Analysis of opportunities for EU SMEs in Japan's Data Economy and Artificial Intelligence in connection with Robotics

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Objective and Scope

This report intends to provide an overview of current AI, robotics and data related policies in Japan. Its scope covers the government regulations, strategies and actions regarding R&D, as requested by the EU-Japan Centre for Industrial Cooperation. Market analysis and business landscape are therefore not covered in this publication.

The objective of this report is to provide a useful source of information on opportunities for European SMEs in AI and related fields against the background of policy landscape. Apart from strategy and regulation's analysis the report contains also a section with recommendations for European SMEs wishing to collaborate with or conduct business in Japan.

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List of Abbreviations

Abbreviation	Meaning
RRI	Robot Revolution Initiative
APPI	Japan Act on the Protection of Personal Information
METI	Ministry of Economy, Trade and Industry
MIC	Ministry of Internal Affairs and Communications
MEXT	Ministry of Education, Culture, Sports, Science and Technology
NEDO	New Energy and Industrial Technology Development Organization
GDPR	General Data Protection Regulation
CSTI	Council for Science, Technology and Innovation
AIP	Center for Advanced Intelligence Project
AIRC	Artificial Intelligence Research Center
UCRI	Universal Communication Research Institute
NICT	National Institute of Information and Communications Technology
CINET	Center for Information and Neural Networks
GHG	Greenhouse Gases
SDGs	Sustainable Development Goals
SMEs	Small and Medium Enterprises

ISO   International Organization for Standardization

IEC   International Electrotechnical Commission

RTF   Robot Test Field

JSCE   Japan Society for Civil Engineers

WIPO   World Intellectual Property Organisation

CNN   Convolutional Neural Network

RNN   Recurrent Neural Network

LSTM   Long Short Term Memory

Executive Summary

In recent years Japan has been intensifying efforts to update its technology-oriented policy. The common denominator of all reviewed and new regulations and strategies is realising the vision of Society 5.0.

Society 5.0 marks the next level of development after information society and is built using the potential of AI. It is diversified, inclusive and capable of meeting the specific needs of each individual in a precise and timely manner, thus allowing for comfortable and fulfilled lives.

Society 5.0 is saturated with AI and related technologies, which help balancing economic advancement with solving main societal issues (aging society, labour shortage, reduction of GHG emissions, optimizing and automating agricultural industry, sustainable industrialization).

Japanese policymakers aiming to realise Society 5.0 began adjusting and updating existing regulations and creating dedicated strategies. There are three important aspects around which the regulations are centred: AI, data and robotics. However, AI dominates the technology-oriented policy landscape and both robotics and data issues are often considered from the perspective of AI.

Japan's true strength lies in industrial and functional robots rather than humanoids that are more often publicised. The Robot Strategy aims to capitalise on that strength making Japan the most advanced robotics society and innovation hub. Practical applications of (AI equipped) robots are detailed for selected priority areas.

In nursing and medical care robots will assist or even replace care workers. In manufacturing/services plans are made to increase sophistication of robots' brain (AI), eyes (sensors) and fingers (control). Infrastructure/disaster response/construction targets increasing robot introduction to inspections and repairs of critical infrastructure and levelling unmanned construction efficiency with manned construction in hazardous environments. Introductions of robots are also planned in agriculture with special focus on self-driving tractors.

In order to develop effectively functioning robots an appropriate testing environment is needed. The government facilitates creating robot test sites offering specialised environments for simulating: disaster response, life support, industrial functions, etc.

Robot strategy recommends intensifying efforts in shaping industry standards as a way of strengthening Japan's international position. Another way to Japan's domination in robotics is the recommended attempt at modularisation of robotic hardware and software, to make production easier and less expensive.

AI Strategy is based on dignity, diversity and inclusion as well as sustainability. It has four main targets: continuous development and acquiring of human resources with AI oriented skillset; raising Japan's industrial competitiveness by leading in practical application of AI for real world industries; implementing a technology and management system for realising and further functioning of diverse and sustainable society; leading the development of an AI related international network comprising research, education and social infrastructure, contributing simultaneously to fulfilling the SDGs and nurturing AI-educated human resources.

Japan struggles with drastic shortage of human resources with AI oriented skillset. Short term solution is encouraging women's participation in job market and attracting professionals from overseas. Long term resolution is a fundamental reform of education system, introducing more science and technology subjects into curricula and creating appropriate learning environment (infrastructure, access to devices for students) and opening technology-focused lifelong education opportunities for current workforce.

R&D in Japan requires efforts in creating collaboration network of specialised research centres that contribute their expertise in different areas and on different levels of R&D process. Aiming to harness the potential of disruptive innovation, the government initiates various research projects (SIP, PRISM, ImPACT, Moonshot). Moonshot R&D project is somewhat similar to Horizon Europe and offers potential opportunities for collaboration.

Bearing in mind crucial role of data in AI development, Japanese government aims to introduce an integrated platform, which collects data from various sources (industries, devices, users). While regulations are being implemented to facilitate use of both public and private sector data, building the actual data platform is still far away.

With regards to IP protection Japan is lagging behind USA and China. Most active group of applicants so far are Japanese companies specialising in consumer electronics, which occupy 12 positions in ranking of 30 applicants with biggest number of patent families in AI field.

In 2019 Japan has published a set of Social Principles of Human-centric AI, which was internationally recognised and is close to EU's own guidelines. Further principles regarding R&D and AI utilisation are under preparation.

Japan's cooperation and business exchange with Europe has strong potential, partly due to shared values and similar ethical approach to technology. Moreover, opening to international research and collaboration opportunities is important part of majority of policies, therefore the will is certainly there.

An excellent opportunity for EU's SMEs is the digital transformation. Japanese businesses adopting AI are looking to expand and go digital. However, European SMEs should increase their visibility and presence in public awareness through more frequent participation in field-related events.

1. Introduction

The current wave of regulations and strategies oriented around the developing technology (AI, robotics) and data-related issues began with Japan Revitalisation Strategy published in 2014 and its introduction of robot-driven industrial revolution as a possible target. Japan's position in robotics began gaining strength in 1980s and maintained that advantage until now, especially in industrial robotics. It does help, that Japan "…holds great share of over 90% worldwide in the field of key robot elements such as precision reduction gear for robots, servo motor and force sensor" [1, p.2]. In order to fully utilise Japan's robotics potential, the government introduced the New Robot Strategy in 2015 and initiated the Robot Revolution. Supervision over activities leading to Japan's transformation into "robotics superpower" was given to a newly formed body – the Robot Revolution Initiative. Year 2016 has marked the beginning of intensification of activities with publication of 5th Science and Technology Basic Plan which introduced the concept of Society 5.0 and advocated widespread transformation of the country by means of AI utilisation. Following that, the Artificial Intelligence Technology Strategy Council has been created and work on the initial version of AI strategy began. Simultaneously, in anticipation of the ever-growing need for data stemming from the AI development, Japanese policymakers introduced a set of laws regulating the circulation and use of data across public and private domains - The Basic Act on the Advancement of Utilising Public and Private Sector Data and The Act on the Protection of Personal Information (which has a similar function to that of European GDPR). In order to fully utilise the potential of AI and robotics an Industrialisation Roadmap has been devised and next, the policy discourse veered towards ethical concerns related to technology development. In a multistakeholder environment discussions commenced on AI Research and Development Guidelines and AI Utilisation Principles both developed with intention of regaining at least some degree of control over development of AI, especially with regards to possible biases and risks that AI might pose in various areas of application. The final element of ethical considerations came to Japanese and international public attention in 2019 with publishing The Social Principles of Human-Centric AI. Finally, in June 2019 the New AI Strategy was finalised [3], [4], [5], [6].

Among the governmental agencies, three ministries are leading the policymaking in this area: METI, MIC and MEXT. Coordination of efforts and information exchange is the responsibility of

Council for Science, Technology and Innovation, with specific focus on AI related issues entrusted to AI Technology Strategy Council and developments in robotics overseen by Robot Revolution Initiative.

2. Society 5.0

The concept of Society 5.0 was first introduced in 2016, in the 5th Science and Technology Basic Plan. Since then it serves as a common denominator for various policies and regulations, that all should ultimately lead to the same outcome – for Japan to become the most advanced, smartest nation in the world, the nation that has reached the 5th stage of society evolution.

While Germany introduced Industrie 4.0, and Singapore initiated "Smart Nation" plan, China followed with Made in China 2025 and finally Japan too developed its own concept. The "information society" term, widely used at the beginning of the century became too narrow to contain the potential of what the developing technologies offer nowadays and thus Japan decided to mark yet another step in social evolution [Fig. 1].

The short definition included in 5th Science and Technology Basic Plan describes this new stage as:

"… a society that is capable of providing the necessary goods and services to the people who need them at the required time and in just the right amount; a society that is able to respond precisely to a wide variety of social needs; a society in which all kinds of people can readily obtain high-quality services, overcome differences of age, gender, region, and language, and live vigorous and comfortable lives" [2, p.13].
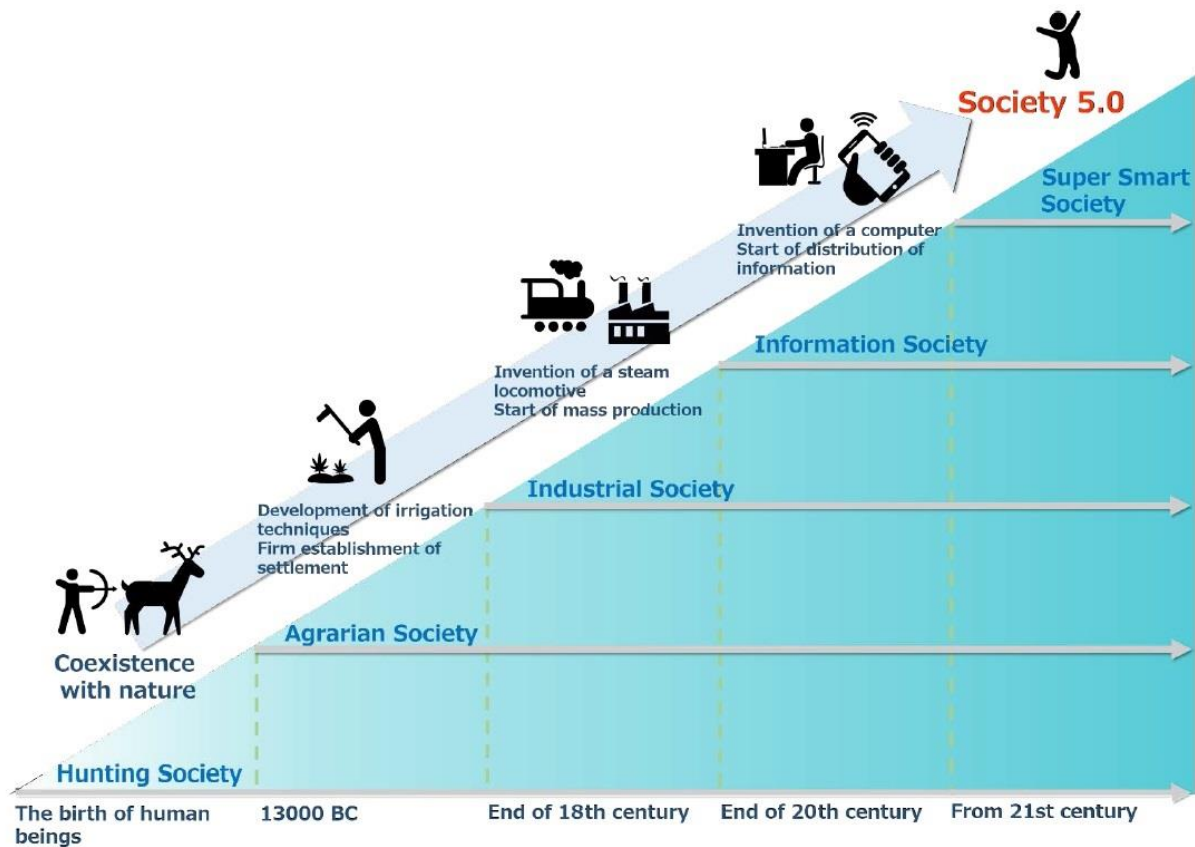
Figure 1. Stages of society development.
Source: Keidanren 2016: Policy & Action – Toward realization of the new economy and society: Reform of the economy and society by the deepening of "Society 5.0"

While the initial transitions from hunting (1.0) society through agrarian (2.0), industrial (3.0) to information society (4.0) seem rather obvious it's the last step that seems most interesting, especially, since it is happening right now. According to the authors of the Society 5.0 concept, while information society has been built around unrestrained, faster and more convenient circulation of information that crosses the boundaries of time and space, the introduction of IoT and AI radically changed this situation. While the claim made in the official introduction to the concept of Society 5.0, that knowledge and information were not shared in information society, does seem rather extreme, other comparisons between the two stages of society development appear accurate. The authors of the introduction point to growing collaboration between various so far often even unrelated fields and indeed, the new tools of gathering and analysing data seem

to both require and facilitate cross-sectoral collaboration be it industry, research or even policymaking. Also, so far, the data analysis was mostly performed by human resources, which – according to the authors – introduced various restrictions such as limited ability to obtain, organise and analyse huge amounts of specific information. Additional factors obstructing work performance such as age and disability were also named, along with general long-term societal challenges such as low birth rate, aging population or depopulation of rural areas. Certainly, in a society that employs IoT to gather vast amounts of data and AI – to coordinate, organise and analyse, the whole process seems not only faster and more efficient, but also new connections are being formed and new ways of sharing data as well as information and thus new values are being created [Fig. 2], [7], [8].

SOCIETY 5.0 – WHAT WILL CHANGE?
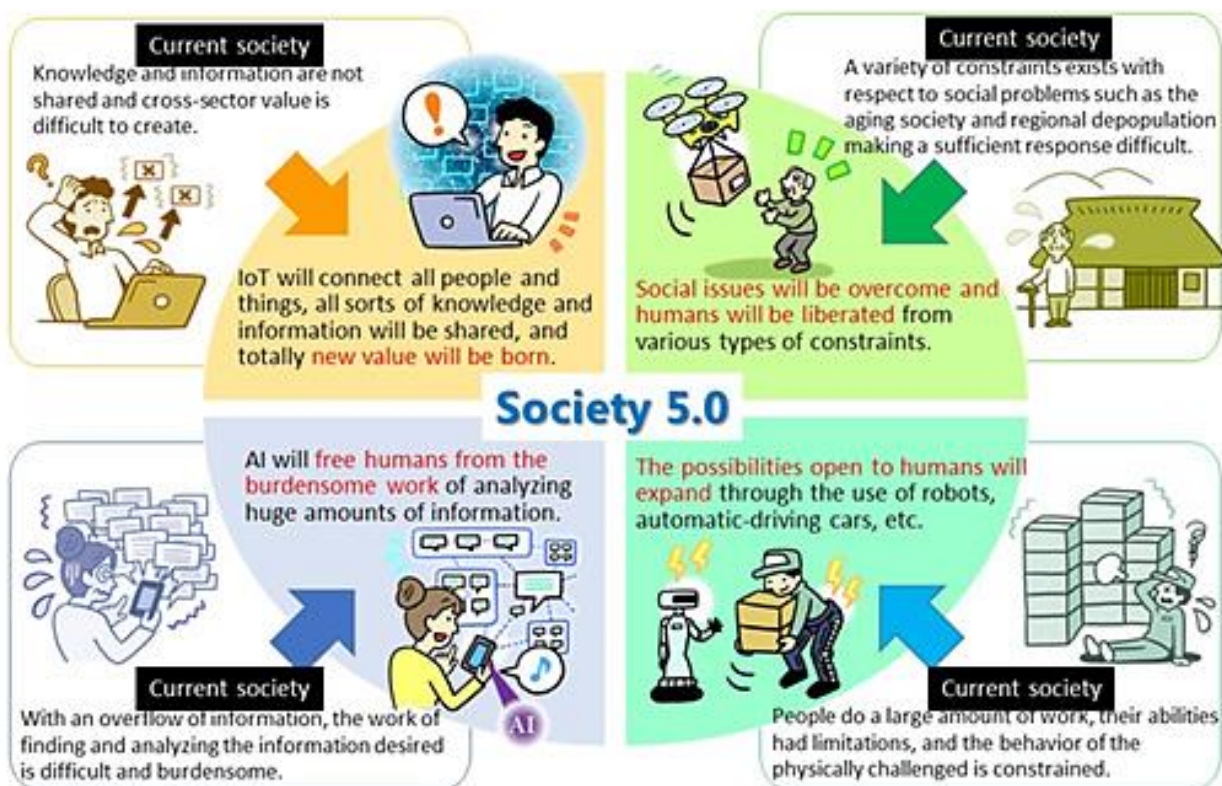
Figure 2. Changed expected to occur after transformation to Society 5.0.

Source: https://www8.cao.go.jp/cstp/english/society5_0/index.html

Further utilization of IoT, AI, robotics and related technologies is expected to help create a society where each and every person, regardless of age, abilities or personal constraints will have a chance to lead an active and fulfilling life [8], [9].

The basis for functioning of this new type of society is the integration of cyber space and physical space, that creates new social reality and offers previously unattainable potential [Fig. 3].

SOCIETY 5.0 AS A CYBER-PHYSICAL SYSTEM
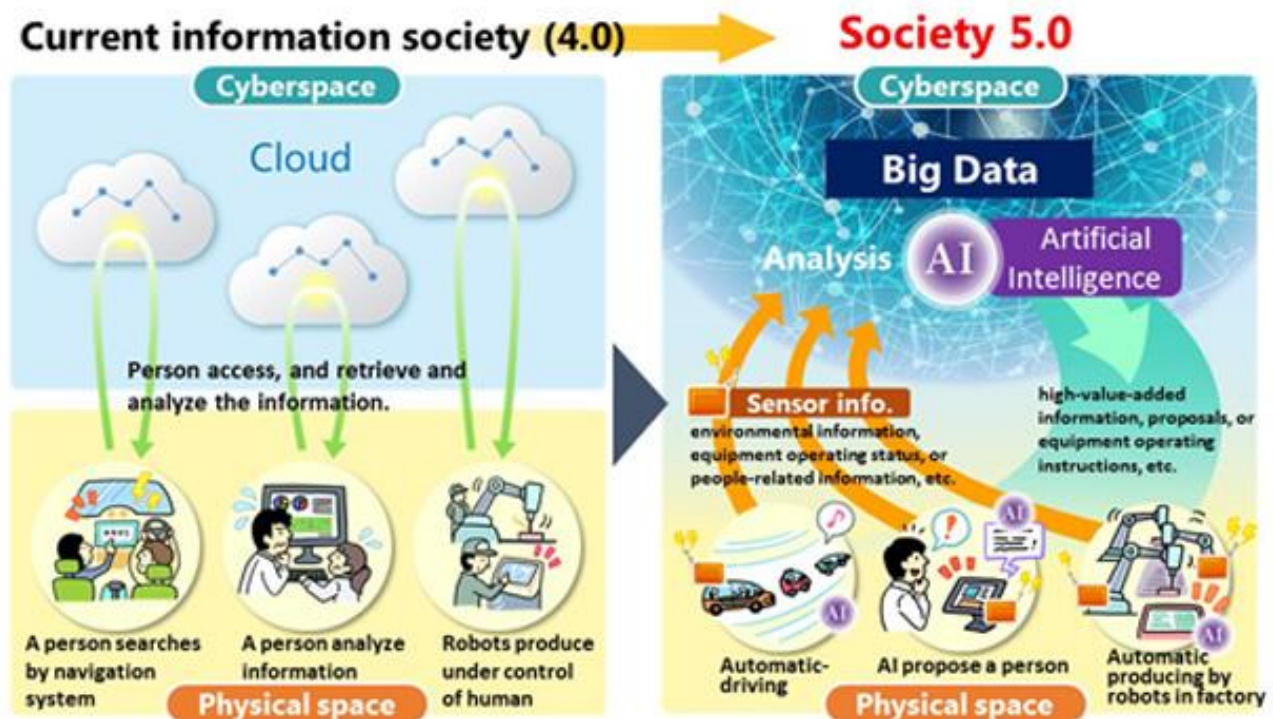
Figure 3. Society 5.0 as a cyber-physical system.

Source: https://www8.cao.go.jp/cstp/english/society5_0/index.html

So far there has been a clear division between the cyber space, where data has been stored and accessed by human resources performing analytical tasks. Consequently, the authors of Society 5.0 emphasize the human control of all the actions, even those carried out by robots, as a defining

feature of society 4.0. However, at the next level of development, majority of tasks seems to be carried out behind the scenes – controlled and coordinated by AI based systems extending to sensors, robots, autonomic vehicles, etc. In the ideal version of Society 5.0 humans as the end beneficiaries of technology would not even differentiate between cyber and physical space, employing seamless technology, functioning in a fusion of both worlds [7], [8], [10].

Still, all the technology readily available for members of Society 5.0 is only one part of the picture. The new model of society not only integrates technology seamlessly, but also utilizes it to bring new, balanced economy at the same time providing solutions to some of the most vital (for Japan but also on a global scale) societal challenges [Fig. 4].

SOCIETY 5.0: ECONOMIC DEVELOPMENT AND SOCIAL CHALLANGES
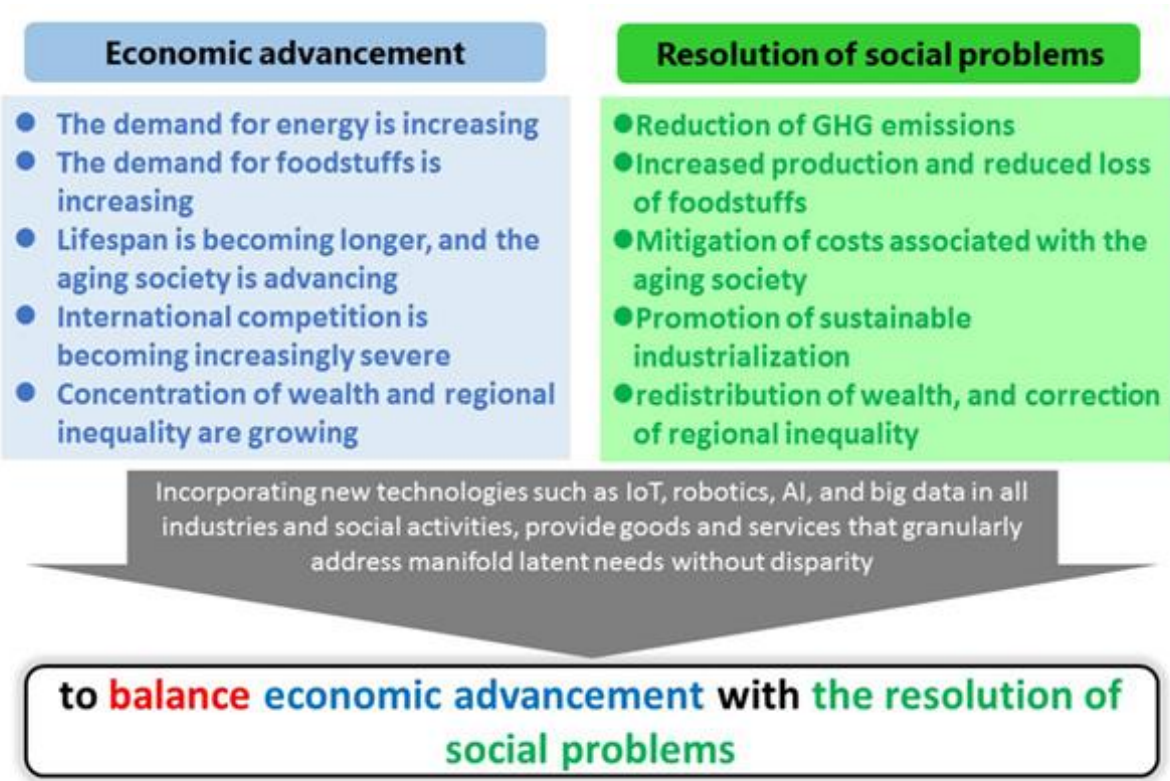
Figure 4. Society 5.0: balancing the economic development and resolving societal challenges.

Source: https://www8.cao.go.jp/cstp/english/society5_0/index.html

According to Keidanren[1] one of the characteristics of new society and economy is greater focus on each person – reform of individuals. That emphasis on each personal circumstances (abilities or limitations) would – by means of technology – empower groups in danger of exclusion such as women or the elderly, but also theoretically enable all the members of society, to lead a desired lifestyle: fulfilling, comfortable, safe and secure. Another feature is the reform of companies, which would result in transformation of the so far way of doing business, emergence of new models, improved productivity and greater employment of technology (also in terms of workforce). Finally, the last of the reforms indicated by Keidanren is resolving the social problems which pose a challenge for Japan, but are equally applicable and vital to global society [7].

The approach outlined by Keidanren comprises three main steps:

1. Identifying main problem areas for Japan (decreasing population and aging, natural disasters, terrorism, environment protection)

2. Utilising the existing or near future strengths of Japan's industry (strong manufacturing potential, incremental and technology-based innovations)

3. Obtaining new potential by linking the existing strengths with possibilities offered by the development of technology (disruptive innovation, software manufacturing) [7, p.11]

Furthermore, it is worth mentioning, that quite a few goals outlined in the plan for achieving new, smart society are aligned with Sustainable Development Goals (SDGs), set by the United Nations in 2015. From diversifying the energy sources, through reduction of GHG emissions, optimizing and automating agricultural industry to sustainable industrialization and more efficient waste management to name a few [Fig. 5].

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[1] Keidanren [日本経済団体連合会] – Japan Business Federation.

RESOLVING SOCIETAL PROBLEMS IN SOCIETY 5.0

Figure 5. Resolving societal problems and realising SDGs in Society 5.0.

Source: https://www8.cao.go.jp/cstp/english/society5_0/index.html

2.1 Practical examples of new benefits brought by Society 5.0

2.1.1 Transportation

With the proper utilisation of data regarding weather, traffic, vehicle position, so far routes as well as accommodation and dining choices, planning an optimal route for a chosen destination would become very easy [Fig. 6].

BENEFITS FOR TRANSPORTATION
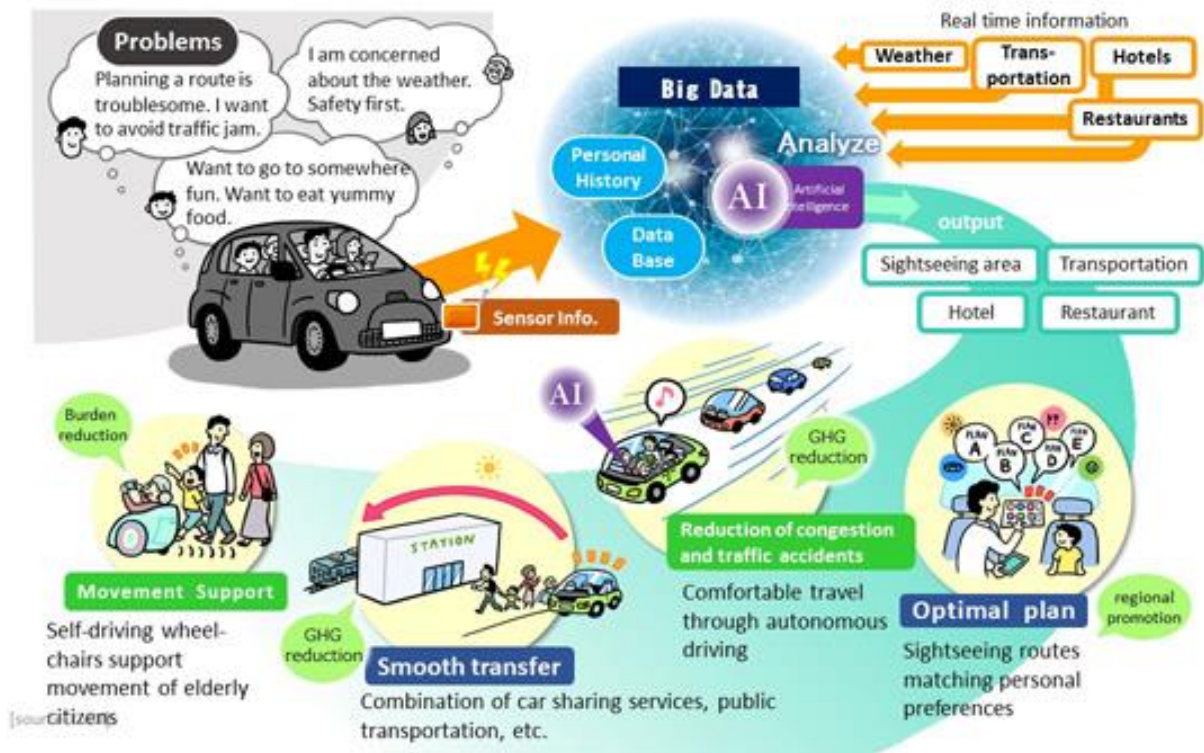
Figure 6. Expected benefits for transportation in Society 5.0.

Source: https://www8.cao.go.jp/cstp/english/society5_0/transportation_e.html

Moreover, with an option of autonomous driving for all sorts of vehicles (wheelchairs included) transportation in Society 5.0 would become less stressful and dangerous, allowing for a smooth movement from one location to another, avoiding congestion and accidents. Transportation system controlled and supervised in real time, apart from the obvious benefits for its users and participants, offers also various advantages for business logistics or regional promotion as well as environment protection (e.g. reduction of CO_2 emissions) [11].

2.1.2 Healthcare and caregiving

Access to various real time medical data (psychological evaluation, possible illnesses, infections, environmental and hereditary factors) would provide much needed flow of information which in turn would facilitate a well informed and smooth diagnosis and treatment anytime, anywhere. What is more, an option of automatic, real-time health checks might contribute to early detection and even elimination of many health problems as well as better and safer life regardless of age or family circumstances. Finally, introduction of robots (especially with the support of AI) would provide a much-needed change of the whole caregiving landscape, offering seemingly instant solution for labour shortages, cost and personal burden reductions [12].

2.1.3 Manufacturing

In manufacturing the timely access to accurate information concerning demand, inventory and delivery can make a difference between failing and succeeding [Fig. 7].

BENEFITS FOR MANUFACTURING
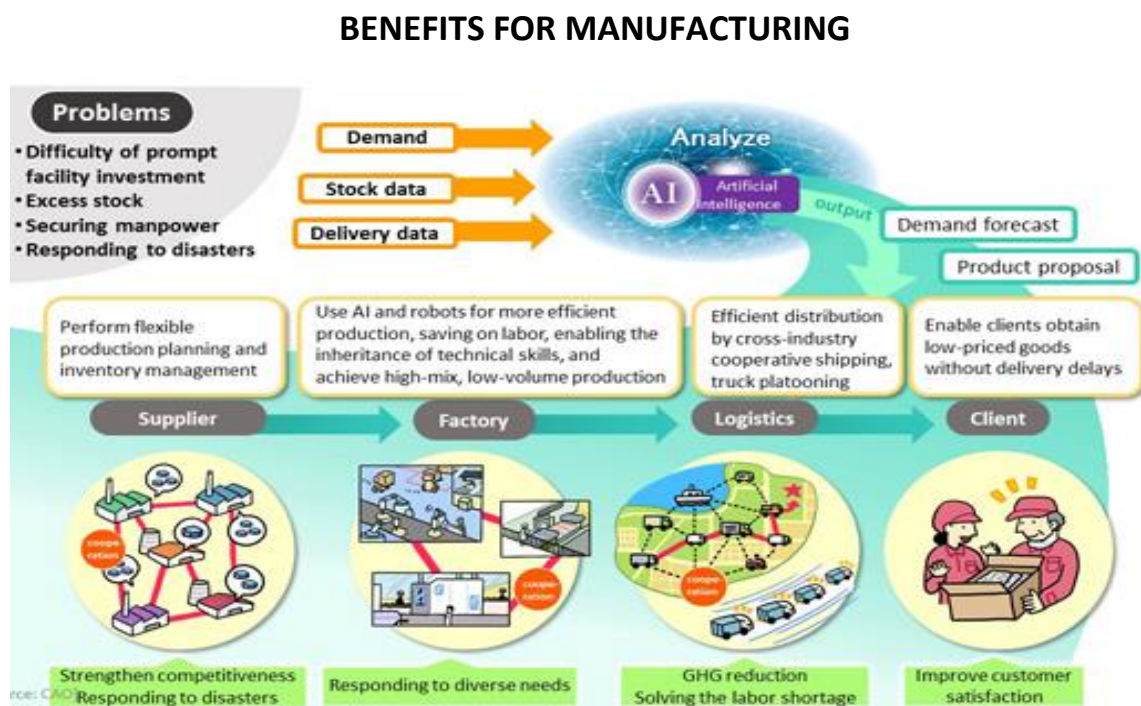
Figure 7. Expected benefits for Manufacturing in Society 5.0.
Source: https://www8.cao.go.jp/cstp/english/society5_0/manufacturing_e.html

Automatization of control and supervision as well as more precise management of particular production tasks due to usage of AI controlled robots is a significant improvement for manufacturers, which allows not only to optimize existing manufacturing models, but also for more flexibility and variety than was profitable so far. Vast amount of manufacturing related data combined with appropriate analysis power offers new opportunities for cross-industry and factory collaboration, even delivery pooling, proper timing and quantity of delivery of even the smallest most specialised orders. Again, the expected benefits will far exceed monetary gains, allowing for positive changes in areas such as disaster preparedness and response or environmental protection [13].

2.1.4 Food

With ever-growing demand for food products and thus constantly increasing production efficient management of food supplies on all levels (individuals, retailers and manufacturers) has become a challenge. Easy access to data gathered on every level could positively influence decisions made by consumers as well as suppliers. Another important factor is access to allergy, dietary, quality, storage conditions and expiry date information, which translate to direct health improvement and generally a wholesome lifestyle [14].

2.1.5 Agriculture

One of the crucial factors determining success in agriculture is water supply. Availability of precise data regarding rivers, water reservoirs, weather conditions and especially being able to automate water management is already a strong advantage. However, with variety of data available within and around the agriculture sector, there are many more opportunities to be seized [Fig. 8].

BENEFITS FOR AGRICULTURE
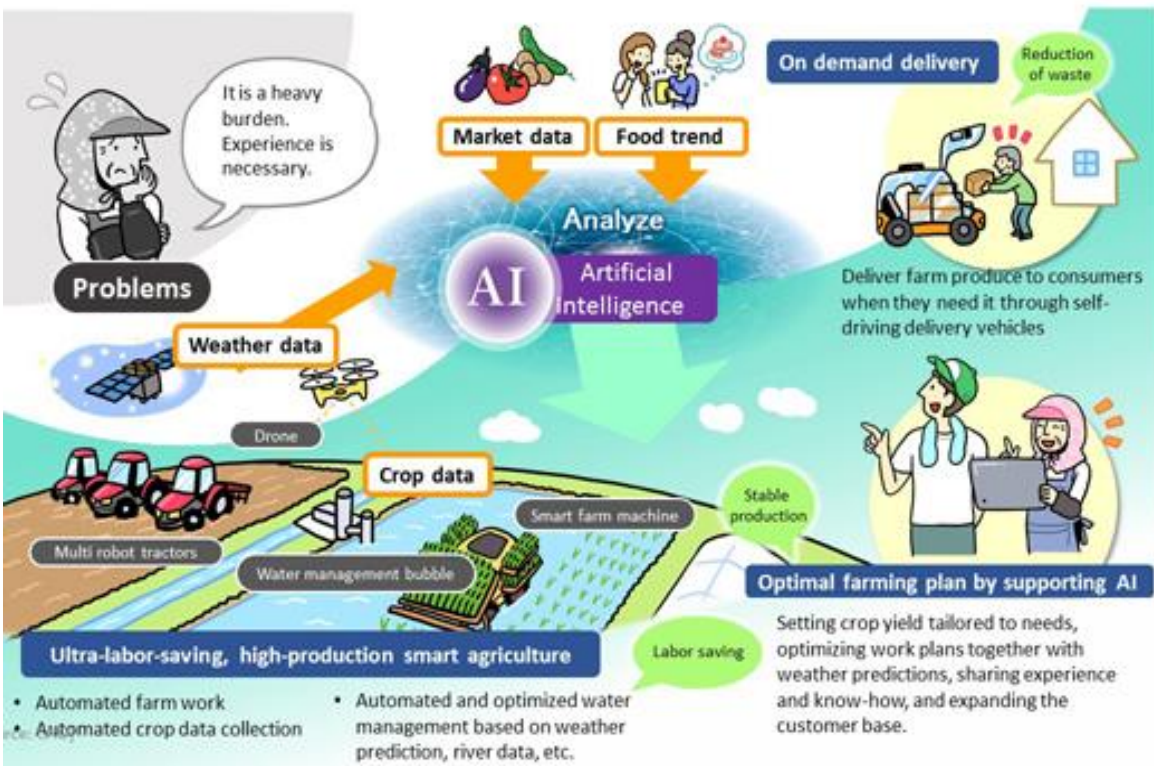
Figure 8. Expected benefits for Agriculture in Society 5.0.

Source: https://www8.cao.go.jp/cstp/english/society5_0/agriculture_e.html

Equipped with information regarding market situation and recent demand, food trends as well as crop growth farmers would be able to optimize their productivity and plans for expected harvests. Additionally, with the use of AI, robots and autonomous vehicles even the smallest and most specific demand for food products could be met in a timely way and required quantity [16].

2.1.6 Disaster prevention

In the event of disaster on of the most vital elements is a fast flow of data and its analysis. Using drones for monitoring areas of disaster and collecting data from sensors in cars, buildings, etc. along with data from satellites, which would be analysed by AI to supply accurate information

required for effective disaster relief distribution and management. It would also make possible for necessary information to be delivered to every individual within the disaster zone via smartphone. Additionally, utilising drones and robots during search and rescue operations would support human teams work, allowing for rescuing and helping more victims even in areas too dangerous or simply unreachable for human rescuers [16].

2.1.7 Energy

Society 5.0 uses AI to analyse big data that includes various information such as weather information, power plant operating conditions, EV charging / discharging, and usage conditions in each home, based on accurate demand forecasts and weather forecasts [Fig. 9].

BENEFITS FOR ENERGY
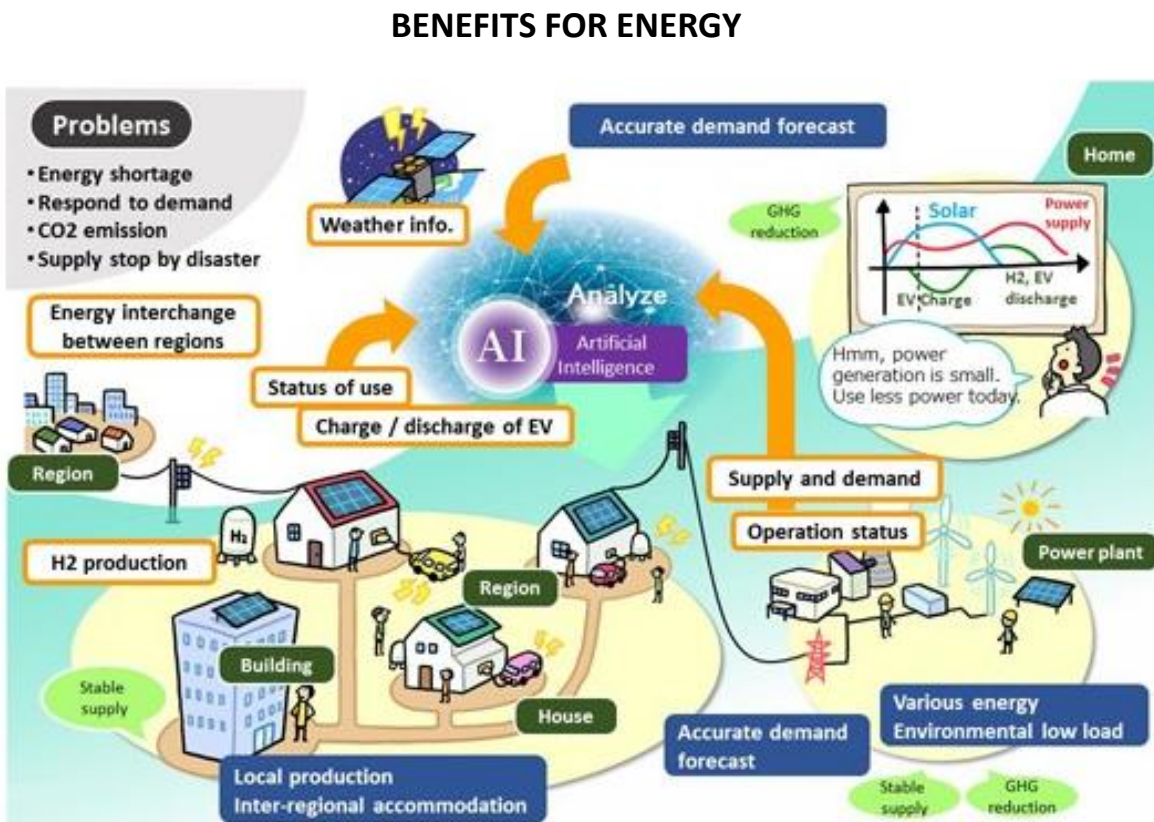
Figure 9. Expected benefits for Energy in Society 5.0.

Source: https://www8.cao.go.jp/cstp/english/society5_0/energy_e.html

Diversifying the sources of energy, utilising hydrogen production and electronic vehicle would facilitate higher savings for individual households and reduce the environmental costs on a societal scale [17].

3. AI Strategy

3.1 AI strategy: overview and main targets

The AI strategy published in June 2019 is a revision of so far policy, developed in response to changing environment both in terms of technology and social issues. The new strategy is a result of multilateral cooperation not only between various ministries and governmental bodies but also business and research/academic stakeholders, brought together to form optimal plan for further development and utilisation of AI as well as sufficient preparedness of its users and beneficiaries.

While strategy itself focuses on reorganisation of education and reforming of R&D system, the proposed modifications are introduced within a wider perspective allowing for presentation of changes and possible results in related areas such as industry and society, government administration, business support or ethics.

The overview of Japan's status quo as the basis for future development of AI related technology does not present an advantageous picture. While the larger goals set for Japan include solving major social issues and making example of a sustainable and diverse society for other countries, achieving that seems rather difficult when Japan lags behind in terms of innovation. It is especially visible with regards to the data aspect of AI, where the top global competitors comprise of mainly American and Chinese companies. While the technology itself has certainly not matured to the saturation point yet and many new fields of application and utilisation haven not been fully exploited, as stated previously Japan still has some catching up to do to reach the leaders, not to mention outrunning them.

The subject of the strategy is defined as "a system that realises intelligent functions" [18, p. 2] and its main purposes are realisation of Society 5.0 as a way of overcoming Japan's social issues and possibly contributing gained experience to resolving global problems and challenges. From the conceptual perspective, the strategy is based on 3 basic principles:

1. <u>Dignity</u> – aiming at creating a society where human dignity is respected

2. <u>Diversity and inclusion</u> – aiming at a society where people with diverse backgrounds can pursue diverse forms of happiness

3. <u>Sustainability</u> – aiming at a sustainable society [18, p. 2,3]

The success of the AI strategy depends not only on developing technology and transforming the society. An important factor influencing the final results would also be promotion of the strategy and dissemination of information regarding targets and required actions. In that regard three main points of interest have been identified by the authors:

1. The industry development is influenced by private sector companies. In order to fully use their potential, it is necessary to establish an effective workflow for introducing new technologies and ensure a well-developed infrastructure for training human resources, R&D promotion and commercialisation support.

2. There are many elements crucial for successful implementation of AI systems, such as: platforms for processing large amounts of data, sufficiently capacious networks, sensors, robots and others.

3. In order for society to accept and properly utilise AI technology it is necessary to ensure its safety both in terms of cybersecurity and ethics as well as appropriate level of skills for its users and beneficiaries [18, p. 3]

The strategy identifies also four main targets that relate to human resources, industrial competitiveness, sustainability and R&D.

Strategic target I.

Continuous development and acquiring of human resources with AI oriented skillset.

Specifically, human resources for pioneering research, practical use of AI in various industries, introduction of AI to SMEs and business transformation by means of AI were indicated. In order to raise the numbers of appropriately skilled resources, two groups of potential workers will be especially important: women and foreigners. Also, to ensure continuity extensive educational reforms are deemed necessary.

Strategic target II

Raising Japan's industrial competitiveness by leading in practical application of AI for real world industries[2].

In order to achieve that goal though, the first requirement would be creation of infrastructure suitable for AI development support, system design and finally also social implementation, which would facilitate the shift of focus to high value added, platform-based industries model.

Strategic target III

Implementing a technology and management system for realising and further functioning of diverse and sustainable society.

In order to ensure inclusion of all groups in the society and allow for a diversity of lifestyles, so that each member of the society could realise his/her own aspirations, a set of social mechanisms and supporting AI related technology is to be developed and introduced into society. Special attention would be given to groups in danger of exclusion: the elderly, women and foreigners. Expanding that goal on a global scale is expected to help other societies and also make a major contribution to achieving SDGs.

Strategic target IV

Leading the development of an AI related international network comprising research, education and social infrastructure, contributing simultaneously to fulfilling the SDGs and nurturing AI educated human resources.

The basic condition underlying this part of the strategy is open cooperation with other countries and communities. Japan alone does not have sufficient means to develop targeted human resources

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[2] Real world industry [実世界産業] is defined as type of industry that brings in material value in reality (as opposed to virtual world). Examples of such industries are: agriculture, manufacturing, logistics, healthcare.

(with regards to both quality and quantity). Only through coordinated effort, exchange of knowledge and experience it will be possible to ensure proper environment for researchers and engineers to strive in this field. The strategy identifies main directions of cooperation as: North America, Europe, ASEAN, India, Middle East and finally Africa [18].

Cooperation between public and private stakeholders

The strategy necessitates a coordinated effort of both public and private sectors in order to fulfil all the set targets. Areas assigned to the public side comprise of actions designed to prepare the basis for effective functioning of the new Society 5.0 model:

- Continuous work on the strategy and related roadmap

- Obliterating institutional or policy related obstacles

- Creating a support network for generating solutions through multilateral cooperation

- Internationally oriented nurturing of human resources

- Cultivation of basic R&D as well as next generation basic research

- Facilitating practical use of AI

- Introducing ethical guidelines

- Establishing a vital node of global network [18, p. 6]

Tasks assigned to private sector cover abiding the rules set for AI development, creating attractive benefits for highly skilled human resources and actively creating opportunities for multilateral cooperation [18].

3.2 Human resources

Development of AI reaches far into the structure of society, transforming not only technology, business but also values and people themselves. Consequently, the new era requires resources capable of using and understanding AI and the newly updated AI Strategy includes a plan to develop such personnel. It is undisputedly a long-term effort which requires coordinated actions on many levels of education – from primary, through secondary and higher up to recurring – the Japanese government is planning dedicated activities on all of them [Fig. 10]. Until 2025 the government, through various initiatives plans to educate almost 1,5 million students on a fundamental literacy level. Among high school, university and college graduates it is expected that some 250000 people per year would acquire basic skills. Finally, as a result of intended reform the number of educated experts is expected to grow by 2000 individuals per year. The group possessing the highest, most sought after skills is estimated to reach 100 people per year [19].

The basis for literacy-oriented reforms targeted at students from primary to high school level comprise not only introduction of basic science and information knowledge, but also problem-oriented analysing and solving skills along with knowledge regarding society. For that purpose, there is planned training for teachers, preparation of appropriate learning environment – including sufficient equipment, network and cloud access, software and communication devices. Also, a cross-disciplinary approach is suggested (STEAM) and creating records of both school and outside projects and activities [18].

The changes for universities, colleges and employment start with introduction of "Information I" subject at schools and later at entrance exams and continue with development of mathematical, data science and AI related skills due to reformed curricula. Emphasis is also placed on transboundary education, inclusion of liberal arts as well as developing analytical and problem-solving skills [18].

MAIN INITIATIVES FOR HUMAN RESOURCE DEVELOPMENT IN THE AI ERA

Training target [2025]

Major Initiatives

Top class development
About 100 people / year

Experts

2,000 people / year

Improving the environment for finding and expanding cutting-edge human resources
Expanding research oportunities for young researchers and overseas collaborations
AI problem solving oriented human resources development

Applied basics

250,000 people / year
(Part of high school,
50% of technical colleges and

Acquisition of AI application skills
Promotion of double major in AI x specialized fields
Human resource development that can solve regional issues with AI (industry-academia collaboration)

Utilization of certification systems and qualifications
Review and promotion in shools of certification programs such as IT passport

Literacy

500,000 people / year
(graduates from universities

Enhancing learning content
University standard curriculum development and deployment (MOOC utilization)
Improvement of training classes that are the foundation of AI in high school

1 million people / year
(high school graduates, elementary

Educational environment in elementary, middle and high schools
Appointment of diverse ICT human resources
Improving the ICT environment in which each student has a terminal

Figure 10. Main initiatives for human resource development in the AI era.

Source: AI 戦略（人材育成関連）, [AI Strategy, (human resource development)]

For the applied basic education, it was determined that certain supporting actions are needed to help students able to reach that level. Specifically, a set curriculum needs to be developed on a national level, introducing accredited courses within the mathematics, data science and AI area. For that purpose, also appropriate teaching materials and sufficiently equipped learning environment need to be readily available. Furthermore, courses in the priority fields should be also available through e-learning and related certification systems made more accessible.

Finally, for fostering the experts in this field various initiatives have been planned: graduate specialised programs, reinforcing and expanding collaboration with overseas (including but not limited to EU, USA, Asia, Australia, Middle East and Africa), facilitating learning at various stages of education and career, providing specialised internship opportunities and actively involving universities, research institutes, business representatives and AI related societies both national and foreign in the whole process.

A significant part of the reform is also the certification system for both educational institutions and individuals. As for the accreditation system, a framework needs to be developed based on so far experience, running programs, good practices from overseas and contributions from multiple stakeholders. In order to provide certifiable qualifications for the individuals, a greater emphasis on AI, problem-based learning, data science courses and related examinations (IT passport) is deemed necessary [18].

3.3 R&D organisation

Nowadays fierce competition can be observed not only with regards to securing or educating human resources, but also in R&D area. Notable examples of leading innovations in R&D can be observed mainly among American and Chinese companies. The authors of AI strategy acknowledge Japan's delay which is clearly visible especially in areas such as big data or computing resources utilisation. One of the more important consequences of that delay are obstacles in effective deployment of AI to vital sectors such as manufacturing or healthcare. While there exist many high-level research centres such as AIP, AIRC, UCRI, NICT or CiNet to name a few, historically, basic, general-purpose and applied types of research were conducted separately, which led to current slowdown. The remedy for this is collaboration between research centres within a network organised around AI-related core centres. Each centre would focus on its own strengths, contributing excellence in particular area to the whole network [18].

Table 1. Summary of research activities.

RESEARCH CENTRE	CURRENT AREA	FUTURE FOCUS
AIP	innovative basic technology, social implementation	innovative basic technology - theoretical research on AI
NICT	natural language processing, multilingual translation, multilingual speech processing, brain cognitive model construction, development of usage environment including accumulated data, and social implementation	interactive technology - natural language processing using large-scale data

| AIRC | social implementation – application of AI in business | construction and application speech processing technologies |

Source: own elaboration based on [18], [20].

After analysing Japan's advantages and strengths two main pillars supporting the process of revitalisation were selected: utilisation of AI in the real world and utilisation of AI for inclusion.

I.   utilisation of AI in the real world – the biggest obstacle is the quality, volume and suitability of data for use. Overcoming this problem requires a solid base in theory, technology as well as development and utilisation models with sufficient infrastructure (sensors, robots, etc.)

II. utilisation of AI for inclusion – indicates a separate technology genre "inclusion technology" which in turn is directly linked to issues such as institutional reform, egovernment and R&D promotion [18].

These two objectives supported by Trusted Quality AI – a technology that holds competitive advantage and at the same time adheres to the model of human-centric AI will shape the next developments in this field [18], [20].

The strategy further supports cultivation of diversity in R&D through setting four main programs:

1. AI basic research (AI Core)

2. R&D for AI application in real world industries

3. AI R&D focused on realising inclusion

4. Wide scope emergent research for generating new values

While the first three programs are designed based on current trends and forecasting with regards to possible direction of technology development, future needs and challenges to be addressed, the fourth program poses a rare chance for a completely free, unlimited by specific requirements or otherwise restrained research conducting. This option is included in hopes of facilitating innovative disruption and possibly honing its potential for creating new, unexpected values [18].

Further actions included in AI strategy 2019 are summarised in six general objectives:

I. creating a complete model for R&D from basic research to the social utilisation of its results

II. achieving top position through developing competitive AI technology and thus shaping international standards

III. consolidation of AI core research and thus AI R&D network in order to create an internationally appealing research environment

IV. achieving diverse and sustainable development through reinforcement of emergent, basic and integrated R&D

V. facilitating freedom and creativity in research as well as utilising highly skilled specialists in order to achieve top position globally

VI. facilitating accumulation of knowledge on a global level by actively promoting research [18]

In line with the above, the strategy indicates specific milestones to be achieved. With regards to research environment there are two points of focus: core research network and emergent research.

Table 2. Establishment of R&D structure.

		Timeframe	Bodies responsible
I. Core research network			
1. Reinforcement and restructuring of AI core centres			
	Integration of content and operations of AIP, AIRC and NICT in order to carry out the tasks	2019	CSTI, MIC, MEXT, METI

	set out in the strategy, supervised by AI strategy Execution Council.		
	Reinforcement of management system at AIP, AIRC and NICT (research teams, recruitment promotion)	2020	CSTI, MIC, MEXT, METI
2. Creation of AI R&D network through combined efforts and knowledge of highly skilled Japanese experts (AI researchers, implementation engineers, basic mathematics and information science researchers)			
	Organising AI core centres, universities and other research centres into the AI R&D Network	2019	CSTI, MIC, MHLW, MAFF, MEXT, METI, MLIT
	Defining the role of AI core centres within the network	2019	CSTI, MIC, MEXT, METI
	Initialising cooperation with industry at AIST	2019	METI
	Launching the following initiatives: • Incorporation of major research institutes, organisations and universities into the AI R&D Network (e.g. JST, NEDO) • Facilitation of free flow of information and researchers between various participating institutions	2019 2019	CSTI, MIC, MHLW, MAFF, MEXT, METI, MLIT

	• Showcasing case studies of AI R&D implementation	2020	
	• Acquisition of members from abroad	2020	
	• Stimulation of human resources' mobility and cooperation	2020	

3. Establishing R&D environment that attracts researchers around the world

	Introduction of research, work and life related benefits for attracting overseas professionals, e.g.: sabbatical, rewards, communication facilitation, etc.	2019	MEXT, METI
	Encouraging private investments in AI R&D	2019	MIC, MEXT, METI
	Determining obstacles (IP protection, administrative procedures) and ways of resolving them	2019	CSTI, CAO, MIC, MEXT, METI
	Reinforcement of R&D bordering on social implementation	2019	CSTI, MIC, MHLW, MAFF, MEXT, METI, MLIT
	Employing testbeds to simulate real world environment	2019	METI
	Supporting collaboration with other countries both in terms of research and funding	2020	MIC, MEXT, MAFF, METI

	Providing research related information in English	2020	MEXT, CAS, MAFF, METI
	Facilitation of free, creative research (emergent research)	2020	MIC, MEXT, METI
	Boosting computational resources (like ABCI), formulation of data related strategies designed to elevate Japan's competitiveness	2020	MIC, MEXT, METI
	Working out rules for utilising private sector resources and networks	2020	MIC, MEXT, METI
	Encouraging international dissemination and standardisation of AI R&D	2020	MIC, MEXT, MAFF, METI
	Making high speed research networks (like SINET) available for multiple AI R&D related stakeholders	2022	MIC, MEXT

II.   Emerging research

1. **Acquisition of highly skilled professionals**
2. **Facilitating ground-breaking research**
3. **Diversification of human resources**

	Supporting researchers' mobility and exchange, attracting overseas specialists to Japan,	2019	MIC, MEXT, METI
	Prioritising ground-breaking research conducted by young professionals	2019	MIC, MEXT, METI

	Supporting research related collaboration with America, Europe, Australia, Asia and Africa	2019	MIC, MOFA, MEXT, MAFF, METI
	Establishing research environment supportive of continuous innovative research that challenges so far boundaries	2020	MIC, MEXT, METI
	Adjust research programs to meet the requirements of research personnel diversification	2020	MIC, MEXT, METI
	Inclusion of JST and other national agencies in global expansion of AI R&D	2021	MIC, MEXT, MAFF, METI

Source: own elaboration based on [18], [20], own translation.

With regards to the second part of research related actions included in the AI strategy 2019, it is focused around core research program. The AI Core research itself is divided into four main aspects [Fig. 11]:

1. "Basic Theories and Technologies of AI

2. Device and Architecture for AI

3. Trusted Quality AI

4. System Components of AI" [18, p. 27]

So far the main task for carrying out the AI core research objective successfully is working out a development schedule, to be updated each year starting from 2019. The bodies responsible include MIC, MEXT and METI.

AI R&D MODEL
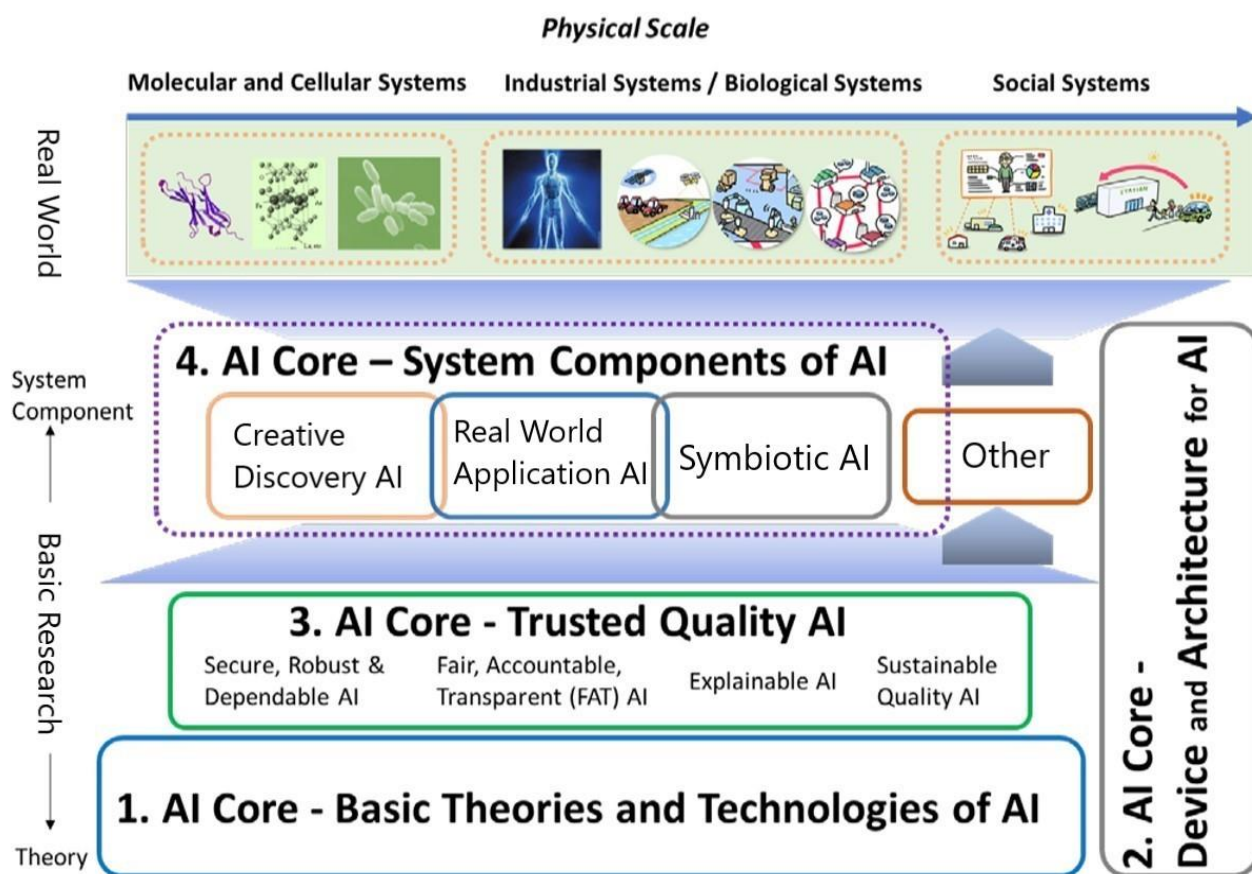
Figure 11. AI R&D model.

Source: ＡＩ戦略 2019: 人・産業・地域・政府全てにＡＩ [AI strategy 2019: AI for all people, industry, region and government]

3.4 Data Infrastructure

Data is undoubtedly the most crucial part of AI development and as such has been a target of various government actions following the recommendations included in the AI Strategy 2019. The main challenges related to data involve its usability and quality as well as security. Not all types of data can be used for AI development, therefore it is especially important to secure appropriate quality (along with quantity). Also, as data becomes more and more valuable in the AI era, it is susceptible to various risks that on the one hand could threaten its privacy and on the other could result in damage or rendering it unusable. Quite another type of challenge is establishment of trust with regards to data and a sufficient degree of verification. In this particular area Japanese policymakers are following closely solutions being introduced in US and EU. Finally, to make better use of various sources of data, the authors of the strategy are also recommending a closer cooperation between public and private sector in order to facilitate integration and even some level of standardisation, while simultaneously avoiding the danger of possible bias in source material and thus in AI solutions as well [18].

The overarching goal in this area would be the next-generation AI data infrastructure developed with the support of international collaboration. With regards to data gathering a collaboration framework in five priority areas (health, medicine and nursing; agriculture; regional strengthening; transportation and logistics) is to be deployed, complete with safety and quality check mechanisms. Prior tasks comprise reviewing the data systems in various ministerial projects with the goal of interoperability, establishing system necessary for handling big data (especially with regards to sources like agriculture, medicine, energy, disaster prevention, environment and manufacturing), ensuring sufficient network operability for big data and risk and bias detection mechanisms [Fig 12].

DATA LINKAGE INFRASTRUCTURE
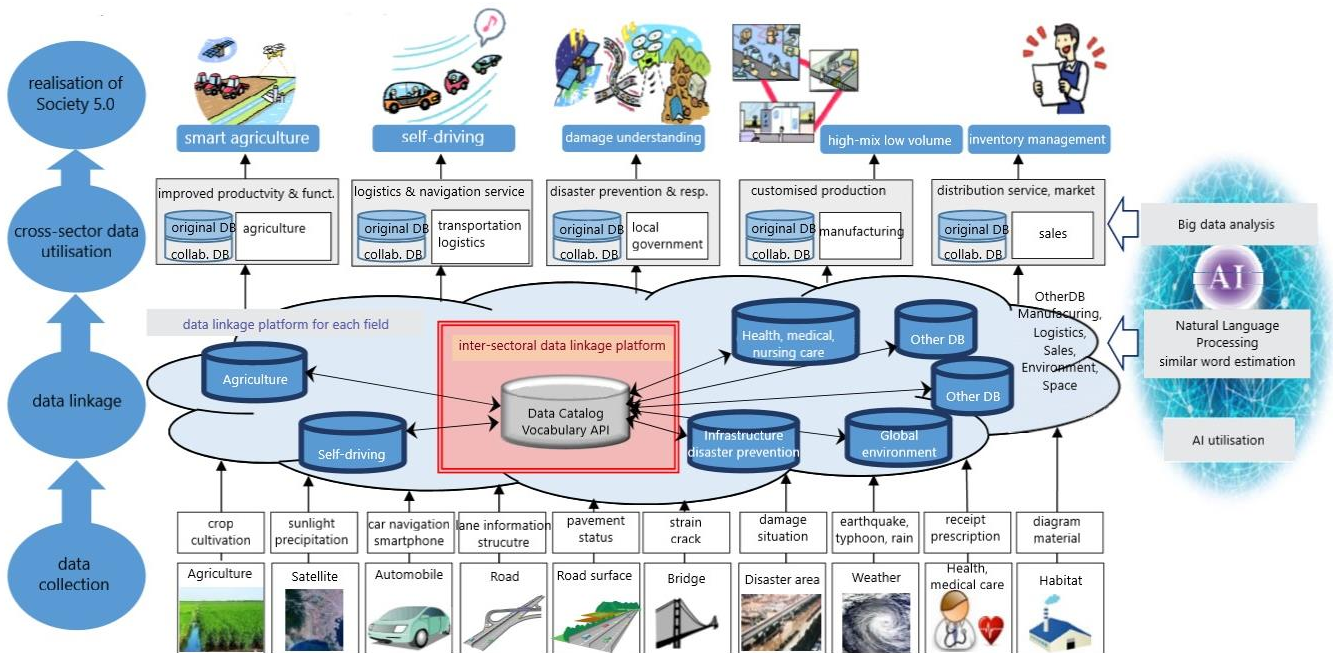
Figure 12. Data linkage infrastructure: data linkage to realize Society 5.0.

Source: [21], own translation

Trust and security targets are constructed around international cooperation and circulation of data with partners such as USA or EU. With that goal in mind, under the Cyber Physical Security Framework a set of security guidelines for specific industries as well as connections reliability and safety inspection tools are to be developed. With the objective to actively contribute to setting the international standards a proposal regarding data quality and AI lifecycle and quality is to be formulated. The other part of trust and security measures is focused around countering and possibly even preventing inevitable cyber-attacks. In order to develop defence technology utilising AI certain areas of R&D are suggested as preferential: "AI for prevention, AI for detection and AI for coping" [18, p.46-47]. Also, in the long-term perspective it is deemed necessary to come up with AI self-defence solutions.

Finally, with regards to infrastructure, further efforts on deployment of 5G and optical fibre are required, including dedicated 5G base stations guidelines. Moreover, in an effort to ensure equal level of safety and reliability of network in the whole country, flexible network control planning and AI network integration platform research is to be promoted [18].

Japan's efforts regarding free circulation of data are not limited to domestic market only, as from January 2019 a free data flow between Japan and EU has been launched. Beyond EU, Japan has been actively promoting creating such free data flows on a wider scale, however, while the initiative has been endorsed in the statement from Ministers Meeting on Trade and Digital Economy in Tsukuba, there still seems to be no agreement on the specific arrangements [22], [23].

3.5 SMEs support

The main goal in this area is focused around improving productivity and growth through developing data infrastructure and utilising AI. Specific support with dedicated funding is also to be given to AI related start-ups.

The authors of the strategy identify low productivity as one of the biggest problems for SMEs to overcome, indicating AI as a possible solution in the wider perspective of Digital Transformation. However, in order to fully utilise AI potential a certain level of skills is required. Therefore, the first general recommendation is for the SMEs to boost the AI related competences. Secondly, since AI offers plethora of various possibilities and uses, there should be conducted an analysis of needs that would allow to tailor the AI technology solution to specific circumstances of each company. The approach outlined in the strategy relies on creating a new type of service – a problem-solving AI human resource development business. First developed as a ministerial project (AI Quest – see Fig. 13) could in the future become a whole new type of service offered by private companies or universities, helping to identify and solve management problems through various uses of AI [18], [24]. [25].

AI Quest is a program run under the auspices of NEDO and METI and operated by Boston Consulting Group, SIGNATE and zero one.

It is described as a Problem-based Learning experiment conducted within the NEDO project "Collaborative area data sharing / AI system development promotion business for Connected Industries / AI Quest"

The experiment aims to provide trained human resources capable of solving corporate problems by means of AI and data. The learning program emphasises practical application aspects of targeted skills, opting for using case studies and real-life company problems.

Figure 13. New type of service: AI Quest - Problem-based learning experiment

Source: own elaboration based on: https://lp.signate.jp/ai-quest/; https://www.bcg.com/ja-jp/d/press/25september2019-BCG-AI-Quest-PBL-Program-230394

3.6 Industrialisation Roadmap

The approach to AI in Japan from the very beginning has been focused on its practical application. The potential to generate new value by AI technology does not come solely from the technical possibilities it offers, but also from its versatility. AI can be applied to any part of industry or economy and the solutions and tools it offers could be found useful in almost any aspect of our lives. Well aware of that fact, Japanese policymakers began to include that perspective in prepared

strategies and recommendations and made efforts to plan its entry into various aspects of society. With focus on resolving social problems and utilising the potential of AI and related technologies to generate more and new kinds of value and thus strengthening Japan's position among global competitors – an Industrialisation Roadmap has been created [Fig. 14].

AI DEVELOPMENT PHASES
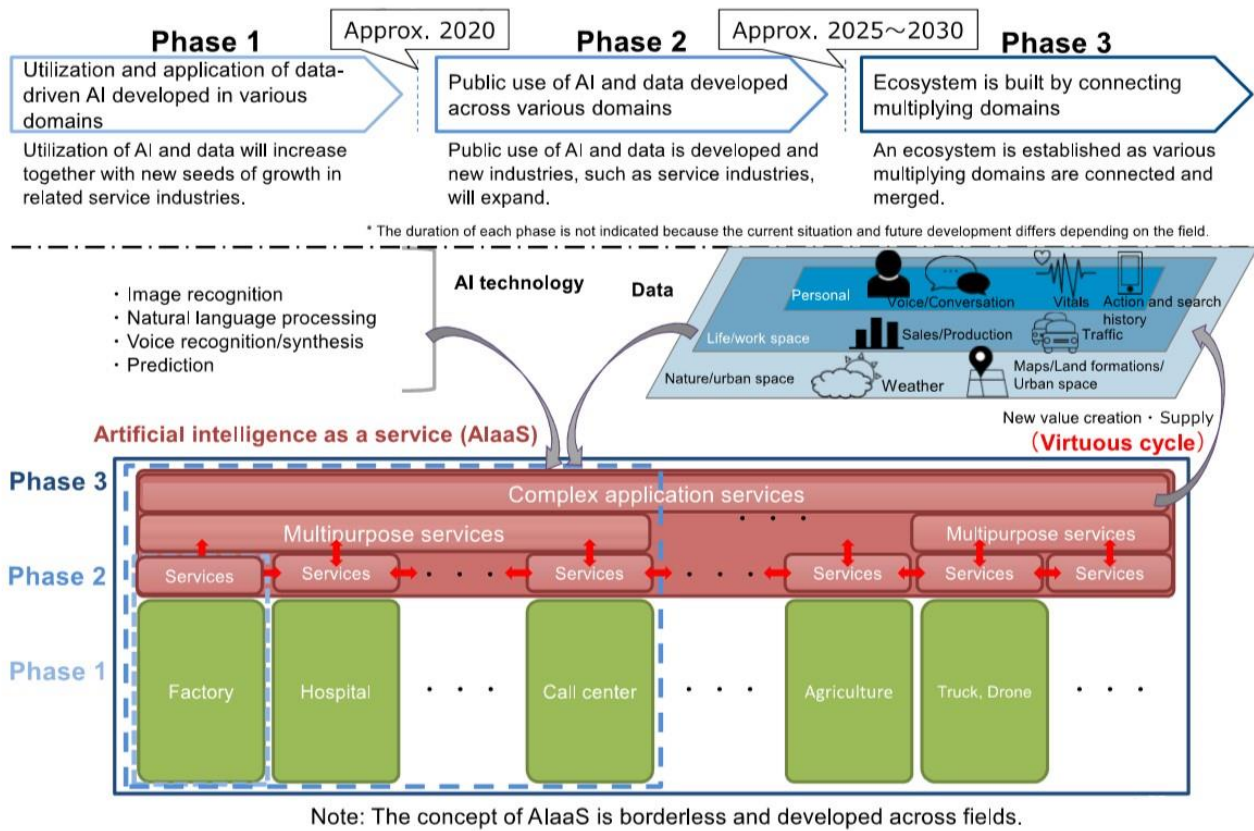
Figure 14. Industrialisation Roadmap: AI development phases.

Source: Artificial Intelligence Technology Strategy (Report of Strategic Council for AI Technology) 2017

Taking into consideration the urgency of existing problems and possible benefits through economic ripple effect four areas have been selected as priority fields: productivity, health and welfare, mobility and information security [26].

The Industrialisation Roadmap has been created from the perspective of AIaaS (AI as a Service), forecasting the entry of AI service into various domains as long as appropriate data would be available. According to the devised scheme, the industrialisation would unfold across three phases:

"Phase 1: Utilization and application of data-driven AI developed in various domains

Phase 2: Public use of AI and data developed across various domains

Phase 3: Ecosystem built by connecting multiplying domains" [26, p.4].

When the roadmap was created in 2017 it was forecasted, that new opportunities for development created in phase 1 would start to transform or open ways for new industries and services around 2020 – which certainly seems to be taking place, though perhaps not at a scale that is was previously hoped for. The common use of data and new developments in business would further facilitate transition to phase 3 around 2030, with an emerging ecosystem of interconnected domains and established virtuous circle of data circulation. Still, it is worth mentioning, that the roadmap has been planned out based on predictions regarding technology development and including other factors (social, industrial, policy-related, etc.) might lengthen the projected timeframe [26].

4. Robot Strategy

The historical first meeting of Robot Revolution Realisation Council was held By Prime Minister Abe in September 2014. While Japan has been long considered a robot powerhouse, a number of issues has emerged to threaten its top position, with China surpassing Japan in the number of robots introduced to industry in 2013 as a tipping point [Fig. 15].

ANNUAL NUMBER OF INDUSTRIAL ROBOTS 1997 – 2014
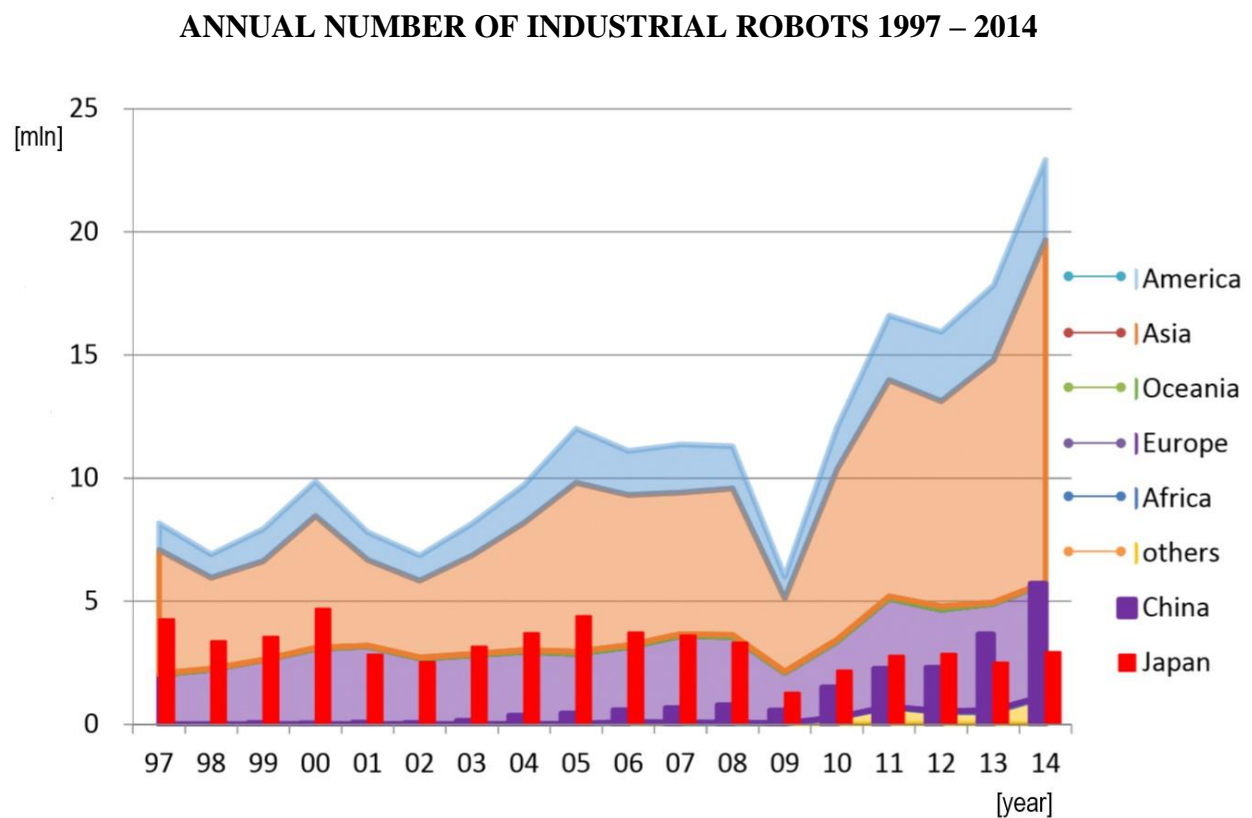
Figure 15. Annual number of industrial robots 1997 – 2014.

Source: https://www.kansai.meti.go.jp/E_Kansai/page/201603/img/01_02.pdf

China's Manufacturing Equipment Industry Development Plan launched in 2012 seemed to be bringing positive results and as other countries began introducing their own robot development agendas, Japanese government began working on a new strategy in this field as well. The final shape of Robot Strategy was announced in February 2015, presenting a plan for Robot Revolution mapped out for the next five years [27], [28].

While in media most publicised cases of robot development in Japan still are the ones involving humanoid robots, the strategy has in fact a very wide scope for the term. METI, following a Robot Policy Study Group Report from May 2006, considers a robot an intelligent machine system containing the following three technologies:

- Sensors

- Intelligent/control system

- Drive system [30]

Therefore, robots covered by the New Robot Strategy comprise a variety of machines from welding and assembly robots, through disaster response and rescue robots, surgical and nursing support robots, unmanned tractors and rice transplanters as well as assist suits.

EXAMPLES OF ROBOTS TARGETED BY JAPAN'S NEW ROBOT STRATEGY:

Figure 17 Double-armed multi-functional robot (image courtesy of Glory - nextgen industrial robot NEXTAGE)

Figure 16 Transfer assistance robot (wearable type)

Figure 18 Transfer assistance robot (non-wearable type)

Figure 19 Mobility support robot
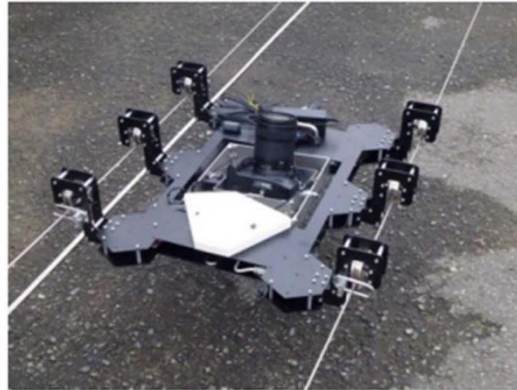
Figure 20 Infrastructure inspection robots

Figure 21 Disaster response robot

Figure 22 Unmanned construction robots

Source: https://www.kansai.meti.go.jp/E_Kansai/page/201603/01.html

The main points forming the foundation of the Robot Revolution include the changing circumstances due to technology development in which many elements of everyday use such as cars or home equipment have been converted to robots by incorporating technology such as sensors or AI. Another important point is the transition of utilisation of robots from manufacturing into everyday life. The final point is the new form of emerging society that simultaneously solves challenges that await Japan (e.g. aging society, labour shortage) and generates new value strengthening Japan's international competitiveness. On that basis three pillars have been identified for the New Robot strategy:

1. **Japan as the future world innovation hub**

In order to achieve that target it will be necessary to build an innovation-inducive environment, strengthened by frequent exchanges between users and manufacturers, public-private partnerships as well as actions in the field of normalisation and standardisation.

2. **Japan as the future world's most advanced robotic society**

Determined actions are required to fully utilise robots in a variety of sectors (manufacturing, nursing, services, infrastructure, agriculture etc.) both by major players and SMEs, while maintaining sustainability and environmental orientation [Fig. 23].

3. **Japan as the strategy leader in new robot era**

With the advancement of IoT and big data the accumulation and utilisation of the latter will be a source of added value. Thus, it will be vital to harness the potential of data as an additional advantage in international competition while maintaining the security and safety as well as advances in standardisation [29], [30], [31].

JAPAN'S ROBOT STRATEGY AT A GLANCE

Manufacturing/Service

• Select best 100 practices related to use of robots in the service field

• Develop and increase sophistication of brain (AI), eyes (sensors) and fingers (control) of robots

• Improve labor productivity by 2% or more, and strengthen competitiveness of domestic locations

• Expand market scale of system integrator (SIer) projects

Infrastructure/Disaster response/Construction

• Utilize intelligent construction technology for 30% which contributes to improvement of productivity and saving labor

• Introduce robots to 20% of inspection and repair of critical/aging infrastructure

• Achieve for unmanned construction efficiency comparable with manned construction in harsh environment such as all sorts of disaster sites, landslides, and volcanic hazardous sites.

Nursing and Medical Care

• Reduce and eliminate any risks of care workers to cause backaches and the like due to heavy workload such as transferring elderly with arms. Support to allieviate care worker's heavy workload

• System reform for nursing care insurance. More flexile nursing care insurance system to reflect needs of introducing new types of devices and robotics to eldery care,

• Expand the number of cases to 100 or more where robot support medical care

Agriculture

• Achieve implementation of automatic driving tractors to actual cultivation by 2020

• Introduce 20 or more types of new robots of which contribute to labor savings

Regulation Reform

Towards realization of a "robot barrier-free society": revise 10 relevant regulations in cooperation with Regulatory Reform Council (Prepare and set rules on radio waves which are used for robots, robotization of visual inspections (infrastructure safety and security), provide rules related to airborne robots, and so forth)

Infrastructure Improvement

Enhance development of human resources for system integrators (Implementation of on-the-job training (OJT) through demonstration projects, and so forth)

Figure 23 Japan's Robot Strategy at a glance

Source: [29]

In line with abovementioned pillars and objectives, government created initiatives to stimulate financial, technological and creative aspects of Robot Revolution. From the financial perspective it was deemed benefitable to increase investment in robot development projects by both government and private sector, with targeted value of 100 billion yen, which in turn could contribute to increasing the robot market from 650 billion yen up to 2,4 trillion yen p.a. Additional value could be obtained by finding a way to reduce robot introduction costs by 20%. To facilitate creativity and technology development the government will make available a test site with proposed location in Fukushima. Also, to promote Japan's achievements and facilitate circulation of knowledge and ideas Japan would organise a World Robot Summit – part contest, part exhibition and part conference [28].

4.1 Manufacturing

Japanese manufacturing is one of the sectors most populated by robots in the industry. However, while robots have been successfully introduced in many instances, the high percentage is mainly due to the contribution of major players, especially in automobile, electrical and electronic industries. The other fields, especially the food, cosmetic and pharmaceutical industries are not making much progress in robot utilisation and as such garnered special attention in the Robot Strategy. The first step is to make use of robots' better suitability in terms of strict hygiene requirements in these three specific industries. Also, in food industry robots could substitute a plethora of temporary jobs in simple processes such as boxed lunches production. According to the Strategy, in cosmetics and pharmaceutical industries the initial application of robots would as well be mainly connected to raising the labour productivity, while maintaining the cost-effectiveness. Moreover, special incentives are also needed to increase the participation of robots in manufacturing among the SMEs [28].

The desired outcome for manufacturing sector would be increasing the labour productivity by at least 2% mentioned above, along with raising the participation of robots in the assembly processes

(25% for large companies and 10% for SMEs), better distribution and circulation of knowledge regarding unique uses of robots in manufacturing (gathering at least 30 cases to publicise).

Examples of actions to be undertaken [Fig.24]:

- technical development project for commercial application utilizing robots – led by METI and targeted at both manufacturing and service sectors, focusing on development of specific functions that answer most popular needs of users as well as training of appropriately skilled human resources

MANUFACTURING

Perspective	Fiscal 2015*	Fiscal 2016	Fiscal 2017	Fiscal 2018	Fiscal 2019
(1) Supporting Robot development	Projects to develop technology for creating market that put robots to best use				
	Technological development in priority areas that meets users' needs				
		As development is completed, technology is put to use for demonstration			
(2) Encouraging users to introduce robots — (Giving incentives)	Encouraging use of robots where currently unutilized				
		Facilitating introduction of interoperable hardware through active system integration			
(improving environment)	Expanding system-integration market through introduction of robots				
	Setting up Robot Revolution Initiative Council	Matching users' needs and robot "seeds"			

Figure 24 Schedule of planned developments in manufacturing (New Robot Strategy).

Source: New Robot Strategy 2015, p. 88

- project for the verification of the effectiveness of the introduction of robots – led by METI, oriented at identifying and measuring the impact of robot introduction in productivity and cost aspects

56

- <u>Robot Revolution Initiative</u> – a multi-stakeholder platform, connecting industry, government and academia in order to cooperate, exchange ideas, information and best practices, overseeing security issues and coordinating education of human resources and finally strengthening international cooperation and promotion [29].

4.2 Construction, infrastructure and disaster response

One of the main challenges which the construction field is facing is shortage of labour – both in terms of general employment, but also with regards to highly skilled engineers, who are necessary to continue delivery of quality outcomes. One of the possible incentives attracting workers into construction field would be improving the working environment, especially its safety and possibly limiting the most difficult tasks carried out by human workers [28], [29].

Japan's infrastructure is also facing problems, with progressing deterioration raising maintenance costs and outflow of qualified workers that could perform the much-needed inspections, diagnostics and renovation.

Also, on the disaster response and recovery front it is essential to try and decrease the time needed for appropriate reaction both for avoiding further damage and restoring the previous functionality. The solutions proposed in The New Robot Strategy to the issues described above include wide introduction and utilisation of robots in construction, especially in the form of computer-aided construction technology, which could not only make working conditions less dangerous but also aid training and gaining high level of skills by entry-level workers, thus attracting the missing labour [Fig. 25].

CONSTRUCTION, INFRASTRUCTURE AND DISASTER RESPONSE

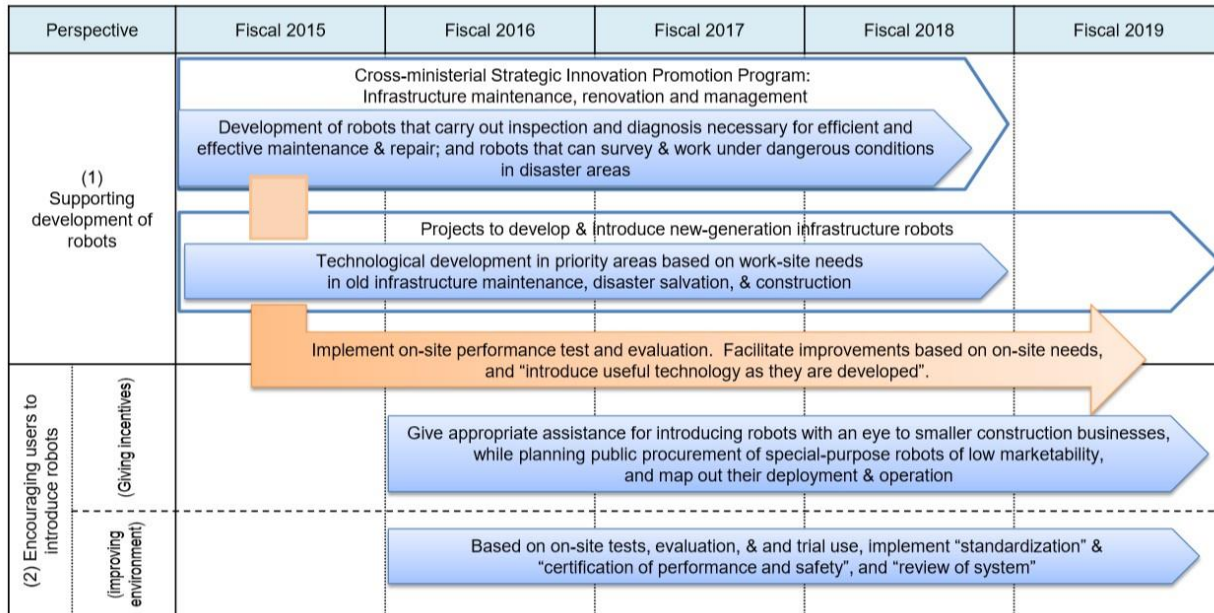| Perspective	Fiscal 2015	Fiscal 2016	Fiscal 2017	Fiscal 2018	Fiscal 2019
(1) Supporting development of robots	Cross-ministerial Strategic Innovation Promotion Program: Infrastructure maintenance, renovation and management				
	Development of robots that carry out inspection and diagnosis necessary for efficient and effective maintenance & repair; and robots that can survey & work under dangerous conditions in disaster areas				
		Projects to develop & introduce new-generation infrastructure robots			
	Technological development in priority areas based on work-site needs in old infrastructure maintenance, disaster salvation, & construction				
	Implement on-site performance test and evaluation. Facilitate improvements based on on-site needs, and "introduce useful technology as they are developed".				
(2) Encouraging users to introduce robots / (Giving incentives)		Give appropriate assistance for introducing robots with an eye to smaller construction businesses, while planning public procurement of special-purpose robots of low marketability, and map out their deployment & operation			
(2) Encouraging users to introduce robots / (Improving environment)		Based on on-site tests, evaluation, & and trial use, implement "standardization" & "certification of performance and safety", and "review of system"			

Figure 25 Schedule of planned developments in construction, infrastructure and disaster response (New Robot Strategy).

Source: [28]

The target set in the strategy indicates 30% introduction rate of computer-aided construction technology. As for the infrastructure, the plan is to use robots, sensors and related technology for the inspection and maintenance of up to 20% of the domestic infrastructure. With regards to disaster response, the use of robots would mainly focus around inspection and condition assessment as well as initial recovery, in the environment that would still be too dangerous for regular human resources. In order to successfully implement the above solutions, the strategy authors propose threefold action. First, in order to effectively support the development of technology targeted specifically for areas with greatest needs there would be established a support framework, along with revised and more attractive incentives for the developers. Second, facilitation of robot introduction requires opportunity to assess its functioning on actual site by users, but also by the developers. In order to advance the process, MLIT will actively participate, showcasing technology adoption in its selected construction projects. Additional assistance is also

planned for SMEs, in order to raise the robot introduction in this group. Final action is targeted at ensuring the ease of communication between adopted devices and their interoperability. For that, there is planned encouragement for standardisation as well as a certification system for robot operations with specific emphasis on safety [29].

The New Robot Strategy, apart from specific measures tailored for selected industries contains also general guidelines for the next five years. Besides the usual emphasis on human resources development and the Robot Revolution Initiative mentioned above, the set covers also technology development, standardisation, field-testing, possible Robot Regulatory Reform and robot related contests and awards.

The technology development guidelines were prepared with outlook far into the future, when robots would truly surpass human beings. However, even if some elements of technology would develop faster than others, for Japan to actually maintain the leading position in the world it would be necessary to master all aspects of robotics, so that Japanese robots would truly excel and fully use their potential. Therefore, special emphasis should be applied to development of AI, sensors, control elements, appropriate software and security related elements:

- with regards to AI there are indicated certain challenges, e.g.: natural flow of conversation, deduction from hidden meanings and even reacting to unexpected, free and flexible movements adjusting naturally to surroundings and situation, finally mirroring human thinking and reflex processes.

- For sensors and recognition related technology the main problems are related to extracting necessary information in difficult environment, such as recognising voice and emotion in noisy surroundings, recognising unclear, partially hidden objects and improving recognition by touch or smell.

- Control and drive elements field struggles with free, flexible movement and manipulation of complicated objects without prior preparation

- Software interoperability and a certain degree of standardisation would ensure easy communication and cooperation between different robots in various situations

- Safety and security measures need more research and testing as well as risk and accident prediction mechanisms and also acceptance from the society [28].

As an example of effective use of innovative technology, a DARPA operating model has been suggested.

4.3 Standardisation and modularisation

Plans set out for standardisation of robotics are designed for both long term and global scope. Fulfilling them would allow Japan not only the develop a dynamic internal market, but also provide it with a significant advantage in the global competition.

- Modularisation of hardware and software – is a way to both make robots more widely used and thus popular and also decrease the costs of their production. While currently robots are mostly still specialised devices with specific range of functionality and objectives, the costs of production are quite high and applicability limited to initial purpose. However, building robots that share certain parts both in terms of hardware and software would significantly lower the costs and make it easier to either produce/acquire new units or simply assemble/rearrange used ones. Not to mention greater capacity for cooperation between different robots and new ways of utilising their potential.

- In order for modularisation to be effective globally, a strategic approach to standardisation is required from the earliest stages of R&D. On the example of Europe, the authors of the strategy indicate, that incorporating efforts at contributing to international standards from the concept stage provides a strong position among global players in terms of business but also R&D.

- Use of platforms (e.g. cloud services) is also recommended as a means to gain access to and analyse big data, which in turn provides valuable information necessary for improving business strategy or offered services/products.

Moreover, a close cooperation with EU is advised in order dispose of obstacles to cooperation in the field of robotics between these entities, specifically: to clarify rules for obtaining CE marking

for devices produced in Japan, as well as for working out clear guidelines on differentiating between machine and medical device.

4.4 Robot Test Sites

The importance of field testing is also included in the guidelines collected in the strategy. In order to create truly world leading robots field testing is deemed necessary not only to detect possible malfunctions, but to test, improve and possibly accelerate achieving the end goal - the robot's practical application. In Japan a number of test sites has already been made available:

1.   **Next generation infrastructure robots test site**

Test field is supervised by MLIT and facilitates testing in five designated priority areas: bridges, tunnels, dams/rivers for maintenance related testing, disaster inspection and disaster recovery [Fig. 26].

NEXT GENERATION INFRASTRUCTURE ROBOTS TEST SITE

Figure 26 Next generation infrastructure robots test site, operated by MLIT

Source: https://www.c-robotech.info/

2. Sagami Robotics Industry Special Zone

Sagami test site offers product verification by actual users from automated driving, through robot lead exercises at nursing facility to utilising remote-operated robot's controlling construction machines. The site also conducts extensive promotional activities, which helps gain exposure for products that are being tested there as well [Fig. 27].
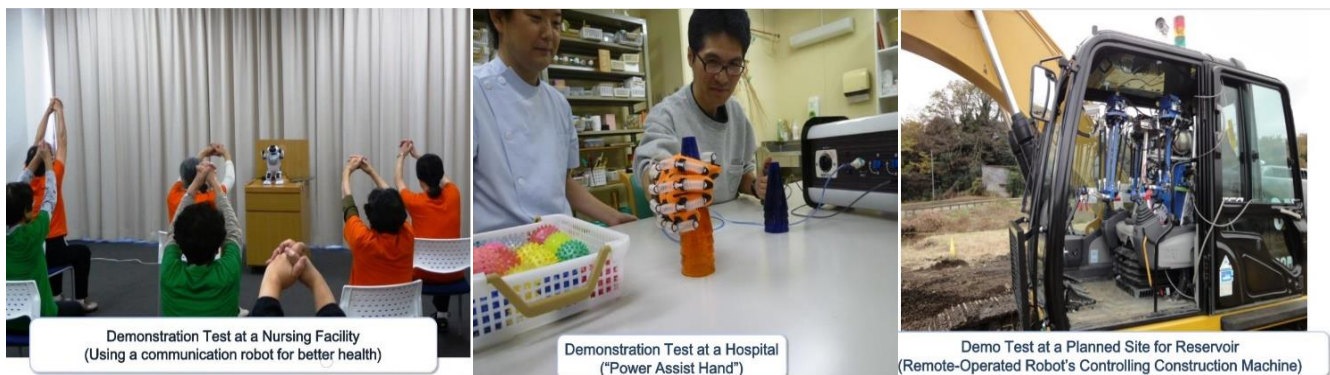
SAGAMI ROBOTICS INDUSTRY SPECIAL ZONE

Figure 27. Sagami Robotics Industry Special Zone in Kanagawa

Source: https://sagamirobot.pref.kanagawa.jp/pdf/Our_Initiative_for_Sagami_Robotics_Industry_Special_Zone.pdf

3. Hyogo Prefectural Emergency Management and Training Centre

The Centre provides disaster related training for professional personnel and citizen education. It is also a disaster centre when necessary. Additionally, the facility conducts also robots testing in the field of disaster response and recovery [Fig. 28].

HYOGO PREFECTURAL EMERGENCY MANAGEMENT AND TRAINING CENTRE

Figure 28. Hyogo Prefectural Emergency Management and Training Center.

Source: https://www.fire-ac-hyogo.jp/

4. Safety Testing Centre for Life Supporting Robots

The test site is located in Tsukuba city. Its special feature is providing testing in accordance with ISO norms in areas such as interacting with humans, EMC, resilience, etc. At the time the Robot Strategy was published already several robots have been granted ISO13482 after being tested at that facility [Fig. 29].

Figure 29. Safety Testing Center for Life Supporting Robots in Tsukuba.

Source: https://www.aist.go.jp/aist_j/news/pr20140205.html

5. Fukushima Robot Test Field

Fukushima RTF is a new addition to robot testing and demonstration areas. While still under development, part of the facility has been opened in August 2018. In its final shape, the RTF will be offering delivery, disaster response and infrastructure inspection testing in onshore, aerial and undersea settings [Fig. 30]. Important part of the facility is the Development Base with state of the art equipment for in depth testing, research, performance assessments, development and even pilot training [29], [32].

FUKUSHIMA ROBOT TEST FIELD FACILITIES

Figure 30. Fukushima Robot Test Field and its facilities.

Source: [29]

The first part of the RTF to be opened was a communications tower allowing for flight control, in-flight monitoring and communication: long-range and inter-drone as well as weather observation. The Fukushima RTF is also scheduled to host Infrastructure and Disaster Response part of the World Robot Summit Challenge [32] [33].

The plans for further development of robot test sites described in the Robot Strategy emphasize the necessity of opening to and collaborating with overseas test sites. Also, additional efforts are recommended to utilise the status of special zones for unrestrained testing options of new robot technology. Finally, the test sites should actively encourage interactions with local public but also allow private sector and possibly international access.

4.4 Review of existing regulations

The new Robot Strategy includes also plans for updating laws and regulations allowing for more open but at the same time safer and more secure environment for robots. In the period up to year 2020 the following changes are indicated:

1. "Deregulation and establishment of new legal system and utilization environment to effectively utilize robots

   a. Establishment of new radio wave utilization system that supports robot utilization

   b. The Act on Securing Quality, Efficacy and Safety of Pharmaceuticals, Medical Devices, Regenerative and Cellular Therapy Products, Gene Therapy Products, 43 and Cosmetics

   c. Long-term care insurance system

   d. Road Traffic Act and Road Transport Vehicle Act

   e. Laws and regulations related to uninhabited airborne type robots (Aviation Law and the like)

   f. Laws and regulations related to public infrastructure maintenance and repair

   g. High Pressure Gas Safety Act

2. Establishment of framework required from the viewpoint of consumer protection

   a. Consumer Product Safety Act, Electric Appliance and Material Safety Act" [28, p. 42-45].

4.5 World Robot Summit

Part of the New Robot strategy is also devoted to initiatives facilitating and appreciating the creativity and innovations, namely the Robot Award and Robot Olympics. Initially planned as separate initiatives in later years the two merged into World Robot Summit. The Summit's tagline is "Robotics for Happiness", since the organisers – METI and NEDO - ultimately, through this event and all related efforts aim for the ideal state which has "humans co-existing with robots and experiencing unprecedented prosperity" [34, p.10]. That idea translated into smaller goals covers:

> ➢ Intensification and stimulation of robot related R&D

> ➢ Realising robot utilisation in real world, in everyday life both in societal and industrial aspects

> ➢ Achieving functioning of humans and robots side by side

In order to achieve those targets, the WRS organisers mapped out a dedicated approach, namely to combine both a competition (World Robot Challenge) and showcase (World Robot Exhibition). This would facilitate valuable exchange between robot innovators from around the world, circulation of ideas between professionals, dissemination of latest achievements in the field among general public and an opportunity for non-professional visitors to interact and learn directly from scientists and engineers. Undeniably it would also be a great opportunity for business representatives to investigate latest trends and needs as well as find potential business partners or even seek out human resources. To additionally reinforce that approach, the most valued qualities in competing or exhibited robots would be approachability by ordinary users and practical use in everyday life [34].

The World Robot Challenge is a competition based on real life situations in line with the general idea of WRS – to accelerate robot utilisation into everyday life. The entries are divided into four main categories: Industrial Robotics, Service Robotics, Disaster Robotics and Junior [Fig. 31].
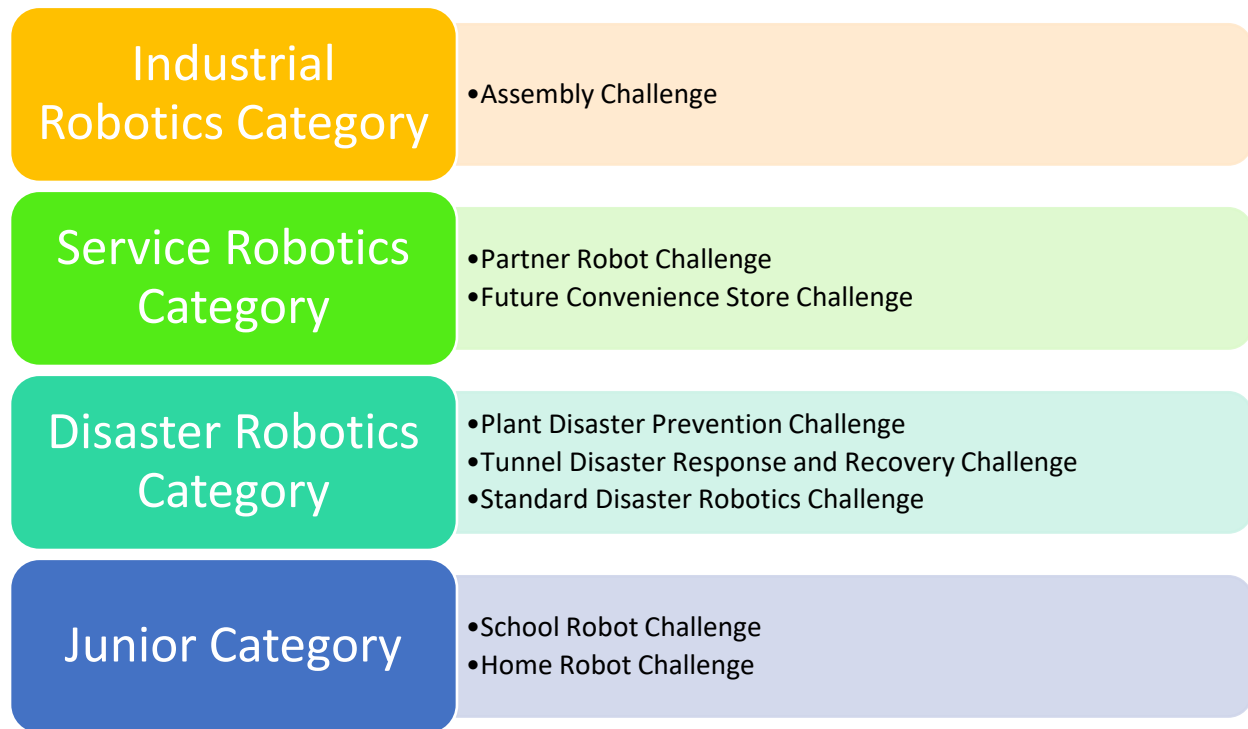
World Robot Challenge: competition categories

Industrial Robotics Category	•Assembly Challenge
Service Robotics Category	•Partner Robot Challenge •Future Convenience Store Challenge
Disaster Robotics Category	•Plant Disaster Prevention Challenge •Tunnel Disaster Response and Recovery Challenge •Standard Disaster Robotics Challenge
Junior Category	•School Robot Challenge •Home Robot Challenge

Figure 31 World Robot Challenge - main categories of competition.

Source: [34]

The task in the Industrial Category is related to a production system, so that participants not only have to create a robot that is capable of putting together a product, but is also flexible enough to accommodate changes in production. The Service Robot category has two tasks assigned to Robot Partner subcategory, and both cover activities related to housekeeping. A unique feature of this category is the Future Convenience Store Challenge since it takes place in a simulation of a real store surrounding and involves basic tasks of a convenience store clerk: lining up products, contact with customers or cleaning. A separate category is designated for disaster response and recovery, which have robots performing tasks related to inspection and maintenance, diagnosis of situation and coping in an enclosed environments like tunnels. Again, placing the competition in tunnel surrounding is a novelty on a global scale. Finally, the Junior category is more of a long-term initiative geared towards facilitating the development of future highly skilled human resources.

The tasks sought after in two subcategories are related either to school or to the home environment [35], [36].

The World Robot Exhibition would be an opportunity to showcase latest achievements in the field from around the world. The special emphasis is placed on the robots' actual applicability in real life.

The final part of the WRS is a symposium including lectures, presentations and even workshops by acknowledged experts or successful business representatives. It offers yet another opportunity for general public to learn more and get closer to robot inventions and for professionals to connect with each other.

So far two events in the World Robot Summit scheme have been planned [Fig. 32].
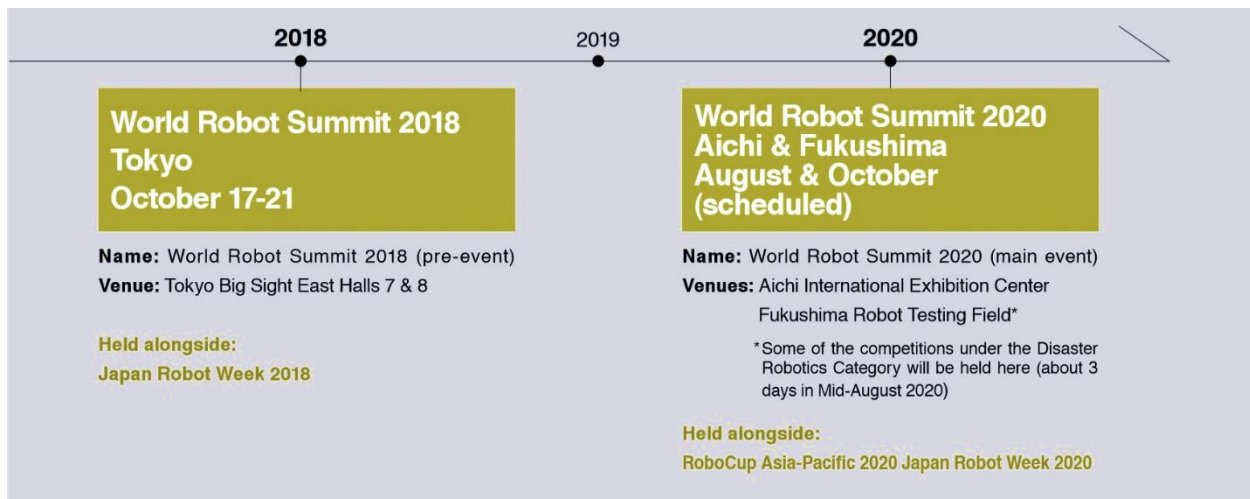
World Robot Summit events

Figure 32. Events planned for the World Robot Summit: 2018 and 2020.

Source: [34]

The first one, considered a preparatory stage, already took place in 2018 and the next one is scheduled for 2020 in two rounds: August and October [Fig. 33].

WORLD ROBOT SUMMIT 2020

Figure 33. Announcement for World Robot Summit 2020.

Source: [35].

5. R&D Programs

R&D is a crucial part of developing AI and Robotics for the realisation of Society 5.0 and strengthening Japan's position in the world. The technology is not yet at the level of development that would allow for immediate transition to the desired model of society and more research as well as more practical exercises are needed to proceed in that direction. For that reason, the need for more efforts in the R&D area is heavily emphasised in numerous plans and strategies along with more open collaboration on both national and international level, smooth information exchange and knowledge transfer between researchers and institutions, engagement of various stakeholders and finally more efficient management of priority research fields.

Since AI and robotics seem to be the very fundament of Japan's future, and therefore are treated as priority areas, there is a plethora of R&D programs and initiatives linked to those fields. Especially worth mentioning are the programs affiliated with Science, Technology and Innovation Council which is a parent authority towards the AI Technology Strategy Council.

Within this wider domain there are four main R&D initiatives:

- Strategic Innovation Creation Program (SIP)

- Public-Private Investment Expansion Program (PRISM)

- Impulsive Paradigm Change through Disruptive Technologies Program (ImPACT)

- Moonshot R&D Program

5.1 Strategic Innovation Creation Program (SIP)

The distinguishing feature of the program is its interdisciplinary character and placement beyond the usual boundaries of institutional division. The specific organisational structure allows the Science, Technology and Innovation Council to be the governing agent over involvement from various ministries. The effort of innovative approach can be seen not only with regards to structure, but also in approach to disciplines, as the initiative allows for wide, interdisciplinary topics of

interest, as long as they align with Japan's pressing social challenges and economic resurgence. Another requirement is developing the complete R&D process, starting from basic research through further stages. However, the projects are not considered finished with only practical implementation of the results but a commercialisation and even exit strategy are fully required in each case. This type of project realisation places a considerable pressure on the position of Program Director, who in fact is a main person responsible for the whole process end-to-end and also coordinating between various stakeholders (public, private and academia) [Fig. 34]. Aiding the Program Directors are the Governing Board consisting specifically of CSTI members and possibly external experts and Promoting Committee – including ministry and funding agencies representatives as well as other invited experts [37], [38], [39].
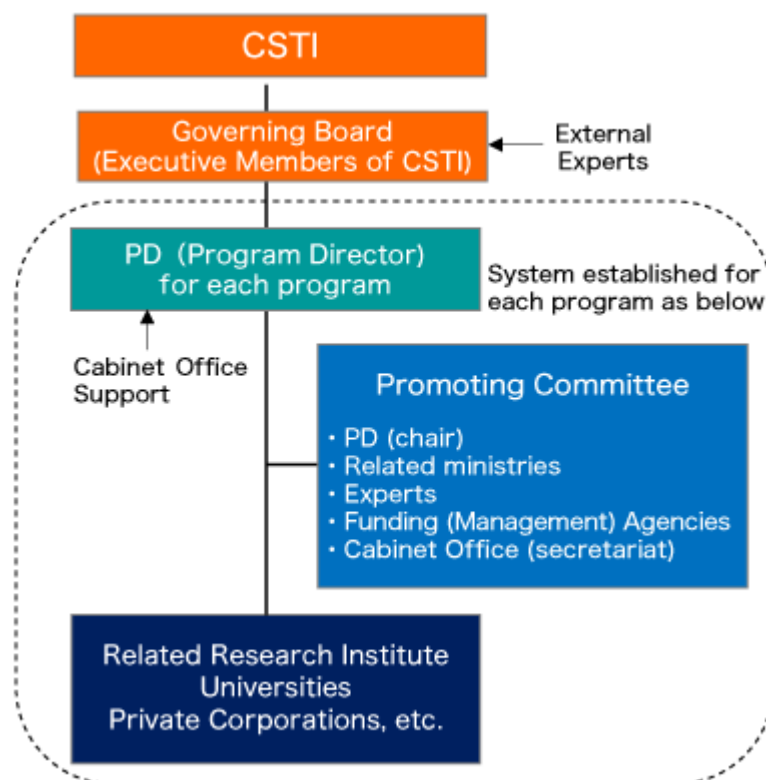
SIP IMPLEMENTATION STRUCTURE

Figure 34. The implementation structure of SIP projects.

Source: https://www.jst.go.jp/sip/k03/sm4i/en/outline/about.html

SIP has been initiated in May 2014 and covered 11 projects in its first phase and 12 in recently initiated second phase. The topics outlined in the first phase leaned towards energy (Energy carrier, Next generation power electronics) and infrastructure related issues (Infrastructure maintenance / update / management technology, Ensuring cybersecurity in critical infrastructure). The other topics included: Next-generation agriculture, forestry and fisheries creation technology, Next-generation marine resource survey technology and Automated driving system among others. The second phase, beginning in 2018 however, is visibly more influenced by AI and Robotics [Tab. 3], [40].

Table 3. Areas and project topics for the second phase of SIP Program.

STRATEGIC INNOVATION CREATION PROGRAM PROJECTS: PHASE 2		
	Challenge area	**Project name**
1	Cyberspace infrastructure technology	Big-data and AI-enabled Cyberspace Technologies
2	Physical space infrastructure technology	Intelligent Knowledge Processing Infrastructure Integrating Physical and Virtual Domains
3	Security (Cyber / Physical Security)	Cyber Physical Security for IoT Society
4	Automated driving	SIP Automated Driving for Universal Services (SIP-adus)
5	Material development platform	"Materials Integration" for revolutionary design system of structural materials
6	Photonics / Quantum Technology Platform	Photonics and Quantum Technology for Society 5.0

7	Bio / Agriculture	Technologies for smart bio-industry and agriculture
8	Energy / Environment	Energy systems toward a decarbonized society
9	Disaster prevention	Enhancement of National Resilience against Natural Disasters
10	Health / Medical	Innovative AI Hospital System
11	Logistics	Smart Logistics Service
12	Ocean resources	Innovative Technology for Exploration of Deep Sea Resources

Source: https://www8.cao.go.jp/cstp/gaiyo/sip/kenkyugaiyo2.pdf

The SIP Program with its dedicated management system and target areas seems to be positively viewed by many environments, especially the industry. Part of the success is deemed to come from its emphasis on practical application and answering real needs of the industry.

5.2 Public-Private Investment Expansion Program (PRISM)

In order to make full use of the potential created by the SIP program, and increase the private investment in priority R&D areas the new initiative has been established at the end of year 2016. Stemming from SIP, the PRISM Program aims to expand the predecessor's specific management system to more actively involve other agencies and institutions. Moreover, the program would also be one of the means to promote the idea of Society 5.0. Final, and most important goal of the program is increasing the private investment in R&D [41].

The Program officially began in 2018 with initial budget set for 10 billion yen and the first priority areas set to:

- AI technology

- Construction and infrastructure maintenance, disaster prevention and mitigation technology

- Biotechnology

In order to align the Program with existing strategies and other R&D initiatives, budget wise there would be a link with SIP Program. With regards to themes – the Program would follow the AI Strategy 2019, with heavy emphasis on human resources development, practical application in specific areas (Health, National resilience, Regional revitalisation, Agriculture, Transport). Again, the management structure resembles the SIP Program, with Science, Technology and Innovation Council at the top, followed by Decision Board down to the specific Project Directors responsible for the three areas described above [42], [43], [44].

There are however concerns that targeting industry investment in R&D PRISM would mainly provide opportunities for major players, while SMEs would only be partially involved. Another question mark, as with many other new R&D initiatives, seems to be related to actual results and conclusions – that is proper evaluation of projects. There seem to be cases of big budget initiatives that did not succeed in advancing Japan's global position or innovation indicators [45].

5.3 Impulsive Paradigm Change through Disruptive Technologies Program (ImPACT)

Stemming from continued search of innovation, the ImPACT program is yet another governmental R&D initiative. What distinguishes it from the others though is a different and rather bold approach to the issue of innovation. The aim with which ImPACT was created was to bring about the disruptive innovation – in other words initiate radical change. The challenge connected with disruptive innovation comes from the fact that it inevitably changes the status quo, which is exactly

why the ImPACT program is described as "high-risk, high-impact" [46]. As one of the global contestants in innovation race, Japan by introducing ImPACT and thus taking down many constraints traditionally imposed in governmental R&D projects hoped for results that would revolutionise both the industry and society.

The enforcement and carrying out of set targets are the responsibility of each Project Manager which seems to be more a business-like managerial position rather than research oriented one. It is the PM's task to attract highly skilled human resources and not only successfully create disruptive innovation, but also create a new innovation development model that could be later adopted by Japanese businesses [Fig. 35] [47], [48].
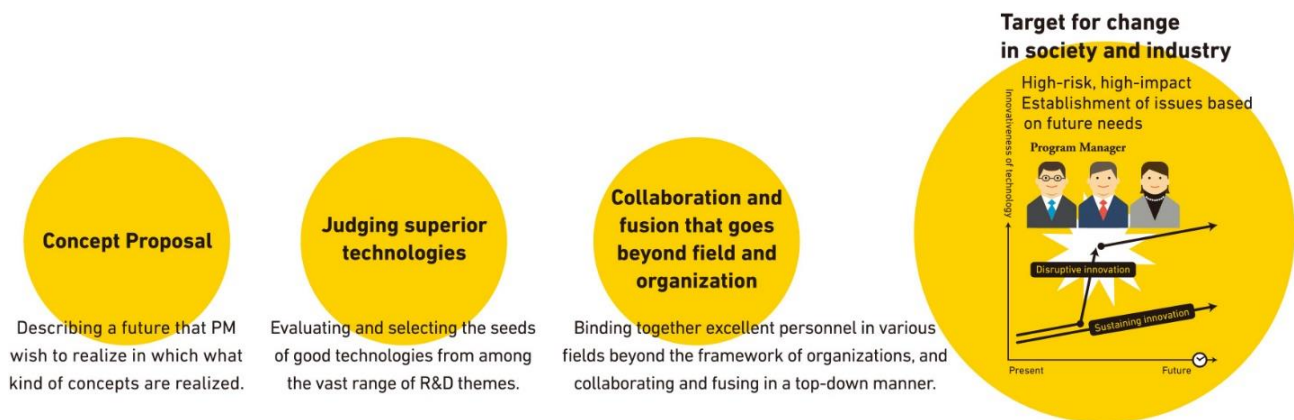
ImPACT MANAGEMENT MODEL

Figure 35. ImPACT model of managing research and development process.
Source: [49]

In an effort to break away from repetitive R&D schemes the idea behind the ImPACT Program is characterised by visible openness not only in terms of topics and challenges but also organisations and researchers. The inspiration can be found anywhere, and realised across many fields and topics as long as it results in desired innovation [49], [50].

The themes are presented in broad strokes:

- "Japan-style value creation for the new century

- Living in harmony with the world

- Smart community that links people with society

- Realize healthy and comfortable lives for everybody

- Realize a resilience that is keenly felt by every individual Japanese" [46].

Again, the emphasis is on the practical solutions such as stepping away from the limitations of resources in manufacturing, creation of harmonious and sustainable lifestyles in energy sector or tackling effectively the natural disasters for a safe and comfortable lifestyle [50], [51].

The ImPACT Program has officially finished its run in 2018, though the evaluation is still in progress and some of the projects are still ongoing.

5.4 Moonshot Research and Development Program

Based on experience (both positive and negative) gained through previous R&D Programs Japanese government is preparing the newest initiative in R&D. The preparations started in 2018 and still many parts of the program are being discussed and decided. The motivation for this initiative seems to come from lack of spectacular success with previous endeavours on one hand and doubled efforts of competitors on the other. The authors of the project indicate bold initiatives from the US, such as Brain Initative or genom editing technology, quantum cryptography technology developed by China or artificial photosynthesis technology and neuro computer projects developed in Europe. Japan so far lacks such projects, and even if the ideas are there and basic research is concluded, the following steps either do not seem to bring in the desired success in practical application or are used by others. The latter situation is illustrated with two interesting examples:

- 1987 - discovery of CRISPR DNA sequence (Professor Ishino, Osaka University) ➔ 2012 genome editing technology developed at University of California

- 1998 – quantum annealing theory (Tokyo Institute of Technology, Professor Nishimori et al.) ➜ 2011 Quantum Computer (Canada D-wave), [52, p.1].

In order to avoid losing opportunities in the future, the construction of the program progresses among considerations and analyses of previous experiences in Japan and abroad.

The broad spectrum of Project Managers' competences and powers is a feature brought into Moonshot Program from previous R&D initiatives. It was positively viewed in previous instances both by participants, government and wider audience (e.g. industry) and is deemed crucial in order to properly lead high-risk initiatives this time as well [Fig. 36], [52].
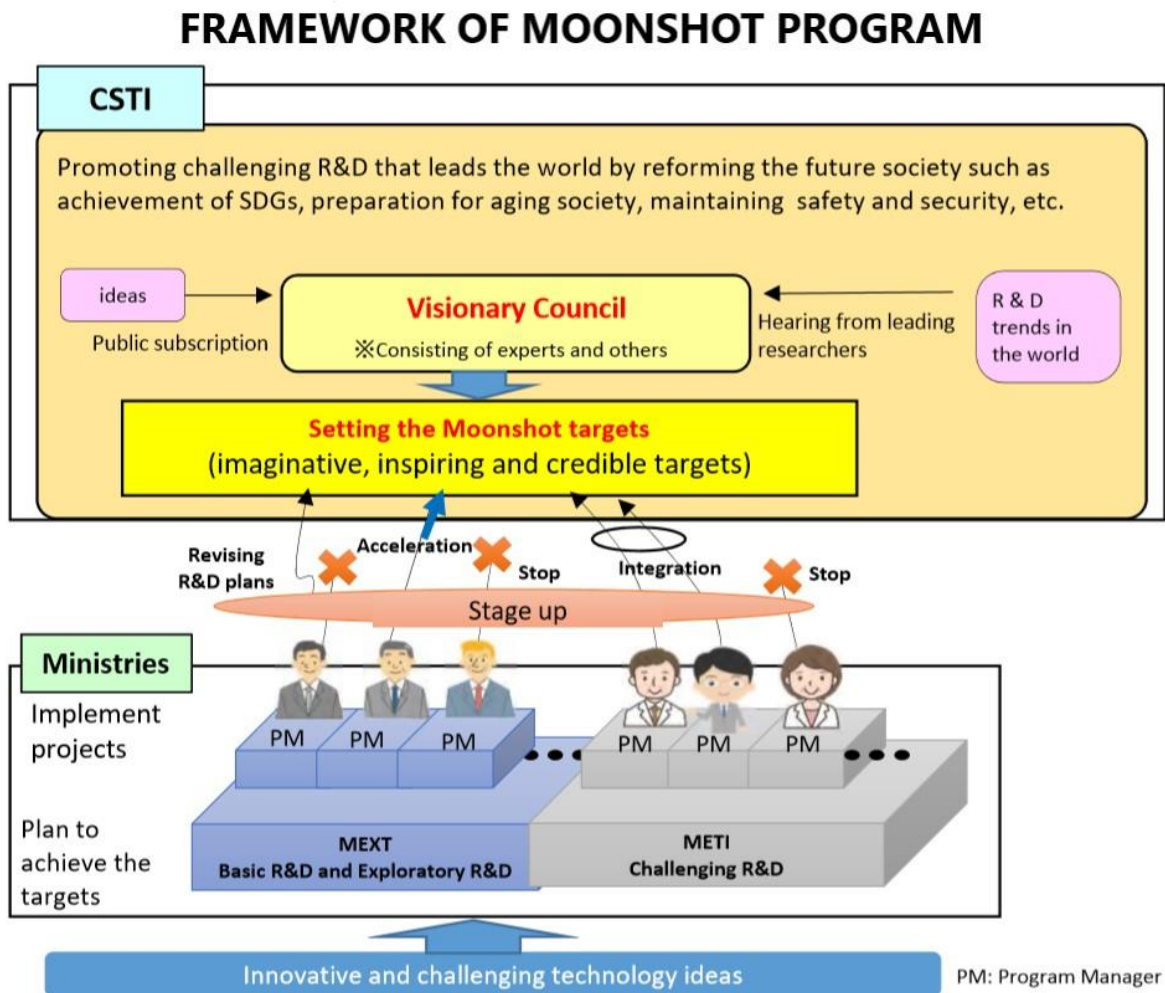

Figure 36. Structural and organisational framework for Moonshot R&D.
Source: [52]

The Ministries primarily responsible for the project are METI and MEXT and also JST and NEDO are involved in direct hiring Project Managers, setting up teams and budgets. The current budget for 2019FY is set to 2 billion yen and the funds are being transferred in two parallel flows. The firs one originates from MEXT (the larger contribution of 1.6 billion yen) goes to JST and from there is entrusted to universities, research institutes and private companies. The second originates from METI (400 million yen) and is directed to NEDO which further distributes the resources to universities, research institutes and private companies in a similar way. As with previous projects CSTI comprises its supervising role, being the point of contact for all the involved agencies and teams, setting out targets, supplying knowledge and experts' advice and coordinating promotion of results. A new addition in this structure is the Visionary Council, which employs acclaimed researchers, specialists but also artists and writers - all in the spirit of opening the scope of research as widely as possible and aiming as far as the moon. The Visionary council is currently in the process of determining targets for the program and it welcomes ideas not only from the experts and specialists, but also from the general public. The areas targeted by Moonshot Program are characterised by three aspects: inspiring, imaginative and credible. The first aspect relates to the answering real needs of the society and creating a positive influence on it as well as strengthening cooperation with the global research environment. The second refers to inducing transformation on a societal level and the last aspect grounds the far-reaching goals to comply with existing regulations and maintain scientific expediency [53], [54], [55].

So far three areas of focus have been determined:

1. Tackling declining birth-rate and aging society with radical innovation

2. Recovering our civilization and healthy global environment

3. Pioneering new frontiers with science and technology

While all three target areas seek to solve important societal challenges while maintaining the human-centric approach and carry the potential of shaping the future of Japan in next decades in line with development of technology, especially the third target is heavily focused on AI and robotics [Fig. 37], [55].
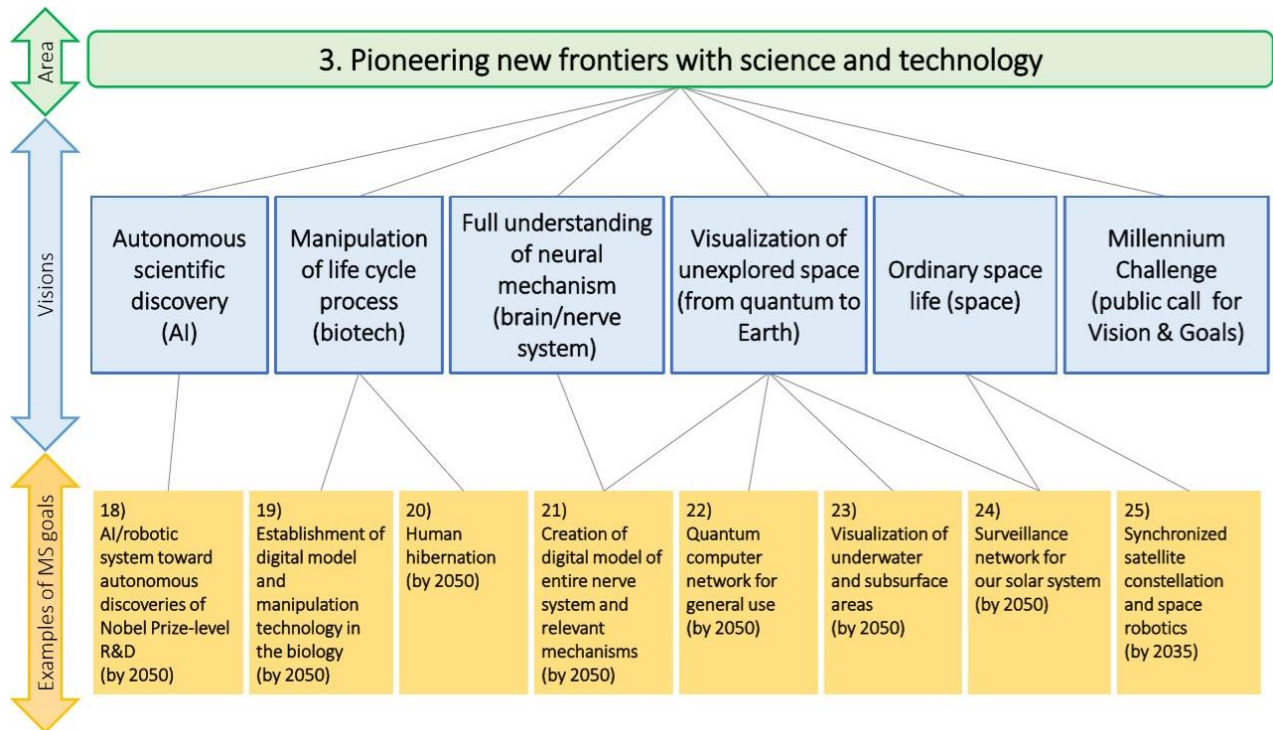
MOONSHOT: AREA, VISIONS AND GOALS

Figure 37. Moonshot R&D: area, visions and goals: "Pioneering new frontiers with science and technology"
Source: [55]

The visions to be explored in this area include "Autonomous scientific discovery", "Full understanding of neural mechanism" or "Ordinary space life". While the actual goals are still under examination by the Council, judging by the examples given, the research could result in achievements such as an AI system capable of making significant scientific (Nobel level) discoveries, functioning digital brain model, space robots and satellite network or solar system surveillance [55].

The Moonshot Program sets ambitious goals to be realised in the long-term perspective, bearing some resemblance to the Horizon Europe. The similarity is certainly not accidental, as the EU program is indicated as one of the model examples. Moreover, the openness for cooperation with EU is being mentioned on many occasions with regards to the Moonshot Program and declarations

from both sides as well as commitments to funding of joint projects and new collaborations between ERC and JSTA are clear evidence of strengthening ties in R&D area [56], [57].

The next opportunity to discuss further endeavours for Moonshot Program will take place at the MS International Symposium, in Tokyo, mid-December 2019 (the exact date is to be agreed still). The organisers intend to attract distinguished researchers and specialists from all over the world to discuss the visions of the future and directions of further progress in R&D [55].

# 6. Efforts in patenting and standardisation

The strategies for AI and Robotics with related plans and regulations place a lot of importance on R&D endeavours – as a guaranteed means of advancing on the global stage and strengthening Japanese position among competitors, however, there is also another way to achieve indisputably strong position in this area, namely through shaping the industry standards and accumulating patents. These two ways are actually complementary and while focusing on one or the other could bring considerable benefits, when combined they can create a significant advantage. Japanese policymakers are certainly aware of that possibility and include recommendations on increasing participation in developing standards and securing patent rights in related strategies. While there is still no detailed action plan pertaining to those areas, they are gradually gaining attention.

In January 2019 WIPO published its first Technology Trends report focusing on AI. While the findings brought a lot attention to China and US – the expected leaders, Japan also entered the spotlight as a close contestant. According to Tech Trends 2019 the first AI related patent applications were filed in Japan almost 40 years ago. Unfortunately, according to the data presented in the report after the initial interest in later years the number of AI patent applications decreased and from 1990s stagnated at under 2000 per year, while China and US recorded constant growth [58].

Currently China and US still maintain the leading positions, however, looking at top 30 applicants with highest number of patent families Japan's presence is clearly strong, as 40% of them are based in Japan [Fig. 38].

TOP 30 PATENT APPLICANTS BY NUMBER OF PATENT FAMILIES

Companies represent 26 of the top 30 AI patent applicants worldwide
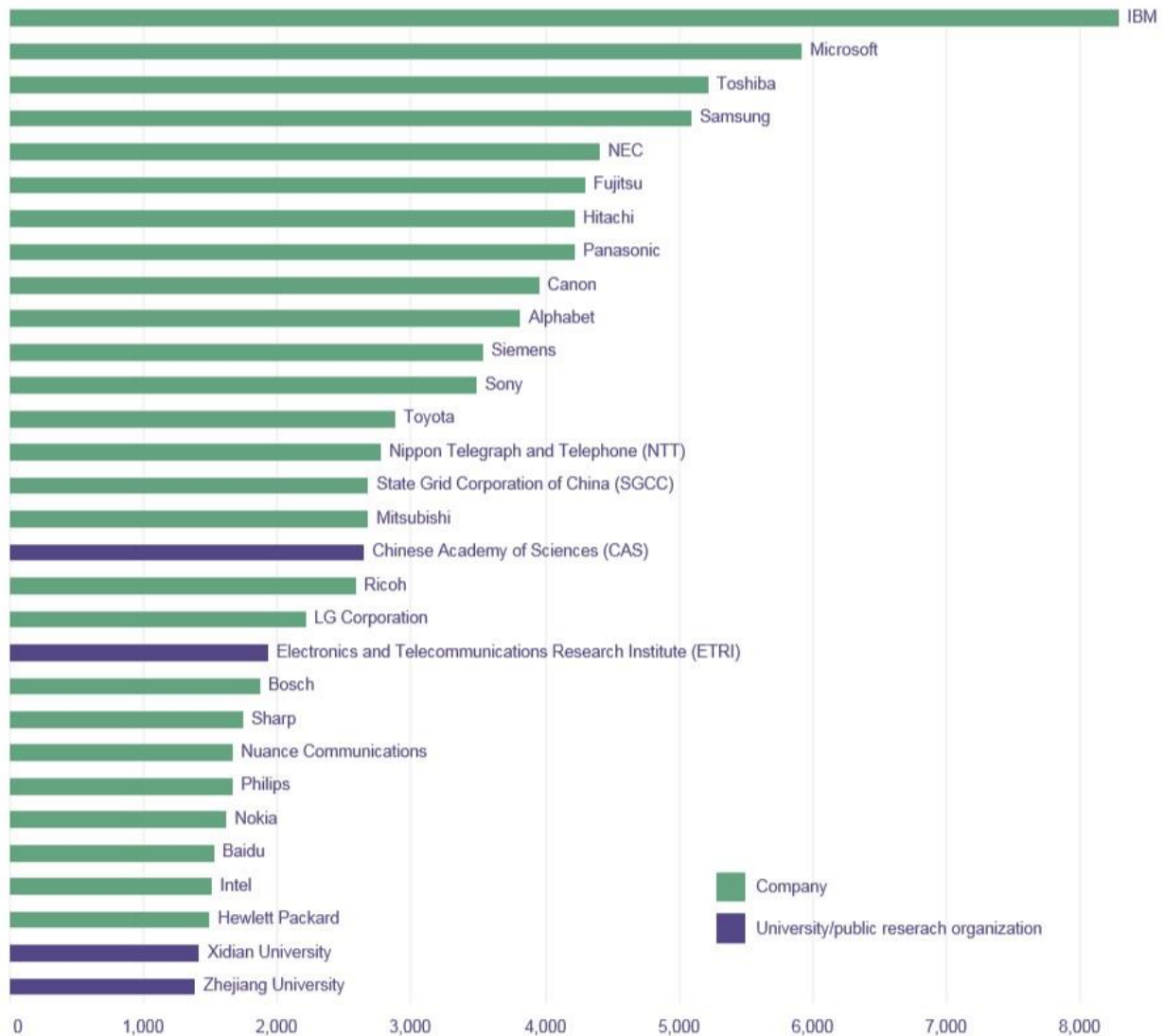
Note: Fujitsu includes PFU; Panasonic includes Sanyo; Alphabet includes Google, Deepmind Technologies, Waymo and X Development; Toyota includes Denso; and Nokia includes Alcatel

Figure 38. WIPO Tech Trends 2019 AI: Top 30 applicants by number of patent families.

Source: [58]

The majority of positions in the top 30 is occupied by companies, with only 4 of them being universities and research institutions (still mostly Chinese). Remaining 26 entities are companies

and 12 of them is affiliated with Japan: Sharp, Ricoh, Mitsubishi, NTT, Toyota, Sony, Canon, Panasonic, Hitachi, Fujitsu, NEC and Toshiba and focusing heavily around consumer electronics field [58].

However, it should be stated that in patent classification there is no dedicated category for AI. The patent classes chosen for the conducted survey were designated by a group of selected experts, to the best of their knowledge. Therefore, while the research was conducted according to widely recognised rules, there always remains the element of experts' choice.

Another report - "Recent Trends in AI-related Inventions" – prepared by Japanese Patent Office, appeared in July 2019. The target definition used by JPO differs somewhat from the approach adopted by WIPO in distinguishing only two areas of interest: AI core invention and AI-applied invention forming the research domain – AI-related inventions. The first one corresponds to "mathematical or statistical information processing technology", while the second covers their actual utilisation in e.g. image or voice processing, device control, robotics, detection or optimisation [59, p.2]

The data for domestic applications in the target group defined by JPO as AI-related inventions indicates the beginning of third AI boom from year 2014 [Fig. 39].

Year 2017 was especially fruitful in this aspect, with 3065 applications submitted. This third wave of applications is mostly induced by the developments in machine learning and especially deep learning. The development in that particular area, previously abandoned eventually became possible with advancement of computer performance and abundance of data for testing and training the AI.

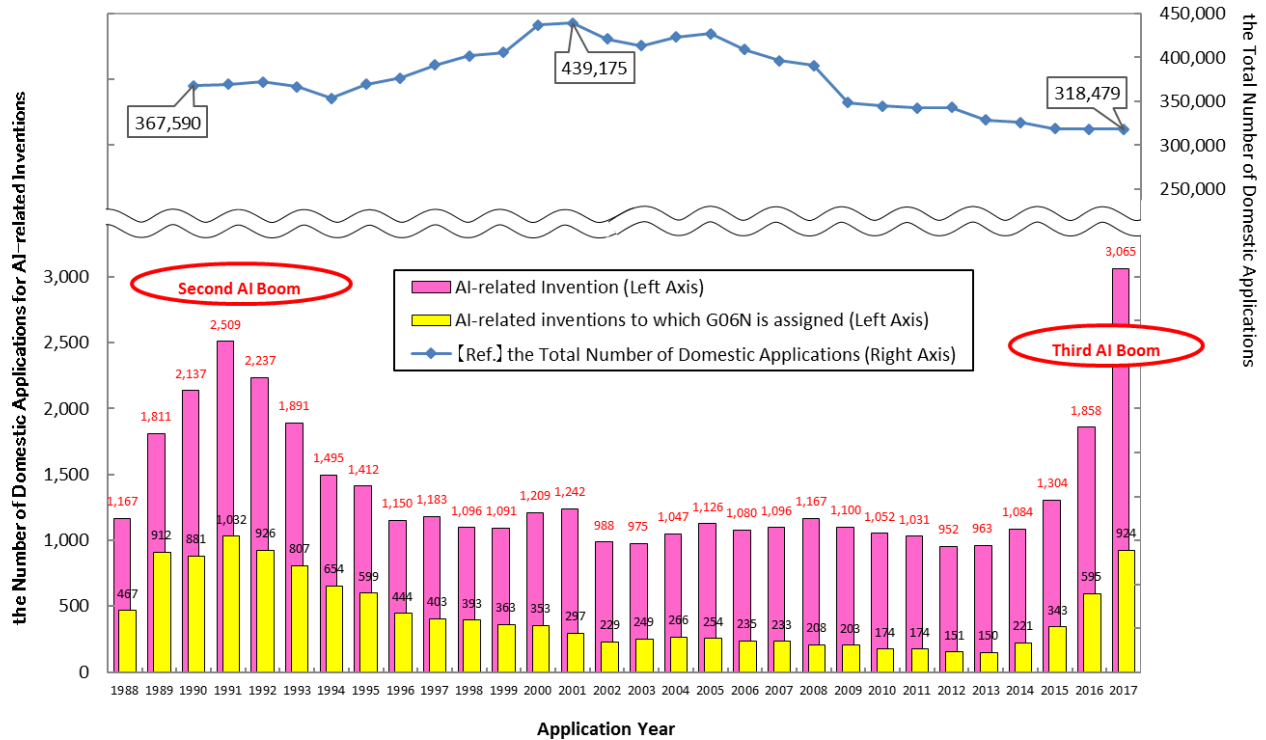**THE NUMBER OF DOMESTIC APPLICATIONS FOR AI-RELATED INVENTIONS**

Figure 39. Japan Patent Organisation report: The number of domestic applications for ai-related inventions.

Source: [59]

According to JPO's data the grant rate for AI-related patent applications has been growing very slowly, but steadily reaching a high level of 80% [Fig. 40].

Another positive indicator is the decreasing rate of patent refusals, which has been steadily decreasing from year 2004. The withdrawn applications, while included in calculation for grant rate, are not separately represented in the data distribution.
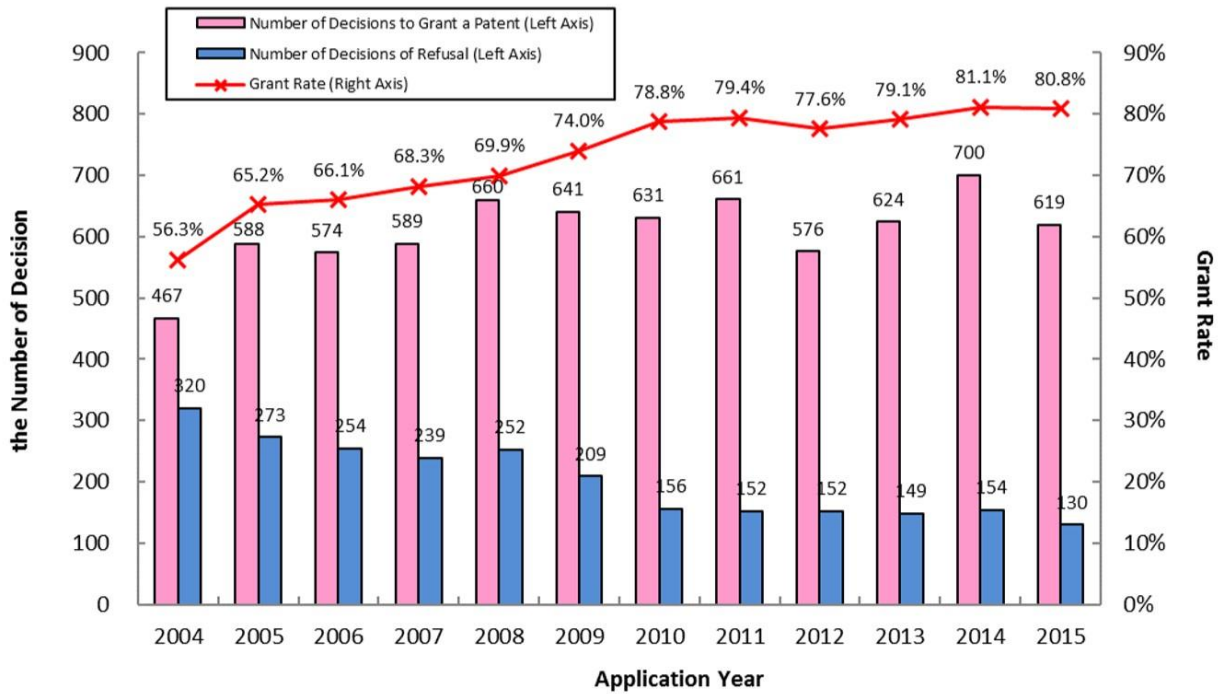
THE GRANT RATE FOR AI-RELATED INVENTIONS

Figure 40. Japan Patent Organisation report: The grant rate for AI-related inventions.

Source: [59]

The heavy influence of deep learning on the whole AI field with regards to patented inventions is further confirmed by comparing the number of AI – related Inventions referring to deep learning to the overall patent applications [Fig. 41].

Starting from year 2013 the share of deep learning related applications grew to reach almost half of all submitted AI-related patent applications. For this particular data set, the connection to deep learning was determined by specific keywords appearing in the applications documents (full list included in Annex 3 of the JPO report). AI-related inventions referring to deep learning when broken down by companies, reveal that NTT, Fujitsu, FANUC and Yahoo! Japan are most active in this patenting area [59].

THE NUMBER OF APPLICATIONs OF AI-RELATED INVENTIONS
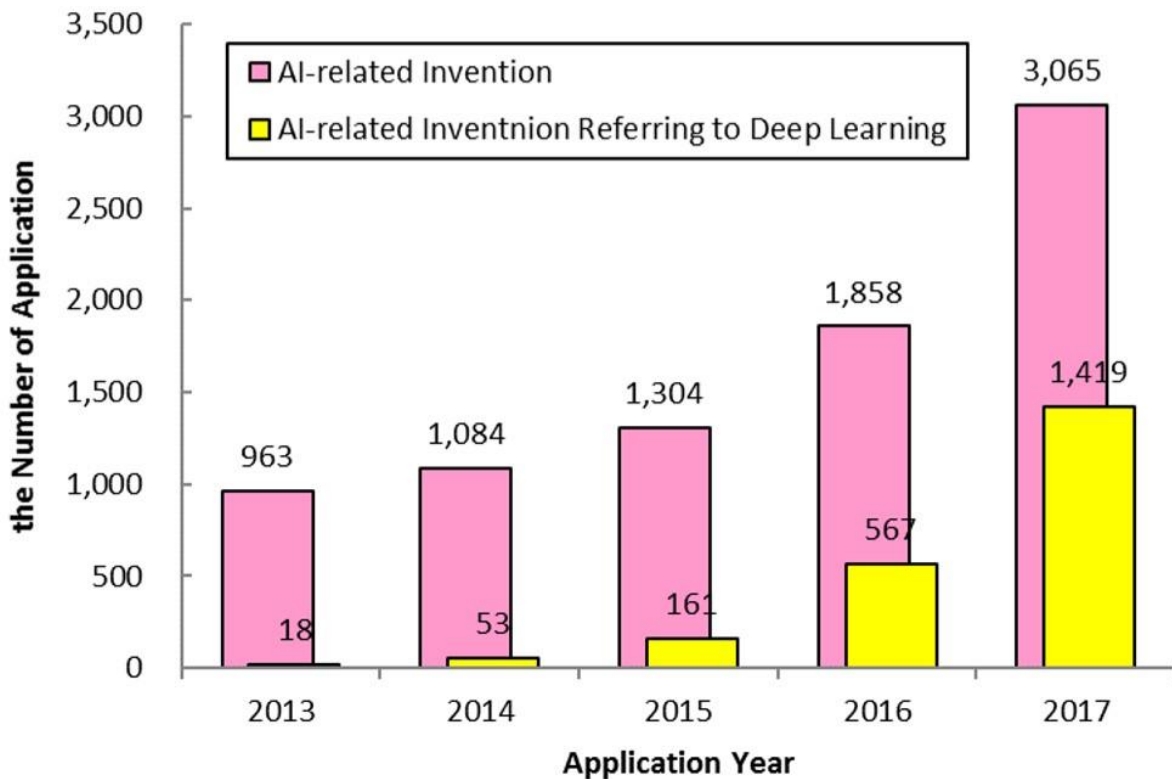
REFERRING TO DEEP LEARNING

Figure 41. Japan Patent Organisation report: The number of applications of ai-related invention referring to deep learning

Source: [59]

Further investigation reveals that within the deep learning area, the most dynamically explored method (based on growth in patent applications) is Convolutional Neural Network (CNN) – which in practice translates to image and video recognition, while Deep Reinforcement Learning applied mainly in system control and optimisation appears in significantly smaller number of submissions. Recurrent Neural Network (RNN) grouped together with Long Short Term Memory (LSTM) and utilised for speech and text processing, oscillates around the middle. Nevertheless, since year 2016 all three categories noted a significant increase in line with the third boom [59].

Investigation of overall composition of AI-related applications as of 2017 reveals general trends for Japan in AI development [Fig. 42].

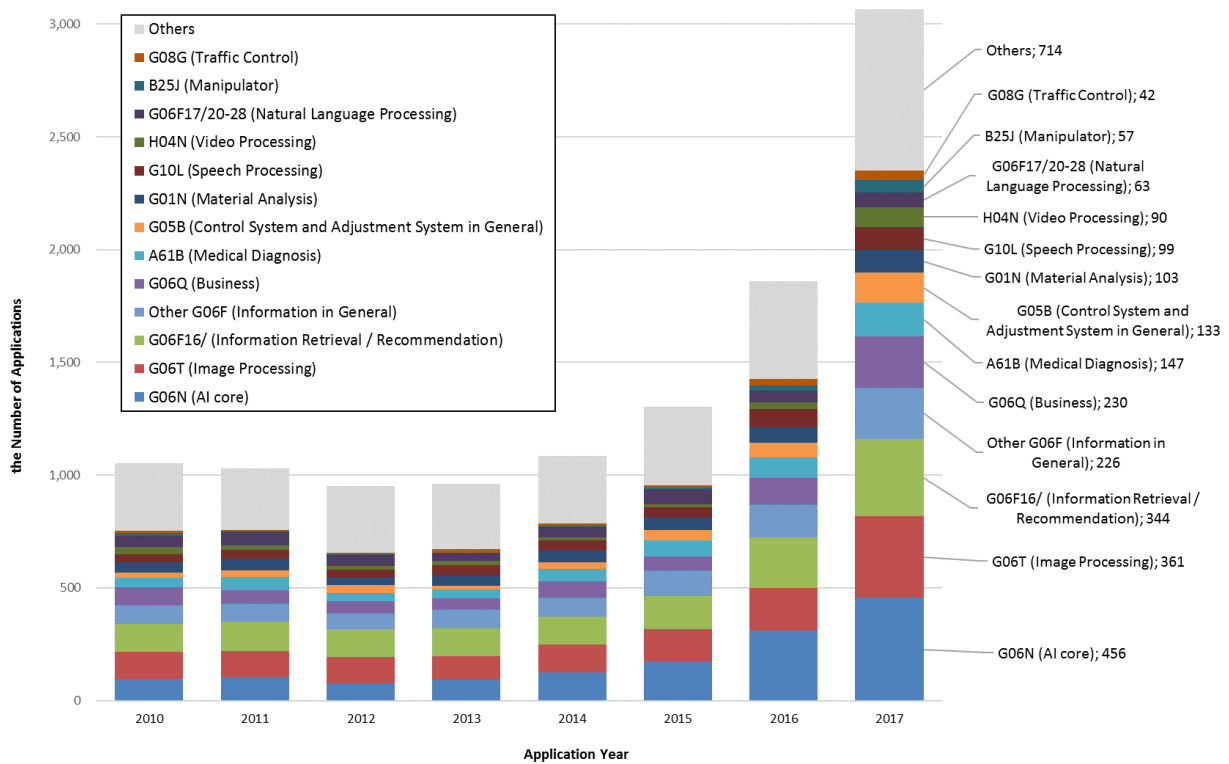## COMPOSITION OF MAIN CLASSIFICATION OF AI-RELATED INVENTIONS

Figure 42. Japan Patent Organisation report: Composition of main classification of ai-related invention (2010 - 2017)

Source: [59]

The most recent data indicates clearly that image processing, information retrieval, business method and medical diagnosis have gained a lot of interest among patent applicants in 2017. Those are however all areas connected with AI application, while the AI-core field itself covers largest portion of patent applications as well. It is also worth mentioning that in the period between 2010 and 2017 the fastest growing field was control and robotics related areas, recording over 400%-

500% growth. Generally, however, according to the JPO data all the fields registered significant growth of 290% in the period between 2010 – 2017. Further analysis of the data in breakdown by applicants, specifically companies, reveals areas of interest for global major players [Fig. 43] [59].

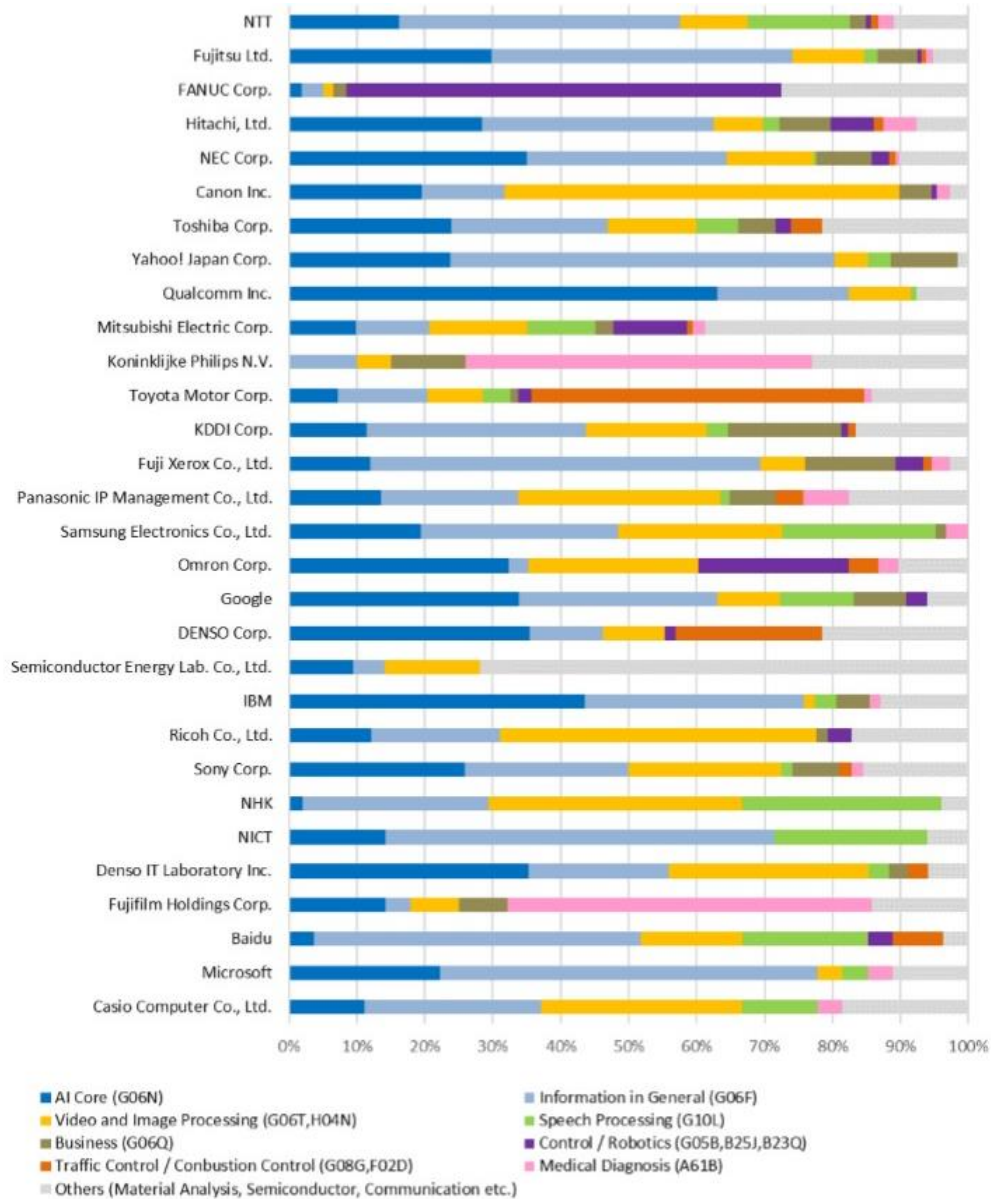## COMPOSITION RATIO OF MAIN CLASSIFICATIONS FOR AI-RELATED INVENTIONS BY APPLICANTS

Figure 43. Japan Patent Organisation report: Composition ratio of main classifications

for AI-related inventions by applicants.
Source: [59]

While almost all the applicants included in the comparison submit applications within AI-core, Information in General and Video and Image processing (with Qualcomm, IBM in the lead for AI-core, Yahoo! Japan, Microsoft, Fuji Xerox leading Information in General and Canon, Ricoh and NHK heading the video and image processing) not many seem to be making developments in Control/Robotics – where FANUC is the undisputed leader with Omron in second position, but still far behind. Efforts in traffic/combustion control are being made by mostly by Toyota with significantly smaller amount of by DENSO. Some interest in this area can also be observed in Baidu, Toshiba, Panasonic and Omron. A significant and comparable interest in medical diagnosis is demonstrated by Philips and Fujifilm and to a decidedly lesser degree by Panasonic and Hitachi, though a lot of other applicants also possesses small number of inventions in this area. As observed by the JPO – most of the efforts concentrate in the areas most closely related to applicants' basic business fields [59].

Finally, a comparison between five major Patent Offices (Japan, US, EPO, China, Korea, WO – referring to PCT type of application) in terms of AI-core applications confirms on a wider scale the significant growth observed in earlier, Japan focused, data sets for 2017 [Fig. 44].

However, application to specific patent office does not indicate the affiliation of applicant, but rather the intention to protect a specific invention on potentially profitable market. From this point of view, as the most competitive are indicated American and Chinese markets, while Japan is considered slightly less favourably than Korea and PCT application path (giving potentially access to 150 countries/markets). The least attractive in terms of AI-core inventions protection seems to be the European market.

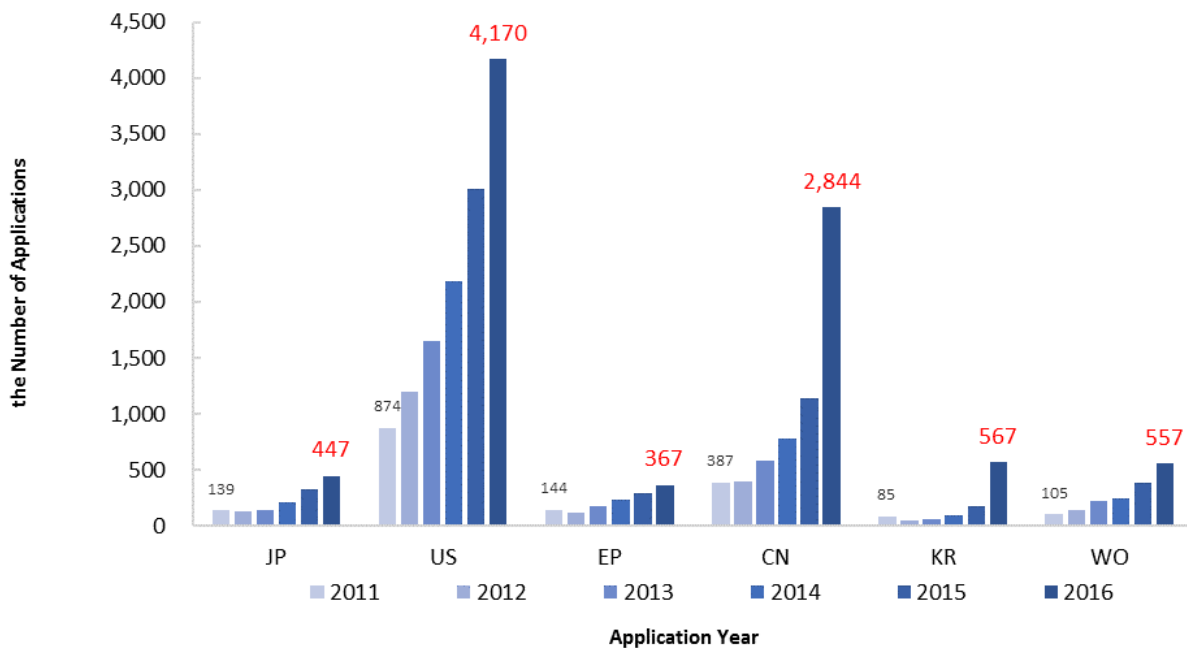## THE NUMBER OF APPLICATIONS TO EACH PATENT OFFICE AND PCT

Figure 44. Japan Patent Organisation report: The number of applications to each patent office and PCT (classified into IPC: G06N).

Source:[59]

Standardisation has been indicated in various recommendations and strategies, as a field necessary to influence in order or Japan to gain dominance on the global market. While the changes in international standards are carefully observed, so far there were few reports on actions being undertaken by the Japanese side. One such instance was leading a joint working group, comprising experts from ISO and IEC, tasked with developing safety and performance criteria for medical robots resulting in newly published standard IEC 80601-2-78: 2019 Medical Electrical Equipment — Part 2-78: Specific requirements for basic safety and essential performance of medical robots for rehabilitation, assessment, compensation or alleviation [60], [61].

7. Ethical aspects

Ethics has always been an important aspect of technology development, however with growth in AI and Robotics as well as data utilization it has been gaining a lot of attention and gradually becoming one of the most vital elements of all field-related discussions. Japanese policymakers have been making efforts in establishing a set of ethical guidelines with regards to various aspects of AI and its applications in order to create a consensus of ethical standards for all stakeholders. The basis of the approach is formed by the three principles mentioned above in connection with the AI Strategy 2019: Dignity, Diversity & Inclusion and Sustainability. Further guidelines are compiled in a set of Social Principles of Human-Centric AI. Those principles were developed by a newformed body dedicated specifically to that area – the Council for Social Principles of Human-centric AI in cooperation with experts and acclaimed professionals from various backgrounds. Perhaps the most distinguishing feature of Japanese approach to setting a code of conduct for all AI related issues is placing humanity at the centre of the problem and starting from there. This view has been further expressed in seven principles:

1. The Human-Centric Principle,

2. The Principle of Education/Literacy,

3. The Principle of Privacy Protection,

4. The Principle of Ensuring Security,

5. The Principle of Fair Competition,

6. The Principle of Fairness, Accountability and Transparency,

7. The Principle of Innovation [63].

First and foremost, the application of AI cannot result in violation of basic human rights. The true goal of employing AI – as suggested by the Council for Social Principles of Human-centric AI should be in improving natural human abilities either by substitution or assistance, while

simultaneously avoiding any threats to equal access and inclusion. Also, such improvement must be voluntary and responsibility for possible problems should be accepted by developers or providers. However, possible mistakes or risks connected with use of AI could also be minimised with raising the level of AI literacy among society. It is one thing to provide services and products as user friendly and transparent as possible, but quite another – to actually use them in a conscious and informed manner. The society (not only in Japan) needs a better understanding of new developments in technology and for that the basics of mathematics and data science are necessary. Therefore, creating an inclusive learning environment for all members of society is one of the most vital points among the Social Principles of AI. Privacy is another point of concern, especially with ever growing demand for data for AI development. Thus, it is necessary to preserve the privacy, freedom and dignity of data owners, who should be able to influence how their data is handled and decide what part of their data they want to make available. Separate activities are required for ensuring security, though with rapid developing technology such as AI the main course of action is to perform more research – to be able to identify possible threats and risks. Another interesting point is being raised in connection with security, namely the sustainability in the AI utilisation. It is recommended to diversify the types of AI utilised rather than rely on a single one in order not to create a dependency. Moreover, according to principle of fair competition, AI technology has such a vast potential of influencing businesses, economies, countries and even social balance, that preventive measures need to be implemented to avoid potential abuse of dominance exercised by a single entity – be it a country, a company or a group of people. Furthermore, in order to ensure transparency, fairness and accountability in AI it is necessary to open a window for dialogue between the developers/providers and users or data owners. The Council for Social Principles of Human-centric AI argues that in certain situations explanations should be made with regards to when and how the AI is applied, from where and what kind of data is being used in the process and what protective measures are implemented in the process. This technology is certainly too advanced for even a literate user to fully understand, which is why efforts should be made for maximum transparency and to avoid the trap of black box situation. Finally, in the spirit of innovation cooperation among various environments, groups, countries, and stakeholders should flourish across boundaries and differences. Not only human resources, but also knowledge, experience and data should be able to move freely among various fields, industries and territories.

The above principles are directed mainly at the society at large, as well as policymakers and administrative bodies. There is also being prepared a separate set of guidelines directed towards developers, operators and business representatives focused on AI utilisation [Fig. 45], [63], [64].

AI UTILISATION PRINCIPLES

Principle of	Description
1. Proper Utilization	Users should make efforts to utilize AI systems or AI services in a proper scope and manner, under the proper assignment of roles between humans and AI systems, or among users.
2. Data quality	Users and data providers should pay attention to the quality of data used for learning or other methods of AI systems.
3. Collaboration	AI service providers, business users, and data providers should pay attention to the collaboration of AI systems or AI services. Users should take into consideration that risks might occur and even be amplified when AI systems are to be networked.
4. Safety	Users should take into consideration that AI systems or AI services in use will not harm the life, body, or property of users or third parties through the actuators or other devices.
5. Security	Users and data providers should pay attention to the security of AI systems or AI services.
6. Privacy	Users and data providers should take into consideration that the utilization of AI systems or AI services will not infringe on the privacy of users' or others.
7. Human dignity and individual autonomy	Users should respect human dignity and individual autonomy in the utilization of AI systems or AI services.
8. Fairness	AI service providers, business users, and data providers should pay attention to the possibility of bias inherent in the judgements of AI systems or AI services, and take into consideration that individuals will not be discriminated unfairly by their judgments.
9. Transparency	AI service providers and business users should pay attention to the verifiability of inputs/outputs of AI systems or AI services and the explainability of their judgments.
10. Accountability	Users should make efforts to fulfill their accountability to the stakeholders.

Mainly related to **Promoting benefit**

Mainly related to **mitigating risks**

Mainly related to **fostering trust**

Figure 45. Draft AI Utilisation Principles.
Source: [64]

The instructions included in the utilisation-oriented set can be assigned to three categories. The first and most popular category is guidelines designed for diminishing risks which covers all principles. The second category contains the principles related to promoting benefits: Proper utilisation, Data quality and Collaboration. The third category is characterised by building trust and encompasses: Human dignity and individual autonomy, Fairness, Transparency and Accountability. The proposed AI utilisation principles are consistent with the Social Principles of AI and with AI R&D Guidelines which are also currently being discussed [65].

The Japanese proposal on ethical aspects of AI has been recognised internationally and found a lot of common points with other similar initiatives. Special recognition of Japan's Social Principles

of AI has also been given by the EU as its own requirements for trustworthy AI cover almost identical set of issues. The common ground with regards to future AI development and its influence on society builds a solid fundament for wider EU-Japan cooperation. That proximity has been further recognised during the meeting between Carlos Moedas, Commissioner for Research, Science and Innovation and Takuya Hirai, the Japanese Minister of State for Science and Technology Policy in May 2019. The G20 Osaka Leader's Declaration also mentions Japanese approach, albeit in wider sense of human-centred Society 5.0 [57], [64], [65], [66], [67].

8. Conclusions

The current developments in AI are centred around deep learning, which turned out to be a game changer technology. It is not a new concept though, but a recycled one, Neural networks and deep learning first surfaced over 15 years ago, but were quickly cast aside in favour of other pursuits. These days they are back in the spotlight and their influence on development of AI results in rapid progress in this field. However, the experts are in agreement, that despite the advancement, there are still some fundamental differences between the natural and artificial intelligence. To put it simply – AI is nowhere near humans. Yet.

This sudden boost dynamic occurring due to deep learning was also mirrored in intellectual property protection endeavours. The first AI related patent application was submitted in Japan but after initial interest the number of new applications decreased, then stagnated and only recently – with deep learning taking the spotlight – started growing noticeably. It is worth mentioning, that while the patent domain is dominated by the US and China, Japan is not yet left behind. Especially Japanese companies active in consumer electronics have a strong presence among applicants with biggest number of patent families in AI field. Internally, Japanese patent domain is dominated by image processing, information retrieval and medical diagnosis related technologies, but the most dramatic growth in recent years can be observed in robotics field. Robotics will probably continue to progress rapidly, partly because of its proximity and links to AI and partly because it has long been one of Japan's strong points and now, that Japan is determined to join the technology leaders – China and US, capitalising the potential it holds in robotics seems to be the best option.

While the most publicised stories about Japanese robots usually depict AI equipped humanoids interacting with people and even performing various social functions, the true strength of the field in Japan lies in industrial robots. Japan has dominated this segment for years, and only recently yielded its position to China. An interesting point of Robot Strategy, which ultimately aims for Japan to be the world innovation hub and most advanced robotic society, is a recommendation on possibility of modularisation of robotic hardware and software. Since currently created robots are highly specialised and therefore expensive, introducing changeable elements that could be shared

between different robots regardless of their intended functionality could indeed significantly strengthen Japanese position in international competition. Even better, if Japan could shape the industry standards with regards to robot modules it would inevitably become a global leader.

The recent wave of technology-oriented policies in Japan has a common denominator – the Society 5.0. It is an ambitious vision of a society, that is saturated with various forms of AI-related technology, which improves the functioning of some of its elements, but also serves as a transforming force creating completely new aspects. It should be noted that AI dominates the technology-oriented policy landscape and both robotics and data issues are often considered from the perspective of AI. Japanese policymakers correctly recognise that one of the most important benefits that AI offers is its ability to penetrate and influence any part of social life, making various processes faster, cheaper or perform tasks that could not be carried out by humans or simply give better insight into various problems.

For that reason, Japanese policy has a strong emphasis on the practical application of AI. It is expected to perform a utilitarian function to solve problems and bring values. While many plans have ambitious targets and timeframes, it is the insistence on practical aspect of AI and robotics that if enforced in that right way, might decide about Japan's success in the world. As stated above, the potential to generate new value by AI technology does not come solely from the technical possibilities it offers, but also from its versatility. AI can be applied to any part of industry or economy and the solutions and tools it offers could be found useful in almost any aspect of our lives. In recently published strategies and recommendations Japanese policymakers plan out carefully possible practical applications of AI from the most general areas down to very specific ones. On general level the AI-related technologies would help solve societal issues such as aging society, labour shortage, need for energy diversification, reduction of GHG or even better waste management. It is worth pointing out, that the targeted societal challenges are aligned with SDGs, and according to the action plan Japan plans to work out solutions on a national level and share them with the world, which would not only contribute enormously to realising SDGs, but also immeasurably strengthen Japan's international position.

On a more detailed level though, both the robot strategy and AI strategy include plans for selected priority areas (manufacturing, transportation and logistics, health and medical care, agriculture and

disaster response). The majority of plans are designed to work in a two-way manner: one direction depicts the deployment of technology and data into the specific field, resulting in creation of robots supporting disaster recovery and inspection works, AI systems for smart crop cultivation, robotic healthcare workers or autonomous vehicles. The other way is the direction of data flow. The policymakers from the beginning took into consideration, that data is the basis for development of AI-related technologies and without it there is simply no way forward. Keeping that in mind, the project of future Society 5.0 is encapsulated within a virtuous cycle of data flows. Technology built and developed on data feed is utilised by society in various forms and the users themselves are feeding the data back to the system.

Various issues and challenges related to data are also targeted by both strategies, especially with regards to its usability and security, since not all data can be used effectively for development of AI. Further concerns addressed by policymakers are the risks to privacy of data and establishment of trust and methods of verifying data. Based on these issues, a general discussion and planning on construction of data linkage platform is in progress. Such an endeavour, if realised, would without a doubt dramatically accelerate the development of AI, however, the sheer scale of the project and work required to balance the issues of privacy, security, quality and finally willingness to share data points toward a rather distant time.

Interestingly enough, while the government is willing to make data available and is taking active steps to facilitate circulation and utilisation of various types of data (The Basic Act on the Advancement of Utilising Public and Private Sector Data; The Act on the Protection of Personal Information) some of the Japanese companies opt to tread carefully on the matter, guarding the privacy and security beyond the official requirements. The explanation for this choice of action is that when dealing with data and information – trust is everything. Once lost, customers' trust is not easy to regain. This is also a valid point to consider for European companies willing to participate in Japanese market, since as "outsiders" they would be at even bigger disadvantage.

However, building the trust is not the only pressing issue for both the public and private sector. One of the biggest challenges for Japan to overcome with regards to technology development is the lack of competent human resources. It certainly doesn't help that the problem is shared with the rest of the world, since attracting skilled professionals is becoming more and more difficult.

Short term solutions offer only partial relief through hiring overseas resources, and opening job market to women domestically. While this could certainly help fill the gap to some degree and simultaneously contribute to introducing diversity and inclusiveness, there still would be required actions to open Japanese work environment, ease the language barrier or offer solutions to maintain the work-life balance.

In the long-term perspective solving this problem requires fundamental reforms in education system, including the lifelong learning for current workforce. In the analysed strategies, the government makes an attempt at adapting the education system to ensure growth in AI-skilled professionals. There is planned introduction of new curricula elements form as early as primary school, making AI related subjects obligatory not only in the course of studies but also on entrance exams. Providing up-to-date knowledge for students means also ensuring sufficient level of skills and knowledge among educators as well as securing a learning inducive environment (infrastructure, access to necessary devices for each student).

While the strategies emphasise, actions required to facilitate the transition to new type of society and full utilisation of AI, the technology itself is not yet at the level of development that would allow for immediate transition to the desired model of society. Certainly, more research as well as more practical exercises (including failures and errors) are needed to proceed in that direction, which makes R&D a crucial part of all the strategies. Japan's R&D is not without problems however, and tackling old ones while simultaneously meeting the new is not an easy task. Divisions in R&D domain are an old obstacle, since historically, basic, general-purpose and applied types of research were conducted separately, which significantly hindered any progress. Therefore, a coordination of research is the first point to be addressed. While each centre specialises in its own topic, a collaboration network allowing for exchange of knowledge and data as well as contributing expertise in specific areas would considerably accelerate the whole process.

Disruptive innovation is another issue of concern, one that Japan cannot afford to ignore. So far Japan doesn't seem to have much luck in that area, since even though innovations are created it happens that the benefits a reaped by other countries. The ImPACT Program was an attempt at creating disruptive innovation, though it has just finished its run, so perhaps it is too early to make a judgement. There are definitely some good points, however, especially with regards to R&D

organisation. The tested structure of managing the research projects in a seemingly business-like manner by Project Managers equipped with a wide range of competences seems to have gained approval from many involved environments (public, private and academia). Moreover, after analysing so far R&D projects the government doubled efforts to actively involve the private sector both in terms of participation and investments. PRISM Program was one of the early attempts to bring closer the private and public stakeholders and certainly not the last one.

From policymakers' point of view disruptive innovation is impossible to plan or predict. While radical innovations can still be forecasted and arranged to some degree, the disruptive innovation is unpredictable. Yet, it should still be taken into account while designing technology related policies. While there is no perfect method, backcasting might provide some solutions. Recently launched Moonshot R&D Project seems to take steps in that direction. Its unique feature is the engagement of Visionary Council, comprising highly distinguished professionals from various backgrounds: academic, business, research but also artistic – for maximising the scope and perspective range of intended research. The Moonshot Project shares some similarities with Horizon Europe and there seem to be some openings for collaboration in that domain. Especially, since both sides on various occasions this year made numerous declarations regarding willingness to strengthen cooperation and made commitments to funding of various joint endeavours.

Certainly, cooperation between Japan and Europe should be fairly easy, as a lot of values and perspectives are similar. In general, Japanese approach to AI and related technologies seems much closer to Europe's point of view then that of the current leaders – US and China. In line with the notion of making available Japan's developments to the world, Japan has recently published a set of Social Principles of Human-Centric AI, which has been warmly welcomed by the EU, all the more so because it mirrors its own Guidelines for Trustworthy AI. Japan currently conducts further work on AI Utilisation Principles and AI R&D Guidelines.

Ethical aspects and R&D are not the only areas where Japan and EU meet and collaborate, since as of January 2019 both share the world's largest free data flow. Japan continues efforts to create free flows of data with other countries as well.

With dedicated strategies and regulations Japan actively enters the technology race, which unfortunately has already begun. While not exactly last, Japan is not in the lead either. Japan's

declaration of opening to the overseas in terms of business, collaboration and human resources mobility seem to be a step in the right direction, and at the same time a great opportunity for EU businesses and resources alike. Japan itself has some significant strengths and since technology has certainly not matured to the saturation point yet, and many new fields of application and utilisation haven not been fully exploited, the game is still on.

To sum up:

1. With resurfacing of deep learning AI gained new speed of development, though there is still a significant gap between natural and artificial intelligence.
2. Japan needs to intensify efforts in IP protection. Currently only Japanese companies active in consumer electronics have a strong presence among patent applicants with biggest number of patent families in AI field.
3. While Japan is recognised for its attempts at humanoid robots its true strength lies with industrial robots.
4. Modularisation of robotic hardware and software recommended in Robot Strategy could be a winning tactic for Japan to dominate global robotics market.
5. Japanese policymakers recognise AI's influence on all aspects of social life and make it a focal point of all technology-related policies and basis of Japan's further growth.
6. Policies emphasise the practical application of technology, planning to balance economy and solve major societal issues (ageing society, labour shortage, sustainable industrialisation) by means of AI.
7. Bearing in mind the key role of data in AI development, the government plans to facilitate data use and circulation, while private sector seems inclined towards more cautious approach.
8. Japan struggles with lack of human resources capable of developing and using AI. Short term solution of this problem is facilitating entry of women and foreigners to the job market. Long term actions involve fundamental reform of education through all levels, including lifelong learning

9. Japan aims to intensify R&D efforts and integrate cooperation between specialised research centres into research collaboration network. Various efforts are made to involve private participation in R&D, especially in terms of funding.

10. Japan hopes to harness the potential of disruptive innovation. Government initiates R&D programs aiming to facilitate disruptive innovation.

11. Japan shares a lot of common ground with EU, especially in its approach to ethics, privacy and security, which should make any collaboration and exchange relatively easy. This year Japan published Social Principles of Human-Centric AI which have been welcomed by the EU. Currently work continues on AI Utilisation Principles and AI R&D Guidelines.

8.1 Recommendations for European SMEs:

Japanese market has a reputation of being difficult to enter. The language barrier and cultural differences both in everyday life and in specific business situations are real obstacles and should not be disregarded by hopeful entrants.

The general direction in which Japan's policy seems to be going is opening the country towards overseas opportunities. While in terms of research, collaboration and human resources this move could generate interesting opportunities, with regards to technology and its application it seems to be turning in the opposite direction – making Japan's solutions and services available to the world. This is however a very simplified picture and there exist openings and ways for European SMEs to conduct their businesses in Japan. For one, Japan certainly does not have sufficient technology specialists to successfully realise its policy vision, so while the hiring and education is continuing, European businesses have perfect opportunity to offer their own solutions and products to fill the gaps.

There is especially one recurring issue in the general AI related discourse that could pose a great opportunity for many European SMEs – the digital transformation (DX). While it is not named in the AI Strategy (and due to the size of the issue also not covered in this report), there are clear recommendations on possible improvements to Japanese businesses by means of AI. The recommendations are twofold:

- Boosting AI related competences
- Conduct analysis of what exactly needs to be improved and tailor AI technology to specific requirements of each company.

The move to become AI-ready is beginning among Japanese companies and that need of transformation might just be the opening some of the European SMEs need.

Points to consider:

- Learning the basics of Japanese culture, and the specifics for related situations (business etiquette, research/laboratory related etiquette)
- Find ways to overcome language barrier. Hiring an interpreter is always a good idea.
- Make your presence known – participate in field related events. With regards to various fairs and exhibitions which make an excellent point of contact it cannot be stressed enough that while most of them advertise being open to international business, the dominating language is still Japanese. Therefore, it is crucial to either be able to communicate in Japanese or be accompanied by someone who can.
- When introducing products/services highlight quality and safety, as these are the features often sought after
- Be prepared to offer extensive customer service – this is important part of Japanese business and while there is a tendency to choose local services, making additional effort certainly shows the commitment and might just be the advantage needed to win over local competition
- Be prepared to customise – Japanese users and customers will be expecting tailoring to specific needs, especially if the products/services would be offered in the context of DX

As stated above, Europe and Japan share many similarities in approach to technology development and related aspects such as trust, values, security, privacy. Main competitors for both entities are also the same. Furthermore, there is a clearly visible movement towards collaboration in research and joint projects are being initiated with funding on both sides. What is still lacking though is EU's presence in terms of general public awareness. Looking at the sheer number of seminars (especially AI-related) and also workshops and lectures conducted during conferences, fairs and exhibitions EU while not exactly absent, is easily outshined by

the US and recently India to some degree. An effective solution to this would be intensifying EU's presence on field-related events. While raising awareness undoubtedly takes a certain amount of time, the benefits could well be worth the wait.

The visibility needs to be increased on both sides: public and private. So far, most of the discussions seem to be focused around policy related issues (and even those are not highly advertised). Even more effort is needed with regards to presenting European businesses. While on most major events there are at least a few presentations from US companies, from Europe there are almost none. Creating awareness of business opportunities with EU is recommended as an action accompanying other efforts, but still equally necessary.

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https://www.g20.org/pdf/documents/FINAL_G20_Osaka_Leaders_Declaration.pdf

ANNEX

List of field-related events:

Event name/website
AI EXPO Tokyo **https://www.ai-expo.jp/en-gb/conference.html**
Japan IT Week – Osaka, Spring (Tokyo) and Autumn Tokyo) editions **https://www.japan-it.jp/en-gb.html**
Nikkei Applied AI Summit - Where AI, Industries and Humanity Evolve Together (Tokyo) **https://aisum.jp/**
CEATEC Japan (Tokyo) **https://www.ceatec.com/en/**
Fujitsu Forum Tokyo **https://www.fujitsu.com/global/about/resources/events/fujitsu-forum-tokyo/**
Informatica World Tour Tokyo **https://event.entryweb.jp/**
World Robot Summit **https://worldrobotsummit.org/en/**