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,

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[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.