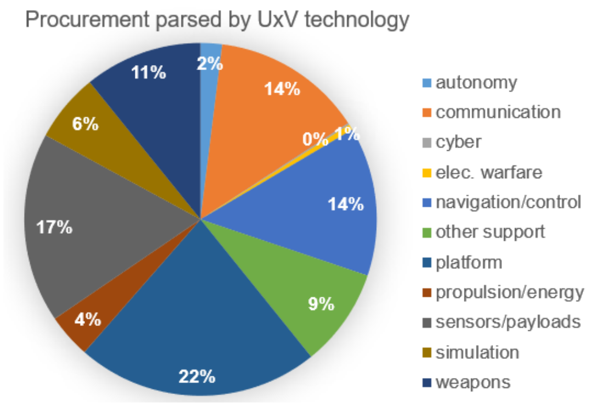
- The FY 2021 funding for new procurement and research, development, test and evaluation (RDT&E) efforts is separated into 17 military agencies and departments, in which the three main services (Air Force, Army and Navy) accounting for 6.55 billion USD or 87% of that total.
- In FY 2021, the RDT&E funding for robotics technologies is distributed by domain with approximately 3.32 billion USD related to the air domain, 1.38 billion USD for subsurface maritime and 1.19 billion USD for surface maritime, 1.36 billion USD related to ground domain. Despite the decrease in total funding in FY 2021, the funding for cross-domain capabilities of UxVs is increase by 49% in comparison with last year. The noticeable efforts of this cross domain UxVs like LOCUST project, Marine Corps Maneuver project, the Common Control System project. Noted that the sum of the all domains will exceed the FY 2021 total amount because of some programs fund in multiple domains.
- The total procurement funding for programs that support UxV relative to domains supported in FY 2021 indicates that UAV related programs dominated the other funding related programs with 2.84 billion USD, following by the maritime subsurface, maritime surface and ground with 284, 210 and 241 million USD, respectively.

2.1. Unmanned System Procurement

- Navy and air force receive 1.1 billion USD budget for each to procure UxV in FY 2021 following by Army (885 million USD), Marine Corps (70 million USD), SOCOM (90 million USD), 19 million USD for other categories.

The procurement parsed by the UxV technology as shown in Figure X reveal some highlight of FY 2021. Procuring platform is the most funding in FY 2021. The next highest technology procurement is sensors/payloads followed by communication systems, navigation/control systems, weapons system, etc.



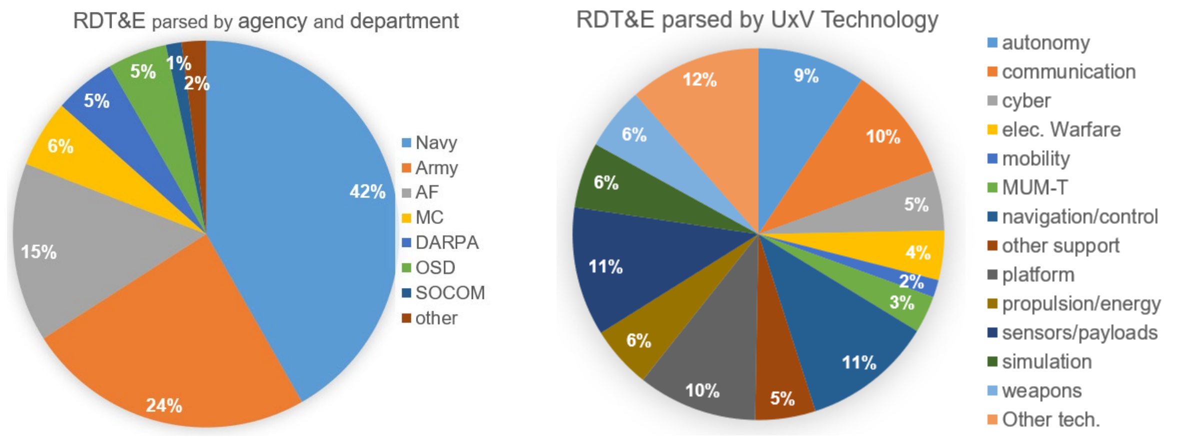


<table>
<tr><th>UxS/UxV</th><th>Main items</th><th>Funding</th><th>Contents</th></tr>
<tr><td rowspan="4">UAS</td><td>MQ-9 Reaper</td><td>568.9 million USD (FY 2021)</td><td>- 287 million USD to procure 16 aircrafts
- Procurement of communication system s, training devices, extended range MQ -9, and MQ-9 upgrades.
- 63.5 million USD support the payload i ntegrated on MQ-9 Reaper</td></tr>
<tr><td>MQ-4C Triton RQ-4</td><td>259.7 million USD (FY 2021)</td><td>- The appropriation bill reveals the fundi ng for one additional aircraft despite a pause in procurement (President's bud get) in FY 2021</td></tr>
<tr><td>MQ-1C Gray Eagle</td><td>140.3 million USD (FY 2021)</td><td>- Procurement of 1 aircraft to avoid signi ficant increased costs in future</td></tr>
<tr><td colspan="3">Other funding programs have approximately 310.5 million USD for aerial target systems through 3 items
• Navy's Aerial Targets (LI 2280);
• Air Force's Target Drones (LI 10TRGT);
• Army's Air Defense Targets (LI1242C93000)</td></tr>
</table>

UUV	USV	50 million USD (FY 2021)	- 3 USV for Remote Mine hunting Modul e - 2 USV for Unmanned Minesweeping M odule
	KNIFEFISH	17 million USD (FY 2021)	- Capable of detecting, classifying, and i dentifying buried mines - Procurement of a platform
	MK 18	21 million USD	- Procure 15 MK18 MOD2 and 12 MK18 MOD1
	ExMCM ROV	~9 million USD	- Procure 18 platforms for Explosive Ord nance Disposal (EOD) mission and 1 w orld class ROV
	Littoral Battlespace Sensing – Glider (LBS-G)	3.7 million USD	- Support of the Navy's oceanographic r esearch efforts - Procure of 18 platforms
	Fleet Survey Team	0.5 million USD	- Procure of 2 platforms
UGV	Squad Multipurpose Equipment Transport (SMET)	28.5 million USD (FY 2021)	- Procurement of 238 vehicles (Multi-Util ity Tactical Transport (MUTT))
	Man Transportable Robotic System Increment (MTRS Inc II)	50 million USD (FY 2021)	- Centaur UGV provided by FLIR Syste ms More than double FY 2020 funding
	CRS-I	37.8 million USD (FY 2021)	- Procurement of 839 platforms (QinetiQ North America)
	CRS-H	24.7 million USD (FY 2021)	- Procurement of 73 platforms (Kobra (U GV, FLIR Systems)
	EOD robot	3.7 million USD (FY 2021)	- Procurement of 29 platforms (FLIR Sys tems)

2.2. Unmanned Systems RDT&E

- The navy leads all service with 1.76 billion USD for UxV RDT&E following by the Army (1.02 billion USD), Air Force (632 million USD), Marine Corps (238 million USD), Defense Advanced Research Projects Agency (DARPA, 216 million USD), Office of the Secretary of Defense (OSD, 210 million USD), Special Operations Command (SOCOM, 55 million USD) and 86 million USD for other categories.
- Figure X shows the proportions of the RDT&E funding parsed by UxV technologies. Among these, technology research that improve the navigation/control system and sensors/payloads arguably have the highest level of support. A robust, reliable Platforms and communications systems are important to development of UxVs with the second most significant funding followed by the autonomy, propulsion/energy systems, weapons systems, and simulation system, etc.



UxS/UxV	Main items	Funding	Contents
UAS	MQ-25 Stingray	257 million USD (FY 2021)	Six sub-project share FY 2021 funding: - Lead system integration product development (26%) - Air segment product development (25%) - Test and evaluation (23%) - Unmanned carrier aviation mission control system (20%) - Support and management (6%)
	MQ-9s Reaper	128.2 million USD (FY 2021)	- Funds the weapons system upgrades, identification of friend or foe, moving target indicator, automated takeoff and landing capability, synthetic aperture radar, multi-spectral targeting system, communication enhancements
	MQ-4C Triton RQ-4	340.2 million USD (FY 2021)	4 projects share FY 2021 funding: - RQ-4 capability enhancement (AF) - RQ-4 block 30 (AF) - RQ-4 modernization (Navy) - MQ-4C Triton (Navy)
	Future Vertical Lift (FVL) UAV	~110 million USD (FY 2021)	Funding divided into programs (PE 0602148A and PE 0603465A) with noteworthy efforts - Advanced teaming concepts and demonstrations. - Sensors/Multi-function imagers - Advancement of autonomy algorithm. - Multi-fuel capable hybrid electric propulsion. - UAS susceptibility and electromagnetic vulnerability reduction technologies
USV	LUSV MUSV	139.3 million USD (FY 2021)	- Decrease an approximately 68% from the request amount - MUSV (Sea Hunter) is being integrated with L3 Harris's ASView aims to an autonomous USV - 2 prototypes of LUSV (Overlord) are being developed
UUV	LUUV Small/medium UUV	~140 million USD (FY 2021)	- Completion of Phase 1 LDUUV (Snakehead) fabrication, submarine integration, battery integration and demo.

	Advanced Undersea prototyping		- Small UUVs (Φ 3-10 inches) are being tested and evaluated of prototype - Medium UUVs (KNIFEFISH, Razorback, MEDUSA, Φ 10-21 inches) are being developed. - >115 million USD to develop the Orca Extra Large UUV for undersea operational awareness and payload delivery
UGV	Robotics Development Next generation combat vehicle advanced technologies Defense research science	~160 million USD (FY 2021)	Focus on Robotic Combat Vehicle (RCV) with 3 classes: RCV-L/-M/-H - 4 Phase 2 RCV-L were developed (QinetiQ) - 2 RCV-M were developed (Textron system) - Other researches include maturation of remote control software, autonomous leader follower capability, autonomous behaviors for MUM-T mission, etc.

2.3. International collaborations in Autonomy

With an aim to strengthening the existing alliances and attracting new partners. he Air Force Research Laboratory (AFRL) and the UK's Defence Science and Technology Laboratory (DSTL) are jointly developed in term of autonomy and AI from 2021.

Autonomy and Artificial Intelligence Collaboration (AAIC) Partnership Agreement (4 years) aims to improve decision-making, increase operational tempo, reduce risk to life, and reduce manpower burden.

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	1.6 billion USD, FY2020 (35 billion USD from 2020 to 2024)
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://www.springer.com/gp/book/9783030385125
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 by 2024. 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 by 2024.

Contents

1. Introduction of the Artemis lunar program

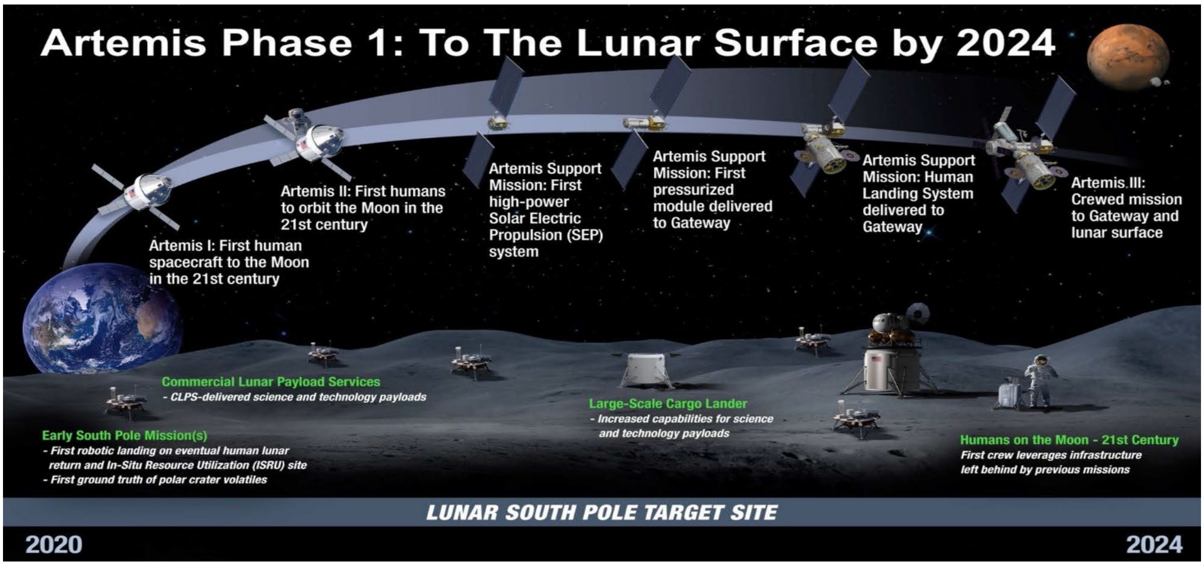
- The Artemis Lunar Program is a new crewed spaceflight program by NASA, the U.S. commercial aerospace industry, and the international partners including ESA (now representing 22 countries), Canada, Japan, and Russia.
- The goal is to land "**the first woman and the next man**" on the lunar South Pole-Aitken Basin by 2024. 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

- Artemis is split into two phases with work on both phases having already begun.
- **Phase 1** is from 2020 until 2024 and will focus on getting systems in place to support the first human lunar surface landing in more than half a century. Phase 1 will include the first uncrewed test flights in retrograde orbit.
  - **Artemis I**: The first launch of the SLS and Orion is called Artemis 1, and it is currently planned for late 2020 but most likely will be mid-2021.
  - **Artemis II**: The second mission, Artemis 2 (the former EM-2 mission) will take a crew on a fligh t around the Moon until 2023.
  - **Artemis III**: The third flight named Artemis 3 is currently scheduled for 2024 and will take a cre w to the Gateway, then down to the lunar.
- **Phase 2** comprises the capabilities necessary to establish a sustainable human presence on and around the Moon by 2029. NASA has begun to prepare for Phase 2 by focusing on surface habitation and mobility, plus In-Situ Resource Utilization (ISRU).

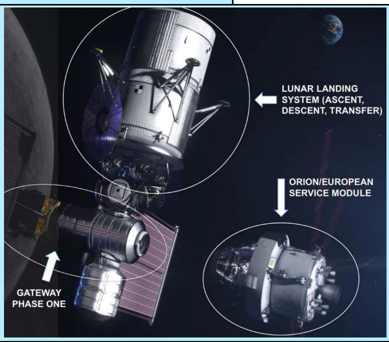
2. Artemis mission: Phase 1 (Lunar South Pole by 2024)



2.1. Achievement by 2024

- Artemis Phase 1 plans to move in parallel to complete the architecture and deliver crew via government and commercial systems.
- Between 2020 and 2024, U.S. industry delivers the launches and human landing system necessary for a faster return to the Moon and sustainability through Gateway.

For CREW		
	Artemis I	First flight test of SLS and Orion as an integrated system

<table>
<tr><td rowspan="2"> </td><td>Artemis II</td><td>First flight of crew to the Moon aboard SLS and Orion</td></tr>
<tr><td>Artemis III</td><td>First crew to the lunar surface: Logistics delivered for 2024 surface mission</td></tr>
<tr><td colspan="3">
◦ Orion spacecraft: The only spacecraft capable of carrying and sustaining crew on missions to deep space, providing emergency abort capability, and safe re-entry from lunar return velocities.
◦ The Space Launch System (SLS): The only rocket with the power and capability required to carry astronauts to deep space onboard the Orion Spacecraft.
◦ National Capability: The SLS and Orion programs (including Exploration Ground Systems support at Kennedy Space Center) leverages over 3,800 suppliers and over 60,000 workers across all 50 states.
</td></tr>
<tr><td colspan="3">For CARGO</td></tr>
<tr><td rowspan="2"> </td><td>Power and Propulsion Element (PPE)</td><td>Power and Propulsion Element arrives at Near Rectilinear Halo Orbit (NRHO) via commercial rocket</td></tr>
<tr><td>Pressurized Module (PM)</td><td>Small area for crew to check out systems prior to lunar transfer and decent</td></tr>
<tr><td rowspan="3">Human Landing System</td><td>Transfer</td><td>Transfers lander from Gateway to low lunar orbit</td></tr>
<tr><td>Descent</td><td>Descends from transfer vehicle to lunar surface</td></tr>
<tr><td>Ascent</td><td>Ascends from lunar surface to Gateway</td></tr>
<tr><td>
</td><td colspan="2">
◦ Initial Gateway focuses on the minimum systems required to support a 2024 human lunar landing while also supporting Phase2
◦ Provides command center and aggregation point for 2024 human landing
◦ Establishes strategic presence around the Moon - US in the leadership role
◦ Creates resilience and robustness in the lunar architecture
◦ Open architecture and interoperability standards provides building blocks for partnerships and future expansion
</td></tr>
</table>

2.2. Lunar Science by 2024

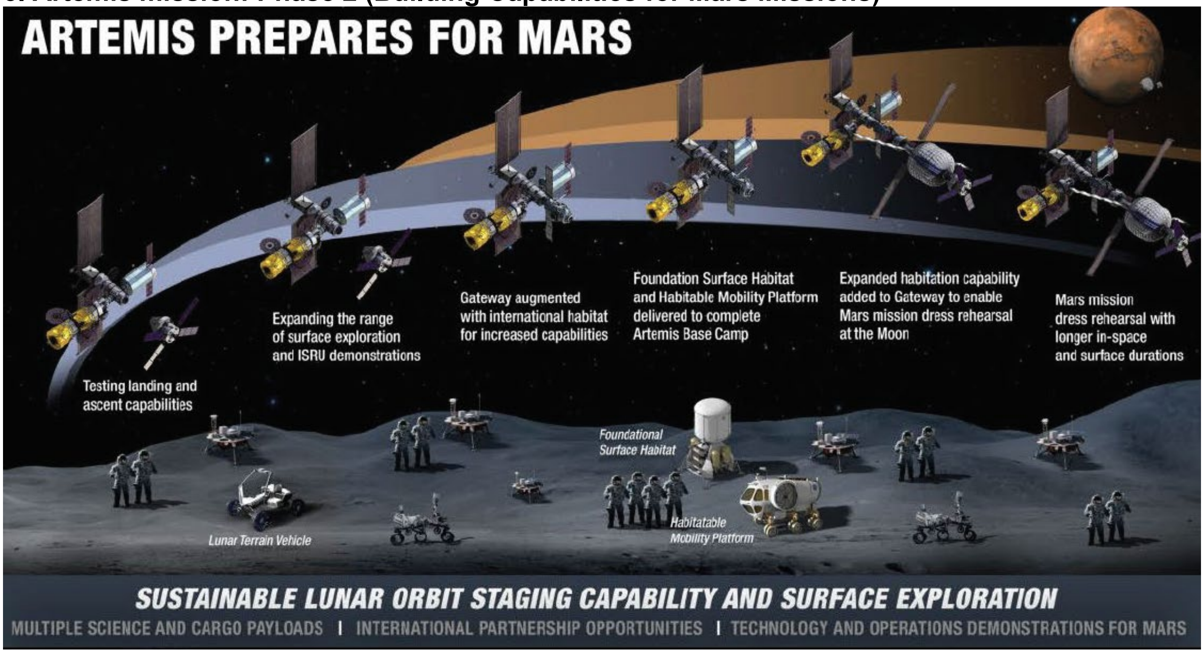
▪ The lunar science goals by 2024 are

➢ To learn about polar volatiles by having landers perform direct measurements
➢ To study the geology of South Pole-Aitken Basin
➢ To land at a “lunar swirl” feature to perform the first direct magnetic measurement on the lunar surface

Polar Landers and Rovers	◦ First direct measurement of polar volatiles, improving understanding of lateral and vertical distribution, physical state, and chemical composition ◦ Provide geology of the South-Pole Aitken basin, largest impact in the solar system
Non-polar Landers and Rovers	◦ Explore scientifically valuable terrains not investigated by Apollo, including landing at a lunar swirl and making first surface magnetic measurement ◦ Using PI-led instruments to generate Discovery-class science, like establishing a geophysical network and visiting a lunar volcanic region to understand volcanic evolution

Orbital Data	◦ Deploy multiple CubeSats with Artemis Ⅰ ◦ Potential to acquire new scientifically valuable datasets through CubeSats delivered by CLPS providers or comm/relay spacecraft
In-situ Resource Initial Research	◦ Answering questions on composition and ability to use lunar ice for sustainment and fuel

3. Artemis mission: Phase 2 (Building Capabilities for Mars Missions)



3.1. Achievement after 2024
▪ Artemis Phase 2 pursues to secure sustainability at the Moon, to make preparation for Mars
▪ After Artemis III, the overall plan is to conduct operations on and around the Moon that help prepare for the mission durations and activities to experience during the first human mission to Mars, while also emplacing and building the infrastructure, systems, and robotic missions that can enable a sustained lunar surface presence.

On the Surface: Artemis Base Camp 	◦ Artemis Base Camp will be the first foothold on the lunar frontier. ◦ The three proposed primary mission elements of Artemis Base Camp are **1) the Lunar Terrain Vehicle** (unpressurized rover) to transport suited astronauts around the site **2) the habitable mobility platform** (pressurized rover) that can enable long-duration trips away from Artemis Base Camp **3) the foundation surface habitat** that will accommodate four crew on the lunar surface and anchoring Artemis Base Camp and the U.S. presence at the South Pole.
Lunar Resources 	◦ As the sustained presence grows at the Moon, opportunities to harvest lunar resources could lead to safer, more efficient operations with less dependence on supplies delivered from Earth. ◦ NASA has several current the in-situ resource utilization (ISRU) investments through partnerships with industry and academia. ◦ Prospecting, extraction and mining initiatives are advancing our capabilities to find and harness resources from the lunar regolith. ◦ The sample will be delivered in place on the lunar surface for retrieval by NASA at a later date.

In Orbit: **The Gateway** 	◦ The first two Gateway modules, the PPE & the HALO, will be integrated on the ground and launched together on a single rocket in 2023. ◦ Maxar Technologies of Westminster is developing the PPE, leveraging heritage systems from the company's geostationary orbit satellites. ◦ Northrop Grumman of Falls Church, Virginia, is developing the HALO, which will be the initial crew cabin for astronauts visiting the Gateway. ◦ Cargo deliveries, initially provided by SpaceX of Hawthorne, California, will service the Gateway with pressurized and unpressurized cargo, including food and water for crew, science instruments, and supplies for the Gateway and lunar surface expeditions. ◦ ESA's radiation investigation, the European Radiation Sensors Array (ERSA) will help provide an understanding of how to keep astronauts safe by monitoring the radiation exposure in Gateway's unique orbit.

3.2. Lunar Science after 2024

▪ The lunar science goal after 2024 is to provide unique science opportunities through human and robotic missions.

On Gateway	◦ Deep space testing of Mars-forward systems ◦ Hosts groundbreaking science study and observation ◦ Mars transit testbed for reducing risk to humans
Surface Exploration	◦ Understanding how to use in-situ resources for fuel and life ◦ Revolutionizing the understanding of the origin and evolution of the Moon ◦ Studying lunar impact craters to understand impact cratering ◦ Setting up complex surface science instrumentation ◦ Informing and supporting sustained human presence
Surface Telerobotics to Provide Constant Science	◦ Sending rovers into areas too difficult for humans to explore

4. Artemis Lunar Surface Technology Strategy

▪ Establishing a sustainable human presence on the Moon allows NASA to develop and test new approaches, technologies, and systems that will enable us to function in other, more challenging environments.

Technology Goals	◦ The Lunar Surface Innovation Initiative (LSII) activities are implemented through a combination of in-house activities, competitive programs, and public-private partnerships aimed to spur the creation of novel technologies needed for lunar surface exploration and accelerate the technology readiness of crucial systems and components.
Priorities	Through LSII, NASA's Space Technology Mission Directorate (STMD) is developing and demonstrating capabilities to retire technology hurdles in the following areas:
	◦ In-situ resource utilization technologies for collecting, processing, storing, and using material found or manufactured on the Moon or other planetary bodies. ◦ Surface power technologies that provide the capability for sustainable, continuous power throughout the lunar day/night. ◦ Dust mitigation technologies that diminish dust hazards on lunar surface systems such as cameras, solar panels, spacesuits, and instrumentation. ◦ Extreme environment technologies that enable systems to operate throughout the range of lunar surface temperatures. ◦ Extreme access technologies that enable humans or robots to

	efficiently access, navigate, and explore previously inaccessible lunar surface or subsurface areas. ◦ Excavation and construction technologies that enable affordable, autonomous manufacturing or construction.
Implementation Strategy	◦ Ensure that there is an ambitious, cohesive, executable agency strategy for developing and deploying the technologies required for successful lunar surface exploration. ◦ Integrate a broad spectrum of stakeholders to develop an acquisition strategy that efficiently facilitates robust collaborations and partnerships with industry and academia. ◦ Address planning, implementation, and budget needs to enable lunar surface activities across STMD programs. ◦ Collaborate with agency stakeholders, other government agencies, universities, industry, and international partners to better align the agency's investments relative to lunar surface demonstrations.
	A key tenet of LSII is the Lunar Surface Innovation Consortium, a collaboration across industry, academia, and government to successfully develop the transformative capabilities for lunar surface exploration. The consortium assists NASA in:
	◦ Identifying lunar surface technology needs and assessing the readiness of relative systems and components. ◦ Making recommendations for a development and deployment strategy of the technologies required for successful lunar surface exploration. ◦ Providing a central resource for gathering information, integrating technology interfaces, and sharing results.

Appendix

A01 China

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

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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

Guide for Program Declaring in 2022 under the Key Special Program for "Intelligent Robots"

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, we are now releasing the annual project declaration guide for 2022.

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

For the 2022 annual guide, the principles of problem-orientation, step-by-step implementation and focus on key program will be adhered to, focusing on five technical directions such as basic frontier technologies, common key technologies, industrial robots, service robots and special robots, to launch 25 guide tasks and arrange a state funding of 315 million yuan. Among them, in terms of basic frontier technologies, it is planned to launch 1 young scientist guide task with a state funding of 10 million yuan, or 2 million yuan for each project to support not more than 5 young scientists projects.

Such projects shall be declared under the research orientation in secondary title (such as 1.1) in the guide. Unless otherwise specified, the number of projects to be supported in each orientation is 1 to 2, with an implementation period of not more than 3 years. The research content of the project to be declared must cover all the research contents and evaluation criteria listed under the secondary title in the guide. Not more than 4 subjects shall be set up under basic research projects with not more than 6 participating units in total; and not more than 5 subjects shall be set up under the common key technology and application demonstration projects with not more than 10 participating units in total. One project director shall be assigned for each project and one subject director shall be assigned for each subject under the project.

No subject will be set up under the young scientist project with less than 3 participating units in total. One project director shall be assigned. Age requirements for young scientist project: the male director shall be born after January 1, 1984 and the female director shall be born after January 1, 1982. In principle, the ages of other participating members shall be subject to the above requirements.

In the guide, the "it is planned to support 1-2 projects" means: under the same research orientation, the top two projects with similar evaluation results and obviously different technical routes can be supported at the same time. The two projects will be supported in two stages. After completing the first stage, the implementation of the two projects will be evaluated and the following supports will be determined according to the evaluation results.

1. Basic frontier technologies

1.1 Theory on integrated design of robot structure-function-performance (basic research)

Research content: In response to the complex environment robot adaptive motion requirements, research shall be carried on the comprehensive design of motion and force analysis theory in the integrated design of structure-function-performance for complex environment robots to reveal the inner mechanism of robot function generation, multi-structure conversion and dynamic performance evolution, and develop a collaborative method of robot design, manufacturing and drive control O&M theory in the whole process of design – mechanics – materials – manufacturing - operation. A principle prototype of the robot shall be developed, which shall be able to change its structure independently according to the external environment through mechanism reconstruction to realize the operation in different environments, and carry out experimental verification with typical requirements.

Evaluation criteria: A robot principle prototype shall be developed to verify the environmental adaptability and motion operation function under more than 4 types of working conditions through active/passive regulation of single structure/structure configuration. At least 2 advanced frontier technologies shall be the first of their kind or have reached the international leading level among similar technologies, and supporting materials shall be provided. No less than 5 invention patents shall have been applied/obtained.

1.2 Controllable cross-media bio-mechanical fusion robot (basic research)

Research content: At the frontier of deep integration of life systems and electromechanical systems, the basic theories and implementation methods of controllable cross-media fusion robot shall be studied to explore the mechanism and model theory of bio-neural feedback and motion control, develop bio-mechanical cross-media integration bi-directional interface technology based on neural signal transmission mode, study embedded multi-mode motion information sensing and online detection method, build cross-media bio-mechanical system and experimental platform of neuromuscular-mechanical fusion, and carry out experimental verification of precise drive control under real-time feedback.

Evaluation criteria: Controllable cross-media fusion robot system shall be developed with biological neural response mechanism with the accuracy rate of ≥70% and a shape variable detection error of≤ 5% based on embedded sensing, which shall be subject to real-time feedback motion control verification in more than three scenarios. At least 2 advanced frontier technologies shall be the first of their kind or have reached the international leading level among similar technologies, and supporting materials shall be provided. No less than 5 invention patents shall have been applied/obtained.

1.3 Interactive control and behavioral integration of bio-mechanical systems (basic research)

Research content: In response to the single mode and analysis difficulty of interactive information of bio-mechatronics, research shall be carried out on the method of simultaneous measurement and multimodal fusion of physiological information on myoelectricity, myoacoustic, blood flow and blood oxygen with physical information on forces and postures to explore the feedback mechanism of mixed ultrasound and electrical stimulation affecting human movement and sensation, develop a multifunctional integrated flexible bi-directional neuromuscular interface device, build an experimental platform for interactive control of bio-mechanical systems with human-machine co-motor function, achieve accurate intent recognition understanding and motion behavior fusion of people in the loop and carry out experimental verification for typical needs.

Evaluation criteria: A flexible bi-directional muscle interface device shall be developed with synchronized detection function for physical and physiological signals and the in situ synchronous measurement and ultrasound stimulation function for achieve three-dimensional forces, temperature, myoacoustic and myoelectric at an ultrasound stimulation spatial resolution of ≤ 8 mm; human-computer interaction intention recognition rate shall be ≥ 90%; construct a bio-mechatronics system interaction control experimental platform with the walking speed of ≥ 1.6m/s, and realize the typical application of human-machine integration in more than three scenarios. At least 2 advanced frontier technologies shall be the first of their kind or have reached the international leading level among similar technologies, and supporting materials shall be provided. No less than 5 invention patents shall have been applied/obtained.

1.4 Multi-robot collaborative universe sensing technology (basic research)

Research content: In response to the problems caused by limited perception of traditional robots, research shall be carried out on the universe scene perception and model representation methods of fusion of information about robot, environment, geography and social activities, the emergence and feedback mechanisms of multi-robot swarm intelligence, the cross-domain matching and cross-fusion of multiple types of information, the multi-robot navigation and localization, the target detection and tracking, the interactive decision-making and other key technologies supported by universe perception; build a multi-robot collaborative universe perception and intelligent decision-making system and conduct typical application verification.

Evaluation criteria: The universe sensing and intelligent decision-making system for multi-robot clusters shall be developed, the sensing fusion of more than 3 types of cross-domain information shall be realized, and the application shall be verified in more than 2 typical scenarios with more than 10 sets of 5 types of robots for each scenario. At least 2 advanced frontier technologies shall be the first of their kind or have reached the international leading level among similar technologies, and supporting materials shall be provided. No less than 5 invention patents shall have been applied/obtained.

1.5 Robot skill learning and intelligence development (basic research)

Research content: In response to the urgent need for the intelligent operation of complex robot tasks and the convenient application to get rid of manual programming, research shall be carried on dexterous manipulation arm-hand design, modeling planning and precise control, complex scene object multimode perception and operation, complex operational skill knowledge expression and learning, operational skill recurrence optimization, cumulative generalization, migration application and other key technologies; and robot skill learning and development system and platform shall be developed based on dexterous manipulator to carry out experimental verification.

Evaluation criteria: The dexterous manipulator shall have various sensing abilities for forces, positions/touching and could carry out the operation movements of not less than 5 kinds, and the objected that can be manipulated shall not be less than 5 categories; the robot skill learning and development and platform shall be able to support HMI skill transfer and independent development to realize the learning of more than 5 complex operation skills and the understanding and independent use of tool functions; and more than 3 scenario verificati on in the same category with no object without reprogramming to show the generalized application capacity. At least 2 technologies/systems shall be the first of their kind or have reached the international leading level among similar technologies, and supporting materials shall be provided. No less than 5 invention patents shall have been applied/obtained.

1.6 Highly mobile wheel-foot bionic robot for complex plateau environment (basic research)

Research content: In response to the demand for high throughput capability of robots in highland mountainous areas, research shall be carried out on the integrated design of wheel-foot composite functional structure, multi-sensor fusion perception, agile gait and stability control and wheel-foot composite behavior planning and decision making methods; breakthroughs shall be made in in key technologies related to high-speed modeling of complex environment and autonomous climbing/agile jumping/omnidirectional movement behavior control and autonomous generation and switching of combined motion modes; a highly mobile wheel-foot bionic robot prototype shall be developed; wheel-foot composite agile motion in typical environment of highland mountainous areas shall be realized; and experimental verification shall be conducted.

Evaluation criteria: Highly mobile wheel-foot bionic robot shall be developed, with the ability to adapt to highland mountainous environments, support at least 3 movement modes with wheel, foot and wheel-foot, create more than four kinds of behavior combinations and quickly cross trenches, steps, vertical obstacles, mud lands and long-distance slopes; self-weight: ≤ 350kg, loading capacity: ≥ 200kg; wheel-mode speed: ≥ 30km/h, slope climbing degree: ≥ 45 °; foot-mode movement over vertical obstacle: ≥ 1m, jump distance: ≥ 2m. At least 2 advanced frontier technologies shall be the first of their kind or have reached the international leading level among similar technologies, and supporting materials shall be provided. No less than 5 invention patents shall have been applied/obtained.

1.7 New concept robot system creation (Young Scientist Project)

Research content: Based on the country demand scenarios, for the cross-fusion of materials, life, chemistry, physics, brain science and nano-science with robotics, research shall be carried out on the new principles, methods and forms to enhance the environmental adaptation capability, task operation capability or intelligent decision-making capability of robots to conduct innovative design and create new concept robot system.

Evaluation criteria: Prototypes of new concept robotic systems with originality shall be developed to demonstrate potential applications in national demands. The specific task objectives and system evaluation criteria shall be independently designed under the declared project. For any technology already existing in the field, at least 1 single technology shall be a breakthrough innovation in improving the robot's environmental adaptation capability, task operation capability or intelligent decision-making capability. At least 5 invention patents shall be filed/obtained.

Note: The number of projects to be supported is no more than 5.

2. Common key technologies

2.1 Performance improvement and application of core robot parts (common key technology)

Research content: In response to the need to improve the performance of core robot parts, research shall be carried out on the technologies of designing and optimizing the retention and reliability of precision reducer of robots, and make breakthroughs in tooth shape optimization design and high precision machining process; research shall be carried out on the design of robot controller performance and scalability and make breakthroughs in in core algorithms for controller dynamics trajectory planning, high-speed vibration suppression, high-performance interpolation and high-performance force control; research shall be carried out on high quality high power density drive and servo motor performance optimization design, and make breakthroughs in key technologies such as drive and servo motor torque pulsation and disturbance suppression; and core components of robots leading among the similar products in the world shall be developed, promoted and applied.

Evaluation criteria: The index system for benchmarking with similar foreign products shall be established, and the performance and consistency of controllers, servo motors, drives and reducers shall be leading in the world among similar products; the rated life of robot precision planetary cycloid (RV) reducer shall be more than 10,000 hours, and the accuracy of tooth gap during the life shall be ≤ 1 arc/minute, and the accuracy of angular drive shall be ≤ 1 arc/minute; the rated life of harmonic reducer shall be longer than 10000 hours, during the life, the K1 stiffness decline shall be ≤ 50% and the two-way angular drive accuracy shall be ≤ 40 arc/second; the average trouble-free time of servo motors and drivers shall be longer than 30,000 hours, with more than 3 times the overload capacity and ≥ 5,000 rpm for the entire system, and cogging torque fluctuations of ≤1%; the average trouble-free time of the controller shall be longer than 10000 hours, with dynamics model recognition, control and planning functions, recognition accuracy of ≥ 90%, tracking error of ≤ 0.004 motor circle, supporting for 9-axis interpolation and multi-machine cooperative interpolation as well as 16-axis linkage in total with additional axes; and more than 10 invention patents shall be applied for/obtained and more than 20,000 sets of ontology packages shall be formed.

Note: The ratio of the supporting funding from the leading enterprise to the state funding shall not be lower than 2:1.

2.2 Overall performance optimization and application of multi-articulated industrial robots (common key technology)

Research content: In response to the urgent need to improve the overall performance of the 6-degree of freedom articulated industrial robots in China, research shall be carried out on the lightweight design of robots, the high speed, high load and high precision dynamics design and control of complete robots and the off-line programming and no-demonstration deployment, breakthroughs shall be made in key technologies such as electromechanical coupling parameter calibration, attitude error compensation and variable inertia high-speed vibration suppression, improve the accuracy, static and dynamic performance and ease of use of domestic industrial robots, and the 6 degree of freedom articulated industrial robot with typical loading capacity to the leading level among the similar products in the world in terms of performance indicators shall be promoted.

Evaluation criteria: An index system for benchmarking with similar foreign products shall be build. The loading capacity of series robots shall reach 6~1000kg. At the speed of 500mm/s, the absolute trajectory accuracy of straight/arc movements of the robots shall be better than ±0.2mm, the movement trajectory error at each speed section shall not be higher than 1mm, the trajectory repeating accuracy in the whole space shall be better than ±0.08mm, no visible overshoot or vibration shall be seen during movement, the stabilization time within 0.1mm in position shall be less than 0.3s and the use rate of the maximum joint rotation torque shall be higher than 90%. The performance index of the 6 degree-of-freedom industrial robots with typical loading capacity that are made in China shall reach the leading level among the similar foreign products in the key industrial robot enterprises in at least 5 countries and more than 20,000 complete robots shall be sold. At least 10 invention patents shall be filed/obtained.

Note: The ratio of the supporting funding from the leading enterprise to the state funding shall not be lower than 2:1.

2.3 Integrated development platform for process applications of industrial robots (common key technology)

Research content: In response to the insufficient application processes in the high end industries of industrial robots, research shall be carried out on processes and technologies for real-time arc tracking in welding, laser seam positioning and tracking, force control and compensation in contact applications such as assembly, drilling, grinding and polishing, precise control of spray flow and path planning, and breakthroughs shall be made in key technologies such as intelligent learning and optimization of process rules and parameters, intelligent process data center and virtual simulation. An integrated development platform shall be developed for process applications of industrial robots and application verification shall be conducted for typical scenarios such as welding, spraying, grinding, polishing and assembly.

Evaluation criteria: An integrated development platform for process applications of industrial robots shall be developed, including intelligent process planning, data center and virtual simulation platform, which shall support more than six typical processes, including welding, painting, grinding, polishing and assembly, with an accuracy rate of more than 95% for simulation and emulation. The platform shall be able to support concurrent operations of more than 10,000 interactions, massive data throughput at the level of more than 100 million and online users of more than 1,000 at the same time. The platform shall be promoted in more than 5 key enterprises in at least three high-end industries with the sales of more than 500 sets. At least 10 invention patents/software copyrights shall be filed/obtained.

Note: The ratio of the supporting funding from the leading enterprise to the state funding shall not be lower than 2:1.

2.4 Intelligent operating system of industrial robots (common key technology)

Research content: In response to the low openness, poor compatibility, poor real-time performance and high threshold of use of existing robot operating systems, research shall be carried out on open and distributed network control system architecture design, robot universal configuration motion control and dynamic trajectory planning, self-learning to adapt to user behavior patterns, process application integration and compatibility porting, breakthroughs shall be made in system multi-task parallel real-time processing, high reliability network control and information security transmission, system multi-awareness fusion and robot control security and other key technologies to develop an intelligent operating system for industrial robots and carry out application verification.

Evaluation criteria: A general-purpose industrial robot intelligent operating system with at least one real-time task interface within 2ms shall be developed. The system shall be integrated with application algorithm library with the average algorithm time of < 50ms. The system shall support the configuration and use in more than 3 structured robots with secondary development environment and interface for kinematics / dynamics / trajectory planning. Network synchronization clock jitter shall be ≤ 1μs, the minimum control period of each node shall be ≤ 1ms and the network bandwidth shall be up to 1000MBT/s. The system shall be subject to application verification in more than 2 typical scenarios and more than 2000 sets shall be used in robots made in China. More than 10 invention patents shall be filed/obtained.

Note: The ratio of the supporting funding from the leading enterprise to the state funding shall not be lower than 2:1.

3. Industrial robots

3.1 Automation line and application demonstration of full-process robots for painting high-speed train bodies in white (application demonstration)

Research content: In response to the body-in-white painting of high-speed and subway vehicles, research shall be carried out on automatic body positioning and measurement technology, automatic sandblasting, automatic robot spraying of primer/putty/intermediate paint/finish and putty/paint robot adaptive polishing process, and breakthroughs shall be made in key technologies such as high precision and efficient calibration and measurement, spraying operation planning, adaptive force control and automatic identification of defects of weak characteristic coating to develop robotic automatic painting system for vehicle bodies, build an automated production line for painting robots for rail vehicles and carry out corresponding application demonstration.

Evaluation criteria: High precision and efficient visual measurement system shall be developed for vehicle bodies with the measurement resolution of 0.05mm (depth direction) and the measurement efficiency of ≥ 4.7m²/min. One full-process automated production line of robots made in China shall be built, including more than 10 robot operation systems covering automatic sandblasting, putty spraying, coating sanding, paint spraying and automatic detection of coating quality, with the sandblasting efficiency of ≥150m²/h, the polishing efficiency of ≥ 40m²/h, the painting efficiency of ≥200m²/h and the vehicle body flatness of more than 0.5mm/m. The coverage of automated operation for surface putty and paint shall be ≥ 95% and the operation efficiency shall be improved by 20% over manual operation. At least 10 invention patents and 3 software copyrights shall be filed/obtained, and more than two enterprise standards shall be made.

Note: The ratio of the supporting funding from the leading enterprise to the state funding shall not be lower than 2:1.

3.2 Flexible integrated manufacturing system and application demonstration for power battery pack multi-robot (application demonstration)

Research content: In response to the complex process needs regarding assembly, welding, gluing and fixing in mass production of battery packs for new energy vehicles, research shall be carried on key technologies such as automatic welding of battery modules, automatic gluing of cases, collaborative human-machine operation of fasteners and agile production of mixed rows of multiple species to develop robot workstations and flexible logistics systems for power battery packaging, welding, gluing and fastening, build a flexible manufacturing system for collaborative operation of multi-category power battery pack robots and carry out application demonstration.

Evaluation criteria: A multi-robot flexible integrated manufacturing system for power battery packs shall be developed, including robotic flexible work cell workstations for assembly, welding, gluing, fastening and testing. Welding positioning error: ≤±0.1mm, fastener torque error: ≤ ± 5%; flexible manufacturing system production beat: 20 workloads/h, capacity index CMK ≥1.67, comprehensive utilization rate: ≥90%, annual production capacity: ≥ 100,000 sets, compatible with more than 3 new energy vehicle battery pack models; application demonstration shall be carried out on more than 3 production lines, and the number of domestic robots applied to each line shall not be less than 50 units in 3 categories. At least 10 invention patents/software copyrights shall be filed/obtained, and more than two enterprise standards shall be made.

Note: The ratio of the supporting funding from the leading enterprise to the state funding shall not be lower than 2:1.

3.3 Automated production line and application demonstration of robots for woven material industry (application demonstration)

Research content: In response to the complex operation objects, low level of automation, high working load and recruitment difficulty, research shall be carried out on the key technologies such as robotized yarn management, finding yarn heads, yarn hanging, yarn threading and shaft (drum) loading and unloading and fabrics loading and preparation for civilian weaving production, robotized assisted complex 3D weaving, cylinder loading and unloading, cutting and palletizing for industrial 3D weaving production and robotized packet arrangement, online inspection, sorting and finishing for medical and health care non-woven production; breakthroughs shall be made in key technologies such as adaptive end-effector design for weaving robots, large-load weaving axis transfer and dexterous operation in restricted spaces, and fabric defect detection and real-time disposal; and a series of special robots for weaving material operation shall be developed to realize robotized process integration and information management, develop robot automated production system for complex production process of weaving materials and carry out application verification.

Evaluation criteria: Domestic robot automated production line shall be developed for the weaving material industry, with quality inspection, fault detection, process informatization, data traceability and other functions. The robot-specific end-effector shall accommodate yarn tubes with inner diameters of 24-60mm, weaving shaft transit load up to 1.5T to realize the aseptic and uncontaminated operation mode of non-woven fabrics for medical and health care with nonwoven online inspection speed up to 240m/min. The production line cylinder yarn hanging efficiency shall reach 700 yarn/hour, the upper and lower weaving shaft diameter shall reach 1.2m, and the sorting fabric roll efficiency shall reach 4/minute. The automation rate of the production line shall be more than 90%, the average trouble-free time shall be more than 8000 hours, and the labor shall be reduced by more than 25%; More than 3 application demonstrations of domestic robot automation production lines shall be carried out for civil/industrial/health industries and each production line shall have more than 10 robot applications (including the textile-specific robots to be developed under the project); and more than 10 invention patents shall be filed/obtained.

Note: The ratio of the supporting funding from the leading enterprise to the state funding shall not be lower than 2:1.

4. Service robots

4.1 R&D of robotic system for assisting spinal laminectomy surgery (application demonstration)

Research content: In response to the needs of ease of use, reliability, stability, and clinical adaptability of the vertebral plate decompression surgery robots, research shall be carried out on key technologies such as autonomous planning, human-machine collaboration, safe and effective local autonomous operation of the vertebral plate decompression surgery robot to improve human-machine interaction performance and surgical intelligence. Robot clinical operation specification and operating room compatibility design shall be studied to establish clinical evaluation method of laminectomy robot surgery and improve clinical adaptability. The product testing and clinical trials as required by the FDA shall be completed to commercialize the product.

Evaluation criteria: Class III medical device license shall be obtained for the complete robotic system for assisted spinal laminectomy; automatic robotic planning and local autonomous operation shall be realized, with a volume difference of ≤5% in resection results compared to preoperative surgical planning; a surgical outcome assessment system shall be established with significant improvement in postoperative perceptual function and visual analog scoring method (VAS) scores; more than 5 invention patents shall be filed/obtained and at least than 60 clinical demonstration applications shall be carried out in more than 5 hospitals with the product technology maturity of ≥ level 8.

Note: The ratio of the supporting funding from the leading enterprise or hospital to the state funding shall not be lower than 2:1.

4.2 R&D of robotic system for soft tissue puncture surgeries such as lungs (application demonstration)

Research content: Research shall be carried out on the ease of use, stability and clinical adaptability of the puncture treatment surgery robot to improve the clinical surgical capability of the product; breakthrough shall be made in high reliability and high safety guarantee technology for surgical robots to realize the reliability design of the whole machine; and research shall be carried on the clinical operation specification and operating room compatibility design for thoracoabdominal puncture oriented to lung, liver or kidney to improve clinical adaptability. The product testing and clinical trials as required by the FDA shall be completed to conduct research on robot system operation specifications, clinical diagnosis and treatment specifications, prepare product configuration plans and achieve productization.

Evaluation criteria: Class III medical device registration license shall be obtained for the lung puncture surgery robot system and more than 60 clinical demonstration applications shall be completed in more than 5 hospitals; accurate puncture of soft tissue organs such as lung, liver and kidney can be realized with target diameter of ≤ 8mm, one-time needle in-place rate of ≥ 90%, one-time needle adjustment rate of ≥ 99% and CT scan times of ≤ 3; puncture positioning mechanism can carry not less than 2 kinds of puncture tools such as sampling needle and ablation needle; the required number of clinical trial cases shall be completed and clinical trial reports shall be prepared; more than 5 invention patents shall be filed/obtained; and the product readiness shall be ≥8.

Note: The ratio of the supporting funding from the leading enterprise or hospital to the state funding shall not be lower than 2:1.

4.3 Brain neurointerventional NMR compatible puncture robot technologies and systems (common key technology)

Research content: In response to the clinical needs for high precision interventional procedures under NMR guidance for functional brain diseases, research shall be carried out on NMR-compatible cerebral neurointerventional robot system design, NMR image processing and real-time navigation, cerebral neurointerventional surgery design and 3D path planning of puncture needle, precision control and safety assurance technology and a prototype NMR-compatible puncture robot system shall be developed for neurological interventions in the brain to carry out experimental validation of animal and human specimens.

Evaluation criteria: Cerebral neurointerventional puncture robotic system shall be compatible with MRI scanners, and able to working at 3T magnetic field with freedom degree ≥ 7, meeting RCM conditions; the repeat positioning accuracy of the robot end shall be better than ±0.3mm; Puncture needle diameter shall be ≤ 2.0mm; end force sensing resolution shall be better than 0.5N with the range of ≥ 5N; the in vivo positioning accuracy of the puncture needle shall be better than 1.0mm under nuclear magnetic image guidance; and system functional validation on 10 live animals and 5 human specimens under NMR navigation shall be completed. System technology readiness shall be ≥ level 7; and at least 5 invention patents shall be filed/obtained.

4.4 Fundus microinjection surgery robot technologies and systems (common key technology)

Research content: For the clinical needs of precision microinjection for fundus diseases, research shall be carried out on microinjection robot mechanism in the confined space of the closed eye to achieve precise and flexible operation under minimally invasive conditions; research shall be carried out on Optical Coherence Tomography (OCT) and microscopic image fusion technology for precise targeting; research shall be carried out on operation state cognition and doctor's intention understanding based on multimodal information perception, and construction of a human-machine shared intelligent interaction system; research shall be carried out on complex soft tissue robotic precision microinjection technology to achieve microscopic precision injection in the fundus; and research shall be carried out on virtual constraint-based master-slave operation technology to enhance the safety of robotic surgical operations. Robot-assisted fundus microinjection surgery system shall be developed, surgical operation specification shall be made and surgical evaluation method shall be formed to complete animal experiment verification.

Evaluation criteria: A robotic system for fundus microinjection surgery shall be developed with a resolution of puncture motion of better than 2μm for microinjection, a sensitivity of puncture force perception of better than 5mN, and a diameter of the puncture needle of ≤80μm; the microscopic image target identification accuracy shall be better than 10μm with OCT probes of ≤ 200μm in diameter, which shall be integrated into surgical instruments; robot-assisted fundus retinal vascular and subretinal drug injection animal experiments shall be completed in more than 10 cases, with a success rate of ≥ 90%, and robotic surgery operation procedures and specifications shall be made; system technology readiness shall be ≥ 7 levels; and at least 5 invention patents shall be filed/obtained.

4.5 Percutaneous spinal endoscopic surgery robot technologies and systems (common key technology)

Research content: In response to problems of small space, lack of operational flexibility and high surgical risk in percutaneous endoscopic spine surgery, research shall be carried out on key technologies such as rigid-flexible coupling robot mechanism adapted to the needs of spinal endoscopic surgery, multi-source information perception and image fusion in narrow water environment, vision-enhanced guidance and human-machine cooperative safety control; and a robotic system for spinal endoscopic operation in confined spaces shall be developed to realize surgical operation functions such as peeling, probing, clamping, cautery and cutting under spinal endoscopy, and robotic surgical operation procedures and specifications shall be made to carry out experimental verification.

Evaluation criteria: A percutaneous spinal endoscopic surgery robot system shall be developed to achieve dexterous and delicate operations such as endoscopic stripping, probing, clamping, cautery and cutting; surgical channel diameter: ≤ 10mm, end freedom: ≥ 5, range of motion: ≥ 30 × 20 × 20mm^3, end load: ≥ 5N, operating error: ≤ 0.5mm, master-slave operation response time: ≤ 100ms; 10 animal experiments and 5 specimen surgical experiments shall be completed with a success rate better than 90%; the system technology readiness shall be ≥level 7; and more than 5 invention patents shall be filed/obtained.

4.6 Intelligent TCM acupuncture robot technologies and systems (common key technology)

Research content: In response to the urgent need for standardized and intelligent acupuncture treatment, research shall be carried on the key technologies such as robot dexterity mechanism that simulates the operation of expert acupuncture techniques such as lifting and twisting, state perception and fine control of robotic humanoid acupuncture operation, digital modeling and automatic identification of acupuncture points under image guidance, automatic positioning planning of acupuncture points, quantitative characterization of acupuncture techniques based on expert experience, construction of a database of acupuncture techniques for different diseases, and establishment of quantitative assessment methods for safety and effectiveness. An intelligent TCM acupuncture robot system shall be developed to realize animal and human application verification.

Evaluation criteria: An autonomous acupuncture robot system shall be developed for indications including nerve injury, urinary incontinence, and pain treatment; the autonomous localization accuracy of acupuncture points based on anatomical features shall be better than 1mm; the needle feed depth accuracy shall be better than 1mm; the twisting angle for accurate control shall be between 0-3600° with an error of less than 3°; the lifting and inserting depth shall be controlled between 0 and 100 mm with an error of less than 3 mm; force sensing detection accuracy shall be better than 0.5N; the puncture failure rate shall be ≤ 0.5%; a knowledge map of human acupuncture points shall be made; procedures and specifications for robotic acupuncture operations shall be made; More than 10 cases of animal experimental validation and more than 20 cases of clinical experimental validation shall be completed; the system technology readiness shall be ≥level 7; and more than 5 invention patents shall be filed/obtained.

4.7 Acquired debilitating rehabilitation robot technologies and systems for critical illnesses (common key technology)

Research content: In response to the problems of communication disorders, weakened respiratory function, neuromuscular dysfunction, and declining limb motor function in the rehabilitation of patients with severe acquired debility, research shall be carried out on the interaction technology of multimodal information fusion of vision, haptics, electrophysiology and ultrasound to achieve patient cognitive state recognition, behavioral intention understanding and human-computer interaction control; and research shall be carried out on assisted respiratory rehabilitation assessment and treatment technology, muscle function recovery method with precise electrical stimulation, variable configuration robot creation method to develop rehabilitation robot for patients with severe acquired debilitation, realize integrated respiratory-motor collaborative rehabilitation of patients and establish quantitative rehabilitation assessment system based on physiological parameters such as cerebral EMG and respiratory and motor parameters.

Evaluation criteria: The wearable system shall be able to collect physiological and morphological information such as EEG, EM and ultrasound and support natural interaction methods such as EEG and expression; Cognitive state, intention recognition categories: ≥ 20, correct recognition rate: ≥ 90%; the robotic platform shall be able to support patients in completing autonomous respiratory rehabilitation training and can use electrical stimulation to promote the recovery of muscle function; it shall be able to assist patients to complete the autonomous conversion of sitting and standing positions and assisted self-balancing walking with the active drive degrees of freedom of ≥ 12; a rehabilitation safety and quantitative assessment system shall be built; clinical trials with more than 5 patients shall be completed; System technology readiness shall be ≥ level 7; and at least 5 invention patents shall be filed/obtained.

4.8 Urination and defecation ability enhancement training and cleaning robot system for bed-ridden elderly people (common key technology)

Research content: In response to the problems of incontinence, bedridden defecation and care for the disabled elderly, research shall be carried out on the assessment and enhancement training methods of defecation ability, and on a robot for defecation ability enhancement training with functions of autonomous diagnosis and assessment, personalized rehabilitation prescription generation, rehabilitation training and effect assessment; breakthrough shall be made in key technologies such as defecation intention monitoring, human position recognition and positioning, human-machine contact force control, hip cleaning robot control, system comfort and safety design to develop the urination and defecation care robot; urination and defecation ability enhancement training and cleaning robot system for bed-ridden elderly people shall be developed to carry out application verification.

Evaluation criteria: Bedridden elderly defecation ability enhancement training and cleaning care robot system shall be developed with defecation ability assessment and enhancement training, bowel movement monitoring, defecation assistance, automatic cleaning and disinfection and urination and defecation collection and disposal and at least 30 cases of application verification shall be carried out; the accuracy rate of urination and defecation monitoring and early warning shall be higher than 95%, the defecation ability training module shall support more than 3 kinds of training modes and the defecation and urination ability shall be improved by 20% after training; the enhancement training human-machine interaction force control error shall be ≤ 0.5N; System technology readiness shall be ≥ level 7; and at least 5 invention patents shall be filed/obtained.

4.9 Single-port cardiac surgery robot technologies and systems (common key technology)

Research content: In response to the challenges of small space, high risk and high precision surgery in complex cardiac surgery, research shall be carried out on robot mechanism configuration and end-effector design in confined spaces to meet surgical operation requirements; research shall be carried on high-precision multidimensional force sensing technology to achieve precise force feedback for surgical operations; research shall be carried out on precise recognition of surgical targets based on image information to achieve real-time dynamic tracking control of the operative area; and research shall be carried out on master-slave and collaborative surgical models to expand surgeons' surgical capabilities. A prototype single-hole cardiac surgery robot system shall be developed to realize typical cardiac surgery operations such as internal mammary artery acquisition and mitral valve surgery, and robotic surgery operation procedures and specifications shall be established to conduct animal experiments for validation.

Evaluation criteria: A single-hole cardiac surgery robotic system shall be developed with a flexible end surgical actuator that enables cardiac surgeries such as internal mammary artery acquisition and mitral valve surgery; the single-hole channel diameter shall be ≤ 30 mm and the number of energy instruments and multifunctional instruments that can be accommodated simultaneously shall be ≥ 3; the surgical actuator end degrees of freedom shall be ≥ 6; the surgical actuator positioning accuracy shall be ≤ 1mm; surgical actuator end effective operation force ≥ 3N; force sensing accuracy shall be better than 0.1N; 10 animal experiments shall be completed with success rates of higher than 90%; system technology readiness shall be ≥ level 7; and at least 5 invention patents shall be filed/obtained.

5. Special robots

5.1 Large hydropower dam underwater intelligent defect detection robot system (common key technology)

Research content: In response to the problem of detecting surface defects in large depth submerged dams of large hydropower plants, research shall be carried out on key technologies such as lightweight structure design of underwater inspection robots, inertial autonomous positioning and navigation technology, dam defect measurement and identification, underwater anti-disturbance motion control, underwater power supply and communication, remote operation and local autonomous fusion, and large hydropower dam underwater intelligent defect detection robot shall be developed to test the horizontal surface, upright surface and slope surface pf the underwater dam and other working conditions, identify a large range of hydropower dam underwater cracks, falling blocks, exposed tendons and other defect, perform defect positioning, defect size measurement and data recording and analysis functions, and carry out application verification.

Evaluation criteria: Large hydropower dam underwater intelligent defect detection robot shall be developed to achieve underwater robot hovering and movements at fixed depth/ fixed height/directional/fixed speed with the maximum working depth of ≥ 300m, the directional positioning accuracy of better than 1 °, the distance positioning accuracy of better than 0.5% slope distance , the depth positioning accuracy of better than 0.05%, the speed estimation accuracy of better than 0.5%, the whole machine underwater comprehensive resistance to flow of higher than 2 knots and the forward current resistance of higher than 3 knots; HD cameras, image sonar, hydroacoustic positioning, laser scanner and other multifunctional task modules shall be integrated to detect cracks, dropping blocks, exposed tendons and other defects with the defect measurement area error of ≤ 5%, the volume error of ≤ 10% and the defect positioning error of lower than 0.5m; and the system technical maturity shall be ≥ level 7. Application validation shall be carried out in major projects such as the Three Gorges Dam. At least 10 invention patents shall be filed/obtained.

Note: The ratio of the supporting funding from the leading enterprise to the state funding shall not be lower than 2:1.

5.2 Key technology and application demonstration of high-speed robot for Mini LED mega-volume transfer (application demonstration)

Research content: In response to the new display panel Mini LED huge transfer technology bottleneck, research shall be carried out on one-time, high-speed, precise and stable giant transfer methods for Mini LEDs; research shall be carried out on key technologies such as lightweight design of intermittent motion transfer robots with ultra-high speed, high precision and high frequency, multi-source error transfer and compensation, fatigue life design under alternating load, and system vibration suppression under high frequency excitation; research shall be carried out on the geometric error characteristics of mega-volume transfer robots, error measurement and compensation techniques under the compound action of multiple sources of errors; research shall be carried out on the relationship between transfer strategy, process parameters and comprehensive efficiency and accuracy, and breakthrough shall be made in the high efficiency and low leakage solid process and optimization technology; and high-speed robot system for Mini LED mega-transfer shall be developed to carry out application demonstration.

Evaluation criteria: High-speed robot system for Mini LED mega-transfer shall be developed and meet the requirements of class 1000 cleanliness; X, Y axis positioning accuracy: ≤ 5μm, maximum transfer target area: ≥ 1450mm × 850mm, minimum transfer chip: ≤ 125μm × 75μm, transfer speed (UPH @ pitch ≤ 2mm): ≥ 180,000pcs/hour; chip transfer accuracy shall be 15@3σ; solid leakage rate shall be lower than 0.001%; the Wafer exchange time shall not be greater than 11s; and Z-and S-shaped transfer paths shall be supported. At least 15 application demonstrations shall be conducted and 5 invention patents shall be filed/obtained.

Note: The ratio of the supporting funding from the leading enterprise to the state funding shall not be lower than 2:1.

A03 Korea

Ministry of Trade, Industry and Energy, Announcement No.2019-523

In accordance with Article 5 of the "Promotion Act for Development and Dissemination of Intelligent Robots" and Article 2 of the Enforcement Decree of the same Act, 'The Third Basic Plan for Intelligent Robots" is announced as follows.

August 29, 2019

Minister of the Ministry of Trade, Industry, and Energy

Third Basic Plan for Intelligent Robots

2019. 8.

Related Departments Jointly

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I. Establishment Backgrounds for Basic Plan

1. Institutional background

◈ To prepare the 'Third basic plan for intelligent robots' to develop the robot industry as the key industry of the Fourth Industrial Revolution and to support innovation of the manufacturing industry and service industry innovation of manufacturing industry as well as service industry

◇ Through the enactment of Robot Act in March 2008, the support foundation was prepared for the development of robot industry

❍ Through the establishment of the first and second basic plans, the Korea Institute for Robot Industry Advancement was founded (2010), and robot projects were excavated for full-pledged support of the robot industry from 2011

❍ As the second basic plan was completed (2014~2018), establishment of the third basic plan for intelligent robots to be enforced from 2019 (2019~2023) was required.

◇ Considering the law maintenance period, the "Support Plan for Market Creation for Robot Products" was prepared for the preferred implementation tasks of 2019.

❍ Through 10-year extension of the Intelligent Robot Act (June 2018) and maintenance of sub-level statutes (December 2018), a foundation was prepared to establish the basic plan.

* Intelligent Robot Act §5: The government needs to establish basic plans every five years to efficiently achieve the purpose of the law concerning the development and dissemination of intelligent robots.

❍ Such preferred tasks as plans for development of service robot technology and expanded dissemination of robot products for the socially disadvantaged were introduced as an item for the Committee for the Fourth Industrial Revolution (December 2018)

◇ For preparation of the third basic plan, a robot specialists firm with the participation of three hundred people from industry, university and research has been organized and operated (December 2018~May 2019)

❍ Each subcommittee was operated for construction of the value chain among conglomerates and medium- to small-enterprises, preparation of the dissemination model, development of finance products, construction of infrastructure, etc.

❍ The major contents of the basic plan discussed in the forum were presented in the "Report Meeting on the Cultivation Strategies for the Robot Industry (VIP Nationwide Economy Tour, March 2019) as a "Development Plan for the Robot Industry".

2. Industrial Background

◇ Meanwhile, multi-faceted efforts have been made for the cultivation of the robot industry, producing some outcomes

❍ The "Promotion Act for the Development and Dissemination of Intelligent Robots*" was enacted in June 2008, and systematic cultivation policies such as R&D, demonstration, dissemination, etc. were implemented.

* The "Basic Plan for Intelligent Robots" was established in units of five years and the Korea Institute for Robot Industry Advancement was established.

❍ Thanks to high robot utilization by automobile, electric and electronic business types, Korea emerged as first in the world in terms of robot density, and fifth in the world in terms of in manufacturing robots

* The number of robot-utilizing units per 10,000 people engaged in the manufacturing industry of our country is 710 units (85 units in global average).

◇ However, the areas of robot utilization are concentrated, and the competitiveness of the robot industry is vulnerable.

❍ In the manufacturing field (root, textile, food and beverage) with poor operation environments such as high risk, high intensity, etc., the robot utilization is not high.

* Business type (No. of robot-disseminated units, robot density): Automobile (87,417, 2,235) vs root (4,112, 84)

❍ In addition, overall competitiveness of robot industry is vulnerable as exemplified by the dependence of key components and software for robots in advanced countries (Japan, Germany, US).

◇ Recently, the robot industry has emerged as a pivotal point in the fourth industrial revolution

❍ Recently, as the new technology of the fourth industrial revolution (AI, 5G, etc.) is grafted to robots, smart robots are rapidly advancing, and areas of utilization are rapidly expanding.

* Robots of diversified forms such as 5G-based cloud robots, outdoor delivery robots, etc. have emerged.

❍ The unprecedented robot boom is taking shape worldwide, including investment in the robot industry, expansion of M&A, etc.

Reference 1. Ecosystem for robot

◈ What is a robot?

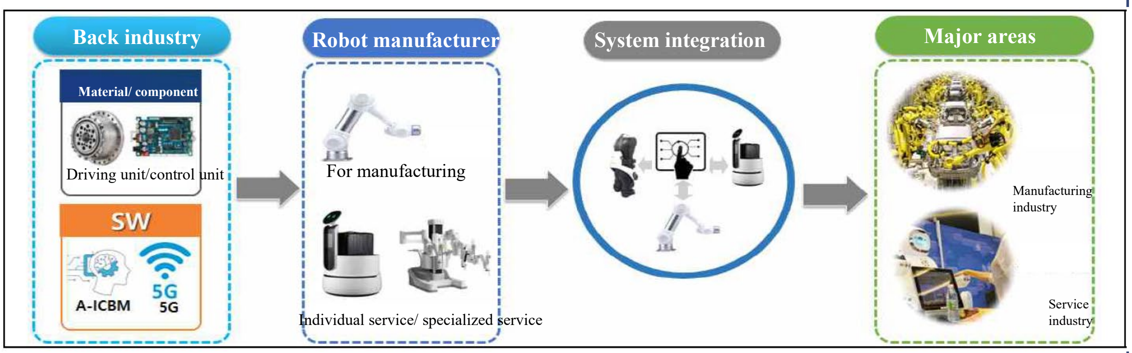
A robot is a mechanical device that independently senses external environments and determines how to act autonomously.

◈ Changes in robot concept

Past	Present
 Substitution for labor force	 Improvement of productivity
 Operation robot	 Collaboration with workers (cooperation robot)
 Improvement of life quality	 Sympathizing robot

◈ Ecosystem for the robot industry

With the robot industry at the center, the ecosystem is composed of areas such as materials, components, and software as the back industry and system integration and consumers for manufacturing and service as the front industry



II. Global trends of the Industry and Response Status of Each Country

1. Status of the Global Industry

◈ The global robot market has grown to $29.8 billion as of 2017 at an annual average rate of 16.5%, and is forecast to be $55.0 billion in 2021.
* Manufacturing: (2017) $16.2 billion → (2021) $23.6 billion (growth at annual rate of about 10%)
Service: (2017) : ('17) 8.6 billion dollars -> ('21) 20.2 billion dollars (growth at annual rate of about 24%)
Component: ('17) 5.0 billion dollars -> ('21) 11.2 billion dollars (growth at annual rate of about 22%)

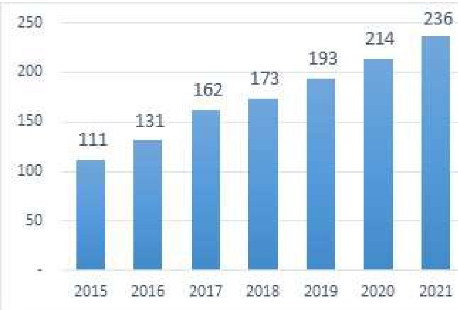
◇ (Manufacturing robots) The traditional powerhouse of the manufacturing industry has led industry, cooperative robots appeared

□ **(Market)** $16.2 billion dollars in 2017 at average annual growth rate of 10% with $23.6 billion forecast for 2021

❍ Powerhouses in the manufacturing industry such as China, US, Germany, Japan, Korea, etc. account for most of the demand for manufacturing robots

【Growth prospect of for global manufacturing robots】

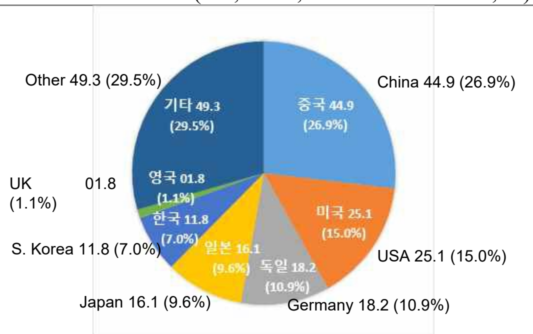
(Unit'; 100 million dollars)



Source : International Federation of Robotics (IFR 2018)

【Relative weight of market per country】

('17, Unit'; 100 million dollars, %)



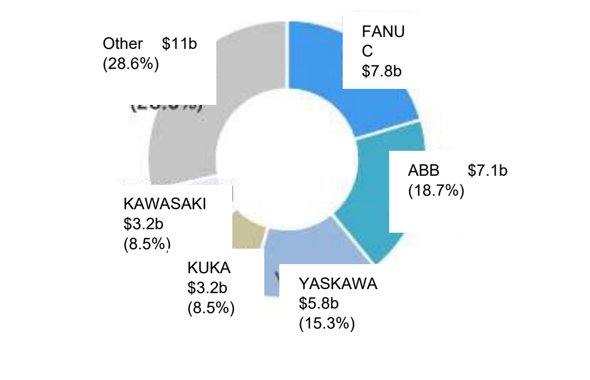
Source : International Federation of Robotics (IFR 2018) Estimation.

□ **(Enterprise)** Japanese-European businesses such as Japan (Fanac, Yaskawa), Europe (ABB, KUKA), etc. lead the global market.

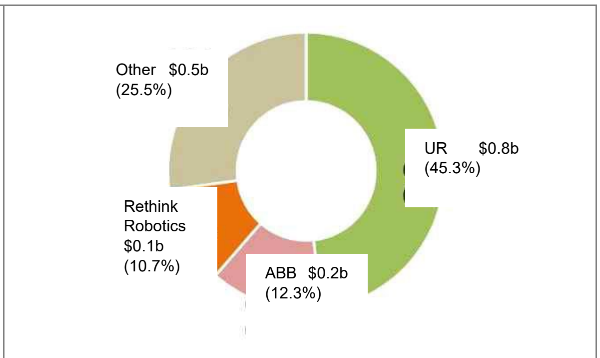
❍ Universal robots (Denmark) created a market for cooperative robots as a manufacturing robot of a new form allowing mutual collaboration between humans and robots.

* Installation is easy and use is convenient, allowing for operation in the same space as humans.

【Share of manufacturing robot enterprises】



【Share of cooperation robot enterprises】

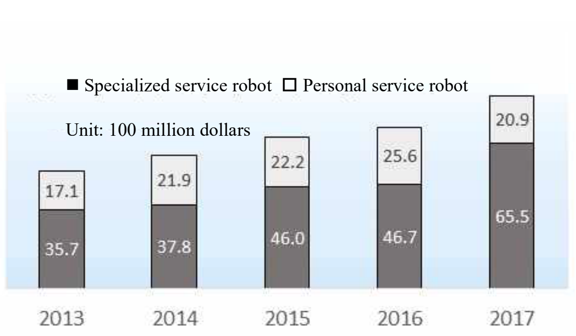


* Source; Markets and markets (2017)

◇ (Service robot) The US leads the industry, with logistics-medical care robots being expected to show high-rate growth

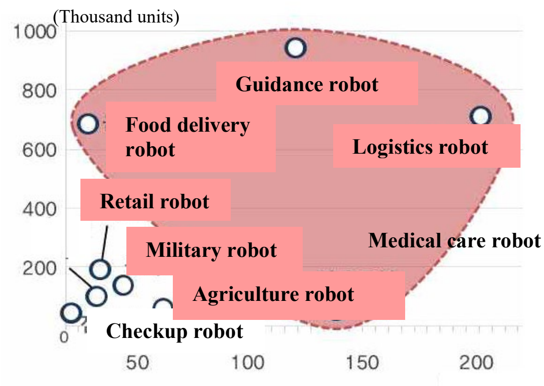
☐ **(Market)** Rapid growth to $8.6 billion dollars (average annual rate of 24%) with forecast of $20.2 billion in 2021

【Global market trend for service robots】



Source; IFR 2014-2018

【Forecast for No. of units sold/shipped (2025)】



Source: Macquarie 2017

❍ New markets being formed with a focus on logistics, medical care, housework robots

Classification	Logistics	Medical care	House work	Agriculture/exploration	National defense	Recreation	Rehabilitation	Other	Total
Amount (100 million dollars)	23.8	19.1	16.3	9.7	9.0	4.4	0.3	3.9	86.4
Relative weight	27.6%	22.1%	18.8%	11.2%	10.4%	5.1%	0.3%	4.5%	100%

☐ **(Enterprise)** Service robot markets such as logistics, medical care, housework, etc. are led by US enterprises firmly based on IT and service

- Amazon (US)is operating transport robots on the world's largest scale (130,000 units) for automation of logistics centers (cost savings by 20%), and is testing autonomously-run delivery robots (2019)
- Intuitive Surgical (US) commercialized laparoscopic surgery robot (Da Vinci) for the first time in the world to capture 80% ($3.1 billion in 2017) of the global market for surgery markets
- iRobot (US) as the first-ranked enterprise for the global market of cleaning robots is expanding its business into related service areas such as care, medical care, etc.

* Had 2017 sales of $8.8 hundred million, accounting for the global market share of 62%.

- Sony (Japan) re-launched a companion robot called Aibo with reinforcement of artificial intelligence (AI) and communication function (LTE) in 2018, confirming the feasibility of the social robot market.

◇ (Component • software) Advanced countries such as US, Japan, EU, etc. lead the market and the technology.

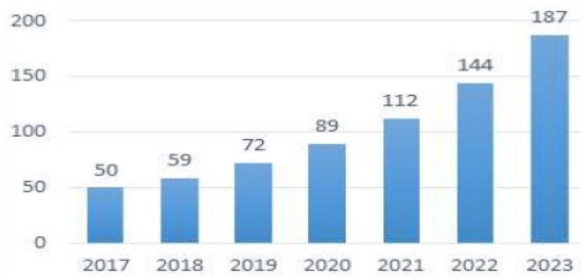
☐ **(Market)** Rapid growth to $5.0 billion in 2017 (average annual rate of 22.3%) with the forecast of $11.2 billion for 2021

- As utilization of AI, cloud is expanded, and the software sector is forecast to grow most rapidly.

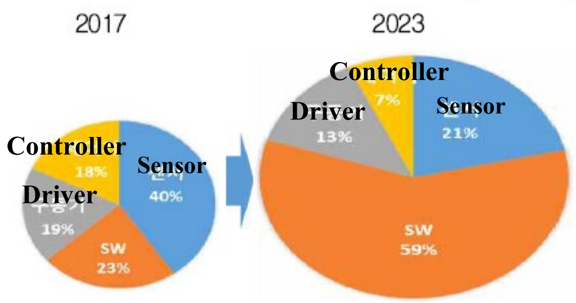
* 2017: Sensor (2.0 billion dollars) 〉SW (1.14 billion dollars) 〉Driver (9.3 hundred million dollars)〉 Controller (8.8 hundred million dollars)

'23: SW(11.0 billion dollars) 〉Sensor(4.0 billion dollars) 〉Driver(2.5 billion dollars)〉 Controller(1.3 billion dollars)

【Forecast of global markets for robot-related component, SW 】



【Relative weight of market per component】



Reference: Driver Market and Markets, 2019, Sensor Global Market Insight, 2018, Controller Mordor Intelligence, 2019, SW Market and Markets, 2018

- As the robot market expands, driver/controller areas tend to be converted to robot-dedicated components substituting for pant-automation components
- The sensor area is being evolved/developed into high-function sensor modules with AI function embedded for processing of high-difficulty operations such as outdoor delivery, logistics handling, etc.

☐ **(Enterprise)** Japanese enterprises with strength in automation of the existing plants remain strong in hardware component areas, while US IT enterprises are strong in robot software areas.

- Yaskawa (Japan), Panasonic (Japan), Harmonic Drive (Japan), etc. control markets for hardware components such as robot motors, decelerators, controllers, etc.

* In the case of manufacturing robots, motors, decelerators, controllers, etc. account for 56.3% of the total cost

- Amazon is providing cloud service for robots by adding RoboMaker function to the existing AWS platform, while Google is also preparing to provide a similar service.

  * AWS: Amazon Web Service,* Google Cloud Robotics Platform

2. Response status of each country

◈ Major countries such as US, Japan, China, etc. selected robots as the key for reinforcement of their competitiveness, and are in the process of reinforcing support policies for robot industry.

◇ National Robotics Initiative

- As a part of the "Advanced Manufacturing Partnership (AMP, June 2011)" for the revival of the manufacturing industry, the "National Robotics Initiative (NRI)" with multi-departmental cooperation is implemented.

  * By implementation of NRI 2.0 since 20017, support is being expanded via healthcare, logistics, etc. with the realization of Ubiquitous Co-Robot as the goal.

- By transfer of robot technologies of pubic research institutes to robot enterprises, and utilization of the developed manufacturing robots, smart processes of manufacturing enterprises are supported.

  * Advanced robotics consortium: Comprises government institutions such as NSF (National Science Foundation), DOE (Department of Energy) , companies such as ABB, AMAZON , etc. and public research institutions such as Michigan, Yale , etc. supporting manufacturing companies.

◇ New Strategy for Robotics

- With solutions to national and social problems such as aging, disaster, etc. as the goal, regulation reform, dissemination and diffusion, technology development, etc. are being implemented in accordance with the "New strategy for Robotics (2015)"

  * By 2020, 200 billion yen is planned to be supported for four largest robotic areas such as care, disaster, agriculture, manufacturing, etc.

- Ministry of Economy, Trade and Industry announced "Connected industry (2017)"and is implementing convergence of robot and IoT, expansion of smart factories, etc. for manufacturing innovation.

◇ China Manufacturing 2025

- Robotics was one of ten greatest key industries (China Manufacturing 2025) and "Smart Manufacturing" project is being implemented (May 2015～)

  * To solve problems of high external dependence for key technology and components of manufacturing business, falling-behind production equipment, and low energy efficiency, smart manufacturing processes and robot utilization are supported.

- The Ministry of Science and Technology announced the 'Guide to Smart Robot Projects' (August, 2017) for embodiment of the 'Development Project for the Robot Industry' (5-yer plan for 2016 ~ 2020)

III. Status of Domestic Robot Industry and Recent Trends

1. Status of Domestic Robot Industry

◇ (Manufacturing robots) Market concentrated on some business types, with market emergence of cooperation robots

□ **(Market)** Globally ranked 5th at a scale of about KRW 3 trillion in 2017 with average annual growth of 10% for the last 5 years

❍ Automotive, electric and electronics markets equipped with small-quantity batch production system accounts for more than 80%.

❍ Poor robot utilization by root, textile, food and beverage business types with a focus on mid- to small enterprises requiring operation environments and lacking in manpower

【Domestic dissemination status of manufacturing robots】

Classification	Automobile	Electric/electronic	Root industry	Plastic chemistry	Food and beverage	Machine	Other manufacturing businesses	Other	Total
Number of units	87,417	141,691	4,112	10,072	1,041	3,624	2,504	22,919	273,380
Ration	32.0%	51.8%	1.5%	3.7%	0.4%	1.3%	0.9%	8.4%	100%

* Source: IFR 2018, WR Industrial Robots (based on accumulation at the end of '17)

□ **(Enterprise)** There are only two enterprises with sales of more than KRW 200 billion among 718 enterprises in total, while medium-and small-enterprises with sales of less than KRW 10 billion account for 95 % at 686 ea.

❍ Hyundai Robotic (automobiles), Robostar (home appliances), Kohyoung Technology (semiconductors), etc. that secures large-scale consumers such as automobiles, home appliances, semiconductors, etc. lead the domestic market

【Enterprise Status per Sales Scale】

Classification	More than 200 billion won	More than 100 billion won	More than 50 billion won	More than 10 billion won	More than 5 billion won	Less than 5 billion won
Count	2	5	7	22	51	631
Distribution	0.3%	0.7%	1.0%	3.1%	7.1%	87.9%

* 1)Hyundai Heavy Industries, Robostar, 2)5 ea. including Kohyoung Technology, Samick THK, Shinsung Eng. etc.

3) 7 ea. including T-robotics, etc.

❍ Recently, late comers such as Hanwha Precision Machinery (Mar. 2017), Neuromeka (Mar. 2017), Doosan Robotics, (Dec, 2017) etc. competitively launched cooperation robots , entering the market for manufacturing robots.

◇ (Service robot) Growth primarily with cleaning robots, now at the early formative stages of the next-generation market

□ (Market) Growth to the scale of KRW 607.3 billion in 2017 with an average annual rate of 9% in last five years, while logistics robots, medical care robots, etc., excluding cleaning robots, spread in the early stage of market formation

＊ Market share: Housework support (38.2%), for medical care (13.7%), for education/research (11.4%), for agriculture, forestry and fishery (6.5%), etc.

❍ Export amount on the scale of about KRW 100 billion, with the cleaning robots achieving KRW62.8 billion (about 60%) / Import amount on the scale of about KRW 40.0 billion with the robots for medical care recording KRW 30.3 billion (about 77%).

□ (Enterprise) Two large corporations (Samsung Electronics, LG Electronics), with midsize businesses accounting for 17 ea. and medium- and small-enterprises for 467ea. or 99% among 472 enterprises

❍ Service robot products such as smart home robots (LG Electronics), Autonomous mobile robot (Naver), wearable robots (Samsung Electronics, Hyundai Motors), etc. are being developed and tested with large corporations at the center.

【Enterprise Status per Sales Scale】

Classification	More than 50.0billion won[1)]	More than 10.0 billion won[2)]	More than 5.0 billion won[3)]	More than 1.0 billion won	Less than 1.0 billion won
Count	2	3	12	133	322
Distribution	0.4%	0.6%	2.5%	28.2%	68.2%

* [1)] LG Electronics, Samsung Electronics, [2)]Yujin Robot, Everybot, Robotics , [3)]Medical Dream, Intromedic, Curexo, etc.

❍ Mirae Company succeeded in commercialization of laparoscope operation for the first time domestically (March 2018)

＊ While diversified medical care robots are being developed as a result of success of Da Vinci robot (Intuitive Surgical of US), excessive time is required domestically for acquisition of licenses related to new medical care instruments.

❍ CJ Logistics, Shinsegae, etc. are preparing for incorporation of logistics robots., and Woowa Brothers are developing outdoor delivery robots for food delivery. *

＊ Through the utilization of the regulation sandbox system, checking for regulations related to outdoor delivery robots is required (January 2019).

- Curaco launched excretion care robots for patients with serious difficulty in moving around, and applied them to care insurance in Japan among global enterprises for the first time (October 2018).
  - * In cooperation with Gwangyang-si from January 2019, 64 units of excretion care robots are being provided to the subject of serious patients.

◇ (Component • Software) Key components dependent on imports, with rapid growth of the robot software market

☐ **(Market)** Growth to the scale of about KRW 1.4 trillion in 2017 with the average annual growth rate of 29.3 % for the last 5 years

* Driving (KRW 387.1 billion) 〉Structure (2,130) 〉Sensing (2,080) 〉Control (1,600) 〉S/W (1,203)

❍ High relative weights for driving, structural components compared with control components and software are due to much use of the robot products with simple sensing and control in electrical/electronic applications, etc.

* Simple/repetition-type orthogonal-coordinate robots are used rather than high-performance vertical multi-joint robots.

❍ Domestic production ratio of components is around 41%, utilization cases for domestically-produced components are scarce, causing limitations to entry in domestic/overseas markets.

❍ Rather than simple domestic production of the components controlled by advanced countries, securing of key components and software technology for next-generation robots needs to be concentrated on.

☐ **(Enterprise)** Engaged in the areas of robot components and software are only one large corporation and twelve midsize enterprises, etc. among more than one thousand enterprises, with the size of most enterprises being small.

* Distribution of component enterprises: In the order of Driving (27%), Sensing (15%), Structure (14%), Control (11%), software (8%)

【Enterprise Status per Sales Scale】

Classification	More than 50.0billion won[1)]	More than 10.0 billion won[2)]	More than 5.0billion won[3)]	More than 1.0 billion won	Less than 1.0 billion won
Count	1	19	43	317	621
Distribution	0.1%	1.9%	4.3%	31.7%	62.0%

* [1)] Panasonic Korea, [2)]Samick HDS, Fastech, etc., [3)]Micro Infinity, etc.

❍ Entry of mechanical component businesses such as SBB Tech (Decelerator), Samick THK (Motor), Haisung TPC (Decelerator), etc. in the robot components market tends to be expanded.

❍ In particular, Ajinextek succeeded in domestic production of "Motion-controlling chip" for the first time in Korea, with the control components maintaining competitiveness on a relatively satisfactory level.

2. Implementation Status in the Meantime and Assessment

◇ **(Technology development) While the level of technology has been improved, market-leading products and technologies are lacking.**

☐ **(Status)** For prompt improvement of technology levels of robot industry, more than KRW 600 billion has been invested in robot technology R&D in the past 10 years.

❍ Compared with the manufacturing robot area, more than 3 times more has been invested in the new service robot areas.

【Support Status for Development of Robot Technology (Unit: KRW 100 million)】

Classification	’10	’11	’12	’13	’14	’15	’16	’17	’18	Total	Relative weight
Manufacturing	96	58	128	124	96	82	54	73	70	781	12.4%
Service	168	267	199	281	290	324	301	370	385	2,585	41.1%
Component/SW	306	349	330	256	271	281	334	401	394	2,922	46.5%
Total	570	674	657	661	657	687	689	844	849	6,288	100%

【Major Robots Development Record】

Classification		R&D	Major Records (Planned)
Manufacturing		Vertical multi-joint robot, Two-arm robot, cooperation robot, etc.	Developed two-arm robot (2016, Korea Institute of Machinery and Materials)
			Cooperation robot in development (~2019, D Company)
Service	Specialized	Clothing, logistics, safety robot, etc.	Launched autonomous mobile logistics robot (2018, Y Company) Launched laparoscope operation robot (2018, M Company)
	Individual	Social robot, HRI technology, etc.	Developed household social robot (2016, I Company)
Robot component		Motor, decelerator, sensor, etc.	Completed development of domestic production of robot-driving module (~’18, R Company)

☐ **(Assessment)** Although the overall technology level has been improved through large-scale improvements, commercialization is sluggish because representative enterprises and products capable of leading the global market are lacking.

* Technology level compared with a country retaining the best technology has been improved by 80.6% in 2015 to 85% in 2017 (Korea Evaluation Institute of Industrial Technology, 2018)

❍ Although the relative weight of R &D for robot components and software is very high, the ratio of domestic production is only 41.1%, and the domestic production ratio of high added-value components is particularly poor.

* Driver: decelerator, motor, Sensor: autonomous mobile sensor, Controller: intelligent motion controller, etc.

* Robot software platform, Gripping technology software, Image processing software, HRI software, etc.

❍ Concerning service robots such as agriculture, exploration robots, construction, dismantling robots, logistics robots, medical care robots, etc. diversified seed-type R and D’s are to be attempted rather than choice and concentration.

◈ By supporting R&D through choice and concentration, cultivation of global robot-specialized enterprises is required.

◇ **(Infrastructure) While the foundation for commercialization of new technologies has been prepared, its utilization is poor.**

☐ **(Status)** Expansion of Technological, Institutional Foundations for Dissemination and Diffusion of Robots

❍ Construct 7 largest bases nationwide for testing, certification, demonstration, enterprise support of the developed robots

* Robot certification center (Daegu), Combination center for safe usage and underwater robot (Gyeongbuk), Manufacturing robot technology center (Gyeongnam), Marine robot center (Busan), Health care robot center(Gwangju), Robot industrialization support center (Daejeon), Convergence component center (Bucheon)

❍ Prepare certification standards* of cooperation robots for their diffusion (June 2018), and incorporate regulation sandbox system through amendment of the Promotion Act for Industry Cconvergence (January 2019)

* Install fence, etc., as the manufacturing robot standard → Use without the fence after risk assessment of the installed operation place

❍ Prepare the basis for additional support during 10 future years through extension of the Intelligent Robot Act (June 2018)

☐ **(Assessment)** The utilization of the already constructed technical infrastructure is not high and the awareness level for the support system of new technologies and new products is also low.

❍ Robot enterprises have difficulties in equipment utilization due to absence of information on equipment construction and utilization.

❍ Test of key components for next-generation robots .Additional construction of certification infrastructure is required

* Hardware: Intelligent controller, smart gripper, Software: Image information processing software, etc.

❍ Although the regulation sandbox system has been recently incorporated (January 2019), robot enterprises have a low understanding of the system such as application process, etc.

【Robot as subject of review for regulation sandbox】

Robot	Outdoor delivery robot	Underwater robot	Home rehabilitation robot	Agriculture robot
Picture				
Difficulty item	Mobile road standard missing	Overall precision diagnosis for marine structures not allowed	Remote rehabilitation with home rehabilitation robot not allowed	Test and approval standards absent Government support not allowed
Related regulation	Road traffic law (National Police Agency)	Facility safe management act (Ministry of Land, Infrastructure and Transport)	Medical law (Ministry of Health and Welfare)	Agricultural mechanization promotion law (Ministry of Agriculture, Forestry and Livestock)

◈ Construction of support system is required to increase utilization of the regulation sandbox

◇ (Dissemination project) Limitations in market creation as supplier-oriented project

□ **(Status)** Dissemination with a focus on service robots primarily for public institutions for market creation

* 6,063 robot units incorporated in 1,365 locations (50 ~ 60% subsidized), Incorporated budget: KRW 133.35 billion

❍ For 93.3% of the 6,063 units, service robots were disseminated during 2011~2018

【Support Status for Robot Dissemination Project (Unit: unit)】

Classification	'11	'12	'13	'14	'15	'16	'17	'18	Total
Manufacturing		97		8	8	93	115	85	406
Service		1,586		346	266	2,573	477	409	5,657
Total		1,683		354	274	2,666	592	494	6,063

❍ Since 2016, 240 units of manufacturing robot have been provided to 35 companies in conjunction with the government's smart plant project.

□ **(Assessment)** Although the base of the robot industry was expanded through dissemination of diversified forms of robot product with a focus on public services, there were limitations in the creation of a significant market.

❍ Consumer needs for service robots were not sufficiently reflected, and it remained on the demonstration level with a focus on robot manufacturers, without resulting in mass production.

❍ In the case of manufacturing robots, standard utilization models tailored to consumer enterprises per business type and process were lacking, and only 406 units were disseminated.

* Through the Japanese Robot Industry Association, Japan is operating a site for standard utilization models called RoboNavi.

* Through manufacturing innovation project for robot utilization (Ministry of SMEs and Startups), three process models of precision casting, forging and welding have been provided (2016 ~ 2018).

◈ In the future, association with the smart plant project is needed while unit dissemination by the unit of individual enterprise after preceding the development of "model for robot utilization" by reflection of consumer needs.

3. Direction of Implementation for the Third Basic Plan

◇ Enhancement of the effectiveness of government support through role assignment for civilians and the government

- **(Government)** For expanded dissemination of manufacturing robots with a focus on the three largest manufacturing businesses, the government leads the development of standard models, dissemination with demonstration and user education, etc.

- **(Civilian)** Through purchases such as rental/lease services, etc. and designation of dedicated banks for robot commercialization, autonomous diffusion such as support in the way low-interests loans, etc. is induced

◇ Concentrated support on the manufacturing field and promising service areas

- **(Manufacturing)** Concentrated dissemination is implemented for the sectors with poor working environments, and there is a need for alleviation of insufficient manpower such as root, textile, food and beverage, etc.

- **(Service)** Technology development and dissemination is supported by selection of the four largest strategic areas (care, clothing, logistics, wearable robots) with high growth possibility.

◇ Creation of early market through association with regulation reform

- **(System)** For creation and growth of domestic markets as a result of development of new technologies, preemptive system improvement such as construction and operation, etc. of a regulation reform center is supported.

- **(Ecosystem)** Creation of new markets supported through cultivation, etc. of enterprises specialized in system integration (SI) is supported for robot areas connecting suppliers and users.

- **(Testing/Certification)** Preparation of mutual certification systems between countries and expanded implementation of the areas acknowledged by internationally authorized test institutions toward entry in overseas markets

Reference 2. Differences from the Second Basic Plan

❍ **(First, Second)** Construction of government-led support system, support areas and growth foundation for growth of robot industry

❍ **(Third)** Implementation of systematic dissemination and diffusion through choice and concentration for promising areas as well as role assignment for government and civilians

Classification	First and Second Basic Plans	Third Basic Plan
Support system	· Focus on creation of early-stage market through establishment and implementation of policies led by the government - Implementation of dissemination projects with focus on domestic public institutions - KRW 628.8 billion incorporated in robot technology R&D for 10 years with improvement of technology level	· Enhancement of support effectiveness through role assignment for government and civilian - (Government) Development of standard models ➪ Leading of dissemination ➪ Education of users - (Civilian) Diffusion of autonomy through support of rental/lease service, etc.
Support area	· Attempt for support of diversified area through implementation of seed-type R&D - Wide support of areas including formation of existing market (manufacturing, education and cleaning robots) and having prospect of growth (agriculture and exploration robot, construction and dismantling robot, etc.) · Dissemination with focus on suppliers and public institutions * 6,063 units incorporated in 1,365 consumers	· Support of promising areas through choice and concentration - Expanded dissemination with focus on three largest manufacturing businesses - Concentrated cultivation of four largest service robot areas - Independence of three largest key components and four greatest software technologies
Growth foundation	· Focus on construction of system and support institutions - Enactment and extension of the Intelligent Robot Act - Establishment of Korea Institute for Robot Industry Advancement - Expansion of the market through quality certification	· Focus on excavation and improvement of regulations, etc. - Support for excavation and improvement of systems through construction regulation reform center - Study on response to robot diffusion through construction of research laboratory for robot economy and management - Support for dissemination through safety certification of cooperation robot operation places

IV. Vision and Goals

Vision	**Leap to become one of the four global powerhouses in the robot industry**
Goal	**▲ Market scale for robot industry: (2018) KRW 5.7 trillion ⇨ (2023) KRW 15 trillion** **▲ No. of robot-specialized enterprises of more than KRW 100 billion: (2018) 6 ea. ⇨ (2023) 20 ea.** **▲ Number of Manufacturing Robots (cumulative): 320,000 ('18) ⇨ 700,000 ('23)**
Implementation strategy	**◇ Enhancement of effectiveness of government support through role assignment for civilians and government** **◇ Concentrated support for manufacturing fields and promising service areas** **◇ Initial market creation through linkage with regulatory reform, etc.**
Implementation task	**❶ Expanded dissemination for manufacturing robots with focus on the three largest manufacturing businesses** **❷ Concentrated cultivation of four largest service robot areas** **❸ Reinforcement of basic stamina for the ecosystem of robot industry**

V. Implementation Tasks

1. Expanded Dissemination of Manufacturing Robots with a Focus on the Three Largest Manufacturing Businesses

◈ **Development of standard models → Preceding dissemination → Education of users → Diffusion of civilian autonomy**

Development of standard models	Preceding dissemination	Education of users	Diffusion of civilian autonomy
▸ Develop considering plant state, regulation, etc.	▸ Improve working environments after subsidy of incorporation costs.	▸ Educate robot users before/after incorporation	▸ Activating Finance and Consumer Networks

◈ **No. of disseminated, diffused units (accumulated): '320,000 units in 2018 → 700,000 units in 2023**

◇ **Preceding of utilization models for 108 robots per business type and per process (Ministry of Industry / Ministry of SMEs and Startups)**

☐ **(Sorting of utilization areas)** Sort 108 processes allowing actual robot utilization among the 150 most possible processes per business type (25ea.), per process (6 ea.)

❍ Two processes such as transfer and loading, test inspection, etc. can be utilized in all 25 business types, while 4 processes such as attachment/detachment., welding, assembly/disassembly, processing, etc. can be applied to some business types only

* Division for manufacturing businesses in classification of Korean standard industries (25ea.) × Manufacturing robots in special classification for robot industry (6ea.) = 150 processes

☐ **(Development of standard models)** First develop the areas where improvement of working environments and alleviation of insufficient manpower are urgently needed, while standard models of robot utilization are to be developed for 108 processes by 2023

* Standard model : Robot products allowing incorporation, design drawing for relevant process, requirements for engineering standard, operation method for robots, video manual, software source code, accessories such as gripper, etc..

❍ First develop standard models for the three largest business types such as root, textile, food and beverage, etc. (2019~)

Reference 3. Standard Models per Business Type, Process (Plan)

Classification (No. of processes)		Robot 1) / Business type 2)	1	2	3	4	5	6
			Transfer, loading	Attachment/detachment of workpiece	Welding	Assembly/disassembly	Processing /surface treatment	Test/inspection
			(Palletizing, handling, wafer return, FPD return, etc.)	(Loading/unlading of metal processing component Extraction of injection molding item)	(Arc welding, spot welding, vessel welding, etc.)	(Component assembly/disassembly, Adhesive/sealant coating/marking/ labelling SMD mounter)	(Grinding deburring, cutting, painting, etc.)	(Performance evaluation, life test, dimension/appearance inspection)
1	Root Industry (44)	Chemical product	❍					❍
		Rubber and plastic	❍			○	❍	❍
		Primary metal manufacturing business	❍				❍	❍
		Metal processing product	❍	❍	❍	❍	❍	❍
		Electronic component, computer, etc.	❍	❍		❍	❍	❍
		Electrical equipment manufacturing	❍	❍	❍	❍	❍	❍
		Other machinery and equipment	❍	❍	❍	❍	❍	❍
		Automobile and trailer	❍	❍	❍	❍	❍	❍
		Other transport equipment	❍	❍	❍	❍	❍	❍
2	Textile Industry (13)	Textile manufacturing	❍			❍		❍
		Clothing/fur product	❍			❍	❍	❍
		Leather/bag/shoes	❍	❍	❍	❍	❍	❍
3	Food and beverage industry (6)	Food manufacturing	❍			❍		❍
		Beverage manufacturing	❍			❍		❍
4	Paper industry (13)	Lumber/wood product	❍	❍		❍	❍	❍
		Pulp/paper	❍			❍	❍	❍
		Printing/recording medium	❍					❍
		Cokes/petroleum refinery product	❍					❍
5	Assembly industry (12)	Furniture manufacturing	❍	❍	❍	❍	❍	❍
		Other products manufacturing	❍	❍	❍	❍	❍	❍
6	Other (20)	Cigarette manufacturing	❍			❍		❍
		Medicine	❍					❍
		Medical care, precision, optics	❍	❍	❍	❍	❍	❍
		Nonmetal mineral product	❍			❍		❍
		Industrial machine	❍	❍	❍	❍	❍	❍

Total	25 industries 108 processes	25	12	10	20	16	25

1) Classification standards for manufacturing robots according to special classification of robot industry (Bio process, and other manufacturing robots excluded.)
2) Division standard for manufacturing businesses according to Korean Standard Industry Classification (KSIC)

◇ Consulting (1,080 companies in total) and dissemination with demonstration (7,560 units) with 10 enterprises per standard model

□ **(Consulting)** Consulting such as process diagnosis, etc. was provided to 1,080 companies based on the standard models by collaboration (MOU, the latter half in 2019) of associations, groups, robot SI enterprises, etc. per business type (Ministry of Industry, Ministry of SMEs and Startups)

* Robot SI: Specialized business helping the enterprises desiring robot incorporation with consulting, installation and operation of robots

□ **(Demonstration)** Manufacturing robots suitable for required processes were demonstrated, beginning with root, textile, food and beverage business types with robot utilization being urgently required (an average of 7 units per company, Ministry of Industry).

* Packages for demonstration were supported after designation of specialized researchers per business type and development of robot utilization models (Excavation of consumer enterprises → Incorporation and demonstration of robots → Consulting and education) was implemented.

❍ **(Root)** “Models of supporting type for vulnerable processes” were supported for the subject of demonstration industrial complexes for smart leading (Changwon, Sihwa Banwol, etc.) suffering from poor work environments, insufficient manpower, etc.

❍ **(Textile)** “Models of improvement type for working environments” such as sewing, clothing, cutting out, dying, etc. were supported by utilization of cooperation robots in conjunction with Dongdaemun Project 4, etc.

❍ **(Food and beverage)** “Models of clean manufacturing process type” considering food hygiene regulations such as HACCP certification were supported together with associations and groups related to food automation.

□ **(Dissemination)** Safe workplace environments were formed by supporting the incorporation of manufacturing robot system with a focus on 3D business types, industrial complexes, etc. suffering from manpower shortage (2019～, Ministry of SMEs and Startups)

❍ Manpower shortage of enterprises was alleviated, safe workplaces provided to workers with improvement of environments by improvement of high-risk, high-intensity, harmful working environments

* For the subject of business type with high risks for industrial accidents such as metal processing, machines, chemical products, etc., support for robot incorporation was expanded, and consulting supported such as Process analysis → Design of process automation→ Improvement of production technology, etc.

☐ **(Safety certification)** Civilian diffusion was induced by reviewing and improving* the safety certification system for installation workplaces to promote dissemination of cooperation robots (2019～, Ministry of Employment, Ministry of Industry, Ministry of SMEs and Startups)

* Screening period (Existing: 45 days → Improved: 14 days): Written screening (15→5 days) → Field due diligence (20→7 days) → Certification screening committee (7 days→ Abolished) → Certificate issuance (3→2 days)

Reference 4. Direction of Improvement for the Safety Certification System for Cooperation Robots

1. Related Status

1. **(Product certification)** Certification is received only through overseas certification institutions as there is no domestic certification institution, requiring excessive certification fee and time (About KRW 200 million /2 years per case)
2. **(Installation certification)** Insufficient screening personnel for certification, complicated certification procedure and documents

❶ <Screening personnel> 11 screening members in total (8 people from Korea Institute for Robot Industry Advancement), with no dedicated personnel

❷ <Certification procedure> Excessive certification period is required due to holding of formal 'Certification screening committee', etc. and insufficient support such as information and consulting , etc. on the certification system (45 days in total)

❸ <Complicated documents> Documents for submittal such as 'Process safety report', etc. are too complicated and uniformly applied irrespective of characteristics of the workplace and circumstances of the enterprise

2. Improvement Tasks

◇ Improvement of the task system for installation certification for a short term, and support formation of cooperation robot market through cultivation of product certification institutions and improvement of the system, etc. for a mid- to long- term

1. **(Product certification)** Excavate certification institutions to allow domestic certification (KTL, regional TP, etc.)
2. **(Installation certification)** Reinforcement of support through improvement of the certification system of Korea Institute for Robot Industry Advancement

❶ <Cultivation of screening personnel> Sharp enlargement of the number of screening personnel by conversion to the utilization system for outside screening personnel from the task system with focus on inside screening personnel

❷ <Simplification of certification procedure> Abolishment of the committee for certification screening, simplification of screening, and shortening of the required time so as to allow issuance of the certificate within 14 days after certification application

❸ < Simplification of documents>Simplify by differentiation of the forms for process safety report, etc. according to characteristics and circumstances of the workplace while maintaining the same safety standards

❹ < Reinforcement of consulting> Provide concentrated support for preparation of application documents such as 1:1 customized support, etc.

◇ **Utilization and education of incumbent robots with focus on the enterprises having incorporated manufacturing robot** (Ministry of Employment, Ministry of Industry, Ministry of SMEs and Startups) (2019: 60 people → '2023: 2,160 people)

□ **(Education and training of incumbents)** Support collective education of unemployed and incumbent as the subject for alleviation of utilization manpower (operators) of individual enterprises resulting from rapid increase in demand for manufacturing robots

* Utilization of the incumbent support program of the Ministry of Employment: KRW 500 million annually

❍ Preparation of the basic education curriculum and practice textbooks for manufacturing robots during the first half of 2019, and conducting full-pledged education and training of incumbents starting with the latter half of 2019

【Configuration of Education and Training Program for Incumbents per Period】

1st week education		2nd week education		3rd week education		4th week education
■Robot utilization -Practice of operation per process	←	■Robot practice - Practice of industrial robot, cooperation robot	←	■Robot fundamentals - Design, control	←	■Common knowledge

□ **(Operation of database for education and training)** Construct database such as standard models per business type, process, curriculum data for education and training, etc. and provide service through internet/mobile

* Database site for education and training www.RoboRetrieve.or.kr built and operated.

◇ **Induce diffusion of civilian autonomy through purchase support such as rental/lease service, etc. (Ministry of Industry) ('18: 320,000 units(accumulated) → '23: 700,000 units(accumulated)**

* 320,000 units ('18) +7500 units (Government-supplied) + 372,500 units (Diffusion of civilian autonomy) ⇒ 700,000 units(2023) Diffusion was supported by the Korea Institute for Robot Industry Advancement through an MOU with civilian associations and groups (Latter half of 2019) along with government's dissemination projects.

□ Cooperation systems with financial institutions such as rental. Lease, etc. were constructed to allow robot manufacturers to lead in sales and dissemination of robots

❍ Rental, lease service, etc. have been provided since 2020 after development of related products together with Capital, bank, etc. in 2019

* (Ex) Shinhan Bank – Doosan Robotics (October 2018) → A Bank-Expanded to Hanwha Precision Machinery, Neuromeka, etc. (October 2019)

◇ **Conversion to civilian-centered loan model from government-led subsidy policy**

□ **(Loan product for cooperation robot)** Cooperation robots were disseminated and diffused by expansion of loan products to support reduction of enterprise's initial investment burden with commercial banks such as Shinhan Bank, etc. (2019～)

❍ **(Shinhan Bank)** Purchase circumstances of the enterprises incorporating cooperation robots were improved in the form of financial service such as installment repayment system, etc. for 3~5 years after 2-year deferment of purchased cooperation robots.

* (Currently) One company of Doosan Robotics → (Later) Expanded to 3 companies of Hanwha Precision Machinery, Hyundai Robotics, and Neuromeka

□ **(Development of loan model)** Financial support model for robot purchase, facility investment, operating fund, etc. is developed and consulting supported (2020～)

❍ Models are developed for reduction of loan interests burden for robot purchase, etc.

◇ Briefing for expansion of consumer-centered robot dissemination and activation of networks

□ **(Nationwide tour briefing on robots)** Briefings for alleviation of difficulties in robot incorporation process and diffusion of robot dissemination for the subject of local consumer enterprises are held (Once per quarter)

* Introduce robot incorporation cases and procedures, robot enterprises and product per business type, provide information on government-supported programs, etc.

❍ Starting with briefings on manufacturing robots*(More than 5 times in 2019), and expanding to service robots in the future

* Automotive components, electronic components, machine, root, textile, food and beverage area, etc.

□ **(Establishment of robot users association)** Establishment of the Robot Users' Association is supported to support network activation for the enterprises requiring robots (2019).

❍ **(Consumer enterprise)** Activities are supported to improve areas of difficulty in robot user enterprises such as improvement of safety certification, preparation of new product-related regulations, etc.

❍ **(SI enterprise)** Cooperation for activation of application of customized robots per process and service environment is implemented through the role as temporary bridge between robot SI enterprise and consumer enterprise

* (Ex) Development of robot SI standards and education programs, construction of common maintenance and insurance systems and domestic/overseas networks, etc.

2. Concentrated Cultivation of the Four Largest Service Robot Areas

◈ Selection of promising areas → Differentiated support → Creation of domestic market → Support for export

Selection of 4 largest promising areas	→	Differentiated support	→	Creation of domestic market	→	Support for export
‣ Select by considering marketability and growth potential		‣ Differentiated Development and countries dissemination support		‣ Support for creation of domestic market by utilization of sandbox		‣ Support for package export to major overseas

◇ Selection of the four largest service robot areas with a high growth potential

☐ Four greatest strategy areas such as care, wearable, medical care, logistics, etc. were selected by considering global market scale, potential business competence, challenge value, etc. among a total of 14 greatest service robot areas

* Tractica, International Federation of Robotics (IFR), etc. also had the same prospect for the four greatest areas as the areas with the greatest growth potential by 2025 among 14 largest service robot areas (2018).

【Reasons for Selecting the Four Largest Service Robot Areas】

Classification		Detailed Area	Reason for Selection
Publicly-led (Government 50%, Local government 50%)	Care	▷ Entry-level meal-assisting robot ▷ Two arm-type transfer lifting robot ▷ Excretion care (Bidet) robot	√ Most closely related to our actual life √ Maximum globally-sold quantity √ High domestic industry competence
	Wearable	▷ Work-supporting robot ▷ Elderly, disabled-assisting robot	√ Most promising based on long term √ Currently most unexplored area
Civilian-led (Government 50%, Civilian 50%)	Medical care	▷ AI-based smart operation robot ▷ Operating robot arm	√ Area with high technology barrier √ High-risk, high-profit area
	Logistics	▷ Smart logistics-handling robot ▷ Multiple robot for indoor/outdoor delivery	√ Area with highest growth rate √ Promising utilization such as logistics center, hospital, etc. √ Area with high domestic industry competence

□ For the ten largest niche market-type areas such as drone-bot, agriculture/exploration robot, etc., technology development and dissemination is supported with leading by the concerned departments such as Ministry of Defense, Ministry of Agriculture, etc. (Collaboration between Ministry of Industry and related departments)

Classification	National Defense Robot	Agriculture/Exploration Robot	Safety Robot	Inspection/ Maintenance Robot
Representative application area	National defense	Agriculture and livestock industry, exploration	Disaster, evacuation	Energy area, etc.
Robot product				
	[Mine-removing robot]	**[Facility-gardening robot]**	**[Exploration robot for disaster area]**	**[Maintenance/repair robot for photovoltaic panel]**
				
	[Runway manufacturing robot]	**[Extreme place robot]**	**[Evacuation robot for disaster area]**	**[Maintenance/repair robot for power cable]**
Related department	Ministry of Defense, Defense Acquisition Program Administration	Ministry of Agriculture and Forestry, Ministry of Oceans and Fisheries, Ministry of Land, Infrastructure and Transport, Rural Development Administration, etc.	National Fire Agency, National Police Agency,	Ministry of Industry, etc.

* Development of guide robot and entertainment robot is being led by the private sector.

❍ **(National defense area)** Development of robot technology resulting from future changes in environments of the battlefields (network-centered, information war, unmanned robot war) is implemented.

- Development of related key technologies such as unmanned surface vehicles, wearable muscular strength-enhancing robots, etc. (2019~2023, Defense Acquisition Program Administration, Ministry of Oceans and Fisheries, and Ministry of Industry in cooperation)

❍ **(Agriculture area)** Development of labor-saving technology and construction of demonstration complexes are supported

- Smart farm robots for facility gardening that allows monitoring of agricultural crops, precision control, harvesting, grafting, etc. are developed (2019 ~ , Ministry of Industry, Rural Development Administration).

- Unmanned tractor, agricultural robot capable of control, harvesting operations, etc. are developed (2019~2023, Ministry of Agriculture and Forestry, Rural Development Administration).

* Formation of autonomously-running demonstration complex utilizing unmanned tractor, unmanned drone, etc. is implemented inside Saemangeum reclaimed land (2019 ~ 2023, Ministry of Agriculture and Forestry).

❍ **(Underwater/exploration area)** Robots supporting farming, accident processing, etc. are developed.

- 'Underwater robot system' capable of monitoring environmental changes such as checking water temperature, red tide detection, production prediction, etc. is developed (2019~, Ministry of Industry).

- Development of safety robots* and commercialization of underwater construction robots for prompt response to marine accidents is implemented (2019~2025, Ministry of Oceans and Fisheries).

* Marine accidents-responding robots capable of supporting tracking and searching of sunken vessel as well as diver collaboration under bad weather, poor visibility and strong current are developed

- Unmanned mobile robots to perform missions such as acquisition operation of scientific operation, etc. under extreme environments are developed (2020~, Ministry of Ocean and Fishery, Ministry of Land, Infrastructure , and Transport, Ministry of Science and ICT, and Ministry of Industry in cooperation)

❍ **(Inspection/maintenance area)** Robot development required for maintenance, etc. of energy facilities is supported.

- 'Detachable robot system' allowing not only cleaning of photovoltaic panels but also diagnosis of breakdown and safety status, etc. is developed (2019~, Ministry of Industry).

* Power generation company: Demonstration of photovoltaic equipment is supported which has been already installed in conjunction with new renewable energy plan and projects.

❍ **(Evacuation/Safety)** Robots supporting firefighting, drugs detection, etc. are developed.

- Search robots for a narrow space to detect and evacuate victims inside buildings collapsed by disasters are developed (2019~, Ministry of Industry)

- Environments for performance evaluation to subdue fire and respond to terrors are constructed and field operation measures are developed (2019~2023, National Fire Agency, National Police Agency, Ministry of Environment, and Ministry of Industry in cooperation)

- Remote mobile measuring device with sensors and detection device for drugs loaded are developed.
  (2020~2024, National Police Agency, Ministry of Environment, Ministry of Science and ICT, National Fire Agency, and Ministry of Industry in cooperation)

◇ 4 Development of robots in four largest areas → Dissemination and demonstration for socially underprivileged, etc. → Civilian diffusion

◈ Support of customized development and dissemination considering characteristics of each of the four largest areas
- A dissemination project of about 10,000 units for 15 local governments and 810 consumers is implemented.
① Care: 5,000 units disseminated to 10 local governments (2019～2023)
② Wearable: 945 units disseminated to 5 local governments (2021～2023)
③ Medical care: (Operation) 5 units disseminated 5 hospitals, (Rehabilitation) 50 units disseminated to 5 rehabilitation hospitals and nursing homes
④ Logistics: 4,000 units disseminated to 800 consumers such as plant, mart, etc.

* Development: Common product technologies for care robots are developed (2019～2021, Ministry of Industry and Ministry of Welfare in cooperation) Key technologies for robot industry are developed(2020～, Ministry of Industry) , etc.

* Demonstration: Demonstration project for market-creating robots (2019～2023, Ministry of Industry, 50% matching for local governments, hospitals, etc.), etc.

☐ **(Care robots)** Concentrated support is provided for R&D and dissemination of care robots for socially underprivileged classes such as severely disabled, etc.

❍ **(Development)** R&D is implemented with a focus on the areas with a low technology level although there is high demand among care robots in diversified forms (2019 ~ 2023, Ministry of Industry, Ministry of Welfare)

* For excretion-supporting robots with marketability due to much demand from consumers, etc. development and dissemination are supported in parallel

【Care Robots R&D Promotion Areas】

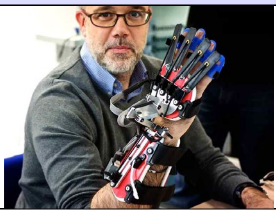
Meal-assisting robot	Transfer/lifting robot	Excretion-supporting robot
		

Support eating by hand-paralyzed patients	Support transfer of severely disabled patients	Automated excretion processing

❍ **(Relay)** Demonstration study and development of service models to realize diversified care environments and user customized care robots through field demonstration project (2019~2022, Ministry of Welfare)

* Smart care space: A space with 4th industrial revolution technology such as smart care robot, etc., for continuous utilization as the base space for data generation demonstration of a new technology/service

❍ **(Demonstration)** Purchase desire is induced and effectiveness of robot products verified through personal experience of hand rehabilitation, dementia prevention by socially underprivileged such as disables, elderly, etc. (2019 ~ 2023, Ministry of Industry)

Hand Rehabilitation Robot		Dementia Prevention Robot	
	Grip effect Muscle strength regeneration Routine activity		Talk to elderly Making telephone calls AI speaker

☐ **(Wearable robots)** Concentrated development and dissemination of wearable robots that enhance muscle strength in socially underprivileged classes such as field workers, elderly, woman, disabled, etc.

❍ **(Development)** Development of finished products with focus on key components such as sensor, driving module, etc. (Ministry of Industry) and technology development for muscle strength-increasing robots for national defense are supported (2019~2020, Defense Acquisition Program Administration, Ministry of Industry in cooperation)

❍ **(Demonstration)** Task- performing possibility such as high risk, high intensity, etc. is verified and feedback of supplementary items supported by implementation of demonstration and dissemination since 2020 (Ministry of Industry, Ministry of SMEs and Startups)

- Supplementation and commercialization of developed products are supported by implementation of demonstration and dissemination projects with focus on field workers in root industry, construction, etc. disabled and elderly

☐ **(Medical care robots)** Implementation of demand-associated technology development where hospital, etc. as the consumer participate from development through dissemination and demonstration-type dissemination project to secure safety, etc.

❍ **(Development)** By breaking away from the sporadic development method according to clinical areas, development is implemented with focus on common technologies such as image processing, robot arm, etc.

- (**Operation robot)** Support for design and analysis of clinical tests, securing of clinical data, etc. shortening of licensing period such as evaluation of new medical care technologies, etc. (Ministry of Industry)

- **(Micro robot)** Robots allowing selective drug release and recovery, etc. are developed

(2019~2022, Ministry of Industry).

- ❍ **(Demonstration)** Clinical data, etc. of robot enterprises is secured for prompt market entry by cooperation with hospitals*, etc. and improvement items, etc. for system in medical laws are excavated.

* Dissemination is supported by designating national and public hospitals, rehabilitation hospitals, etc. throughout the country as "specialization centers for medical care robots"

- **(Operation robots)** Shortening of license periods such as evaluation of new medical care technologies, etc. is supported through support for design and analysis of clinical tests, securing of clinical data, etc. (Ministry of Industry).

- **(Rehabilitation robots)** Utility is verified through experience, etc. of socially underprivileged classes (Ministry of Industry).

* Five institutions are supported after nationwide announcement for the subject of rehabilitation hospitals and nursing homes

- **(Micro robot)** Product launching of enterprises is supported through construction of practical use of common foundation technologies (2019~2022, Ministry of Welfare).

☐ **(Logistics robot)** Safety and suitability of the product are to be verified through the demonstration project, while improvements in working environments and productivity are achieved through development and dissemination of key technologies.

- ❍ **(Development)** "Smart logistics-handling robot" allowing combined operations, "Indoor and outdoor delivery robot", allowing autonomous transfer, running and moving of articles" etc. are developed (Ministry of Industry).
- ❍ **(Demonstration)** Field utility, safety, etc. are verified by dissemination with focus on plants, logistics centers, distribution stores, etc., and improvement items for systems, etc. are excavated (2019~2023).

- **(Indoors)** Starting with the second half of 2020, the utility is verified by dissemination to post office, etc. of Korea Post as well as in civilian markets such as supermarkets, hotels, etc. (~2021, Ministry of Industry, Ministry of SMEs and Startups).

- **(Outdoors)** Safety according to road and traffic law is verified through demonstration project for outdoor delivery robots with smart cities such as Busan, Sejong, etc. as the targets (~2023, Ministry of Industry, Ministry of Land, Infrastructure, and Transport).

【Wearable】	【Medical Care Robot】		【Logistics Robot】	
Work support	**Operation robot**	**Rehabilitation robot**	**Indoors**	**Outdoors**
				

◇ Creation of domestic/overseas markets through support for areas such as regulations improvement, overseas entry, etc.

□ **(Regulations improvement)** Constant support through the "Regulations Reform Center" constructed in the Korea Institute for Robot Industry Advancement (May 2019) for enhancement of completeness in all cycles of the "regulation sandbox" (Ministry of Industry)

* First identification of regulations → Prompt solution, trouble consultation (Consulting) → Review of regulations and standard issues → Prompt solution

❍ **(Special cases of demonstration)** Designation of special cases for robot demonstration is implemented for the four largest areas such as care, wearable, clothing, logistics robots, etc.(2019~, KRW 50 million per product was provided for local governments)

❍ **(Customization support)** Liability insurance, standard/certification development, etc. required for robot enterprises having received special case of demonstration to subscribe to protect users are supported (KRW 120 million is provided per product)

□ **(System study)** "Research laboratory for robot economy and management" is constructed and operated within Korea Institute for Robot Industry Advancement for preemptive response to social phenomena resulting from technology development (2020~, Ministry of Industry)

* Studies on robot and jobs, development of robot industry and employment effects, effectiveness of dissemination project policy, financial support plan for robot enterprises, robot ethics charter of constitution, etc. are implemented.

□ **(Customized export per country)** Customized export is supported by considering national industry characteristics such as new southern countries, Mideast, etc.(2019~, consumer country matching, Ministry of Industry)

❍ Exports are supported in conjunction with Malaysia (automobile production line), Thailand (logistics industry), Saudi Arabia (hospital), Turkey (education facilities), Singapore (airport and hospitals), etc. (2019 ~)

❍ Export routes out for Korean robot enterprises are secured through construction of regional robot support centers (KRC) and implementation of ODA (official development aid).

□ **(Support for test, certification)** Test and certification of domestic robot-exporting enterprises are supported through MOU with global test/certification institutions and expansion of approved areas of internationally authorized test institutions (2019 ~ , Ministry of Industry).

❍ Support of certification (CE, CSA) procedures are expanded for the entry in European and American markets

* (US)(KIRIA-UL MOU, 2019) / (Norway) (KIRIA-DNV GL MOU, 2019) ⇨ (Canada) (CSA, 2020 ~)

❍ Expansion of areas approved by the internationally authorized test institution (KOLAS) is implemented.

* Industrial robots (2019) ⇨ Home service robots (2020) ⇨ Mobile robots (2021)

3. Reinforcement of Basic Stamina for Robot Industry Ecosystem

◈ Reinforcement of basic stamina and promotion of entry into new markets for the domestic robot industry through reinforcement of basic technology competitiveness such as key components and software, etc. of next-generation robots

Develop next-generation components and SW	→	Evaluate and demonstrate performance	→	Promote convergence with other industries
‣ Implement independence of 3 key components • 4 main softwares		‣ Upgrade foundation for test and evaluation ‣ Implement components demonstration and dissemination project		‣ Implement mechanization of machines ‣ Implement convergence with AI, 5G, etc.

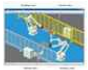
◇ Selection of next-generation key components and software for reinforcement of competitiveness of the back industry

☐ Select strategic items for reinforcement of competitiveness of the back industry based on relative weight of costs, technological competence, existing extent of support, etc. for robots

❍ **(Technology development•performance evaluation)** Support independence of the three key next-generation components among 13 hardware components and the four key software components among 7 software components

❍ **(Demonstration and dissemination)** Support decelerator, motor, motion controller, etc. with high existing support level with focus on demonstration and dissemination

Component / Criterion	Driver					Sensor				
	Smart gripper	**Decelerator**	**Motor**	**Driving module**	**Power transmission device**	**Autonomous mobile sensor**	**Visual sensor**	**Tactile force sensor**	**Motion sensor**	**Other sensor**
										
Importance (+)	●●●●	●●●●●	●●●●●	●●●	●●	●●●●	●●●●	●●●	●●●	●●
Relative weight of cost(+)	●●●●	●●●●●	●●●●	●●●	●●	●●●	●●	●●●	●	●
Technical competence(+)	●●●●	●●●	●●●●	●●●●	●●●●	●●●	●●●	●●●	●●	●●
Support level (-)	●●	●●●●	●●●●	●●●●	●●●	●●	●●●	●●●	●●	●
Overall ranking	1	2	2	11	16	7	11	11	17	17

Component / Criterion	Controller			S/W						
	Intelligent controller	**Motion controller**	**PC-type controller**	**Robot SW platform**	**Gripping technology SW**	**Image processing**	**HRI SW**	**Simulator**	**Development tool**	**OS for robot**
										ROS
Importance(+)	●●●●	●●●●	●●●	●●●	●●●●	●●●●	●●●	●●●	●●●●	●●●
Relative weight of cost(+)	●●●●	●●●	●●●	●●●	●●●●	●●●●	●●●●	●●●	●●	●
Technical competence(+)	●●●	●●●●	●●●●	●●●●	●●●	●●●	●●●	●●	●●	●●●
Support level (-)	●●	●●●●	●●●●	●	●●	●●●	●●●	●●	●●●●	●●●●●
Overall ranking	2	9	11	2	2	7	9	11	17	20

* Item for technology development and performance evaluation

Subject item for demonstration and dissemination

◇ Independence of three key next-generation components and four key softwares

☐ Independence for three key components of next-generation robots through demand-associated technology development with participation of robot manufacturers and components businesses (Ministry of Industry)

Technology	Intelligent controller	Autonomous mobile sensor	Smart gripper
Utilization area	High-performance manufacturing, wearable robot	Manufacturing, logistics, life-supporting robot	High-performance manufacturing, logistics robot
			

❍ **(Intelligent controller)** Robot utility in the manufacturing field is enhanced by development of controllers* allowing even non-specialists to readily utilize them.

* Performance of workpiece gripping, operation instruction, collaboration manipulation, etc. without separate programming

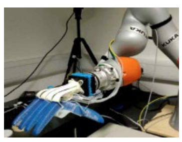
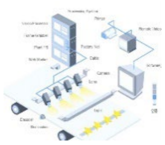
❍ **(Autonomous mobile sensor)** Logistics efficiency inside the plant is improved through the development of low-priced sensor modules* for indoor/outdoor autonomous running of robots.

* Development of a SoC (System on Chip) that supports image recognition, position identification, and autonomous running

❍ **(Smart gripper)** Productivity is enhanced by development of grippers to enable high-speed recognition of diversified articles and stable gripping.

* Joint-type gripper, soft gripper, universal gripping controller, etc., are included.

☐ Implementation of technology independence four key softwares controlling service competitiveness (Ministry of Industry)

Technology	Robot SW platform		Gripping technology SW	Image information-processing SW	HRI technology
Utilization area	Common		Life-supporting, logistics robot	Operation robot	Life-supporting robot
		+			

❍ **(Robot SW platform)** Supports connection between robot and peripherals and stable motion.
❍ **(Gripping technology SW)** Supports gripping manipulation at a judgment speed on human level.
❍ **(Image information-processing SW)** Acquires, processes, and visualizes precision medical images in real time based on AI.
❍ **(Human-robot interaction)** Understands user's intended emotion and reacts according to situations.

☐ **(Performance evaluation)** Evaluation of performance of next-generation components, software in each area and upgrading the certification support system through the utilization of the existing infrastructure (2020 ~ , Ministry of Industry)

* Performance evaluation is applied to common technologies for the three key next-generation components and four key software areas

❍ **(Metropolitan area)** Support center for robot convergence components provides support development of performance evaluation methods and test/certification for enhancement of sophistication and reliability of the three key next-generation components

❍ **(Southern area)** Korea Institute for Robot Industry Advancement supports reliability evaluation/certification and promotion of commercialization of the four key next-generation software areas (development of beta test platform, consulting, and patents)

❍ **(Nationwide)** Utilization of common equipment of robot-supporting institutions is promoted through "Construction of Robo-Tube" that provides matching between the support institutions and consumer enterprises

* Benchmarking is conducted for the e-tube as the equipment support system for the five major business types such as automobiles already in operation.

◇ Promotion of demonstration/dissemination for domestically produced components

☐ **(Demonstration/dissemination)** A demonstration project for robot components is implemented with the participation of consumer enterprises, robot manufacturers, and component enterprises, and domestically produced components are preferentially adopted in the government's dissemination project (Ministry of Industry).

❍ **(Demonstration)** Implemented with a focus on the components with a high relative weight for cost and a low ratio of domestic production.

* Support through the utilization of the 'Dissemination and Diffusion Project for Intelligent Robots (Dissemination of Market Creating-type Robots)' (2020 ~)

- **(Product demonstration**) Support for performance evaluation and improvement of components by mounting domestically produced components onto robot products

- **(Field demonstration)** Implement demonstration at the final industry fields in conjunction with robot consumers enterprises concerning the components having secured product reliability

❍ **(Dissemination)** Preferentially use the domestically-produced components with a low usage due to insufficient records while there is no difference in performance compared with overseas components

◇ Creation of new market by diffusion of robot convergence technology to other industries

□ **(Machine)** Implementation of 「Machine robotization * project」with application of robot technology to machine tools

* Improvement of performance and intelligence by mounting hardware/software modules such as AI, gripper, etc. to machines and equipment (Implementation of 3 stages: 1st stage, 2020～2024 / 2nd stage, 2021～2025, / 3rd stage, 2022 ~ 2026, Ministry of Industry)

【Robotization effects for machines】

Autonomous, active control		Flexibility, customization		Energy reduction·optimization	
	.Smart monitoring .Autonomous, active control		. Modularization of equipment, system . Expansion of robot application . Production of variety, mixed types		.Energy reduction/ management . Optimization of manufacturing process

□ **(IT)** Support of development of robot products of convergence with IT new technologies such as AI, 5G, etc.

❍ **(Advanced robot)** Implement development of advanced next-generation robots through R&D projects, etc. with collaboration of Ministry of Industry (robot) and Ministry of Science and ICT (AI, 5G) (2019～2022, Collaboration between Ministry of Industry and Ministry of Science and ICT)

- **(Furniture-assembling robot)** Performance of assembly operation after independent understanding of assembly instructions (2019～2020)

- **(Autonomous delivery robot)** Run based on already-learned experience even in the absence of GPS (2019～2022)

❍ **(Convergence robot)** Construction and operation of the test infrastructure for convergence robot products under virtual and actual environments (2020～, Ministry of Industry)

- Provision of the test environment of Digital Twin for robot components based on AI, 5G such as sensor, controller, etc.

- Construction of actual assembly processes for electronic components, etc. and support demonstration tests for smart cooperation robots

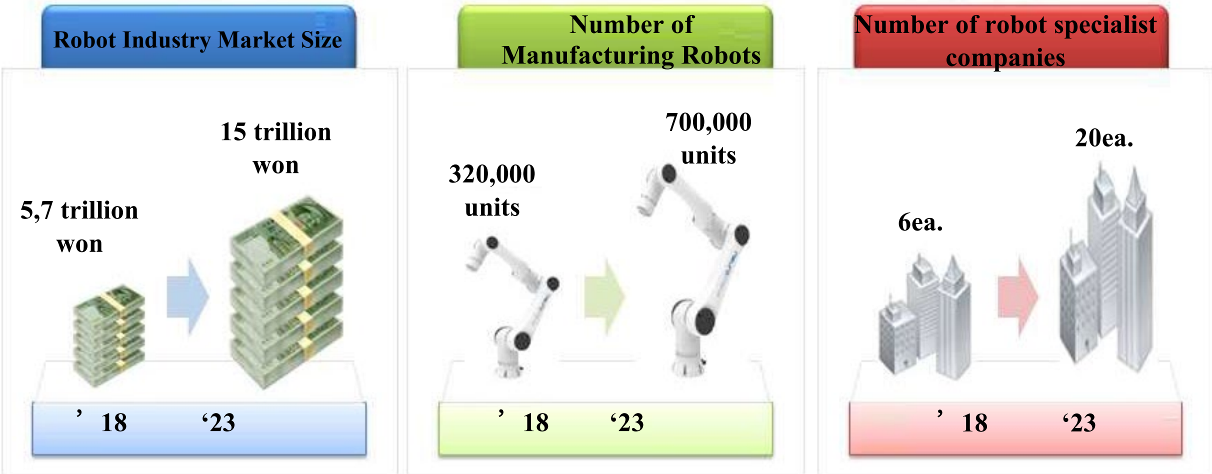
* Safety certification for workplace, verification of success in autonomous running mission, verification of position accuracy and safety performance, etc.

□ **(Other industries)** Reinforcement of robot ecosystem by construction and operation of convergence alliance with other robot-related business types such as autonomously run vehicle, drone etc. as well as robot enterprises (Latter half of 2019)

❍ Support for cultivation of specialized enterprises for reinforcement of robot ecosystem by construction of alliance between manufacturing robots and service robots

VI. Expected Effects

◈ **Leap to become one of the four greatest global powerhouses in the robot industry with 20 star robot enterprises**



VII. Future Implementation Plans

Implementation Task	Period	Remarks
❶ Expanded dissemination of manufacturing robots with focus on three key manufacturing businesses		
Preceding development of 108 robot utilization models per business type and per process	2019~	Collaboration with Ministry of SMEs and Startups
Consulting and demonstration/dissemination for 10 enterprises per standard model	2019~2023	Collaboration with Ministry of SMEs and Startups
Robot utilization education for workers with a focus on the enterprises supporting incorporation of manufacturing robots Induction of autonomous diffusion through purchase support such as rental/lease services, etc.	2019~2023 2020~	Collaboration of Ministry of Employment and Ministry of SMEs and Startups
Conversion from government-led subsidy policy to civilian-centered loan model Activation of briefings and networks for diffusion of consumer-oriented dissemination/diffusion of robots	2019~ 2019~	
❷ Concentrated cultivation of four key service robot areas		
Selection of the four key service robot areas with the highest growth potential Support of technology development/dissemination in the ten key areas of niche market type	Completed 2019~2023	Collaboration of related departments
Development of the four key robots → Dissemination/demonstration for socially underprivileged, etc. →Civilian diffusion Creation of domestic/overseas markets through regulations improvement, overseas entry of package type	2019~2023 2019~2023	Collaboration of related departments
❸ Reinforcement of basic stamina for robot industry ecosystem		
Selection of next-generation key components and software for reinforcement of competitiveness of rear industry	Completed	
Independence of three key next-generation components and four key software areas	'20~'23	
Promotion of demonstration/dissemination for domestically-produced components Creation of new markets by diffusion of convergence technology to other industries	2020~2023 2019~2023	Collaboration with Ministry of Science and ICT

2021 Action Plan for the Intelligent Robot Project

May 2021

Joint Compilation by Relevant Ministries

IFR International Federation of Robotics

Contents

Ⅰ. Background

◈ In 2008, Intelligent Robots Development and Distribution Promotion Act (hereinafter "Intelligent Robot Act") was enacted in order to prepare a systematic and consistent basis for supporting the robotics industry.

□ Article 5 of the Intelligent Robot Act stipulates that a **basic plan be established every five years** and an **action plan be prepared for every year** for the promotion of the robotics industry.

【Article 5 of the Intelligent Robot Act】

① The Government shall establish a basic plan every five years (hereinafter referred to as "basic plan") in order to achieve the purposes of this Act for the development and distribution of intelligent robots in an efficient manner.

② The head of a relevant central administrative agency shall annually establish and implement an implementation plan to develop and distribute intelligent robots and to establish the foundation therefor (hereinafter referred to as "action plan") within the scope of the affairs under his/her jurisdiction in conformity with the basic plan.

□ Accordingly, The Third Basic Plan (2019~2023) was established and an annual action plan was prepared to expand and spread manufacturing robots, develop the 4 major service robots, and strengthen the ecosystem.

【 Overview of the Third Master Plan for Intelligent Robots】

Vision	**To establish Korea as one of the top four powerhouses in the global robotics industry**	
Objectives	◆ To expand the market size of the robotics industry (KRW 15 trillion by 2023) ◆ To increase the number of companies specializing in robotics valued at over KRW 100 billion (at least 20 companies by 2023) ◆ To expand the number of manufacturing robots (700,000 in cumulative total by 2023)	
Main Projects	1. To increase the penetration of manufacturing robots in the 3 major manufacturing industries	To develop 108 model applications for industries and processes To provide consulting, demonstration, and distribution to 10 companies per standard model To train the employees at companies adopting manufacturing robots · To offer robots on a rental/lease basis and transition into a loan model in the private sector
	2. To develop 4 major types of service robots intensively	To develop technologies for 4 types of promising service robots To distribute and demonstrate 4 types of service robots → disseminated in the private sector · To create new markets in Korea and abroad by regulation improvement and overseas expansion

	3. To strengthen the foundations of the robotics industry's ecosystem	· To develop next-generation core technologies for parts and software To promote the demonstration and distribution of domestically manufactured parts · To create new markets by disseminating convergence robotics technologies to other industries

Ⅱ. Robotics Industry Trend

□ **(Global market)** In 2019, the global robotics market size reached **USD 30.5 billion, a 3% YOY increase**-with market growth primarily driven by service robots.

【Global Robotics Market Sales (Unit: USD million)】

Classification	2014	2015	2016	2017	2018	2019	CAGR
Total	16,371	17,988	19,476	26,474	29,666	30,533	13.3%
Manufacturing robot	10,196	11,162	13,125	16,306	16,502	13,712	6.1%
Service robot	6,175	6,826	6,351	10,168	13,164	16,821	22.2%

* Source: World Robotics 2020 (IFR: International Federation of Robotics, Sept. 2020)

○ **(Manufacturing robots)** Sales of manufacturing robots recorded **USD 13.7 billion, a 17% YOY decrease**, as a result of reduced facility investment by major demand area such as the electrical and electronic industry (△15%), automotive industry (△19%), and food and beverage (F&B) industry (△ 7%).

* (Electrical & Electronic) 105,153 units in 2018 → 89,052 units in 2019 (△15%), (Automotive) 125,581 units in 2018 → 102,043 units in 2019 (△19%), (F&B) 12,326 units in 2018 → 11,496 units in 2019 (△7%)

○ **(Service robots)** Sales of service robots recorded **USD 16.8 billion, a 28% YOY increase**, due to the surge in demand in the areas of surveying and maintenance* (+131%), logistics (+110%), and medical robots (+28%).

* Inspection and maintenance of facilities, factories, tanks, tubes, pipes, sewers, and other

** Global market size of service robots (2019, Source: IFR): Medical (USD 5.2 billion), home (KRW 4.2 billion), logistics (USD 1.8 billion), national defense (USD 1.7 billion), entertainment (USD 1.2 billion), exploration and maintenance (USD200 million), etc.

□ **(Domestic market)** As of 2019, the size of the domestic robotics market was **KRW 5.3 trillion**, **growing at an average annual rate of 13.3%**, however slightly contracted following **a decrease of 8.0% compared to the previous year.**

* For the 2019 survey, the robotics industry special classification revised in the previous year was applied.

【Domestic Robotics Market Sales (Unit: KRW 100 million)**】**

Year	2014	2015	2016	2017	2018	2018	CAGR
Total	28,540	42,169	45,972	55,255	58,019	53,351	13.3%
Manufacturing robot	21,013	25,831	27,009	34,017	34,202	29,443	7.0%
Service robot	3,565	6,277	7,464	6,459	6,650	6,358	12.3%
Robotic parts	3,962	10,061	11,499	14,779	17,167	17,550	34.7%

* Source: 2019 Robot Industry Survey (January 2021, Korea Institute for Robot Industry Advancement)

○ **(Manufacturing)** The manufacturing robot market in 2019 was valued at **KRW 2.9 trillion, a 13.9 % YOY decrease**.

- **A slowdown in growth** due to factors such as **a decrease in new facility investment** in major demand industries* and **the global economic recession** caused by the China-US trade dispute

* 2019 facility investment change rate: Automobile (△15.1%) and semiconductor (△0.2%) (KDB Institute for Future Strategies)

- Out of 525 companies, there are 4 companies* with sales of KRW 100 billion or more that have secured large-scale customers, and there are 486 small and medium-sized companies (SMEs) with sales of less than KRW 10 billion, accounting for 92.6%.

* Hanwha Precision Machinery (KRW 353.4 billion), Koh Young Technology (KRW 209.5 billion), Hyundai Robotics (KRW 189.2 billion), and Robostar (KRW 170.6 billion)

【Classification of Companies by Sales Volume】

Classification	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
Number of companies	4	7	28	19	467
Ratio	0.8%	1.3%	5.3%	3.6%	89.0%

- The number of manufacturing robots introduced was 320,000, up 7.9% compared to the previous year (300,000). The use of robots increased in the metal industry (22% ↑), F&B industry (28% ↑), and electrical and electronic industry (9.2% ↑).

【Status of Introduction of Manufacturing Robots in Korea (Unit: units)】

Classification	Auto-motive	Electrical/ Electronic	Metal	Plastics & Chemicals	F&B	Textile, lumber, paper	Other manufacturing industries	Other	**Total**
Number of robots	95,561	172,488	9,029	9,053	1,557	105	3,432	32,824	**324,049**
Ratio	29.5%	53.2%	2.8%	2.8%	0.5%	0.03%	1.1%	10.1%	**100%**

* Source: IFR 2020, WR Industrial Robots (on a cumulative basis at the end of 2019)

○ **(Service)** The service robot market in 2019 was valued at **KRW 0.6 trillion, a 4.4% YOY decrease**.

- While the personal service market (robot vacuum cleaner, educational robot, etc.) contracted (△14.6%), the specialized service* market sales such as wearables and medical services increased (8.3% ↑).

* 27% ↑ in the sales of wearable robots and 8.7% ↑ in the sales of medical robots

- Out of 350 companies, there are 2 companies with sales of KRW 50 billion or more, 6 companies with KRW 10 billion or more, and 339 SMEs with less than KRW 5 billion, accounting for 96.9% of the total.

【Classification of Companies by Sales Volume】

	KRW 50 billion or more*	KRW 10 billion or more**	KRW 5 billion or more	Less than KRW 5 billion	Less than KRW 1 billion
Number of companies	2	6	3	106	233
Ratio	0.6%	1.7%	0.9%	30.3%	66.6%

* LG Electronics and Samsung Electronics ** Daeyang Electric, CUREXO, Huneed Technologies, Yujin Robot, etc.

○ **(Parts)** The robotic parts market in 2019 was valued at **KRW 1.8 trillion, a 2.2 % YOY increase**, and recorded a **CAGR of 9.0% over the past three years**.

- Slight increase in sales by substituting domestic products for key robotic parts (servo motors, reducers, etc.) that are highly dependent on Japan as a result of the export restrictions imposed by Japan

(secured spares from the consumers)

- Of the total 1,360 companies, there is 1 company with sales of KRW 50 billion or more, 22 companies with sales of KRW 10 billion or more, and 1,317 SMEs with sales of less than KRW 5 billion, accounting for 96.9%.

【Classification of Companies by Sales Volume】

Classification	KRW 50 billion or more[1)]	KRW 10 billion or more[2)]	KRW 5 billion or more	Less than KRW 5 billion	Less than KRW 1 billion
Number of companies	1	22	20	424	893
Ratio	0.1%	1.6%	1.5%	31.2%	65.7%

* 1) Panasonic Korea, 2) Olzetek, SEMES, Roborobo, Higen Motor, etc.

○ **(Export)** Exports in 2019 amounted to **KRW 1.1 trillion, a 4.5% YOY decrease**.

- There was a decline in exports of manufacturing robot parts due to recession in demand industries (automotive, electrical & electronic, etc.)

* Exports (KRW 100 million, Change rate): (2017) 10,984 (17.6%) → (2018) 11,319 (3.1%) → (2019) 10,808 (△4.5%)

○ **(Import)** Imports in 2019 amounted to **KRW 0.6 trillion, a 10.3% YOY increase**.

- While there was a decline in imports of educational robots (shrinking of the domestic market) and medical robots (increased utilization of domestic medical robots), there was an increase in imports of smart factory-related parts.

* Yearly imports (Change rate): (2017) KRW 745.0 billion (19.9%) → (2018) KRW 573.3 billion (△23%) → (2019) KRW 632.2 billion (10.3%)

○ **(Companies)** The number of companies in the robotics industry in 2019 was 2,235, **a 10.9% YOY decrease**, and increased a **CAGR of 1.0% over the past three years**.

* Number of businesses by year (Change rate): (2017) 2,191 (3.0%) → (2018) 2,508 (14.5%) → (2019) 2,235 (△10.9%)

○ **(Employment)** The number of employees in the robotics industry in 2019 was 31,035, down **16.4% from the previous year** with an average annual growth rate of **3.3% over the past three years.**

* Employment by year (Change rate): (2017) 29,000 (1.0%) → (2018) 37,000 (27.5%) → (2019) 31,000 (△16.4%)

Ⅲ. Key Performance Analysis for 2020

1	**1. To increase the penetration of manufacturing robots in the 3 major manufacturing industries**

□ **(Standard process model development)** Standard process models using robots for the 3 major manufacturing industries (ppuri ("root" industries in which processing or machining technology such as casting, welding, and surface treatment is applied) textile, and F&B) and a **development council was launched.**

○ **(Additional development) 23 standard process models** for industries such as kimchi and automotive parts were developed.

* (2019) Development of the first 14 standard process models ⇨ (2020) Development of 23 additional models

【Standard Process Models Developed in 2020】

Field		Process	Model Name
Ppuri (15)	Automotive (4)	Processing	① Automotive Parts_Thermoforming Process for the Friction Materials of Brake Pads
		Testing & Inspection	② Automotive Parts_Mobile Inspection Process for Brake Pads
		Post processing	③ Automotive Parts_Grinding Process for the Backplates of Brake Pads
		Post processing	④ Automotive Parts_Washing Process for the Backplates of Automobile Brake Pads
	Machinery (4)	Assembly & Disassembly	⑤ Gas Filter Mechanical Parts_Bolting Assembly Process
		Detachment	⑥ Air Condition System Mechanical Parts_Input Process for the Electronics
		Detachment	⑦ Automotive Engine Parts_Aluminum Die Casting, Blowdown and Trimming Processes
		Transport & Loading	⑧ Vehicle Body and Automotive Parts of Special Vehicles_Press Transport and Feeding Process for Sheet Materials
	Metal & Plastic (4)	Processing	⑨ Metal and Special-Purpose Machinery_Arc Welding Process
		Processing	⑩ Metal and Automotive Parts_Machine Tending Inspection and Measurement Processes
		Processing	⑪ Metal Castings_Finishing Process After Casting
		Post processing	⑫ Metal and Plastic Products_Painting Process
	Electrical & Electronic (3)	Detachment	⑬ Electronic Parts_Printed Circuit Board_Automatic Insertion and Withdrawal: Optical and X-Ray Inspection Equipment Process
		Detachment	⑭ Electronic Parts_Printed Circuit Board_Operation of Insertion Handle for Surface Treatment Using Chemicals
		Post processing	⑮ Electronic Parts_Printed Circuit Board_Automated and Unmanned Packaging Process (Complex Process)
		Transport & Loading	⑯ Textile & Weaving_Transport and Loading Processes for Bobbins

Textile (4)	Post processing	⑰ Textile Product Dyeing and Finishing_Solution Supply and Input Processes
	Feeding & Loading	⑱ Other Textile Products_Pickup and Transport Processes
	Post processing	⑲ Other Textile Products_Packaging Process
F&B (4)	Transport & Loading	⑳ Kimchi_Transport, Loading and Input Processes
	Detachment	㉑ Kimchi_Detached Core Removal and Cutting Processes
	Assembly & Disassembly	㉒ Kimchi_Assembly & Disassembly and Seasoning Mix Process
	Testing & Inspection	㉓ Kimchi_Palletizing Process After Testing and Inspection

○ **(Development Council)** The 'Manufacturing Robot Innovation Support Group' consisting of 6 research institutes* was launched to accelerate the development of standard process models (June, 2020).

* Korea Automobile Technology Institute (automotive), Korea Electronics Technology Institute (electrical & electronic), Korea Institute of Machinery and Materials (machinery), Korea Food Research Institute (F&B), Korea Textile Machinery Convergence Research Institute (textile) and Korea Institute of Industrial Technology (metal & plastic)

□ **(Distribution of manufacturing robots)** Based on the demand for standard process models* and the demand of individual companies, **330 manufacturing robots were supplied** (45%↑ compared to the previous year)

* Held relay briefing sessions by industry and region (Busan, Daegu, and Siheung)

○ **(Demonstration and distribution)** Based on 14 **standard process models** that had been developed, **130 manufacturing robots*** were demonstrated and supplied to 70 companies for 81 processes (Ministry of Trade, Industry and Energy, MOTIE)

* Metal & plastic (51 units), automobile (57 units), textile (7 units), and F&B (15 units)

○ **(Distribution to individual companies)** Based on their demands, **200 manufacturing robots*** were supplied to 39 companies **participating in the Smart Factory Project** (Ministry of SMEs and Startups, MSS)

* Metal processing (30), lumber & paper (2), textile & apparel (7), F&B (4), medical optical machinery (4), automotive parts (76), electronic parts and equipment (40), plastic & chemical (25), and other (12)

○ **(Safety certification) 26 companies** including those that introduced the standard process models were provided with support regarding obtaining **safety certification** (MOTIE) and **40 safety inspection consulting** sessions (MSS).

□ **(Employee training)** The robot utilization training program was operated and infrastructure was established for employees.

○ **(Training program) 16 programs** on the standard process models (MOTIE), **28 programs tailored to user demands** (Ministry of Employment and Labor, MOEL), and programs on **Smart Factory Construction** (MSS) were developed and operated.

○ **(Practical training) 82 people completed** the standard process model training programs designed for employees (MOTIE) and **822 people completed** the basic to advanced programs (MOEL).

○ **(Training center)** The facilities* and equipment of the Robot **Vocational Training Center** to train professional manpower (robot operators and coordinators) that can utilize robots began to be constructed.

* In the Gumi Electronics & Information Technology Research Institute (Gumi National Industrial Complex IV), total floor area of 3,369 m^2 (3 floors in total)

□ **(Financial services)** Financial support programs, such as **rental services** and **prime interest rates**, were promoted for robot manufacturers and companies that use robots.

○ **(Rental pilot project)** A consortium was formed between a rental management company (Korea Rental) and user companies (5 companies) to support **robot rental fees** (5 cobots, a total of KRW 49 million).

○ **(Prime interest rate) Low interest rate** (1.5%) loans were offered to robot companies (issued loans worth KRW 4.8 billion for 9 companies) using a bank dedicated to its commercialization (Shinhan Bank) .

2 To develop 4 major types of service robots intensively

□ **(Technology development) KRW 7.6 billion was newly invested in 7 projects** in the areas of wearable, medical, and logistics.

【Key Projects Promoted in 2020】

Sector	Overview	2020 budget
Caregiving	Development of 4 types of caregiving robots (assistance in transport, meal, excretion, and bedsore prevention)	KRW 4.0 billion
	Translational research on caregiving robots and development of service models (Ministry of Health and Welfare, MOHW)	KRW 2.2 billion
Wearable	Development of an exoskeleton robot for paraplegics	KRW 1.4 billion
	Development of an upper limb exoskeleton with excellent muscle assistance and wearability for construction workers	KRW 0.8 billion
	Development of a robot suit that can travel 100 m in 7 seconds	KRW 1.3 billion
	(New) Development of soft sensor-embedded fabric-based actuators and garment-type robotic technology	KRW 0.4 billion
Medical	Development of a navigation system of a micro robot for brain disease treatment	KRW 1.1 billion
	Development of a dental surgical robot enabling high-precision implant procedures	KRW 1.0 billion
	(New) Development of an artificial intelligence-based robotic system for spinal hard tissue surgeries	KRW 1.0 billion
	(New) Development of surgical assistant robots for general operations	KRW 0.8 billion
	Technological development for commercialization of micro medical robots (MOHW)	KRW 8.7 billion
	Translational research on rehabilitation robots (MOHW)	KRW 3.7 billion
	(New) Development of pandemic response robots and ICT convergence-based disease prevention and control system (MSIT)	KRW 2.5 billion

Logistics	Development of autonomous driving technology for robots capable of agile maneuvers among dense crowds indoors and outdoors	KRW 2.4 billion
	Development of an Autonomous Mobile Robot (AMR) that can follow humans and transfer goods in industrial sites and daily life	KRW 1.2 billion
	(New) Development of parking robots that provide parking convenience and improve spatial efficiency	KRW 1.0 billion
	(New) Development of robotic systems for autonomous elevator operations and indoor deliveries	KRW 0.8 billion
	(New) Development of robot-enabled unloading system for trunk cargo transport vehicles	KRW 1.1 billion

□ **(Demonstration and distribution) 2,561 service robots** such as caregiving robots were **demonstrated and distributed** (845% ↑ from the previous year).

Sector	Description	Supplied units
Caregiving	Supplied walking therapy robots (6 units), excretion and defecation caregiving robots (150 units), companion robots (950 units), and dementia prevention robots (9 units) by forming a consortium among local governments and companies, etc.	1,115 units
Wearable	Supplied robots to warehouses (50 units), airport cargo terminals (7 units), food ingredient warehouses (9 units), postal warehouses (2 units), and a rehabilitation hospital (1 unit) in the public and private sectors	69 units
Medical	Supplied robots for surgery (3 units) and rehabilitation (11 units) to robot-assisted surgery centers (Yonsei Medical Center and Chung-Ang University Hospital) and robot-assisted rehabilitation centers (National Rehabilitation Center)	14 units
Logistics	Supplied robots to manufacturing plants (4 units), large distribution facilities (6 units), private and public logistics facilities (20 units), indoor/outdoor delivery service providers, etc. (85 units) centering on factories and logistics centers	115 units
Other	Supplied educational robots (1,200 units), robots for preparation of F&B such as chicken (18 units), coffee (17 units), pizza (6 units), ice cream (3 units), and omelettes (4 units), robots for photography (1 unit), beer serving (1 unit), and transportation of samples (2 units) to support the introduction of contactless services	1,248 units

□ **(10 niche market-type technology development)** 2 **new projects were initiated** on an inspection robot for hazardous materials storage tanks (MOTIE) and high-speed human-machine synchronization technology (Defense Acquisition Program Administration, DAPA).

【Key Projects Undertaken by Ministry】

Ministry	Overview	2020 budget
Ministry of Trade, Industry and Energy (MOTIE)	Development of robotics technologies for exploring narrow spaces for search and rescue of people buried in collapsed buildings, etc.	KRW 0.9 billion
	Unmanned automation robot capable of monitoring horticultural facilities, harvesting and transporting crops, and controlling disease and pest	KRW 1.3 billion
	Smart underwater robots and underwater environment monitoring systems	KRW 1.3 billion
	Fault diagnosis and cleaning robot for maintenance of solar power plants	KRW 1.4 billion
	(New) Development of a robot system for non-destructive examination of hazardous materials storage tanks	KRW 0.8 billion
National Policy Agency (NPA)	Development of a mobile robot for collection and identification of hazardous gases (with the cooperation of MOTIE)	KRW 1.5 billion
Ministry of Agriculture, Food and Rural Affairs (MAFRA)	Design of basic mechanisms for an agricultural robot platform for vegetable farms and development of a prototype robot	KRW 0.9 billion
Rural Development Administration	Improvement of the accuracy of deep learning-based analysis technology of crop growth information	KRW 1.2 billion
	Unmanned tractor steering control and autonomous driving	KRW 0.5 billion

(RDA)	technology based on image information analysis of the farming environment	
	Recognition of existence of trees and their shape by applying radar sensors to pest control robots	KRW 0.2 billion
Defense Acquisition Program Administration (DAPA)	Performance test and trial run of powered exoskeleton	KRW 3.9 billion
	(New) Development of high-speed human-machine synchronization control technology	KRW 0.1 billion
National Fire Agency (NFA)	Establishment of training test bed to develop robots against chemical terrorism including toxic gases	KRW 0.8 billion
Ministry of Oceans and Fisheries (MOF)	Development and field test of a shipboard support system for underwater construction robots	KRW 5.0 billion
Ministry of the Interior and Safety (MOIS)	Creation of a disaster robot simulator and a mobile robot system	KRW 0.8 billion
Ministry of Environment (MOE)	Field test and reliability assessment on in-house high-precision probe robots	KRW 1.7 billion

■ **(Regulatory improvement)** Support was provided for early market entry of new technologies in the field of robots, and for discovery and improvement of regulations that are expected to impede future proliferation.

○ **(Regulatory sandbox) Support for 9 cases of fast track verification** of the regulatory status and **1 case of special demonstration***

* 9 cases of fast track verification (logistics, disease control, security, pest and disease control, unmanned charging, etc.) and 1 case of special demonstration (parking)

○ **(Regulatory innovation, Hackathon)** Agreements* among institutions, including MOHW, were drawn in relation to **rehabilitation robots (national health insurance coverage)** and **caregiving robots (incl. those eligible for subsidies)** (July 2020, 4th Industrial Revolution Committee)

* Promotion of a demonstration project to confirm the effectiveness of robots (MOTIE) → Review of system improvement (MOHW)

○ **(Regulatory Innovation Roadmap)** A 'preemptive regulatory innovation roadmap' was established that predicts the stage of technological development and commercialization and responds to business models using robots.*

* Discovery of 33 regulatory improvement tasks and announcement of a roadmap for improving regulations on robots (Oct. 2020, in connection with the Prime Minister's Office)

□ **(Export support) 'Export support tailored for each country** was provided in consideration of the industrial characteristics of each country.

○ **(Malaysia) 18 domestic manufacturing robots*** were supplied to the bottled water production sector.

* Palletizing robots (3 units), AGV (6 units), vertical multi-joint robots (3 units), orthogonal robots (6 units)

○ **(Philippines, etc.) 275 robots for training and education** of teachers and students were supplied to the Philippines and Uzbekistan.

3	To strengthen the foundations of the robotics industry's ecosystem

□ **(Technology development) KRW 5.0 billion was newly invested in 6 projects** in the 3 major part and 4 software areas*.

* **(Parts)** Intelligent controller, autonomous driving sensor, and smart gripper

(Software) Robotic software platform, grabbing technology software, image information processing software, and HRI technology

【New Key Projects for Technology Development in 2020】

Sector	Overview	2020 budget
Intelligent controller	Development of a versatile device for direct demonstration of high-level assembly work	KRW 1.1 billion
Smart gripper	Soft morphing robot technology (soft gripper) for assisting workers	KRW 0.5 billion
	Development of a versatile soft gripper for automation of agricultural process	KRW 0.5 billion
	Development of recognition, gripping, and manipulation technology for flexible cable wiring	KRW 1.1 billion
Gripping technology	Development of robot-based palletizing technology for efficient and safe loading of various types of boxes	KRW 1.1 billion
Human-Robotics	Development of shared work framework technology to intelligently respond to atypical work environments	KRW 0.7 billion

□ **(Infrastructure)** Establishment of infrastructure for the joint use of robot development equipment held by the institutions to support the performance evaluation and certification of next-generation convergence parts

○ **(Parts performance evaluation)** Establishment of performance evaluation and certification support base for the 3 major parts (2020-2023, KRW 1.9 billion in 2020)

[Key Details in Performance Evaluation and Building Certification Support for Next-Generation Convergence Parts]

Sector	Key Performances
Evaluation infrastructure	Establishment of the evaluation equipment and testbed such as an intelligent controller convergence performance evaluation system * Robotic platform for intelligent controller evaluation, driving environment for autonomous driving sensor evaluation, etc.
Boost for commercialization	Support for cooperation among robotic part manufacturers and system providers, and support for marketing/commercialization of convergence parts using empirical data

Standard registration for robotic parts	Establishment of KOROS standards for ensuring the quality of autonomous driving sensors, intelligent controllers, smart grippers, etc.

○ **(Shared use of equipment)** Robo-Tube, an online platform for shared use of equipment, was established to enhance the utilization of equipment owned by robot support institutions.*

* Korea Robot Industry Promotion Agency (Daegu), Bucheon Industry Promotion Agency, Chonnam National University (Gwangju), KITECH (Busan), Daegu Machinery and Parts Research Institute, Korea Institute of Robot and Convergence (Pohang), Daejeon TP, Gyeongnam TP, Gwangju TP, etc.

□ **(Demonstration and demand matching)** Support was provided for the demonstration of **10 types* of robotic parts** for 7 robots by matching robot manufacturers and parts suppliers.

* Decelerators, drive modules, motion controllers, bolt fastening systems, 3 types of motor drivers (for driving, steering, and lifting), and 3 types of gripper (gripper fingers, gripper hand, and gripper step motor)

□ **(Cross-industry convergence)** Development, demonstration, and commercialization of next-generation core robotics technologies converged with AI and 5G technologies

○ **(Artificial intelligence)** Construction and technical support of demonstration testbeds for intelligent implementation of general machinery (2020-2024, KRW 2.4 billion in 2020), and Assembly AI-Robot Challenge*

* Assembling furniture with a robot developed through the collaborative R&D between the MOTIE (Robot)-Ministry of Science and ICT (AI)

【Key Details of the Intelligent Machinery Project (Collaborative Intelligence-based Robot Plus)】

Sector	Overview
Demonstration infrastructure	Establishment of a testbed for complex-processing processes based on collaborative intelligence and development of performance evaluation methods for simple processing processes * Multi-axis processing machine, process simulation software, and 3D spatial recognition software
Technical support	Collaborative intelligence software development kit (SDK) packaging and dissemination of collaborative intelligence operation technology for Simple and complex processing processes

○ **(5G)** The foundation for demonstration was established to support the use of heterogeneous and multi-robots that are connected via 5G for collaboration at manufacturing sites (2020-2023, KRW 3.8 billion in 2020)

【Key Details of Demonstration Base Establishment Project for 5G-based Advanced Manufacturing Robots】

Sector	Overview

Demonstration infrastructure	Provision of open collaboration demonstration test services between suppliers and users by establishing various virtual environments and simulated manufacturing environments similar to the actual manufacturing environments * Real environment testbed facilities, software reliability, and equipment for performance evaluation and certification of high-tech manufacturing robots
Technical support	Support for early commercialization by addressing issues based on actual data and verifying safety through a demonstration environment that is based on virtual and real environments * Reliability verification, internationally accredited testing and certification system, and development of safety guidelines

- **(Cloud)** Development of AI brain technology that can **connect and control robots in the cloud** and learn data produced by multiple robots in real time* (Ministry of Science and ICT, MSIT)

* Development of core AI technologies for cloud robots (2020-2023, KRW 5.5 billion in 2020)

IV. Direction for 2021

◈ Responding to social needs (population reduction, improvement of quality of life, etc.) by spreading robots that collaborate with humans
◈ Driving acceleration of contactless and digital transformation of all industries by utilizing robots
◈ Creating an environment using robots through preemptive institutional improvement and expansion of demonstration bases

1. Development and Spread of User-Oriented Robot Utilization Models

○ **Developing process models and expanding demonstrations** for **industries with a high level of robot utilization** (aerospace, shipbuilding, chemical, and bio) other than the 3 major manufacturing industries to address issues of labor shortage and work environment improvement

○ Establishing a systematic support system from development to supply of problem-solving BMs for users and inducing them to spread autonomously in the private sector through joint purchase, rental, and subscription

○ **Supporting extensive demonstration** fused with multiple and various robots and services based on important places (such as airports, hospitals, and logistics centers) in response to the demand for **improvement of working environments and proliferation of contactless services**

2. Inducement of Digital Transformation of All Industries Using Robots

○ Promoting contactless and digitalization of manufacturing and service sites by **spreading robot services** fused with 5G and AI to all industries including primary (agriculture), secondary (manufacturing), and tertiary (service) industries
○ Supporting the establishment of a foundation for **process automation using robots and internalization of the know-how of skilled workers** in line with the accelerated digital transformation

3. Creation of a Foundation for the Growth of High-Tech Robots through Deregulations and Preparation of a Demonstration Environment

○ Operating a regulatory innovation center and **implementing the Regulatory Innovation Roadmap in phases** for **preemptive institutional improvement** such as preparing regulations and safety standards expected according to the proliferation of the utilization of robots
○ **Supporting the early commercialization of high-tech robots** by **establishing and operating a demonstration test environment** for next-generation key parts and robots

V. Action Plan for 2021

1 **To increase the penetration of manufacturing robots in the 3 major manufacturing industries**

Development of Standard Process Models	**Early distribution**	**User training**	Autonomous dissemination in the private sector
3 major fields + new fields such as shipping and aviation + improvement of existing models bio, etc.)	Distribution and demonstration of standard models that have been developed	Robot user training before and after the introduction to current employees	Vitalization of finance, lease/rental support and demand networks

□ **(Development of standard process models) Additionally developing** standard process models for 3 major manufacturing industries and **expand industrial sectors** for the development of standard process models

○ **(3 major fields)** Additionally developing **23 standard models** by analyzing the urgency to introduce robots and utilization of robots for each production process (37 in 2019 and 2020 ➪ **23 in 2021** ➪ 48 from 2022 to 2023)

○ **(New fields)** Newly developing standard process models for **aviation, shipbuilding, and chemical, and bio** fields in response to the accelerated digital transformation of the manufacturing sector* (**9 in 2021** ➪ 18 from 2022 to 2023)

○ **(Database establishment)** Establishing a **database* of the standard process models that have been demonstrated and spread** to provide detailed data for companies operating similar processes to review whether to adopt robots

* Planning to operate a website where companies can search for similar processes and consult on the cost and technical aspects (2021 2H~)

□ **(Distribution of manufacturing robots) Supporting packages that include consulting, early distribution, and user training, based on the developed standard process models and the demand of individual companies***

* Hold briefing sessions in connection with representative users by industry (6 times a year)

○ **(Standard process model-associated) Demonstrating and distributing 220 manufacturing robots** centering on 3 major fields* using the standard process models that have been developed

* Including industries that can improve and apply existing standard process models such as cosmetic manufacturing and packaging processes

○ **(Support for individual companies)** Supporting the spread of increased introduction of robots to strengthen **manufacturing competitiveness** of SMEs and **reshoring companies** with **weak digital**

infrastructure (57 companies, MSS)

□ **(Employee training)** Providing specialized training for manpower (robot operators and coordinators) using vocational training centers centered on field training

○ **(Training center operation)** Training 183 people by operating a robotics vocational training center equipped with robots, systems, and software specialized for robot operation practice in manufacturing sites

○ **(Training programs)** Developing the **curricula for 27 programs** for the developed standard process models and providing operational training for the employees of companies introducing robots

* Increase the operational efficiency and training effectiveness by providing an online training platform

○ **(Practical training)** Operating 14 programs 35 times to train **500 people** (MOEL) and training robot operators, coordinators, etc. (MSS) to **prepare for changes in the work environment**

□ **(Dissemination in the private sector)** Operating **financial services programs** using the financial support infrastructure of the private sector and inducing diversification of the use of robots in the private sector.

○ **(Insurance)** Providing support such as preferential insurance premiums for **Robot-Specific Insurance** (KBIZ Korea Federation of SMEs , Korea Chamber of Commerce and Industry) introduced to address the limitations and high costs of insurance subscription faced by robot companies

* Product liability (PL), business liability deduction, and fire insurance deduction

○ **(Loan)** Offering **prime interest rates** (approx. KRW 10 billion, 1.5%p cut) and **support for the payment of guarantee fees** (approx. KRW 100 million each and issuance of guarantee certificates worth KRW 20 billion in total) through a bank dedicated to robot commercialization

○ **(Joint purchase, etc.)** Discovering cooperative programs to diversify ways to adopt and use robots such as **joint purchase*, rental, subscription of robots**, etc. and create a market

* Support matching, supervision, and introduction between associations of industries with demand for robots and robot manufacturers

【Lease/Rental Plan】

Project stage	Stage 1 (2021~)	Stage 2	Stage 3
Objective	**Support discovery**	**Support growth**	**Support market advancement**
Description	• Discover leading companies and products in the market • Support the utilization of leased/rented products (financial support for lease and rental fees) • Expand the distribution of manufacturing robots	• Support the operation of a BM innovation committee • Support a BM consulting • Support the development of a consortium of users • Provide support linked to the purchased products	• Support networking spread among industries • Increase products linked to financial services (financial lease, installment financing, etc.)

2	To develop 4 major types of service robots intensively

□ **(Technology development) Investing KRW 10.7 billion to develop new technologies** in the 4 major service robot areas, focusing on solving **social issues** such as the spread of infectious diseases and surge in logistics volume

【New Key Projects for Technology Development in 2021】

Sector	Overview	2021 budget
Caregiving	Development of a human-following semi-autonomous robotic bed for the isolation of infected patients	KRW 0.8 billion
	Development of nursing assistance and patient monitoring robotic systems for infection isolation wards	KRW 0.9 billion
	Development of caregiving robots for isolation treatment facilities (MOIS)	KRW 1.0 billion
Medical	Development of a lightweight wearable rehabilitation robot for self-rehabilitation of arms	KRW 1.1 billion
Logistics	Development of technology for a robot-based cargo loading system	KRW 0.9 billion
	Development of mobile logistics handling robotic technology to streamline operations at Korean-style logistics warehouses	KRW 3.0 billion
Integrated	Development of field-applied robotic systems for implementing business models for robotics services	KRW 3.0 billion

□ **(Demonstration and distribution)** Continuing to promote demonstration and distribution by service area, but **promoting new types of demonstration that can serve tangible benefits to the daily lives of people** such as modification/improvement and integrated demonstration tailored to the needs

○ **(By Sector)** Promoting demonstration and distribution in the areas of **caregiving (1,200 units), wearables (100 units), medical (12 units), and logistics (200 units) with a focus on newly developed robot products**

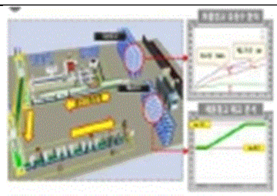
【Content of Demonstration and Distribution by Area】

Sector	Distribution plan	Target for distribution
Caregiving	Promote benefits for the socially disadvantaged, such as the elderly and the disabled, and secure product references (companion robots, excretion/defecation and transport support robots, dementia prevention robots, upper and lower limb assistance robots, etc.)	1,200 units
Wearables	Carry out market verification through distribution to the public (airport, post office, etc.) and private (factory, logistics center) sectors	100 units
Medical	Support the demonstration and distribution of customized medical robots in consideration of the characteristics of each field, such as robot-assisted surgery centers, rehabilitation hospitals, and nursing homes	12 units
Logistics	Supply indoor and outdoor logistics robots (transportation, transport, delivery, serving, etc.) to various users to support on-site verification and discovery of areas requiring institutional improvement (manufacturing plants, stores, distribution centers, post offices, hospitals, hotels, restaurants, etc.)	200 units
Other	Demonstrate and support the spread of manufacturing robots (collaborative robots, or cobots) in the service industry such as chicken and coffee shops (promote successful cases and create a boom of robots by hosting tasting events using cobots)	-

○ **(Demand-based development and distribution)** Supporting the development and renovation of service models using robots to solve problems faced by users in each service area (2021-2025, KRW 2.2 billion in 2021)

* (Step 1) Service model development → (Step 2) Product renovation and demonstration support

【Development and Distribution Tailored to Demand (Examples)】

			
<User demands>	<Expert consulting>	<Renovation>	<Distribution of solution>
Demand improved work environment (contactless) and efficient logistics	Analyze processes and services and propose a solution utilizing robotics	Renovate existing robots to meet the performance requirements	Distribute optimized solutions

○ **(Large-scale convergence demonstration)** Supporting **convergence demonstration** using **multiple**

numbers and types of robots using industrial complexes and airports as bases

【Large-Scale Convergence Demonstration (Examples)】

* **(Industrial complex)** Manufacturing robot cluster, logistics robot, cleaning robot, parking robot, delivery robot, etc.
* **(Airport)** Guide robot, parking robot, delivery robot, security screening robot, monitoring robot, cleaning robot, etc.
* **(Apartment)** Smart farm, delivery robot, parking robot, cleaning robot, security robot, electric vehicle charging robot, etc.
* **(Hospital)** Surgical robot, telemedicine robots, unmanned pharmacies, pharmaceutical compounding robot, sample transport robot, etc.
* **(Building)** Parking robot, guide robot, library robot, robotic chef, indoor delivery robot, etc.

□ **(10 niche market-type technology development) Investing KRW 14.5 billion in 9 projects** such as the development of a polar environment robot (MOTIE) and an intelligent agricultural robot (MAFRA)

【New Projects for 2021 by Ministry】

Ministry	Overview	2021 budget
MOTIE	Development of a robot system and an operation technology applicable into the polar (Antarctic) environment	KRW 1.2 billion
MAFRA	Development of intelligent farming robots for smart greenhouses	KRW 1.9 billion
	Development of robots for harvesting horticultural crops based on the collaboration of multiple robots	KRW 0.8 billion
RDA	Development of a robot that uses image data to determine ripeness and to measure yield	KRW 1.4 billion
	Development of a smart pest control robot for orchards and research to verify effectiveness and apply it in the field	KRW 0.3 billion
	Development of intelligent weeder for apple orchards	KRW 0.2 billion
	Research on operation mechanism based on robotic-arms for autonomous harvest	KRW 0.1 billion
Korea Coast Guard	Development of an autonomous underwater robot system for swarm search in case of maritime accident	KRW 2.1 billion
MOE	Development of contactless collection and treatment technology for medical waste	KRW 6.5 billion

□ **(Regulatory improvement) Following up on "Regulatory Innovation Roadmap for Robots** (announced in Oct. 2020)" and conducting in-depth research on anticipated issues when using robots

○ **(Regulatory innovation projects) Completing 4 projects* within 2021**, such as continuation to verify **the effectiveness and safety of robots** in connection with sandboxes and demonstration projects and robots boarding elevators

* Improvement of safety standards for self-certification for cobot workplaces (MOEL), establishment of safety standards for delivery robots to board elevators (MOIS & MOTIE), establishment of personal information protection guidelines for robots (Personal Information Protection Commission & MOTIE), and amendment of the approval criteria for port services using

underwater cleaning robots (MOF, completed in Jan. 2021)

○ **(Research on issues)** Promoting in-depth research* on the **issues related to the use of robots** across the society and creating a platform for the robot industry to share information (a window for integrating collected and analyzed data)

* Analysis of the effectiveness of the policy support, research on strategies to promote the service robot/SI industry, research on the impact on jobs, etc.

□ **(Export support)** Providing customized export support for promising markets considering the characteristics of each country, and supporting to the **acquisition of certifications** for domestic robot products to **expand to overseas markets**

○ **(Customized export support by country)** Supporting the introduction of domestic manufacturing robots into **overseas industrial sites** by matching domestic robotic manufacturers with overseas customers as targeting **the ASEAN market**

* (~2021) Major ASEAN countries (manufacturing) → (2022) Middle East and Central Asia (healthcare & rehabilitation)

○ **(Certification support**) Promoting the acquisition of **designated testing laboratories** (CBTL*) for a **cross-border (CB) certification system** to assist domestic companies in acquiring the necessary certifications to enter overseas markets

* Certification Body Testing Laboratories: By mutually recognizing the test results in more than 50 countries, it is possible to obtain the certification of the relevant country without duplicate tests.

□ **(Human resources training)** Training working-level manpower by operating specialized training programs for **convergence between robots and other industries** and **human-robot field collaboration**

○ **(Convergence with other industries)** Operating master's and Ph.D. programs by region to **train working-level manpower for SMEs** capable of converging between robots and other industries

* Training experts leading robot-based innovation (2019-2023, KRW 1.95 billion in 2021)

○ **(Human-robot collaboration)** Operating new degree programs in specialized fields that reflect the industry demand to improve efficiency through **collaboration between workers and robots** at manufacturing sites

* Training experts in human-machine collaboration technology based on AI robots (2021-2025, KRW 1.66 billion in 2021)

3 To strengthen the foundations of the robotics industry's ecosystem

□ **(Technology development) Newly investing KRW 2.2 billion in 2 projects** to develop core technologies in the areas of intelligent controllers and smart grippers.

【New Key Projects for Technology Development in 2021】

Sector	Overview	2021 budget
Gripper	Development of recognition technology and gripper	KRW 1.2 billion

	capable of picking various kinds of random pieces	
Controller	Development of 5kHz or higher general-purpose intelligent robot controller in consideration of worker safety	KRW 1.0 billion

□ **(Establishment of the foundation)** Build the **foundation for safety certification of cobots**** to secure competitiveness of cobots which are expected to grow rapidly* (2021-2025, KRW 2.0 billion in 2021)

* Proportion of cobots among manufacturing robots: 4% in 2018 → 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

【Key Details of the Establishment of a Foundation for Safety Certification for Cobots】

Sector	Overview
Demonstration environment	Support suppliers and users by setting up equipment and demonstration test facilities for testing and certification
Establishment of a safety certification system	Support cobot manufacturers by establishing cobot product certification (based on ISO 10218-1) and KOLAS testing and certification system
Certification support and dissemination of technology	Establish an internationally accredited safety and performance testing system for cobot product certification and devices and provide technical consulting

□ **(Demonstration in connection with demand) Supporting new demonstration projects** (decelerator, lidar, etc.) through cooperation between domestic and foreign robot manufacturers and domestic parts manufacturers (KRW 1.2 billion in 2021)

□ **(Big Data convergence)** Commence **building the foundation for big data-based meister robotization*** centering on **4 key areas** (metal processing, automotive parts, electrical & electronic, and textiles) (2021-2025, KRW 2.0 billion in 2021)

* Digitization and automation of the know-how (tacit knowledge) of skilled workers by applying the big data technique to the already established ppuri machinery

【Key Details of the Establishment of a Foundation for Meister Robotization】

Field	Description
Demonstration environment	Establish a demonstration environment to upgrade the existing process system in a short period of time by utilizing the digitalization and automation-based technology of public research institutes
Technical support	Support the development of performance evaluation methods and the expansion of field application of the meister robotization technology developed using the demonstration infrastructure
Workforce training	Develop working-level experts for companies by supporting education and training centering on process solutions and user companies' (prospective) manpower and developing standard teaching plans for process application

VI. List of Projects

Project		Ministry in charge	Budget (unit: KRW 100 million) 2020	2021
1. To increase the penetration of manufacturing robots in the 3 major manufacturing industries				
1-1	Develop 108 robot utilization models for each industry and process in advance	MOTIE, MSS	65	109
1-2	Provide consulting and demonstration to 10 enterprises for each standard model	MOTIE, MSS	237	407
1-3	Provide training on using robots for employees centered on companies that support the introduction of manufacturing robots	MOTIE, MOEL	25	32
1-4	Induce autonomous dissemination in the private sector through purchase support for rental/lease services	MOTIE	1	1
1-5	Shift from a government-led subsidy policy to a private loan model	MOTIE	-	-
1-6	Host briefing sessions and vitalize networks to spread demand-driven robot dissemination	MOTIE	-	-
2. To develop 4 major types of service robots intensively				
2-1	Select 4 service robot areas with high growth potential	Inter-departmental collaboration	-	-
2-2	Support 10 niche market-type technology development and distribution	MOTIE, NPA, MOE MAFRA, RDA, DAPA, NFA, NCG, MOF, MOIS,	223	319
2-3	Develop robots in 4 major areas → Distribute and demonstrate robots to socially vulnerable classes, etc.→ Spread them to the private sector	MOTIE, MIST, MOHW, MOIS	482	738
2-4	Create new markets in Korea and abroad by easing regulatory restrictions and supporting package-type overseas expansion	MOTIE	14	14
3. To strengthen the foundations of the robotics industry's ecosystem				
3-1	Select next-generation core parts and software to strengthen the competitiveness of downstream industries	MOTIE	-	-
3-2	Promote self-reliance in the top 3 next-generation core parts and 4 major software technologies	MOTIE	70	113
3-3	Promote demonstration and distribution of domestically manufactured parts	MOTIE	31	39

	3-4	Create a new market by spreading robot convergence technology across other industries	MOTIE, MSIT	257	398
Total				1,405	2,170

Public Announcement No. 2022- 209, Ministry of Trade, Industry and Energy

In accordance with Article 5 of the “Intelligent Robot Development and Dissemination Promotion Act” and Article 3 of the Enforcement Decree of the same Law, the “Intelligent Robot Execution Plan for 2022” is announced as follows:

March 7, 2022

Minister of Trade, Industry and Energy

2022 Action Plan
for the Intelligent Robot Project

February 2022

Joint Compilation by Relevant Ministries

I. Background

◈ **In 2008, Intelligent Robot Development and Distribution Promotion Act (hereinafter "Intelligent Robot Act") was enacted in order to prepare a systematic and consistent basis for supporting the robotics industry.**

☐ Article 5 of the Intelligent Robot Act stipulates that a **basic plan be established every five years** and an **action plan be prepared for every year** for the promotion of the robotics industry.

[Article 5 of the Intelligent Robot Act]

① The Government shall establish a basic plan every five years (hereinafter referred to as "basic 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 a relevant central administrative agency shall annually establish and implement an action plan to develop and distribute intelligent robots and to establish the foundation therefor (hereinafter referred to as "action plan") within the scope of the affairs under his/her jurisdiction in conformity with the basic plan.

☐ Accordingly, **The Third Basic Plan (2019–2023)** was established and an annual action plan was prepared to expand and spread manufacturing robots, develop the 4 major service robots, and strengthen the ecosystem.

[Overview of the Third Basic Plan for Intelligent Robots]

Vision	**To establish Korea as one of the top four powerhouses in the global robotics industry**	
Objectives	◆ **To expand the market size of the robotics industry (KRW 15 trillion by 2023)** ◆ **To increase the number of companies specializing in robotics valued at over KRW 100 billion (at least 20 companies by 2023)** ◆ **To expand the number of manufacturing robots (cumulative 700,000 units by ' 23)**	
Main Projects	☐,1 **To increase the penetration of manufacturing robots in the 3 major manufacturing industries**	▪ To develop 108 model applications for industries and processes ▪ To provide consulting, demonstration, and distribution to 10 companies per standard model ▪ To train the employees at companies adopting manufacturing robots ▪ To offer robots on a rental/lease basis and transition into a loan model in the private sector
	☐,2 **To develop 4 major types of**	▪ To develop technologies for 4 types of promising service robots

	service robots intensively	▪ To distribute and demonstrate 4 types of service rob → disseminated in the private sector ▪ To create new markets in Korea and abroad regulation improvement and overseas expansion
	☐,3To strengthen the foundations of the robotics industry's ecosystem	▪ To develop next-generation core technologies for pa and software ▪ To promote the demonstration and distribution domestically manufactured parts ▪ To create new markets by disseminating converge robotics technologies to other industries

II. Robotics Industry Trend

☐ **(Global market)** In 2020, the global robotics market size reached USD 24.3 billion, a 3% YOY increase with market growth primarily driven by service robots.

[Global Robotics Market Sales (unit: Million USD)]

Classification		2015	2016	2017	2018	2019	2020	YoY	CAGR
Total		**15,584**	**16,949**	**24,086**	**27,018**	**23,559**	**24,257**	**3%**	**6%**
	Manufacturing robots	8,758	10,598	13,918	13,854	13,753	13,168	-4%	8%
	Service robots	6,826	6,351	10,168	13,164	9,806	11,089	13%	10%

*Source: World Robotics 2021 (IFR: International Federation of Robotics, Oct. 2021)

○ (Manufacturing robots) Sales of manufacturing robots recorded USD 13.2 billion, a 4% YoY decrease, due to the contraction of the automotive market (-22%) despite the rapid rise in demands for electronic devices during the pandemic that boosted the electrical and electronic industry (+23%).

* (Electrical & Electronic) 88,925 units in 2019 → 109,315 units in 2020 (+23%), (Automotive) 101,875 units in 2019→ 79,849 units in 2020 (-22%), (Metal/Machinery) 45,843 units in 2019 → 41,332 units in 2020 (-10%)

○ (Service robots) Sales of service robots recorded USD 11.1 billion, a 13% YOY increase, due to the surge in medical robots (+174%), cleaning robots for disinfection (+95%), and logistics robots for indoor deliveries, etc. (+33%).

* (Medical) 6,518 units in 2019 → 17,884 units in 2020 (+174%), (Cleaning) 17,895 units in 2019 → 34,433 units in 2020 (+92%), (Logistics) → 32,680 units in 2019 → 43,519 units in 2020 (+33%)

** Global market size for service robots (IFR, 2021): Home (USD 4.3 billion), medical (USD 3.6 billion), logistics (USD 1 billion), field (USD 950 million), cleaning (USD 320 million), and inspection and maintenance (USD 250 million).

☐ (Domestic market) As of 2020, the domestic robotics market size reached KRW 5.5 trillion, with a compound annual growth rate (CAGR) of 5.4%. Due to the rapid growth of the service robot market, the entire industry grew 2.6% compared to the previous year.

[Domestic Robotics Market Sales (Unit: KRW 100 million)]

Classification		2015	2016	2017	2018	2019	2020	YoY	CAGR
Total		**42,169**	**45,972**	**55,255**	**58,019**	**53,351**	**54,736**	**2.6**	**5.4**
	Manufacturing robots	25,831	27,009	34,017	34,202	29,443	28,658	△2.7	0.6
	Service robots	6,277	7,464	6,459	6,650	6,358	8,577	34.9	6.4

Classification		2015	2016	2017	2018	2019	2020	YoY	CAGR
	Robotic parts	10,061	11,499	14,779	17,167	17,550	17,501	△0.3	11.7

*Source: 2020 Robotic Industry Survey (January 2021, Korea Institute for Robotics Industry Advancement)

○ (Manufacturing) The manufacturing robot market was valued at KRW 2.9 trillion, a slight decline (-2.7%) compared to the previous year due to the contraction of new investment in key industries in demand due to the prolonged COVID-19 situation.

* Facility investment: KRW 8,726.8 billion in 2019 → KRW 7,920.7 billion won in 2020 (+9.2%) (ISTANS (Industrial Statistics Analysis System))

- Out of 558 companies, 5 companies* (1 more compared to the previous year) posted KRW 100 billion or more in sales, and 514 companies were SMEs that earned KRW 10 billion or less (92.1%).

* Hanwha Precision Machinery, Hyundai Robotics, Koh Young Technology, Cymechs (new), and Robostar

○ (Service) The service robotics market in 2020 was valued at KRW 800 billion, a 34.9% YOY increase, due to the broader commercialization of high-performance, high-priced surgical robots and increase in sales of cleaning robots that help reduce housework.

* (2020 sales) KRW 46.1 billion (+4.1%) for professional service robots and KRW 396.6 billion (+25.5%) for personal service robots

- Out of 458 companies, there are 2 companies posted sales of KRW 50 billion or more,* 9 companies KRW 10 billion or more,** and 437 companies (95.4%) were SMEs that earned less than KRW 5 billion.

* LG Electronics, Samsung Electronics ** Everybot, Huneed Technologies, Daeyang Electric, Yujin Robot, etc.

○ (Parts) Due to the reduction (-0.4%) in the production of manufacturing robots, the market sized down 0.3% year-on-year to KRW 1.7 trillion, recording an 11.7% CAGR.

[Classification of Companies by Sales Volume (Unit: No. of Companies)]

Classification	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
Manufacturing	5(0.9%)	6(1.1%)	33(5.9%)	41(7.3%)	473(84.8%)
Service	-	2(0.4)	9(2.0%)	10(2.2%)	437(95.4%)
Parts	-	1(0.1%)	34(2.4%)	25(1.8%)	1,351(95.7%)

□ (Industrial trends) Overseas exports of robots increased, while imports decreased slightly.

○ (Imports and exports) Exports increased by 5.2% YoY to KRW 1.1 trillion due to the boost in exports of semiconductor manufacturing robots,* and imports decreased by 11.6% YoY to KRW 0.5 trillion due to the decline in imports of parts.**

* Global semiconductor equipment investment: USD 63.2 billion in 2020, +6% YoY <SEMICON West 2020, SEMI>

** Imports by year (Change rate): (2018) KRW 573.3 billion (-23%) → (2019) KRW 632.2 billion (+10.3%) → (2020) KRW 559.2 billion (-11.6%)

○ (Businesses) In 2020, the number of businesses decreased by 8.6% YoY to 2,427, an increase of 5% in CAGR in the last six years.

* Number of businesses by year (Change rate): (2015) 2,191 (+1.5%) → (2018) 2,508 (14.5%) → (2020) 2,427 (8.6%)

○ (Employment) The number of employees in the robotics industry dropped 0.8% from the previous year to 30,786 in 2020 and the CAGR increased by 4% in the last six years.

* Employment by year (Change rate): (2015) 25,000 (+5.3%) → (2018) 37,000 (+27.5%) → (2020) 30,000 people

(-0.8%)

III. Key Performances Analysis for 2021

1 To increase the penetration of manufacturing robots in the 3 major manufacturing industries

☐ (Standard process model development) Additional standard process models were developed to accelerate industrial digital transformation* and establish an integrated database management system for disseminating robot applications.

ㅇ (Additional development) 26 standard process models were developed in major manufacturing areas (ppuri, textiles, food and beverage) and 9 for new industries such as shipping and aviation.

* Development of standard process models: 14 in 2019 ⇨ 23 in 2020 ⇨ 35 in 2021

[Standard Process Models Developed in 2021]

Field		Process	Model Name
Ppuri (18)	Automotive (5)	Post-processing	① Automotive Parts_Contaminant removal process
		Assembly/Disassembly	② Automotive Parts_Application process
		Processing	③ Automotive Parts:_Projection and inspection process
		Testing/Inspection	④ Automotive Parts_Missing product detection process
		Testing/Inspection	⑤ Automotive Parts_Riveting and operation inspection process
	Machinery (4)	Assembly/Disassembly	⑥ Gas Filter Mechanical Parts_Bolting assembly process
		Post-processing	⑦ Air Condition System Mechanical Parts_Packaging process for electronics manufacturing tray
		Post-processing	⑧ Automotive Parts for New Engines_Deburring Process
		Processing	⑨ Vehicle Body and Special Vehicle Exterior Panel Parts_ Discharge and riveting process for semi-finished products
	Metal/Plastic (6)	Post-treatment	⑩ Metal/Automotive Parts_Casting post-treatment process
		Detachment/Inspection	⑪ Loading/unloading and inspection processes of injection-molded plastic parts
		Detachment	⑫ Welding quality inspection process on arc welding for special-purpose machinery
		Processing	⑬ Metal/Automotive Parts_Welding quality inspection process on resistance welding process
		Processing	⑭ Metal/Automotive Parts_Re-processing process associated with machine tending
		Processing	⑮ Metal/Plastic Parts_Plating rack loading/unloading process
	Electrical and Electronic (3)	Transport/loading process	⑯ Non-standard parts mounting process
		Testing/Inspection	⑰ Assembled PCB inspection process
		Post-processing	⑱ PCB coating agent application process
Textile (4)		Post-processing	⑲ Dyeing and Finishing_Shrink packaging process

Field		Process	Model Name
		Transport/loading process	⑳ Dyeing and Finishing_Cart loading process
		Detachment	㉑ Other textile products_Fabric/roll mounting process
		Transport/loading process	㉒ Other textile products_Transporting/loading sheets
Food and beverage (4)		Transport/loading process	㉓ Meal replacement_Transporting/loading process
		Detachment	㉔ Meal replacement_Detachment process
		Assembly/Disassembly	㉕ Meal replacement_Assembly/disassembly process
		Testing/Inspection	㉖ Meal replacement_Testing and inspection process (encasing)
New (9)	Shipping (3)	Processing	㉗ Mobile welding process to replace hand-welding
		Post-processing	㉘ Small plate round cutting (RC) process
		Testing/Inspection	㉙ Automatic recognition inspection process for round cutting (RC)
	Aviation (3)	Post-processing	㉚ Shaping process after hardening_Trimming
		Post-processing	㉛ Lightweight structure polishing process_ Deburring
		Processing	㉜ Machining process after composite lamination_Cutting
	Bio/Chemistry (3)	Transport/loading process	㉝ Bio/Pharmaceutical Products_Packaging process (transport and loading)
		Transport/loading process	㉞ Bio/Medical Device_Packaging/inspection process
		Transport/loading process	㉟ Chemical Container/Plastic_Packaging process (transport and loading)

○ (DB construction) An integrated DB management system for standard process models was established to provide information such as process design, videos, and installation costs required for reviewing the introduction of robots.

* Integrated DB Management System www.erobot.or.kr (Demonstration operation since Dec. 2021)

□ (Distribution of manufacturing robots) To implement smart manufacturing innovation, 519 manufacturing robots were distributed based on standard process models and each company's demands (57%↑).

○ (Demonstration and distribution) Based on the existing 37 standard process models, 204 manufacturing robots* were provided to 104 companies' 136 processes for demonstration and distribution (MOTIE).

* New standard process models (134 units) in machinery, metal, and plastic industries, and improved models in cosmetics and other industries (70 units)

** Briefing sessions organized by sector and region (6 times a year): Aviation: Sacheon (August), Machinery: Changwon (October), and more

○ (Distribution to individual companies) Based on their demands, 315 manufacturing robots* were supplied to 64 small and medium manufacturing companies (MSS).

* Automotive parts (14 units), metal processing (63 units), food and beverage(34 units), electronic parts and equipment (16 units), medical optical machinery (14 units), plastics and chemicals (11 units), textiles and clothing (10 units), machinery and equipment(6 units), wood and paper (1 unit), and other (16 units)

○ (Safety certification) The MOTIE supported the acquisition of safety certification for 64 companies, including collaborative robot installation companies, and the MSS offered 70 safety inspection consulting sessions that are customized for companies.

☐ (Employee training) Companies were supported to train current employees in utilizing standard process models, and a robotics vocational training center was operated.

○ (Standard model-associated) In total, 35 training programs* were developed; introductory/basic and field practice/operational training courses were offered to 104 companies participating in development and demonstration projects. A total of 416 trainees completed the courses.

* (Training program development) Field practice and operations in manufacturing robot demonstration project (26), Manufacturing Robot Plus Project (9)

○ (Training center) The necessary equipment was established at the robotics vocational training center to nurture a professional robotics workforce, which raised 302 professionals.

* 7 types of equipment (20 robots, 2 copies of software) were prepared and 15 new processes were developed and operated.

☐ (Financial services) Financial services were developed and operated in the private sector to promote the wider distribution of robots.

○ (Insurance) A preferential robotics premium program (25–33%) was offered to relieve robotics companies' financial burden in purchasing insurance.
* Support for product liability (PL) was provided to 2 companies.

○ (Purchase support) Robot purchasing methods were diversified* to lay the foundation for disseminating private-led manufacturing robots.

* (Lease and rental) Purchase-based robot rental fee support (KRW 114 million) (collaborative robots (7) and systems (2) to 5 companies) (Joint purchases) Through MOU between the Korea Association of Robot Industry and associations from industries with demand for robotics (4 cases), planned joint purchases of 7 robot units (5 companies)

○ (Loan support) Preferential interest rates (1.5%p) and guarantee fees were supported through a bank dedicated to commercialization.

* Guarantees were issued to 27 companies (approximately KRW 10 billion) with preferential rates (up to 0.5%p) for the guarantee fee.

2 To develop 4 major types of service robots intensively

☐ (Technology development) New robots were developed for infectious disease response and logistics.

[Key Projects Promoted in 2021]

Sector	Overview	2021 budget
Caregiving	(New) Development of a human-following semi-autonomous robotic bed for the isolation of infected patients	KRW 900 million
	(New) Development of nursing assistance and patient monitoring robotic systems for infection isolation wards	KRW 800 million
	(New) Development of caregiving robots for isolation treatment facilities (MIS)	KRW 1 billion
Wearables	Development of soft sensor-embedded fabric-based actuators and garment-type robotic technology	KRW 700 million
Medical	Development of an artificial intelligence-based robotic system for spinal hard tissue surgeries	KRW 1.6 billion
	Development of surgical assistant robots for general operations	KRW 1.2 billion
	Development of pandemic response robots and ICT convergence-based disease prevention and control system (MSIT)	KRW 3.9 billion
	(New) Development of a lightweight wearable rehabilitation robot for self-rehabilitation of arms	KRW 1.1 billion
Logistics	Development of parking robots that provide parking convenience and improve spatial efficiency	KRW 1.8 billion
	Development of robotic systems for autonomous elevator operations and indoor deliveries	KRW 1.2 billion
	Development of robot-enabled unloading system for trunk cargo transport vehicles	KRW 1.6 billion
	(New) Development of technology for a robot-based cargo loading system	KRW 500 million
	(New) Development of mobile logistics handling robotic technology to streamline operations at Korean-style logistics warehouses	KRW 3 billion
Integrated	(New) Development of field-applied robotic systems for implementing business models for robotics services	KRW 2.9 billion

☐ (Demonstration and distribution) By developing demand-tailored robotic services and conducting convergence-based demonstrations, a recognizable service robot market will be created.

○ (By sector) 1,449 units of service robots will be demonstrated and distributed, centered in the promising robotics fields.

① **Caregiving robots (1,266 units)** Walking therapy robots (21), companion robots (1,225), and dementia prevention robots (20)

② **Wearable robots (31 units)** Wearables for transporting heavy items (31)

③ **Medical robots (16 units)** Surgical robots(3), rehabilitation robots (10), rehabilitation robots for clinical trials (3)

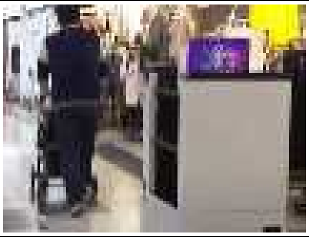
④ **Logistics robots (72 units)** For manufacturing plants (18), airport logistics centers (5), tertiary hospitals (6), public facilities (1), indoor and outdoor deliveries (42)

⑤ **Other (64 units)** Disease prevention and control (8), patrol (5), information (3), cooking (47), food truck (1)

○ (Large-scale convergence demonstration of AI and 5G) Establishment of a 5G-based integrated control system in underground shopping malls* and convergence demonstration of logistics, disease prevention and control, and serving robots

* Launch ceremony of AI·5G-based service robot convergence model demonstration project in Jungang-ro Underground Shopping Center, Daejeon City (October 2021)

[Large-scale Convergence Demonstration Based at Underground Shopping Center]

Base	Demonstration details		
Jungang-ro Underground Shopping Center, Daejeon City (AI·5G-based service robot convergence model demonstration)			
	Logistics robots	Disease prevention and control robots	Serving robots

○ (Demand-tailored development and distribution) Service companies and robotics companies jointly discovered 22 service robot utilization models for solving demand problems.

* **(Step 1) Service model development (2021)** → (Step 2) Renovation and improvement (2022) → (Step 3) Demonstration and distribution (2023–2025)

[Development Performance for Service Models]

Classification	Sector	Model name
Industrial (4)	Manufacturing (1)	① Development of integrated solutions for piling, storage, and picking using robot shuttles
	Construction (1)	② Verification of the effectiveness of wearable robots for construction workers and development of business models
	Agriculture (2)	③ Demonstration and commercialization strategy for smart farm robots based on mobile collaborative robot platforms
		④ Development and distribution of wearable farming robots suitable for the agricultural industry
Commercial (6)	Delivery (4)	⑤ Autonomous robotic goods delivery service at Incheon International Airport
		⑥ Development of multi-service robots using AI element technology on cloud-based variable platforms
		⑦ Activation of indoor and outdoor autonomous courier robots in apartment complexes
		⑧ Development of franchise-specific indoor F&B delivery service robots
	Parking (2)	⑨ Development and demonstration of high-efficiency parking robots to solve urban parking problems
		⑩ Development of autonomous electric vehicle charging system
Medical (5)	Rehabilitation (1)	⑪ Distribution of remote rehabilitation platforms for Rebless rehabilitation robots
	Caregiving (4)	⑫ (Improvement of regulation on privacy) Development and distribution of client-type multipurpose home service robots (Improvement and care of developmental disorders) Development and commercialization of contactless AI robots

Classification	Sector	Model name
		⑬ Development and commercialization of contactless AI robots for improvement and care of developmental disorders
		⑭ Development and distribution support project for multi-functional medical assistance robots, including dementia care
		⑮ Verification of effectiveness and safety of welfare services through AI caregiving robots
Public (4)	Disease prevention and control (2)	⑯ Robot-based automation of patrol and nursing assistance processes in closed hospital wards
		⑰ Introduction of multi-functional autonomous robots for theme park visitors and establishment of integrated concierge
	Safety (2)	⑱ Development of park-specific guidance and patrol robots
		⑲ Autonomous driving and remote control solutions for the use of patrol robots in poor environments
Other (3)	Information (1)	⑳ Development and distribution of entry-level standard model of "NANA," an assistance robot for service workers
	Cleaning (2)	㉑ A robotic system for cleaning the exterior walls of low- and mid-rise buildings using high-altitude work vehicles
		㉒ Autonomous outdoor robot cleaner

☐ (Regulatory Improvement) The plan to systematically implement the Robot Regulatory Innovation Roadmap (October 2020) was announced (April 2021) and the Robot Regulatory Innovation Forum, an industry-university-research institute council, was organized (June 2021).

○ (Regulatory Innovation Projects) From the projects in Step 1, 4 projects were implemented intensively in 2021*. Also, in conjunction with the continued projects in 2022, regulatory sandbox** was continuously monitored.

* Safety standards for robots' elevator use, privacy protection guidelines, port service business permit standards for underwater cleaning robots, and safety certification for collaborative robots' work environments

** Delivery robot's passage of urban parks (2 cases, May 2020–April 2022), operation of parking robots allowed (October 2020–September 2022), mobile electric vehicle charging allowed in Jeju Regulation-Free Zone (December 2019–November 2023)

○ (Regulatory sandbox) 16 special demonstration cases* of regulatory sandbox carried out in delivery, parking, security, and more.

* Outdoor autonomous driving robots, smart parking robots (MOTIE, 7 cases), Regulation-Free Zone for mobile collaborative robots (MSS, 3 cases), autonomous driving delivery robots (MSIT, 4 cases), and patrol robots (MOLIT, 2 cases), etc.

☐ (10 niche market-type technology development) 9 new projects such as robots for polar environments (MOTIE), agricultural robots (MAFRA), and swarm search robots (KCG) were launched.

[Overview of Projects by Ministry]

Ministry	Overview	2021 budget
MOTIE	Development of robotic systems and operational technologies that can be used in polar (Antarctic) environments	KRW 1.2 billion
MAFRA	Development of intelligent farming robots for smart greenhouses	KRW 1.9 billion
	Development of robots for harvesting horticultural crops based on the collaboration of multiple robots	KRW 800 million

RDA	Robotics technologies for hydroponic cultivation, monitoring of fruit growing, fruit thinning and harvesting	KRW 1.5 billion
	Development of intelligent weeder for apple orchards	KRW 200 million
	Research on the application of robot safety technology for agricultural robot development	KRW 100 million
	Fruit enlargement and harvester diagnosis technology for labor-reducing mechanical harvesting	KRW 100 million
KCG	Development of an autonomous underwater robotic system for swarm search on marine accidents	KRW 2.1 billion
MOE	Development of contactless collection and treatment technology for medical waste	KRW 6.5 billion

☐ (Export support) Customized export support for promising markets considering industrial characteristics by country and certification support for overseas entry of robotic products

○ (Customized export support) 8 domestic robots* supported in manufacturing for pizza dough shipping (Domino’s Pizza in Singapore) and electronic device parts (Air conditioner factory in Thailand)

* Delta robot (1 unit), cartesian robot (1 unit), collaborative robots (6 units)

○ (Establishment of contactless support system) Contactless export support projects, such as e-Commercial market entry and support, video consultations, etc.

* Support for entering Alibaba.com (11 companies), Amazon (3 companies), and eBay (3 companies)

○ (Testing and certification support) Acquisition of designated certification agencies in North America, such as UL (Underwriters Laboratories), for domestic service robots to enter the US market (April 2021, Korea Institute for Robot Industry Advancement)

3 To strengthen the foundations of the robotics industry's ecosystem

☐ (Technology development) 2 new projects were undertaken to secure core parts technology.

[New Key Projects for Technology Development in 2021]

Sector	Overview	2021 budget
Smart Gripper	Development of multi-variety, random piece-picking recognition technology and gripper	KRW 1.1 billion
Intelligent Controller	Development of 5kHz or higher universal intelligent robotic controller for worker safety	KRW 1 billion

○ (Demonstration and demand connection) Field demonstration support by applying 21 types and robotic parts to 82 robots for verification of domestic key parts' reliability

* (Product verification) Reducers (6 types, 3 units), drives (2 types, 2 units), position sensors (3 types, 1 unit), and servo motors (2 types, 22 units)

** (Field demonstration) LiDAR sensors (1 type, 51 units), drive modules (2 types, 1 unit), reducers (3 types, 1 unit), and motors (2 types, 1 unit)

☐ (Infrastructure) Establishment of infrastructure for the joint use of robot development equipment held by the institutions to support the performance evaluation and certification of next-generation convergence parts

○ (Parts performance evaluation) Establishment of performance evaluation and certification support base for advanced and reliable convergence parts (2020–2023, KRW 3.2 billion in 2021)

[Key Performances in Performance Evaluation and Building Certification Support for Next-Generation Convergence Parts]

Sector	Key Performances
Evaluation Infrastructure	Setting up a robotics platform for intelligent controller evaluation, robot reducer performance tester, etc.
Boost for commercialization	Support for the commercialization of convergence parts, such as the development and commercialization of grippers for gripping traditional sauce containers
Standard registration for robotic parts	Deliberation on the enactment of KOROS standards, such as the performance evaluation method for grippers that pick-up fabric

○ (Safety Certification) Building a functional safety and certification system* for collaborative robot safety certification and risk demonstration (2021–2025, KRW 2 billion in 2021)

* Demonstration environment (2 types of equipment), establishment of safety certification system, certification support, technology dissemination, etc.

[Key Performances in Building the Safety Certification Foundation for Collaborative Robots]

Sector	Key Performances
Demonstration Environment	Establishment of equipment such as those for testing mechanical properties and safety evaluation of collaborative robots
Certification system	Development of functional safety requirements verification system for robotic control system based on the functional safety of machinery (ISO 13849)
Technology dissemination	Support for improved safety in accordance with international standards for collaborative robot installation processes

○ (Shared use of equipment) Establishment and operation of Robo-Tube,* an online platform system for research equipment and service matching at robotics support agencies (institutions and companies)

* (Customized technological support map) One-stop joint technological support, sorted by robotic product

(Robotics support market) and provides upstream and downstream robotics industry products, technical cooperation services, etc.(robotube.kiria.org, September 2021)

☐ (Cross-industry convergence) Development, demonstration, and commercialization of next-generation core robotics technologies converged with AI and 5G technologies

○ (Artificial intelligence) Construction and technical support of demonstration testbeds for intelligent implementation of general machinery (2020–2024, KRW 7.7 billion in 2021)

[Key Performances of Intelligent Machinery Project (Collaborative Intelligence-based Robot Plus)]

Sector	Key Performances
Demonstration Environment	Establishment of a testbed for complex processing based on collaborative intelligence (13 types of equipment), development of performance evaluation methods for simple processing, and promotion of standard registration
Technological support	Distribution of collaborative intelligence SDK (software development kit) packaging (2 copyright registrations) for simple and complex processes and collaborative intelligence operation technology* * Development of demonstration cases for collaborative intelligence-based process automation concepts (4 cases) and training (40 people)

○ (5G) Establishing an open demonstration base to support the use of 5G-based robots on the manufacturing site, and testing and certification support (2020–2023, KRW 9.9 billion in 2021)

[Key Performances of Demonstration Base Establishment Project for 5G-based Advanced Manufacturing Robots]

Sector	Key Performances
Demonstration Environment	Establishment of various virtual environments similar to manufacturing environments* and providing open collaboration demonstration tests * Testbed equipment, reliability and advanced manufacturing robot performance certification equipment (3 types, 5 units)
Support for companies	Support for early commercialization of advanced manufacturing robots (7 companies) and establishment of KOLAS certified test system (securing proficiency performance in new robotics software)

○ (Big data) Big data-based meister robotization* and infrastructure construction centered on 3 major fields (metal processing, automotive parts, electrical and electronic) (2021–2025, KRW 2.1 billion in 2021)

* Application of big data techniques to existing ppuri machines to digitize and automate the know-how of skilled workers (tacit knowledge)

[Key Performances for the Establishment of Foundation for Meister Robotization]

Sector	Key Performances
Demonstration Environment	Establishment of testbed (4 types of equipment, Suseo) and meister robot utilization support center (Changwon), and development of a concept patent for the meister robotization system (Application No. 10-2021-0146202) and big data collection procedures
Technological support	Establishment of a corporate support system, such as meister data acquisition support track, meister robotization PoC support track, and MOU with the Korean Master Hand Association
Workforce training	Completion of the development of the meister robotization training curriculum and initial development of the Learning Management System (LMS)

☐ (Workforce training) Corporate hands-on workforce training through the operation of professional training courses for convergence between robotics and other industries and human-robot field collaboration

○ (Convergence with other industries) Training of 121 field-oriented professionals that can lead convergence between robotics and other industries through MA/Ph.D. degree programs at regional universities

* Nurturing professional workforce to lead robot-based innovations (2019–2023, KRW 19.5 billion in 2021)

○ (Human-robot collaboration) Operation of 3 specialized courses for the collaboration of workers and robots on the manufacturing site (human-machine interaction, collaborative manufacturing technology, industrial intelligence) and training of 41 professional workforce

* Training of professionals in AI robot-based human-machine collaboration technology (2021–2025, KRW 1.66 billion in 2021)

IV. Direction for 2022

◈ **Accelerating smart manufacturing and service** market growth through robot-based industrial innovations

◈ **Creating an environment that applies robotics** to **improve people's convenience and awareness**

◈ Building a foundation for **creating innovative fields** with new technologies and businesses

,1 Establishing the basis for the overall industrial adaptation of robots through the discovery and development of robotics application models

○ Further development of robotics application models in aviation, shipbuilding, and chemical industries with significant upstream and downstream association effects, and smartization throughout the manufacturing industry through disseminating the existing applications

○ Support for the discovery of new business models customized for contactless demands, such as serving, cooking, and education, and the expansion of robotic service models for resolving customer issues

○ Development and support of private-oriented financial support models such as robot-specific insurance, lease, rental, and refurb to increase the demand for robots in all directions

,2 Early popularization of robots through diversifying demonstrations

○ Demonstration of large-scale robotics convergence services with national recognition centered on close facilities for everyday life to help solve social problems, such as an aging society and low birthrate

○ More widespread distribution of lifestyle robots such as in-home healthcare robots and emotional companion robots for convenience of one-person households

,3 Fostering innovative growth fields through pre-emptive regulatory improvement and high-tech demonstrations

○ Continuous pre-emptive on-site regulatory improvement efforts through the step-by-step implementation of the regulatory innovation roadmap and creation of environments suitable for new product commercialization

○ Establishing a demonstration infrastructure and technological support system to promote the commercialization of high-value-added robot products that are converged with high-tech technologies such as 5G, AI, and big data

V. Action Plan for 2022

1 To increase the penetration of manufacturing robots in the 3 major manufacturing industries

[Demonstration of Manufacturing Robots for Early Distribution]

1 Development of standard process models		2 Early distribution		3 User training		4 Autonomous dissemination in the private sector
3 major fields + new fields such as shipping and aviation + improvement of existing models	→	Distribution and demonstration of standard models that have been developed	→	Robot user training before and after the introduction to current employees	→	Vitalization of finance, lease/rental support and demand networks

☐ (Development of standard process models) Development of standard process models and their dissemination system including the three existing manufacturing industries (ppuri, textiles, food and beverage) as well as flagship industries including aviation, shipbuilding, and biochemistry

ㅇ (Expansion to other industries) Consideration of the need and usability for introducing robots in the three existing manufacturing sectors, and expansion of standard model development in accordance with the acceleration of digital transformation in flagship industries

* Standard model development (ppuri, fiber, food and beverage) 63 models (2019–2021) → **25 models (2022)**
(aviation, shipbuilding, biochemistry) 20 models 2021) → **12 models (2022)**

ㅇ (DB management) Providing services through the DB management system for the dissemination of related technologies in the private sector, such as process manuals and videos of standard process models that have been developed

* Operation of an integrated DB management system (www.erobot.or.kr) since January 2022, which allows custom process search

☐ (Demonstration and distribution of manufacturing robots) Supporting packages that include consulting, early distribution, and user training, based on the developed standard process models and the demand of individual companies*

* Operation of the integrated briefing sessions and process model promotion halls to promote the performances of standard process models (October 2022)

ㅇ (Standard process model-associated) Demonstration and distribution of 220 manufacturing robots for ppuri, fiber, food and beverage and aviation, shipbuilding, and biochemical industries using existing standard process models

ㅇ (Support for individual companies) Support for the introduction of robots to strengthen the manufacturing competitiveness of small and medium-sized enterprises and reshoring companies with vulnerable digital bases (60 companies, MSS)

☐ (Employee training) Field practice-oriented training of professional workforce (operators, coordinators) for robot utilization using standard process models and robotics vocational training centers

○ (Standard model-associated) Development of training programs and teaching materials for 35 standard process models developed in 2021, step-by-step training* support for current employees at companies introducing robots

* (Before robot introduction) Introductory and basic course, (after robot introduction) Field practice and operational course

○ (Training Center) Construction of robotics vocational training center to be completed (Gumi, October 2022) where 400 professional workforce will be trained to utilize robots with training programs specializing in manufacturing robot operations

☐ (Dissemination in the private sector) Operation of financial services programs leveraging private financial support bases and promotion of robotics distribution and dissemination with a focus on the private sector

○ (Insurance) Identifying corporate demand and expanding support through insurance membership survey and promotion of robot insurance (deductions)

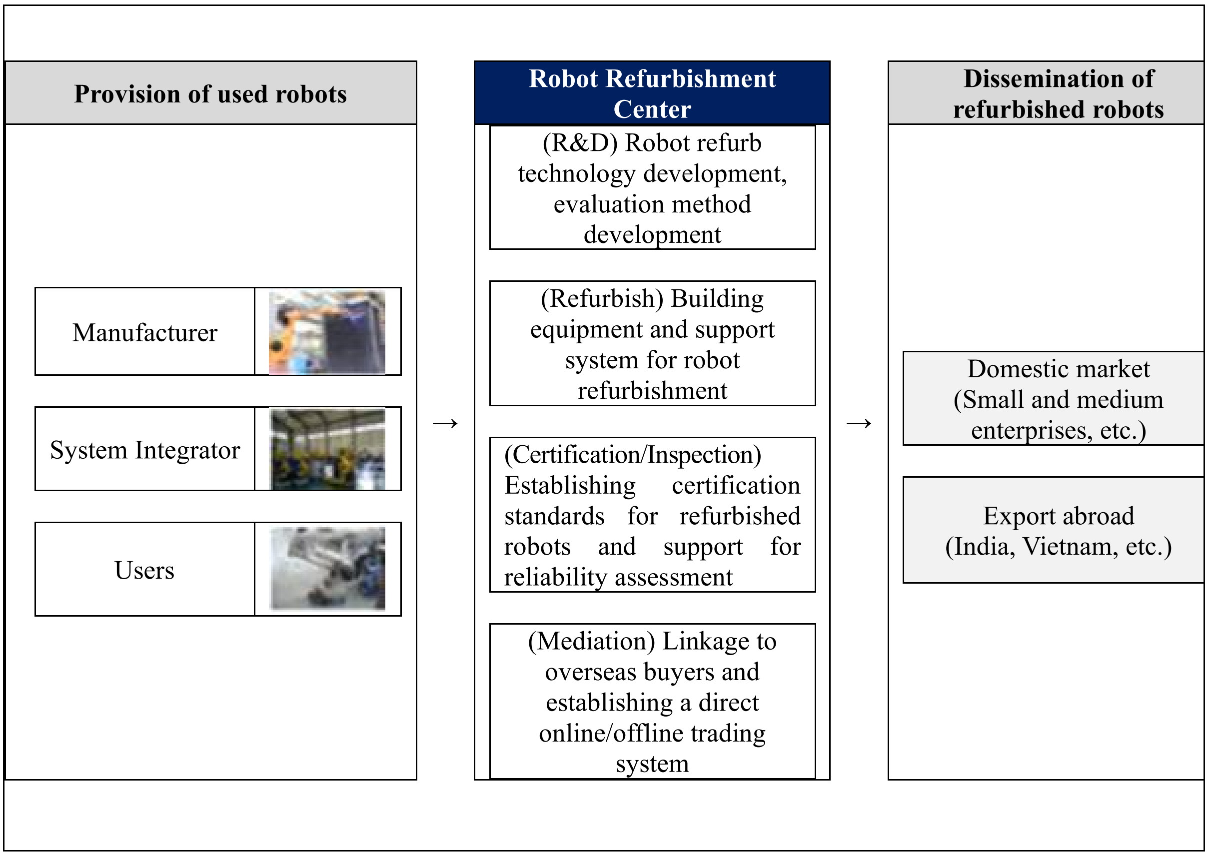
* Securing robot insurance references through PL insurance demonstration support to the (prospective) institutions implementing demonstration projects

○ (Loans) Issuance of guarantee through the agreement guarantee program (guarantee rate 95%, preferential support for guarantee fees) and preferential support for loan interest rates at 7 major banks

○ (Purchase support) Operation of customized robot finance programs* for industries with the need to expand the market and additional support for joint purchases

* Support for the discovery and utilization of products such as manufacturing robot lease, rental, and subscription, and support for establishing cooperative systems for industries with the need (consultative group between manufacturing and rental companies, MOU between rental and finance companies/manufacturing and capital companies)

○ (Robot Refurbishing Center) Establishment of a refurb center for re-manufacturing used (old) robots to promote the dissemination of refurbished robots in Korea (KRW 1.5 billion in 2022)


Provision of used robots
Manufacturer
System Integrator
Users
→
Robot Refurbishment Center
(R&D) Robot refurb technology development, evaluation method development
(Refurbish) Building equipment and support system for robot refurbishment
(Certification/Inspection) Establishing certification standards for refurbished robots and support for reliability assessment
(Mediation) Linkage to overseas buyers and establishing a direct online/offline trading system
→
Dissemination of refurbished robots
Domestic market (Small and medium enterprises, etc.)
Export abroad (India, Vietnam, etc.)

2 To develop 4 major types of service robots intensively

☐ (Technology development) Promotion of technology development focused on solving social problems such as the lack of caregiving professionals and the arrival of a contactless society due to prolonged infectious disease conditions

○ New development of HRI (human-robot interaction)-based companion robots for the aging society, increased single-person households, and integrated control of multiple outdoor delivery robots

[Key Projects for Technology Development in 2022]

Sector	Overview	2022 budget
Caregiving	Development of a human-following semi-autonomous robotic bed for the isolation of infected patients	KRW 1 billion
	Development of nursing assistance and patient monitoring robotic systems for infection isolation wards	KRW 1.2 billion
	Development of caregiving robots for isolation treatment facilities (MOIS)	KRW 1.3 billion
	Translational research for caregiving robots and development of service models (MOHW)	KRW 3 billion
	(New) Development of a companion robot that can communicate emotionally through physical and cognitive interaction between humans and robots	KRW 1.4 billion
Wearables	Development of soft sensor-embedded fabric-based actuators and garment-type robotic technology	KRW 700 million
	(New) Wearable walking aid robot for everyday use for healthcare at home	KRW 1.2 billion
Medical	Development of an artificial intelligence-based robotic system for spinal hard tissue surgeries	KRW 1.6 billion
	Development of surgical assistant robots for general operations	KRW 1.2 billion
	Development of a lightweight wearable rehabilitation robot for self-rehabilitation of arms	KRW 1.5 billion
	Development of pandemic response robots and ICT convergence-based disease prevention and control system (MSIT)	KRW 6.1 billion
	Development of technology for commercialization of micro-medical robots (MOHW)	KRW 10.1 billion
	Translational research for rehabilitation robots (MOHW)	KRW 4.5 billion
Logistics	Development of parking robots that provide parking convenience and improve spatial efficiency	KRW 1.4 billion
	Development of robotic systems for autonomous elevator operations and indoor deliveries	KRW 1.2 billion
	Development of robot-enabled unloading system for trunk cargo transport vehicles	KRW 1.6 billion
	Development of technology for a robot-based cargo loading system	KRW 600 million
	Development of mobile logistics handling robotic technology to streamline operations at Korean-style logistics warehouses	KRW 4 billion
	Development of goods management robots that autonomously identify and manage inventory of goods in retail stores	KRW 1 billion
	(New) Development of collaborative autonomous planning technology to control multiple outdoor terminal delivery robots in an integrated manner	KRW 800 million
	(New) Development of service robot technology for post-meal empty dish collection	KRW 1.4 billion
Integrated	Development of field-applied robotic systems for implementing business	KRW 3 billion

Sector	Overview	2022 budget
	models for robotics services	
	(New) Development of AI convergence service robot system to improve user convenience and efficiency	KRW 1 billion

☐ (Demonstration and distribution) Through demand-based customized demonstration projects and large-scale demonstration projects of service robots, the creation of a nationally recognized market that helps solve social problems

○ (By sector) 1,449 units of service robots will be demonstrated and distributed, centered in the promising robotics fields.

① **(Caregiving robots)** Distribution of 1,200 rehabilitation, companion, and dementia prevention robots by forming a consortium between local autonomous governments and companies

② **(Wearable robots)** Distribution of 100 wearable robots in public and private sectors

③ **(Medical robots)** Distribution of 15 units through the designation of a robotic rehabilitation center and demonstration of rehabilitation robot costs

④ **(Logistics robots)** Support for the introduction of 200 indoor and outdoor logistics and transport robots in the public and private sectors

⑤ **(Other)** Support for the introduction of 85 contactless services and collaborative robots in the service field

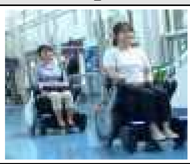
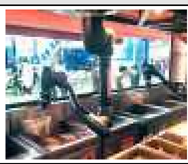
○ (Demand-based development and distribution) Support for custom robot modification and improvement of developed service robot application models (Step 2) and discovery of demand-based new models (Step 1) (KRW 7.2 billion in 2022)

* (Step 1) Planning BM → **(Step 2) Renovation, improvement, and verification**→ (Step 3) Demonstration and distribution

○ (Demonstration of large-scale robot convergence models) Based on the integrated control service, pursuing solutions for social issues and national recognition through demonstration of numerous and multiple kinds of robots

* **(Social problem solving)** Collaboration between ministries **(national recognition)**, Private sector bases (airports, hospitals, restaurants, etc.)

[Examples of Large-scale Convergence Demonstration]

Social problem-solving			National recognition		
					
Farming support (MAFRA)	Support for the transportation vulnerable (MPVA)	Improvement in military life (i.e. Cooking) (MND)	Airports (Mobility support)	Hospitals (Specimen transport)	Restaurants (Cleaning)

☐ (Regulatory improvement) Redesign of the Robotics Industry Regulation Roadmap (Roadmap 2.0) and promote pre-emptive research on robot utilization issues through the Robot Regulation Innovation Forum

○ (Regulatory innovation projects) Implementing the roadmap by verifying safety and effectiveness in conjunction with existing demonstration and distribution projects while revising the “Intelligent Robot Act” to allow autonomous driving robots to travel on the sidewalk

* Consulting and demonstration of regulatory innovation issues in cooperation with the Korea Chamber of

Commerce and Industry and KIAT

○ (Researching issues) Research on securing DB for the current status of robot utilization and creating a pre-emptive environment necessary for the dissemination of robots

* Research on “Robot Census” (tentative name), research on the revision of the Robot Act, and plans to provide vocational training according to the introduction of robots

☐ (10 niche market-type technology development) Technology development that responds to social issues and reflects the demand of individual ministries from the field

[Each Ministry's Major Projects in 2022]

Ministry	Overview	2022 budget
MOTIE	(New) Development of remote inspection robot system for cableway facilities (wire rope and pulley devices)	KRW 1 billion
	(New) Development of human-robot collaboration technology for dismantling various EV waste battery packs	KRW 1.1 billion
	(New) Safety robotic technology that can be detected and responded wirelessly in small spaces	KRW 1.2 billion
MAFRA	Development of intelligent farming robots for smart greenhouses	KRW 2.1 billion
	Development of robots for harvesting horticultural crops based on the collaboration of multiple robots	KRW 1 billion
RDA	Hydroponic cultivation, monitoring of fruit growth, excess fruit thinning, and harvesting robot technology	KRW 1.6 billion
	Development of intelligent weeder for apple orchards	KRW 200 million
	Research on the application of robot safety technology for agricultural robot development	KRW 100 million
	Fruit enlargement and harvester diagnosis technology for labor-reducing mechanical harvest	KRW 100 million
DAPA	Development of complex signal-based human body-machine high-speed synchronization control technology	KRW 1.6 billion
	(New) Development of autonomous planning technology for multi-robot collaboration	KRW 200 million
NPA	Development of gas molecule identification technology that can respond to harmful factors	KRW 500 million
NFA	Development of efficient response technology for hazardous gases at chemical terrorism sites	KRW 1.7 billion
MOF	Field demonstration and commercialization of underwater construction robots	KRW 2.8 billion
MOE	Development of contactless collection and treatment technology for medical waste	KRW 7.6 billion

□ (Export support) Online and offline support accommodating export destinations and assistance for acquiring international standard certifications required by the target country

○ (Customized export support by country) Support for the distribution and dissemination of Korean robots through matching between domestic robot companies and overseas demand for promising markets abroad (ASEAN, Middle East, etc.)

○ (Online and offline export support) Establishment of online-offline support system, including export consultation conferences, local export marketing services (continued promotion at KRC in China), etc.

○ (Testing and Certification support) Acquisition of the global certification institution (CSA, Canada Standards Association) as the designated certification agency and renewal of qualification as an international accredited test institution (KOLAS)

3 To strengthen the foundations of the robotics industry's ecosystem

☐ (Technology development) Technology development, performance evaluation, and certification of 3 core parts and 4 software

[Key Projects for Technology Development Launched in 2022]

Sector	Project name	2022 budget
Smart Gripper	Development of autonomous operation and object grasping technology using imitation learning technology based on the tactile sensing end effector	KRW 900 million
	Gripper system technology for various production processes, including unspecified objects of various shapes, weights, and strengths	KRW 800 million
	Development of a flexible tactile sensor system that accommodates the curves of the hand and gripper of the robot	KRW 900 million
Robotic SW platform	Development of mobile intelligence SW for autonomous movement of walking robots in dynamic and atypical environments	KRW 800 million

☐ (Infrastructure) Promotion of innovative technology development and support for the establishment of a safe utilization environment

○ (Parts performance evaluation) Establishment of performance evaluation and certification support system for sophisticated and reliable convergence parts (2020–2023, KRW 2.184 billion in 2022)

[Key Plans in Performance Evaluation and Building Certification Support for Next-Generation Convergence Parts]

Sector	Key Plan
Evaluation Infrastructure	• Creating 6 types of equipment in addition to an injury assessment system for user safety evaluation of smart grippers
Boost for commercialization	• Support for commercializing robotic parts (5), support for prototype production (5), and certification support for robotic parts companies (10)
Standard registration for robotic parts	• Establishing KOROS standard for autonomous driving sensors and intelligent controllers for robots

○ (Safety certification) Establishing the basis for an international standard for collaborative robot safety certification to ensure their safety (2021–2025, KRW 2 billion in 2022)

* Demonstration environment (equipment and facility construction), safety certification system (collaborative robot product certification, KOLAS test certification), establishing certification bodies, and technology dissemination (developing international certification test systems and technical consulting)

○ (Robo-Tube) Full-scale support for technological cooperation with companies, universities, and research institutions centered on the R&BD process to expand the value chain of the robotics industry and establish a win-win system

* (Robo-Tube technological support) Product planning, design, prototype production, test/evaluation, technological consulting, etc.

☐ (Demonstration and demand-associated) Support for reliability verification of domestic core parts and field demonstration of finished robots equipped with domestic parts (KRW 1.2 billion in 2022)

○ Reception of difficulties in the field to promote the participation of companies with the need in the demonstration of domestic parts; diversification of support methods for demonstration models

☐ (Cross-industry convergence) Support for the development of core convergence technologies to overcome the limitations of robotics

○ (Artificial intelligence) Support for establishing demonstration testbed and application of industrial site operation technology to implement simple and complex processes with collaborative intelligence and intelligent testing processes

* Support project for collaborative intelligence-based Robot Plus competitiveness (2020–2024, KRW 4.53 billion in 2022)

[Key Details of Intelligent Machinery Project (Collaborative Intelligence-based Robot Plus)]

Sector	Details
Demonstration Infrastructure	• Building testbeds for collaborative intelligence-based inspection processes └ Establishing 5 types of equipment, such as AI robot service platform and 3D shape reconstruction SW
Technological support	• Distribution of collaborative intelligence SDK (Software Development Kit) packaging based on testing process testbed and collaborative intelligence operation technology

○ (Big data) Sophistication of equipment for acquiring metal processing data and establishing robotic demonstration testbeds using big data in the electrical and electronic industry

* Project to establish meister robotization infrastructure using big data (2021–2025, KRW 8.6 billion in 2022)

[Key Details for the Establishment of Foundation for Meister Robotization]

Sector	Details
Demonstration Environment	• Sophistication of equipment for acquiring metal processing data and establishing robotic demonstration testbeds using big data in the electrical and electronic industry
Technological support	• Development of meister robot performance evaluation method using big data • Solution packaging and use case-based business support
Workforce training	• Big data-enabled meister robotization training and development and operation of training programs for the metal processing industry

○ (5G) Technology demonstration, support for commercialization of technologies, and technology dissemination through establishing the demonstration base for advanced 5G manufacturing robots* (2021–2023, KRW 8 billion in 2022)

* Collaborative robotic systems, autonomous mobile robots (AMR), and mobile manipulator systems that coexist and cooperate with humans in an advanced 5G-based manufacturing environment

[Key Details on Establishing the Demonstration Base for Advanced 5G Manufacturing Robots]

Sector	Details
Establishing the demonstration support center	• Establishing open, collaborative demonstration test facilities and corporate support systems through the construction of various virtual environments and real simulation manufacturing environments similar to real environments
Demonstration of advanced 5G manufacturing robots	• Integrated support for advanced 5G-based manufacturing robot demonstration test and certification through 5G wireless communication verification, robotic SW reliability verification, and product and system certification test for advanced manufacturing robots
Support for companies commercializing their technologies	• Planning and operation of step-by-step corporate support projects to assist and promote companies related to advanced 5G-based manufacturing robots (suppliers, SI companies, buyers) and accelerate the commercialization of such technologies

Technology dissemination	• Establishment of an international certification test and certification system for robotic performance, safety and SW reliability verification, and development and dissemination of safety guidelines for standard process models based on the demonstration environment

○ (Cloud) Securing complex cloud-based artificial intelligence robotic technologies and providing personalized services by plugging-in robot intelligence and artificial general intelligence (MSIT)

* Development of complex cloud-based artificial intelligence robotic technologies (2020–2023, KRW 7.3 billion in 2022)

☐ (Workforce training) Offering professional training programs centered on cross-industrial convergence and human-robot collaboration to train an innovative workforce suitable for field practices

○ (Training of professional workforce leading robot-based innovations) Support for employment-associated activities of robot-based professional workforce and eliminating the gap in the supply and demand of professionals through strengthening employment competitiveness

* Nurturing professional workforce to lead robot-based innovations (2019–2023, KRW 1.95 billion in 2022, 108 professionals)

○ (Human-robot collaboration) Offering degree programs to nurture a professional workforce capable of applying high-demand AI technology such as high value-added intelligent robot-based SI 2.0

* Training of professional workforce in AI robot-based human-machine collaboration technology (2021–2025, KRW 1.66 billion in 2022, 72 professionals)

VI. List of Projects

Project		Ministry in charge	Budget (KRW 100 million)	
			2021	2022
□,1 **To increase the penetration of manufacturing robots in the 3 major manufacturing industries**				
	1-1. Develop 108 robot utilization models for each industry and process in advance	MOTIE, MSS	109	150
	1-2. Provide consulting and demonstration to 10 enterprises for each standard model	MOTIE, MSS	407	407
	1-3. Provide training on using robots for employees centered on companies that support the introduction of manufacturing robots	MOTIE, MEL	32	32
	1-4. Induce autonomous dissemination in the private sector through purchase support for rental/lease services	MOTIE	1	16
	1-5. Convert a government-led subsidy policy to a private-oriented financing model	MOTIE		
	1-6. Host briefing sessions and vitalize networks to spread demand-driven robot dissemination	MOTIE		
□,2 **To develop 4 major types of service robots intensively**				
	2-1. Support 10 niche market-type technology development and distribution	MOTIE, NPA, MAFRA, RDA, DAPA, NFA, KCG, MOF, MOIS, MOE	319	368
	2-2. Develop robots in 4 major areas → Distribute and demonstrate robots to the underprivileged → Spread them to the private sector	MOTIE, MSIT, MOHW, MOIS	738	915
	2-3. Create new markets in Korea and abroad by easing regulatory restrictions and supporting package-type overseas expansion	MOTIE	14	14
□,3 **To strengthen the foundations of the robotics industry's ecosystem**				
	3-1. Promote self-sufficiency in the next-generation core parts/software and parts demonstration	MOTIE	152	192
	3-2. Expand infrastructure for the penetration of robot convergence technology	MOTIE, MSIT	398	310
	3-3. Nurture professional workforce in the robotics field	MOTIE	36	36
Total			**2,206**	**2,440**

References Each Ministry's Plan for 2022

Ministry of Science and ICT

☐,1 **Development of pandemic response robots and ICT convergence-based disease prevention and control system**

1. Background and Purpose

☐ Development of robot-based support technology for the national living environment that reduces the burden on the medical system and contributes to the efficient prevention of diseases and their diffusion

ㅇ Establishing an efficient response system that minimizes human input by strengthening capacity for everyday disease prevention and control using robotics and ICT technology

[Project Overview]

① Support area: Establishing an efficient infectious disease response support system for everyday disease prevention and control (infection prevention, disinfection, automatic diagnosis and service support, etc.) through the use of convergence technology to minimize human input

② Support target: Industrial, academic, and institutional researchers

③ Support period: 2020–2024, KRW 18.1 billion total

④ Support details: Intensive medical field management with the convergence of robotics and ICT technology, support for residential treatment centers, development and field demonstration of convergence solutions necessary for the expansion of everyday disease prevention and control at all times

* To achieve the technological level applicable to hospitals and multi-use facilities with innovative and progressive qualities

* Demonstrated by using "everyday life quarantine sites" such as hospitals and multi-use facilities (collaborative effort with MHW)

2. 2021 Performance

☐ Establishment of new concept on disease prevention and control system and development of system sample for each infectious disease response site

ㅇ (Intensive medical field) Establishing scenarios for disease prevention and control support using robotic ICT technology (automatic contactless sampling, remote operation of treatment equipment, tracking of confirmed cases), certification consulting for demonstration, and development of samples

ㅇ (Residential treatment centers) Establishment of real-world use scenario including procedures for on-site use and contactless goods transport services based on evident implementation effects, development of robot elementary technology and samples

ㅇ (Residential spaces) Materialization of disease prevention and control guidelines based on the requirements of medical institutions and experts and development of samples based on them

☐ Establishment of information and technology cooperation system between selected research groups, planning and establishing a full-cycle performance management system to increase and disseminate application of R&D results

○ Introduction of milestone inspection system and promotion of field inspection accommodating the timing of major project performance output

○ In response to changes in the research environment, enhancing the quality of the outcome, expanding the scope of demonstration, and support for global standardization

3. Evaluation of 2021 and Next Direction

☐ Improvement of research projects' key performances and focused promotion of their dissemination and utilization

○ Enhancement of the performance quality considering the actual user applications

○ Expansion of demonstration scope for application to disease prevention and control sites and strengthening demonstration cooperation

○ Comprehensive capacity building of public-private cooperation for the outcome's global-level standardization as Korean-style disease prevention and control, including certification, review for standardization, management, and support

4. Action Plan for 2022

☐ Support for system sophistication, certification, and standardization for the demonstration of convergence disease prevention and control solutions

○ (Intensive medical field) Integration and enhanced performance of system sample with improved safety, acceptability, and accuracy for applications on the site

○ (Residential treatment center) Segmentation of system operation method and specifications considering the effect and practicality of replacing workers on the site

○ (Residential spaces) Materialization of disease prevention and control scenarios using robotic solutions and certified verification and evaluation of objectives

5. Project Schedule

Detailed project	Project Details (2022)	2019	2020	2021	2022				2023
					1Q	2Q	3Q	4Q	
Development of robotics and ICT convergence-based disease prevention and control system for pandemic response	Operation and management of disease prevention and control system development								
	Research on the disease prevention and control system in the intensive medical field								
	Research on the disease prevention and control system at residential treatment centers								
	Research on disease prevention and control systems in residential spaces								

6. Budget

Details		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Innovative Challenge demonstration project (Development of robotics and ICT convergence-based disease prevention and control system for	Central government	-	24.5	38.75	61	41	165.25
	Private sector	-	-	-	-	-	-

pandemic response)	Subtotal	-	24.5	38.75	61	41	165.25

7. Project organization

☐ Full-cycle management of the projects by the disease prevention and control robot project group and management of the overall project through the National Research Foundation of Korea

☐,2 Technology development of intelligent information-robotics convergence services and complex cloud-based artificial intelligence robotic technologies

1. Background and Purpose

☐ Intelligent information and robotics convergence services

○ Implementation of intelligent information society and expansion of new future growth engines by securing technical competitiveness for applying intelligent information technology to robots, ICT devices, etc.

☐ Development of complex cloud-based artificial intelligence robotic technologies

○ Development of complex cloud-based core artificial intelligence robotic technology that utilizes the real-time and hyper-connected properties of 5G to remotely control multiple robots and advances intelligence through lifelong learning

2. 2021 Performance

☐ Intelligent information and robotics convergence services

○ Continued development of artificial intelligence technologies necessary for caregiving robots, unmanned security robots, robotic hand operation, and goods assembly robots

○ Driving test of "autonomous mobile robots" on actual sidewalks through special regulatory demonstration cases (near COEX, Gangnam-gu)

☐ Development of complex cloud-based artificial intelligence robotic technologies

○ Development of AI brain technology that can connect and control robots on cloud platforms and learn real-time data produced by multiple robots

○ Utilization by plugging in robotic intelligence under development*(tactile intelligence, spatial intelligence, social intelligence, etc.) and general-purpose artificial intelligence**(linguistic intelligence, visual intelligence, auditory intelligence)

* Technology development project for ICT convergence industry source technology (intelligent information and robotics convergence services)

** Growth engine projects for AI innovation (exobrain, DeepView, voice recognition, etc.)

3. Evaluation of 2021 and Next Direction

☐ Intelligent information and robotics convergence services

○ Securing source technology and creating new convergence services through the continuous development of AI and robot convergence technologies

○ Introducing R&D methodologies that take on challenges in an effort to expand and strengthen the scope of AI and robot-related technologies through enterprising technological development and competing in good faith

☐ Development of complex cloud-based artificial intelligence robotic technologies

○ By allowing full use of advanced artificial intelligence in robotics to improve the technological competitiveness of artificial intelligence, establishing the foundation for convergence and dissemination in promising artificial intelligence-based industries

○ Securing complex cloud-based artificial intelligence robotic technologies based on data collection and analysis from various robots and providing personalized services

4. Action Plan for 2022

☐ Intelligent information and robotics convergence services

○ Continued implementation of continuing project (1 project, KRW 2 billion) and final evaluation for completed projects

☐ Development of complex cloud-based artificial intelligence robotic technologies

○ Continuing projects and mid-term inspections for 3 projects (3 projects in 2022, total KRW 7.3 billion)

5. Project Schedule

Detailed project	Project Details (2022)	2019	2020	2021	2022				2023
					1Q	2Q	3Q	4Q	
Technology development of ICT convergence industrial innovation (Intelligent information and robotics convergence services)	Project implementation								
	Final evaluation of the completed projects								
	Mid-term inspection of continuing projects								
Development of complex cloud-based artificial intelligence robotic technologies	Project implementation								
	Final evaluation of the completed projects								
	Mid-term inspection of continuing projects								

6. Budget

Details		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Technology development of ICT convergence industrial innovation (Intelligent information and robotics convergence services)	Central 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 complex cloud-based artificial intelligence robotic technologies	Central 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 organization

☐ Full-cycle management of project planning, announcement, evaluation, and performance through the Institute for Information & Communication Technology Planning and Evaluation (IITP)

Ministry of Agriculture, Food and Rural Affairs

1. Background and Purpose

☐ Development of intelligent robots for field farming

○ Development, commercialization, and practical application of intelligent platforms (farmbots) capable of farm work centered around field farming

☐ Development of intelligent farming robots for smart greenhouses

○ Development of agricultural robots and operating platforms that can transform farm work such as transplanting, planting, overgrown leaf removal, and cleaning into unmanned activities in smart greenhouses

☐ Development of robots for harvesting horticultural crops based on the collaboration of multiple robots

○ Development of multi-robot collaboration-based harvesting robots for efficient harvesting of horticultural crops

☐ Formation of an advanced demonstration complex for unmanned and automated agricultural production

○ Formation of a demonstration complex for agricultural production systems using advanced agricultural machineries such as unmanned autonomous tractors, agricultural drones, and agricultural robots

2. 2021 Performance

☐ Development of intelligent robots for field farming

○ Performance verification and stabilization through testbed and real-world applications

○ Sophistication of platform technology (HW/SW, driving control technology, cognition/planning technology)

○ Completion of model development for commercialization and field demonstration evaluation

○ Support for optimization and lightweight and high-strength transformation of 5 types of work modules

☐ Development of intelligent farming robots for smart greenhouses

○ Development of an electrically powered platform suitable for operation in new and existing greenhouse environments

○ Production of transplanting/planting manipulator end effectors, configuration of the control system, and implementation of the synced robotic platform

○ Development of proper leaf management algorithm for crops based on growth data

○ Conceptual design of cleaning module systems mounted on autonomous mobile platforms and their mechanism

○ Building autonomous driving simulations for greenhouses, including obstacle avoidance and rail docking

☐ Development of robots for harvesting horticultural crops based on the collaboration of multiple robots

○ Development of multiple robot collaboration systems for harvesting and transport

○ Development of AI mobile-manipulator for harvesting horticultural crops

○ Activity monitoring and development of multiple robot operation systems

○ Remote work management system

☐ Formation of an advanced demonstration complex for unmanned and automated agricultural production

○ Completion of working design, zoning construction for the demonstration complex area (50ha), and establishment of unmanned automated agricultural production control system platform

3. Evaluation of 2021 and Next Direction

○ Selection and stage evaluation of new projects (development of intelligent agricultural robots for smart greenhouses, development of robots for harvesting horticultural crops based on multiple robot collaboration) (December 2022)

○ Continued support for continuing projects (development of intelligent robots for field farming) (May 2022) and final evaluation

○ Completion of basic and working designs of advanced unmanned automated agricultural production demonstration complex, formation of demonstration complex, and establishment of farm work system

4. Action Plan for 2022

☐ Development of intelligent robots for field farming

○ Final evaluation at the end of research (May 2022)

☐ Development of intelligent farming robots for smart greenhouses

○ Development of data communication modules and sub-level control systems for electrically powered platforms

○ Development of manipulation algorithms for robot implantation and demonstration of work sites

○ Protocol design for manipulator interface to remove overgrown leaves

○ Production of overgrown leaf removal and cleaning mechanisms for the autonomous mobile platform in smart greenhouses

○ Development of farm work automation and control system, synchronization of robots for each module

☐ Development of robots for harvesting horticultural crops based on the collaboration of multiple robots

○ On-site application of harvesting and loading-unloading robot and autonomous transport robot

○ Sophistication of harvesting and transport robots and testing of multiple robot monitoring systems

○ Acquiring time series data and building a database for crop recognition

○ Technology development of two-dimensional location information synchronization for harvesting controlled horticultural crops

☐ Formation of an advanced demonstration complex for unmanned and automated agricultural production

○ Construction completed for demonstration complex, including zoning

○ Establishment of unmanned and automated farm work system (introduction of unmanned agricultural machinery, automatic pipe drainage system, establishment of unmanned control system platform for agricultural production)

○ Construction of automated nursery and control centers

5. Project Schedule

Detailed project	Project Details (2021)	2019	2020	2021	2022				2023
					1Q	2Q	3Q	4Q	
Development of intelligent robots for field farming	Performance verification and stabilization through testbed and real-world applications								
	Sophistication of platform technology								
	Completion of model development for commercialization and field demonstration evaluation								
	Support for optimization and lightweight and high-strength transformation of 5 types of work modules								
Development of intelligent farming robots for smart greenhouses	Development of data communication modules and sub-level control systems for electrically powered platforms								
	Development of manipulation algorithms for robot implantation and demonstration of work sites								
	Protocol design for manipulator interface to remove overgrown leaves								
	Production of overgrown leaf removal and cleaning mechanisms for the autonomous mobile platform in smart greenhouses								
	Development of farm work automation and control system, synchronization of robots for each module								
Development of robots for harvesting horticultural crops based on collaboration of multiple robots	Development of multiple robot collaboration systems for harvesting and transport								
	Development of AI mobile-manipulator for harvesting horticultural crops								
	Activity monitoring and development of multiple robot operation systems								
	Technology development and functional improvement for field-applied study								
Agricultural production through advanced unmanned automation Creation of demonstration complex	Basic and working designs								
	Formation of model complex, including zoning process								
	Establishment of unmanned automated agricultural work system								
	Construction of automated nurseries and control centers								

6. Budget

Details		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Development of intelligent robots for field farming	Central 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 intelligent farming robots for smart greenhouses	Central 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 robots for harvesting horticultural crops based on the collaboration of multiple robots	Central government	-	-	7.5	10.0	-	17.5
	Private sector	-	-	0.7	1.0	-	1.7
	Subtotal	-	-	8.2	11	-	19.2
Formation of an advanced demonstration complex for unmanned and automated agricultural production	Central government	-	6	44	75	75	200
	Local autonomous government	-	6	44	75	75	200
	Subtotal	-	12	88	150	150	400

7. Project organization

Classification	Roles for each ministry	
Development of robots for field farming, smart greenhouses, and harvesting	MAFRA	(Supervision) General responsibility and key policy decisions of the project, such as project planning, operation, and performance evaluation
	IPET	(Leading institution) General planning, budget execution, research group management, call for project, and agreement conclusion
Formation of an advanced demonstration complex for unmanned and automated agricultural production	MAFRA	(Supervision) Plan for forming an advanced demonstration complex for unmanned and automated agricultural production, preparation of project implementation guidelines, detailed implementation by year, planning and project promotion, operation and performance analysis
	Jeollanam-do	(Implementing institution) Implementation of the project promotion, budget execution, and progress inspection

IFR International Federation of Robotics

Ministry of Health and Welfare

□,1 Translational research for caregiving robots and development of service models

1. Background and Purpose

○ Improving quality of life through residential support for the severely disabled and the elderly with mobility impairment

- Development of integrated solution technologies and services using robots for care-related problems that could not be solved by conventional devices (technology development, translational research, field demonstration, and system improvement)

2. 2021 Performance

○ Since 2019, 4 continuing projects have been conducted on service models, safety, and data technology for the severely disabled and the elderly with mobility impairment

○ Since 2020, 4 continuing projects have been conducted for caregiving robots assisting transport, bedsores and posture change, elimination, and eating.

○ Since 2021, 1 new project has been conducted for analysis of the caregiving burden and the social value of caregiving robots

○ Establishment and operation of caregiving robot network forum and smart caregiving spaces to lay the foundations for demand-based research

3. Evaluation of 2021 and Next Direction

○ Continued support for 8 continuing projects and completed promotion of 1 new project (project completed in 2022)

4. Action Plan for 2022

○ Continued support for 9 continuing projects (project completed in 2022)

5. Project Schedule

Detailed project	Project Details (2022)	2019	2020	2021	2022				2023
					1Q	2Q	3Q	4Q	
Translational research for caregiving robots and development of service models	Continued support and research for continuing R&D projects								
	End of study and evaluation								

6. Budget

Details		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Translational research for caregiving robots and development of service	Central government	13	22	29	30	-	94

Details		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
models	Private sector						
	Subtotal	12	22	29	30	-	94

7. Project organization

Classification	Roles for each ministry	
Translational research for caregiving robots and development of service models	MOHW	(General management) General management of the project, such as annual budget planning (draft)
	Korea Health Industry Development Institute	(Leading institution) Project operation, including evaluation and management
	National Rehabilitation Center and other research institutes	(Implementation) Implementation of the project

☐,2 Technology development of micro-medical robots for practical application

1. Background and Purpose

○ Support for the development of common utilization technologies and commercialization of micro-medical robots for actual applications in hospitals

2. 2021 Performance

○ Project conducted since 2019, a total of 6 detailed projects are being carried out

	Project name	Period	Agent
1	Basic and common technology development center for commercialization of medical microrobots	2019–2022	Korea Institute of Medical Microrobotics
2	Development of Guidewire products and systems based on medical microrobots for peripheral vascular intervention	2019–2022	Seoul National University Bundang Hospital
3	Development of near-infrared fluorescence-induced integrated panoramic endoscopes, cancer cell-specific nanorobots, and microrobots for injection to improve the diagnostic accuracy of laparoscopic lymphadenectomy for uterine cancer	2019–2022	Seoul National University Hospital
4	Development of micro 3D wireless endoscopes and artificial intelligence reading system with magnetic field-based active driving	2019–2022	Industry-Academic Cooperation Foundation at Dongguk University
5	Development of capsule endoscope robots for upper gastrointestinal tract examination	2019–2022	Woo Young Medical Co., Ltd.
6	Development of micro-medical robot system and approval of exploratory clinical trials for the treatment of obstructive vascular diseases, prevention of embolism	2019–2022	Industry-University-Research Cooperation Foundation at Hanyang University

3. Evaluation of 2021 and Next Direction

○ Continued support of existing selected R&D projects (6 projects) (project completed in 2022)

4. Action Plan for 2022

○ Continued support and completion of existing selected R&D projects (6 projects)

5. Project Schedule

Detailed project	Project Details (2022)	2019	2020	2021	2022 1Q	2022 2Q	2022 3Q	2022 4Q	2023
Technology development of micro-medical robots for practical application	Support for continuing projects	■	■	■	■	■	■	■	
	Final evaluation of the completed projects								■

6. Budget

Details		Budget (KRW 100 million) 2019	2020	2021	2022	2023	Total
Technology development of micro-medical robots for practical application	Central government	76	87	101	101	-	365
	Private sector	-	-	-	-	-	-
	Subtotal	76	87	101	101	-	365

7. Project organization

Classification	Roles for each ministry	
Technology development of micro-medical robots for practical application	MOHW	(General management) General management of the project, such as annual budget planning (draft)
	Korea Health Industry Development Institute	(Leading institution) Planning, evaluation and management of projects, application of results
	Industries, universities, research institutions, hospitals	(Implementation) Implementation of the project

☐,3 Translational research on rehabilitation robots

1. Background and Purpose

○ Support for the development of rehabilitation research and nurturing of the rehabilitation aid industry to improve the quality of life of disabled and socially vulnerable people, promoting their social recovery

- Rehabilitation robot-oriented translational research that links research results of robot-related source technology with clinical research centered on the rehabilitation robot-specialized infrastructure of the National Rehabilitation Center (the largest rehabilitation hospital in Korea with a 300-bed capacity, a rehabilitation institute, and experience in rehabilitation robot operation)

2. 2021 Performance

○ Between 2013 and 2021, a total of 26 projects were conducted. 4 medical device licenses, 1 technology transfer, 12 patent registrations, and 13 SCI(E)-level publications were accomplished in 2021.

* (Cumulative) Between 2013 and 2021, 21 medical device licenses, 8 technology transfers, 88 patent registrations, and 63 SCI(E)-level publications were accomplished.

3. Evaluation of 2021 and Next Direction

○ Continued support for existing projects and launched 28 new projects

4. Action Plan for 2022

○ Undertaking 22 translational research services for rehabilitation robots and 6 internal translational research projects on rehabilitation robots in 2022

- (Basic direction) Undertaking intensive research to develop and disseminate advanced convergence medical devices based on high-sensitivity robot technology, such as rehabilitation robots

① Safety testing and inspection for licensing medical devices
② Translational research on rehabilitation robots with measurement, evaluation, analysis, and feedback
③ Pediatric rehabilitation robots
④ Multi-agency translational research to secure clinical grounds for improving the system, such as proper pricing
⑤ Translational research on wearable robots in conjunction with clinical research

○ (Expansion) Expansion of rehabilitation robot research with sophisticated technology

① High-tech convergence translational research on rehabilitation robots, including fNIRS imaging for body/cognitive interaction
② Translational research on rehabilitation robots combining augmented/virtual reality technologies and learning theory
③ AI-based pediatric rehabilitation robot capable of providing stimulus feedback
④ Rehabilitation robots capable of intent analysis using biological signals
⑤ Rehabilitation robots for home use, etc.

5. Project Schedule

Detailed project	Project Details (2022)	2019	2020	2021	2022				2023
					1Q	2Q	3Q	4Q	
Translational research on rehabilitation robots	Selection of R&D project implementing institutions				■				
	Conducting R&D research projects				■	■	■	■	
	End of study and evaluation (annual and final evaluation)							■	

6. Budget

Details		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Translational research on rehabilitation robots (Continued project)	Central government	36	37	37	45	Undetermined	Undetermined
	Private sector	-	-	-	-	-	-
	Subtotal	36	37	37	45	Undetermined	Undetermined

7. Project organization

Classification	Roles for each ministry	
Translational research on rehabilitation robots	National Rehabilitation Center under MOHW	(General management) General management of the project, such as annual budget planning (draft)
	Translational research project group and institutions on rehabilitation robots (industry-university-research-hospital)	(Project promotion) Promotion of translational research project on rehabilitation robots

Ministry of Environment

☐,1 **Development of advanced intelligent nondestructive precision technology for internal and external diagnosis of pipelines**

1. Background and Purpose

☐ Responding to future water market issues

○ The maintenance market is expected to expand with the increase in pipeline infrastructure

○ Rapid boost in demand with the aging of pipelines and the need for improvement

2. 2021 Performance

☐ Securing reliability and verifying field application of intelligent precision pipeline probing robots

○ Technology development to obtain smooth driving path on curved pipes and ramps and overcome small obstacles (steps, welding beads, and foreign objects)

○ Development of defect analysis algorithm using artificial neural network-based deep learning

☐ Improving the internal pipe inspection program

○ Simplification of complex functions and reinforcing convenience (post-processing analysis program)

3. Evaluation of 2021 and Next Direction: Completed Projects in 2021

4. Action Plan in 2022: Completed Projects in 2021

5. Project Schedule: N/A

6. Budget

Details		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Development of advanced intelligent nondestructive precision technology for internal and external diagnosis of pipelines*	Central government	7.70	16.76	9.61	Completed	-	34.07
	Private sector	-	-	-			-
	Subtotal	7.70	16.76	9.61			34.07

* Water management research project

7. Project organization

☐ Korea Institute of Robotics and Technology Convergence (Supervising institution)

○ Verifying field application and development of intelligent precision pipeline probing robots

☐ Institute for Research & Industry Cooperation at PNU (Consignment institution)

○ Performance evaluation and improvement of defect evaluation algorithms for MFL (magnetic flux leakage) sensors of precision probing robots

□,2 Technology development of contactless medical waste collection and treatment

1. Background and Purpose

□ Since COVID-19, concerns are growing about frequent outbreaks of new infectious diseases, necessitating environmental response technologies and policies for proper treatment of medical waste and prevention of further infections

○ Development of contactless collection and treatment technology using robots to relieve infection concerns of medical waste, expected to surge in the event of an infectious disease outbreak

2. 2021 Performance

□ Technology development of contactless collection and treatment for medical waste with high-risk infection concerns

○ Determination of robotic disinfection device specifications for wards/unloading

○ Development of basic robotic functions for medical waste transport

○ Development of RFID electronic tag recognition device for medical waste

3. Evaluation of 2021 and Next Direction

□ Technology development of contactless collection and treatment for medical waste with high-risk infection concerns

○ (Evaluation) Development of basic functions for medical waste transport and completion of disinfection device design

○ (Direction) Establishment of performance standards for contactless medical waste treatment robots and development of disinfection and sterilization devices

4. Action Plan for 2022

□ Technology development of contactless collection and treatment for medical waste with high-risk infection concerns

○ Structure design and prototype production of robotic disinfection devices for wards/unloading

○ Development of robotic functions for entry and exit to/from elevators and automatic doors

○ Development of medical waste loading/unloading auxiliary device for autonomous driving robots

5. Project Schedule

Detailed project	Project Details (2022)	2019	2020	2021	2022				2023
					1Q	2Q	3Q	4Q	
Technology development of contactless collection and treatment for medical waste with high-risk infection	Development of hospital maps and robot control systems for autonomous driving mobile robots								
	Development of cycles by disinfection level								
	Development of HW system prototypes for medical waste loading/unloading device								
	Establishment of a portable robot management program for managers								

Detailed project	Project Details (2022)	2019	2020	2021	2022				2023
					1Q	2Q	3Q	4Q	
concerns									

6. Budget

Details		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Technology development of contactless collection and treatment for medical waste with high-risk infection concerns*	Central government	-	-	2,020	2,310	2,310	6,640
	Private sector	-	-	-	-	-	-
	Subtotal	-	-	2,020	2,310	2,310	6,640

* Project for technology development of contactless collection and treatment for medical waste with infection concerns

7. Project organization

General managing agency (MOE)
Policy and financial support

Project officer
Linked with development projects and environmental policies

Leading institution (Korea Environmental Industry & Technology Institute)
Development project planning, evaluation, and management

R&D project evaluation group and deliberation committee by sector
Expert deliberations on the selection and evaluation of projects

Supervising R&D institution
Implementation of R&D projects

Joint R&D institution
Joint implementation of R&D projects

Consigned R&D institution
Partial implementation of R&D projects upon consignment

IFR International Federation of Robotics

Ministry of Oceans and Fisheries

1. Background and Purpose

○ Through field demonstration and commercialization of underwater construction robots, introducing 3 types of underwater construction robots already developed* to the field to secure track record

* For light-duty work (URI-L), heavy-duty work(URI-T), and track-based heavy-duty work (URI-R)

2. 2021 Performance

○ Testing of underwater construction robots (3 types) in real sea environment and acquisition of compliance statement from KTC

○ Selection of top 100 National R&D Excellence in 2021*

* Successful commercialization of URI-T, domestic submarine cable and pipeline burial robot, and entry into overseas markets

○ Ordering services to secure track record* of construction robots for lightweight work

* Lease and service of unmanned deep-sea submersibles / KRW 500 million / May 1, 2021–2028 /Western Pacific seamount in international waters / Collection of image data and biological and geological samples through an unmanned submersible operation

3. Evaluation of 2021 and Next Direction

○ Strengthen the foundation for commercialization by enhancing the reliability of underwater robot technology through performance verification and track record accumulation

○ Commercialization of underwater construction robots through acquiring additional track records

4. Action Plan for 2022

○ (Underwater construction) To analyze the test results to improve the performance of the equipment and try to obtain additional track records after the real sea environment is tested for the underwater construction robot

- (Performance sophistication) To improve equipment performance and services through testing of 3 underwater construction robots in a real sea environment and analysis of field application results

- (Equipment commercialization) To secure additional track records through consultation with relevant agencies and winning construction orders for underwater robotic construction sites

5. Project Schedule

Detailed project	Project Details (2022)	2019	2020	2021	2022				2023
					1Q	2Q	3Q	4Q	
Field demonstration and commercialization of underwater construction robots	Performance sophistication, maintenance, and performance verification								
	Establishment of support equipment for underwater construction robots and finding the testbed								
	Testing and field application of underwater construction robots in real waters								

6. Budget

Details		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Field demonstration and commercialization of underwater construction robots	Central government	19.2	50	62.5	28.2	-	159.9
	Private sector	13	30.3	10.6	7.2	-	61.1
	Subtotal	32.2	80.3	73.1	35.4	-	221

7. Project organization

Classification	Roles for each ministry	
Field demonstration and commercialization of underwater construction robots	MOF	(General project management) General management of the overall project
	KIMST	(Leading institution) Project operation
	KIOST	(General project management) Support for field demonstration and commercialization of underwater construction robots
	Red One Tech	(Detailed project) Field demonstration and commercialization of ROV for light-duty work
	KESTI	(Detailed project) Field demonstration and commercialization of ROV for heavy-duty work
	KOC	(Detailed project) Field demonstration and commercialization of ROV for track-based heavy-duty work

Ministry of SMEs and Startups

1. Background and Purpose

○ To ensure the competitiveness of manufacturing, the basis of the Korean economy, it is needed to support manufacturing innovation using robots.

- Production efficiency and quality competitiveness must be improved through the introduction of robots in the production and manufacturing process; the competitiveness of small and medium-sized manufacturing companies needs to be enhanced by creating safe jobs.

2. 2021 Performance

○ (Consulting) Support for feasibility study and introduction of robots by analyzing manufacturing processes of companies with the need and supporting robot utilization process design to improve productivity (64 companies)

○ (Distribution) Selection of 64 companies and support for establishing robotic automation systems, including automotive parts and metal processing industries (support for introducing 319 units such as industrial robots)

○ (Safety) Support for industrial safety inspections such as risk assessment reports and safety training for companies introducing robotic automation systems (70 companies)

3. Evaluation of 2021 and Next Direction

○ (Performance) Successful implementation of the given tasks such as process consulting, robot distribution, and safety support without problems

- By 2020, 114 companies received support for the introduction of robots to improve their manufacturing competitiveness; productivity rose 71%, defect rate fell 69%, and industrial disasters dropped 24%.

Classification	Improving productivity	Reducing defect rate	Cost reduction	Growth rate of delivery compliance	Reducing industrial disaster rates
Outcome	70.8%	69.2%	45.5%	14.5%	24%

* Based on final report for each support project and external evaluation service results

** Supported companies in 2021 will be evaluated during the second half of 2022

○ (Future direction) Creating synergy effects through linkage of smart factories and robots, enhancing the matching effects between buyers and suppliers to improve project performance

4. Action Plan for 2022

☐ Enhancing the effectiveness of robotic applications

○ Support up to KRW 700 million* by selecting sophisticated smart factories first when supporting robotics projects (exemption from document review, omitting field evaluation, etc.)

* Support up to KRW 700 million, including KRW 400 million for smart factories (sophistication 2) + KRW 300 million for robots

- Selection of excellent companies among those that received support and completed the smart factory (sophistication 1, sophistication 2) project

* Companies that have completed the establishment as of the announcement date and performance have been measured through external supervisory agencies

[Selection Process for Excellent Smart Factory Companies]

① Applications submitted	→	② Selection of excellent smart factory companies
KIRIA (1st Avenue System)		Selection of companies based on excellent smart factory criteria (collaboration with KOSMO)

↓

⑥ Deliberation of the final project cost and agreement conclusion	←	⑤ On-site evaluation	←	④ Presentation evaluation	←	③ Document review
KIRIA		Proxy inspection (via video)		Evaluation committee		Exempted

- When they satisfy all four excellent smart factory standards, the companies receive preferential evaluation; if not, the evaluation will be carried out on the same basis as other support projects

○ Consulting support for industrial safety inspection (70 companies), survey on high-risk workplaces for robot accidents by industry, process, and company size, and research on the effectiveness of robot applications

* Article 36 of the Occupational Safety And Health Act (Conducting Risk Assessment), Guidelines for Workplace Risk Assessment (Notice of the Ministry of Employment and Labor), Article 93 of the Occupational Safety And Health Act (Health Measures), inspection of robotic systems' technological factors (international standards on robots), Article 9 of the Act on Punishing Severe Disasters (Obligation to Ensure Safety and Health)

○ Support for feasibility study and introduction of robots by analyzing manufacturing processes of companies with the need and supporting robot utilization process design to improve productivity (60 companies)

- Technical consulting support using experts in related fields for small and medium-sized manufacturing companies wishing to introduce robots

- Resolving on-site issues that occur when performing the project of selected buyers

○ To enhance the effectiveness of matching between suppliers and buyers, matching consultations and evaluation of suppliers are conducted

- Company matching according to pre-survey of robot application demands by industry and sector, and on-site matching according to operating situation

[Matching Consultation Procedure]

Promotion of consultation meetings (Cooperation with associations and organizations in industries with need) (Using press, e-mail, etc.)	⇨	Submission of applications	⇨	Supply-Demand Corporate matching	⇨	Information shared in advance (Matching consultation schedule)	⇨	Matching Consultation	⇨	Report results

- Suppliers' prior projects are evaluated by the buyers based on "robotic automation system installation technology and response capacity by post management level"*

* Level 0 (Do not or cannot respond), Level 1 (Can be outsourced), Level 2 (Capable of independent response), Level 3 (Company's strength)

5. Project Schedule

Detailed project	Project Details (2022)	2019	2020	2021	2022				2023
					1Q	2Q	3Q	4Q	
To provide consulting, demonstration, and distribution to 10 companies per model application	Engineering consulting								
	Support for introducing robots								
	Support for safety inspection								

6. Budget

Details*		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Support for robot-enabled manufacturing innovations	Central government	117	105	181	181	205	789
	Private sector	117	105	181	181	205	789
	Subtotal	234	210	362	362	410	1,578

* The private sector budget is based on 5:5 matching standards, and the 2023 budget is based on the mid-term financial budget

7. Project organization

Classification	Roles for each ministry	
Support for robot-enabled manufacturing innovations	MSS	(General management) General management of the project, such as annual budget planning (draft)
	KIRIA	(Dedicated institution) Planning, task evaluation, management, and application of results
	KITECH, KIMM	(Consignment institution) Robot engineering and technical support
	KAR	(Consignment institution) Robot safety inspection support

IFR International Federation of Robotics

Defense Acquisition Program Administration

1. Background and Purpose

☐ **Development of robotic technology in response to future changes in battlefield environments**

○ Development of unmanned and robot related key technologies for the performance of missions that are difficult for humans to perform in battlefield environments

☐ **Implementation of efficient R&D through cross-ministry collaboration**

○ Discovering and jointly planning robot R&D fields that can be jointly utilized by the military and the private sector, preventing duplication and creating synergies

* Joint promotion from the discovery stage with the civilian-demanded R&D implementing ministries such as MSIT and MOTIE

2. 2021 Performance

☐ **Development of complex signal-based human body-machine high-speed synchronization control technology**

○ Close consultations organized between researchers and participating ministries for cross-ministerial cooperation

* September 2021 Working Meeting of Supervising Institutions, DAPA-MOTIE-MSIT, November 2021 Council of Ministries

○ Promotion of consigned research to establish the concept of operating the wearable robots, review of the detailed design of the system, and production purchase for the implementation and verification of the design concept

3. Evaluation of 2021 and Next Direction

☐ **Development of complex signal-based human body-machine high-speed synchronization control technology**

○ (Evaluation) Completion of tasks within the set schedule, including the application of 9 patents for securing the rights of established concepts by module comprising the system, and promotion of production purchase for the production of the detailed design of the system

○ (Direction) Production of experimental samples and integrated performance testing to satisfy target performance and verify design concepts for each module

4. Action Plan for 2022

☐ **Development of complex signal-based human body-machine high-speed synchronization control technology**

○ Promotion of researchers' working meetings for consultation on the flexible sensor module interface and technological exchange between ministries through the presentation of research project results at academic conferences

○ Product improvement and performance testing for each component of the drivetrain and flexible sensor modules, walking performance tests using integrated experimental samples

☐ Technology development of the multi-robot autonomous collaborative plan (new initiative in 2022)

○ Establishment of R&D plan, analysis of requirements, allocation of system functions, etc.

5. Project Schedule

Detailed project	Project Details (2022)	2019	2020	2021	2022				2023
					1Q	2Q	3Q	4Q	
Development of complex signal-based human body-machine high-speed synchronization control technology	Improving basic prototype and production designs								
	Single-item performance testing of the basic prototype by module								
	Module integration and gait test of basic prototype								
	Implementation of flexible sensor signal processing algorithm								
Development of autonomous planning technology for multi-robot collaboration	Establishment of R&D Plan								
	Project launch and requirements analysis								
	Assignments for system functions								

6. Budget

Details		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Development of complex signal-based human body-machine high-speed synchronization control technology	Central government	-	1.0	9.99	15.73	15.56	42.28
	Private sector	-	-	-	-	-	-
	Subtotal	-	1.0	9.99	15.73	15.56	42.28
Development of autonomous planning technology for multi-robot collaboration	Central government	-	-	-	2.47	17.59	20.06
	Private sector	-	-	-	-	-	-
	Subtotal	-	-	-	2.47	17.59	20.06

7. Project organization

Classification	Roles for each ministry	
Development of complex signal-based human body-machine high-speed synchronization control technology	DAPA	Development of flexible wearable robots for soldiers
	MOTIE	Development of muscle support robots for workers
	MSIT	Development of flexible bio-signal sensor modules
Development of autonomous planning technology for multi-robot collaboration	DAPA	Collaborative control system to be used for surveillance reconnaissance
	MOTIE	Collaborative control system to be used for logistics shipping

National Police Agency

1. Background and Purpose

○ There is an increasing trend of disasters and accidents, such as the possibility of domestic terrorism and chemical explosions. The risk of secondary accidents due to the lack of information on various harmful gases is always looming as well.

- It is critical to secure the safety of initial response personnel and prevent further damage through proper initial action.
- There is rising demand for strengthening the response capacity to terrorism, disaster, and crimes, as well as securing national safety.
- Ensuring the safety of the site and first response personnel due to secondary damage from harmful gases at terrorist, disaster, and crime scenes; development of pan-governmental gas capture and identification equipment and response systems, such as the identification of explosives and narcotics, for the prevention of terrorism and crime

※ Multi-ministerial special committee (May 4, 2016) 4.) Selection for the multi-ministry joint planning project in 2017 (Supervising ministry: NPA/Cooperating ministries: MSIT, MOTIE, MOE, NFA)

2. 2021 Performance

☐ Verification of mobile robot platforms to overcome obstacles (stairs, slopes) and rough terrain (gravel, sand, rocks)

○ Drawing of detailed design for mobile platforms that overcome obstacles and rough terrain

○ Drawing of detailed design for modules equipped with gas sensors and capture devices

○ Technological feasibility study for the remote mobile measurement robot design

○ Robotic sample production and system integration for the remote mobile measurement robot

○ Performance evaluation of remote mobile measurement robot performance through test operations

☐ Development and performance evaluation of portable remote control and convergence sensor modules

○ Design and manufacture of portable remote control and convergence sensor modules

○ Implementation of simultaneous localization and mapping (SLAM) and monitoring of surrounding environment based on convergence sensor module

○ Development of portable remote control SW and evaluation through demonstrative operations

3. Evaluation of 2021 and Next Direction

☐ Two-step evaluation (December 2021)

○ Entry to Step 3 with comprehensive rating A for target projects

Ministry	Project name	Supervising institution (Person in charge)	Comprehensive rating	2022 Research period	2022 Research expenses*
MOTIE	Development of remote mobile measurement robots and operation technologies equipped with gas sensors and capture devices	KIRO (Kim Mu-rim)	A	January 1–December 31, 2022	449

4. Action Plan for 2022

☐ Improvement of robotic mission scenarios and design of the final prototype of the robot

- Draft development of education/training programs for field crew (police officers, fire fighters)
- Review of the robot's final trial manufacturing design, derivation of action Item, and progress performance management

☐ Improvement of robot sample performance and final prototype design

- Design to improve the mobile platform for overcoming obstacles and rough terrain by reflecting user feedback
- Complemented design for improving gas circulation module performance for gas sensor and capture device
- Operation technology of remote mobile measurement robots and improving the remote control environment
- Review of production preparations after interpretation and simulation using improved design

☐ Complementation of portable remote control device and convergence sensor module SW and design of the final prototype

- Complemented design of portable remote control device and convergence sensor module
- Implementation of algorithm for monitoring surrounding environment based on convergence sensor module
- Establishment of simulated mission scenario environment for optimal remote control technology development
- Development of simulation-based optimal remote control technology

5. Project Schedule

Detailed project	Project Details (2022)	2019	2020	2021	2022				2023
					1Q	2Q	3Q	4Q	
Korea Institute of Robotics and Technology Convergence (Kim Mu-rim)	Draft development of education/training programs for field crew (police officers, fire fighters) and progress performance management								
	Performance of remote mobile measurement robots using demonstration infrastructure and development of verification technologies for their application								
	Design to improve the mobile platform for overcoming obstacles and rough terrain by reflecting user feedback								
	Complemented design for improving the performance of gas circulation module performance for gas sensor and capture device								
	Operation technology of remote mobile measurement robots and improving remote control environment								
	Review of production preparations after interpretation and simulation using improved design								
	Complemented design for portable remote control								
	Establishment of simulated mission scenario environment for optimal remote control technology development								
	Development of simulation-based optimal remote control technology								

6. Budget

Details		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Development of gas molecule identification and analysis technology that can respond to harmful factors	Central government	-	2	3.5	4.54	4.57	14.61
	Private sector	-	-	-	-	-	-
	Subtotal	-	2	3.5	4.54	4.57	14.61

7. Project organization

☐ KIRO

○ (Remote mobile measurement robot) Development of remote mobile measurement robot sample equipped with gas sensor and capture device

Rural Development Administration

1. Background and Purpose

○ Increased demand for high-tech unmanned farm work at Korean-style smart farms

- The need for quantification (digitization) of agriculture using technologies of the Fourth Industrial Revolution

- High-tech technology is necessary to prepare for the instability of the agricultural production workforce due to aging, COVID-19, etc.

* Implementation of data agriculture through interworking with ICT equipment configuring smart farms

○ Development and distribution of advanced agricultural machinery in preparation for the fourth Industrial Revolution according to the 8th Basic Plan to Mechanize Agriculture

* **“National Task 34-☐,2: Discover and nurture future-oriented new industries to create high added value”**: Support for R&D, demonstration, and infrastructure construction to foster high-tech industries such as intelligent robots and 3D printing

- Development of advanced agricultural machinery to respond to the fourth Industrial Revolution by achieving technological excellence in IT, BT, and NT industries that can realize advanced agriculture through robotization, automation, and smart farming

2. 2021 Performance

☐ **(Growth measurement) Development of robots for fruit growth monitoring, excess fruit thinning, and harvesting**

○ Development of data acquisition automation system for object recognition and machine work

○ Estimation of tomato ripeness using hyperspectral imaging * Prediction accuracy: 97.6%

○ Design of driving platforms for greenhouses and sophistication of integrated power systems

☐ **(Pest control robot) Field application and performance evaluation of smart pest control robot for fruit orchards**

○ Comparison of data recognition rate for fruit tree shapes and pest control performance by orchard

* Gaussian filter to improve fruit recognition rate accuracy: (apple) 22.67%↑, (pear) 14.77%↑

** Application of high-efficiency control algorithm on injection nozzles resulted in 40% reduction in pesticide use compared to before

○ Early commercialization and dissemination preparations for pest control robot technology

* Automated apple farming technology demonstration (2022): 11 locations, budget: KRW 616 million

☐ **(Weeding robots) Development of unmanned weeding robots with autonomous driving technology and fruit (apple) detection**

○ Acquisition of 3D spatial information and mapping mechanism design

* Development of fruit trees and obstacle recognition, and local path worker following technology using LiDAR and imaging

○ Production of LiDAR-based orbital variable weeding robot test device

* (Environmental recognition) Using RTK-GPS, IMU, and LiDAR, (Weeding) design and production of variable weeding machines and orbital autonomous driving platform prototype

☐ **(Autonomous driving) Development of an automatic steering system that can be attached to GPS-based passenger-type farm machinery**

○ Modular steering control interface construction and performance testing

* (Configuration) RTK-GPS, IMU, HMI, (Data) CAN-ID (HEX), (Control) Hydraulic valve (Cylinder)

** (Testing) Analysis of tractor driving speed and driving (autonomous steering in a straight line) properties depending on road conditions

☐ **(Harvesting robots) Research on automated fruit harvesting mechanism using robot arm control technology**

○ Building interfaces for fruit recognition and harvesting with ROS-based sensors and robotic arms

* Linux and ROS-based data acquisition and environment settings, 3D harvesting target positioning using RGB-depth camera

		
[Mobile Platform for Data Acquisition]	[Smart Robot Pest Control Machine]	Automated Straight Driving Property Testing

3. Evaluation of 2021 and Next Direction

☐ **(Growth measurement) Development of automated robots for hydroponically cultivated fruits and vegetables at Korean-style smart farms**

○ **(Evaluation)** Sophistication of fruit and vegetable recognition technology based on deep learning object detection

○ **(Direction)** Development of elementary technology and sophisticated field applications

* Development of Korean-type manipulator control technology for predicting harvesting time and production of fruits and vegetables

☐ **(Weeding robots) Development of GPS-based orbital autonomous driving platform and autonomous navigation technology**

○ **(Evaluation)** 3D spatial information acquisition and mapping technology, design of an orbital autonomous driving platform

* Patent application: LiDAR-based fruit trees and obstacle recognition and operator following technology for autonomous driving platforms

○ **(Direction)** Development of fruit detecting variable weeding machine based on AI obstacle recognition and avoidance technology

☐ **(Autonomous driving) Laying the foundations for localization of modular autonomous steering system and development of fully unmanned farm work technology**

○ **(Evaluation)** laying the foundations for autonomous driving based on tracking path extraction and MHI-based pre-path setting

○ **(Direction)** Modular steering control system design and prototype production, improving and enhancing autonomous tractor driving properties through test evaluation

* User-friendly graphical user interface (GUI) configuration for integrated management, including pre-path setting and farm machine location

☐ **(Harvesting robots) Research on automated fruit harvesting mechanism using robot arm control technology**

○ **(Evaluation)** Optimal sensing and driving device derivation through fruit harvesting robot case investigation

○ **(Direction)** Development of object position recognition in 3D spaces and robot posture determination technology for automated hydration

* Image-based fruit position labeling by growth stage, training data construction, location detection using a thermal map regression technique

4. Action Plan for 2022

☐ **(Growth measurement) Development of robots for fruit growth monitoring, excess fruit thinning, and harvesting**

○ Improving recognition accuracy and sophistication of vision in consideration of greenhouse environmental conditions

* Establishment of criteria for determining harvesting time by crop and technology development for determining ripeness using artificial intelligence (AI)

** Development of sophisticated vision system technology for obtaining high-quality image data

○ Development of real-time target recognition technology and three-dimensional position extraction technology

○ Development of autonomous mobile robot platform and deep learning object area recognition technology

☐ **(Weeding robots) Development of unmanned weeding robots with autonomous driving technology and fruit detection**

○ Acquisition of 3D spatial information and mapping technology implementation

* Development of data clustering, geometric spatial analysis, and local path tracking technologies

○ Development of obstacle recognition and avoidance technology

* Implementing LiDAR or image-based obstacle recognition and avoidance algorithms

○ Development of expert imitation driving path generation technology

* GPS-equipped weeding robots execute weeding along the stored path

☐ **(Autonomous driving) Development of modular steering control system for unmanned farm work**

○ ISO-based virtual terminal device interface environment configuration and protocol development

* Modular unmanned steering control, virtual terminal selection and integration with a steering system

○ Field application testing and performance evaluation of unmanned steering control algorithm and steering device

☐ **(Harvesting robots) Research on automated fruit harvesting mechanism using robot arm control technology**

○ Planning and determination of robotic arm movement for the automated harvesting of apples and peaches

* Planning the route of the harvesting mechanism to be mounted on the end effector of the fruit harvesting prototype

** Development of optimal path algorithm that excludes harvesting interference factors (supports, irrigation pipes, twigs, etc.)

5. Project Schedule

Detailed project	Project Details (2022)	2019	2020	2021	2022				2023
					1Q	2Q	3Q	4Q	
Technology development for hydroponic cultivation, monitoring of fruit growth, excess fruit thinning, and harvesting robot	Development of crop-specific production forecast system								
	Development of vision system sophistication technology								
	Research on properties of crop handling work factors								
Development of intelligent weeder for apple orchards	Development of AI-based obstacle recognition and avoidance technology								
	Development of mechanism, driving, control algorithm and system integration								
Technological application research on robot safety for agricultural robot development	Environment configuration for an ISO-based virtual terminal device interface and protocol development								
	Modular steering control system and VT integration								
	Evaluation of algorithm performance through field application testing								
Development of oversized fruit and harvester diagnosis technology for labor-saving machine harvesting	Production of Robot arm-based automatic harvester prototype								
	Determination and optimization of robot arm movement path for automated harvesting								
	Development of robot arm movement path planning algorithm for apples and peaches								

6. Budget

Details		Budget (KRW 100 million)					
		2019	2020	2021	2022	2023	Total
Technology development for hydroponic cultivation, monitoring of fruit growth, excess fruit thinning, and harvesting robot (2021–2024)	Central government	-	-	15	16	16	47
	Private sector	-	-	-	-	-	-
	Subtotal	-	-	15	16	16	47
Development of intelligent weeder for apple orchards (2021–2023)	Central government	-	2	2	2	-	6
	Private sector	-	-	-	-	-	
	Subtotal	-	2	2	2	-	6
Research on application of robot safety technology for agricultural robot	Central government	-	0.88	0.88	0.88	-	2.64

<table>
<tr><th colspan="2" rowspan="2">Details</th><th colspan="6">Budget (KRW 100 million)</th></tr>
<tr><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>Total</th></tr>
<tr><td rowspan="2">development (2020–2022)</td><td>Private sector</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Subtotal</td><td>-</td><td>0.88</td><td>0.88</td><td>0.88</td><td>-</td><td>2.64</td></tr>
<tr><td rowspan="3">Development of fruit enlargement and harvester diagnosis technology for labor-reducing mechanical harvesting (2021–2024)</td><td>Central government</td><td>-</td><td>-</td><td>1.2</td><td>1.2</td><td>1.2</td><td>3.6</td></tr>
<tr><td>Private sector</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Subtotal</td><td>-</td><td>-</td><td>1.2</td><td>1.2</td><td>1.2</td><td>3.6</td></tr>
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7. Project organization

<table>
<tr><th>Classification</th><th colspan="2">Roles for each ministry</th></tr>
<tr><td rowspan="2">(Growth measurement) Technology development for hydroponic cultivation, monitoring of fruit growth, excess fruit thinning, and harvesting robot</td><td>RDA</td><td>(General management) General management of project, coordination, and administration</td></tr>
<tr><td>NIAS, University, Companies</td><td>(Implementation) Project implementation</td></tr>
<tr><td rowspan="2">(Weeding robots) Development of intelligent weeder for apple orchards</td><td>RDA</td><td>(General management) General management of project, coordination, and administration</td></tr>
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<tr><td>National Academy of Agricultural Sciences</td><td>(Implementation) Project implementation</td></tr>
<tr><td rowspan="2">(Harvesting robots) Fruit enlargement and harvester diagnosis technology for labor-reducing mechanical harvesting</td><td>RDA</td><td>(General management) General management of project, coordination, and administration</td></tr>
<tr><td>National Academy of Agricultural Sciences</td><td>(Implementation) Project implementation</td></tr>
</table>

National Fire Agency

1. Background and Purpose

○ Establishment of performance evaluation environment and development of field operations for efficient response to chemical terrorism, such as harmful gases

- Establishment of a training testbed for joint training* for counterterrorism ministries (NFA, NPA)

* Operational training of robots developed by MOTIE (equipped with gas sensors and capture devices) during joint training

- Establishment of testbeds and multi-ministry (NFA, NPA, MOE) training scenarios for proper first response at sites and situations, such as terrorism, disaster, crime, etc.

2. 2021 Performance

○ Development of human dummies (6 types: 2 elderly, 2 adults, 2 infants) for preemptive gas detection and search for life through robots before police and firefighters enter in case of hazardous gas releases

○ Promotion of action plan and building permit to break ground for the training testbed

* Review of permit and certification matters through expert companies, consultation with Gongju City (site of training testbed) for approval of action plan

3. Evaluation of 2021 and Next Direction

○ Preparation of local government consultations and revisions such as the site permit to ensure that each ministry's research results can operate smoothly in the testbed

4. Action Plan for 2022

○ Improvement of training scenarios through consultation with relevant agencies (when to send in robots, firefighters, and police)

○ After improving the design and completing various certification* procedures for the testbed, construction begins

* Energy efficiency rating, energy-saving plan, zero energy building certification, renewable energy, etc.

5. Project Schedule

Detailed project	Project Details (2022)	2019	2020	2021	2022				2023
					1Q	2Q	3Q	4Q	
Development of efficient response technology for hazardous gases at chemical terrorism sites	▪ Composition of working design documents for the training testbed								
	▪ Permit for the action plan and construction for the testbed establishment								
	▪ Testbed building construction								

6. Budget

Details*		Budget (KRW 100 million)						
		2019	2020	2021	2022	2023	2023	Total
Development of efficient response technology for hazardous gases at chemical terrorism sites	Central government	3.09	8.26	15.52	17.01	14.24	5	63.12
	Private sector	-	-	-	-	-	-	-
	Subtotal	3.09	8.26	15.52	17.01	14.24	5	63.12

* The budget includes R&D (real-time training status monitoring, equipment construction, etc.) costs in addition to the cost of building the training testbed (Training testbed construction cost: approximately KRW 2.8 billion)

7. Project organization

Classification	Roles for each ministry	
Development of efficient response technology for hazardous gases at chemical terrorism sites	NFA	(Supervision) General management, coordination, and administration of the project, related matters deliberation and voting, and research progress review
	National Research Foundation of Korea	(Leading institution) R&D project management, payment and settlement of endowment
	Hoseo University	(Research management) Coordination of work between research and implementing institutions
	Taesan Electronics Co. Ltd	(Detailed project) Coordination of work between research and implementing institutions

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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[93].

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, 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.

[93] https://ec.europa.eu/eip/agriculture/en, accessed on 19/11/2020.

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.